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"LET KNOWLEDGE GROW FROM MORE TO MORE
AND THUS BE HUMAN LIFE ENRICHED."

A New Survey of Universal Knowledge

ENCYCLOPÆDIA BRITANNICA

Volume 15

MARYBOROUGH TO MUSHET STEEL

ENCYCLOPEDIA BRITANNICA, INC.

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Volume 15

MARYBOROUGH *TO* MUSHET STEEL

MARYBOROUGH, a coastal city in the southeast of Queensland, Austr., 167 mi. by rail N. of Brisbane on the Mary river, about 20 mi. from the mouth. Pop. (1954) 17,952. In the Wide Bay district is the Burrum coal field. The Gympie and Kilkivan mining fields also find their outlet at Maryborough. Inland, valuable hardwoods such as Queensland maple and walnut are cut in the Kingaroy district. Cattle and sheep are raised in the Gayndah area. Sugar cane (Isis district) and citrus fruits are grown, with dairying and mixed farming near the city. Industries include foundries. railway engineering and pipe works, also sugar refineries and butter making.

MARYLAND, one of the 13 original states of the United States, extends along both sides of Chesapeake bay on the Atlantic coast. It is bounded on the north by the Mason and Dixon line (*q.v.*), which separates it from Pennsylvania: on the east by Delaware and the Atlantic ocean; on the south and west by the District of Columbia and the Potomac river; and on its extreme west by West Virginia. In area it ranks 42nd among the states, having a total area of 10,577 sqmi., of which 9,874 sq.mi. are land, 703 inland water excluding 1,726 sq.mi. of the Chesapeake bay. In population it ranks 21st among the states, with 3,100,689 inhabitants in 1960. Since 1694 Maryland's capital city has been Annapolis. which is also the seat of the U.S. Naval academy and St. John's college. Baltimore, a thriving port on Chesapeake bay, is the state's largest city.

Maryland mas named in honour of Queen Henrietta Maria, wife of Charles I of England. who granted the territory to Lord Baltimore (Cecil Calvert) on June 20, 1632. It is popularly known as the "Old Line state" because of the distinguished service of Maryland's regular "troops of the line" during the American Revolution. The state flower is the black-eyed Susan, the state bird the Baltimore oriole, and the state tree the white oak. The state flag is a colourful one, bearing the arms of both the Calvert family and the Crosland family, to which the mother of the first Lord Baltimore belonged. (See FLAG.)

"Maryland, My Maryland" is one of the best known of all state songs. The words, written in 1861 by James Ryder Randall, a Marylander living in the south. are sung to the German tune, "O, Tannenbaum." The national anthem nas nritten in Maryland by another Marylander, Francis Scott Key (*q.v.*), while Fort McHenry was under attack during the War of 1812.

PHYSICAL GEOGRAPHY

Physical Features.——Maryland. which lies between approximately 37° 53' and 39° 43' N. and approximately 75° 4' and 79° 29' W., possesses a great diversity of surface features. It is crossed from north to south by each of the leading topographical regions of the eastern portion of the United States—the coastal plain, the piedmont plateau and the Appalachian system. The part within the coastal plain includes nearly all of the southeastern half of the state and is commonly known as tide ater Maryland. It is marked off from the piedmont plateau by the fall line, a zone in which a descent of about 100 ft. or more occurs in many places within a few miles, creating waterfalls and rapids in the streams. The fall line extends northeast from Washington, D.C., through Baltimore to the northeast corner of the state. Chesapeake bay divides the coastal plain into two main sections: all of Maryland east of the bay and south of the Elk river is known as the eastern shore; the western shore or "Maryland main" extends westward from the bay to the fall line.

The eastern shore is a low, level plain, rising northward to a height of only about 100 ft. above sea level. Along its Atlantic coast extends the narrow sandy Sinepuxent beach, formerly enclosing the Sinepuxent bay on the north and Chincoteague bay on the south. A storm in the 1930s cut an opening into Sinepuxent bay at Ocean City. Md., making available a fine harbour for fishing fleets and other boats at the seaside resort. The eastern shore is drained by the Northeast, Elk. Sassafras, Chester, Miles, Tred Avon, Choptank. Nanticoke. Wicomico, and Pocomoke rivers. It is connected with the western shore by the Chesapeake bay bridge.

The western shore is somewhat more undulating and higher than the eastern shore, sloping generally from northwest to southeast. Along the western border are points 300 ft. or more above sea level. The Patuxent and Potomac are the principal rivers crossing this section, but the Severn, Magothy, Patapsco, Gunpowder and Bush rivers also drain it.

The piedmont plateau or foothill region extends west from the fall line to the crest of the Blue Ridge mountains. In general, it has a broad rolling surface and rises gradually to heights of over

1,000 ft. Its principal streams wind their way toward the southeast in narrow steep-sided gorges and broad limestone valleys.

Appalachian Maryland lies in the area extending from the crest of the Blue Ridge mountains to the western boundary of the state. It includes most of Washington and Allegany counties. To the eastward it abounds in mountains and valleys but is a rolling plateau in the extreme western portion. Antietam creek to the east and Conococheague creek to the west flow through its eastern portion in trenches that in places exceed 75 ft. in depth.

The Appalachian ridges of the western portion begin with North mountain on the east and end with Wills mountain on the west. Overlooking these ridges are the higher ranges of the Alleghenies among which the Savage, Backbone and Negro mountains reach elevations of 3.000 ft. or more. The highest peak in the state is Backbone mountain (3,360 ft.) in Garrett county. Located in the extreme western part of the state, these mountains merge into the rolling Appalachian plateau. The mean elevation of the state is 350 ft. All rivers of western Maryland flow south into the Potomac except the waters of the Youghiogheny and its tributaries in the extreme west, which flow into the Monongahela.

Chesapeake bay is 180 mi. long, with 115 mi. in Maryland and 70 mi. in Virginia. It is from 2.6 to 27 mi. wide and is navigable for ocean-going ships. It has two outlets to the Atlantic ocean, one through the Chesapeake and Delaware canal built at the northern end of the bay in 1829, and the other through the mouth of the bay between the Virginia capes.

Climate.—The Atlantic ocean, Chesapeake bay and Appalachian mountains greatly influence the climate of Maryland. Prevailing winds are westerly—generally northwesterly in minter in the western section and southwesterly in summer in the southern area. In the south the winter is usually mild and the summer rather hot; in the west the winter is usually cold, the summer cool. The normal average annual temperature for the entire state is between 53° and 54° F. The average precipitation is about 43 in.

Soil.—Maryland has a great variety of soils that provide rich farmland in most of the coastal and piedmont regidns. The upper eastern shore has a light marly loam while the lower area has a stiff soil with light-coloured clay. In southern and central Maryland, sandy and tidal marsh loam prevails. Along the lower edge of the fall line is a belt so heavy with clay that it is of little agricultural value. Soils of the eastern piedmont plateau are variable but most are heavier nith clay than those of the coastal plain and better for general agriculture. Limestone and sandstone provide the soil in the western piedmont area. Much of the far western part of the state is too rugged for agriculture.

Vegetation.—The state's 2,900,000 ac. of forested areas are mostly farm woodland or other private holdings. They comprise about 46% of the land surface, but contain virtually no virgin timber. The state administers 12 state forests with a total area of approximately 120,000 ac. There are about 150 species of trees in the state, including black and white oak, beech, poplar, locust, hickory, ash, gum, elm, spruce, hemlock and dogwood. The most numerous types are pine and oak; chestnut and walnut have become rare. Blackberry and raspberry bushes are common in some areas. Wild flowers include roses, goldenrod, honeysuckle, trailing arbutus, mountain laurel, azalea and violets.

Animal Life.—Occasional bobcats and bears are the state's most imposing animals in the mountainous areas, while deer, foxes, opossums, raccoons, squirrels, chipmunks and rabbits may be found elsewhere in the state. The copperhead and the timber rattler are the only poisonous snakes. The Japanese beetle and the 17-year locust are among the most destructive insects.

Wild ducks and geese of many kinds abound in the Chesapeake bay area in season. The Chesapeake bay retriever, used for hunting water fowl, is native to the state. Game birds found in the inland regions include quail, partridge, wild turkey and ruffed grouse. Songbirds are plentiful, especially Baltimore orioles, thrushes, finches, warblers and whippoorwills. Hawks, bald eagles, herons and owls are fairly common.

The Chesapeake bay and coastal waters contain some 200 species of fish and large quantities of oysters and crabs. Both commercial and sports fishing are important.

Historic Sites, Parks and Forests.—Maryland has many attractions for persons interested in early U.S. history. Annapolis, the site of the oldest state capitol in continuous use, has more original colonial buildings standing than any other city in the United States. Here also are St. John's college, established as a secondary school in 1696; the United States Naval academy dating from 1854; and such splendid examples of colonial architecture as the Hammond-Harwood house and the Chase home.

Doughoregan Manor in Howard county and Homewood in Baltimore were built by Charles Carroll of Carrollton, a signer of the Declaration of Independence. The homes of Roger B. Taney, famed chief justice of the United States, and of Barbara Fritchie, a Union patriot, are in Frederick. Antietam National battlefield and National Cemetery in Washington county are dedicated to soldiers of that Civil War battle. Near Boonsboro stands the rough stone monument, now restored, erected on July 4, 1827, in honour of George Washington. The Washington monument in Baltimore was completed in 1829 in modified form. Fort McHenry, and Mount Clare station, the first railroad passenger and freight station to be erected in the United States, are in Baltimore. (See BALTIMORE.)

The eastern shore abounds in historic sites. At Chestertown in Kent county is Washington college, Maryland's oldest. It was founded in 1782 by the Rev. Dr. William Smith. George Washington contributed financially and gave the use of his name. In Kent county also is St. Paul's church, dating to the late 17th century. At Easton in Talbot county is Third Haven meeting house, built by the Quakers in 1682–83 and said to be the oldest frame structure for worship in the United States. A replica of the original capitol of the colony has been built at St. Mary's City on the St. Mary's river about 6 mi. N. of Blakistone Island. Tours of these and other historic sites are conducted annually.

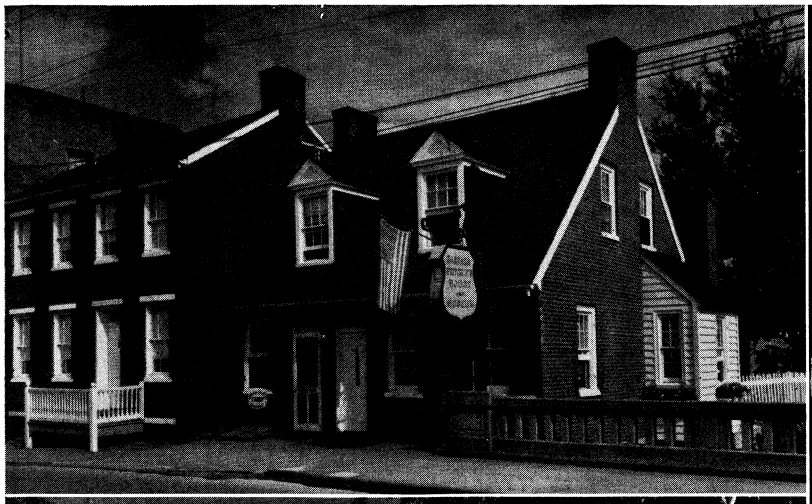
Maryland has more than 25 state parks, state forests and recreational areas, including ocean beaches, bay shore, dense forests and mountains. Their total area is nearly 150.000 ac. Among the better known state parks are Elk Neck, Fort Frederick, Gambrill, Patapsco, Sandy Point and Washington Monument. Camp David is located in the Catoctin Recreational Demonstration area, a federal project near Thurmont. Ocean City is a popular summer resort on the Atlantic coast.

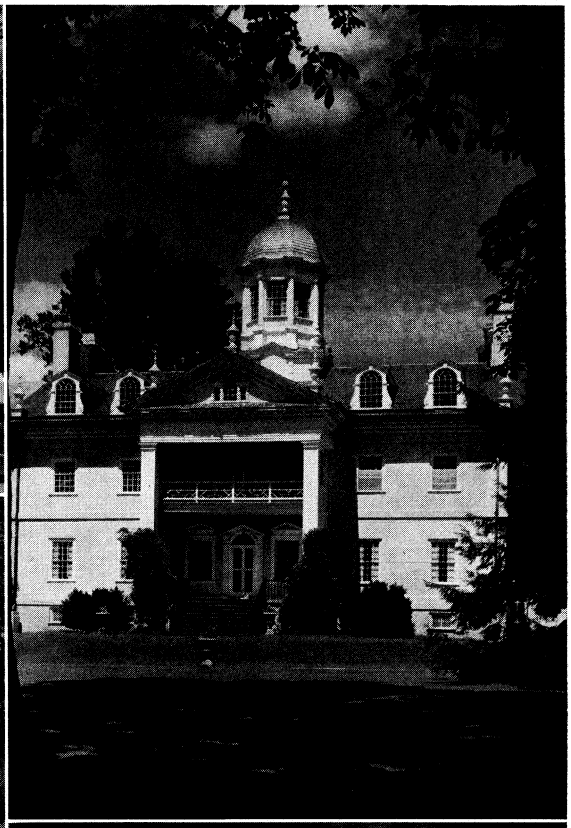
HISTORY

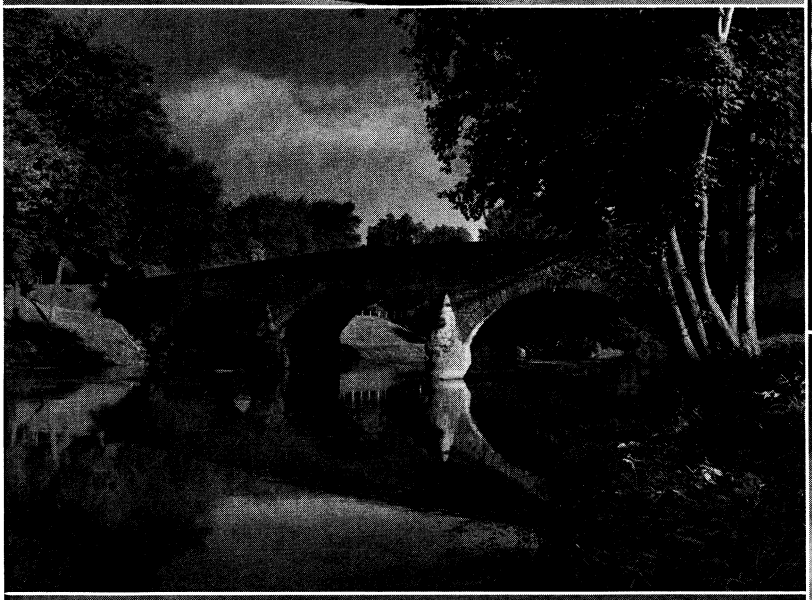
Establishment and Early History.—The colony of Maryland owed its existence to George Calvert (c. 1580–1632), first Lord Baltimore, who petitioned for a charter from Charles I of England in 1632. (See BALTIMORE, GEORGE CALVERT.) A man of stature and high position, Calvert had been converted to Roman Catholicism and desired, among other things, to establish a haven for the Roman Catholics. Earlier, he had attempted without success to found a colony at Avalon, Newfoundland.

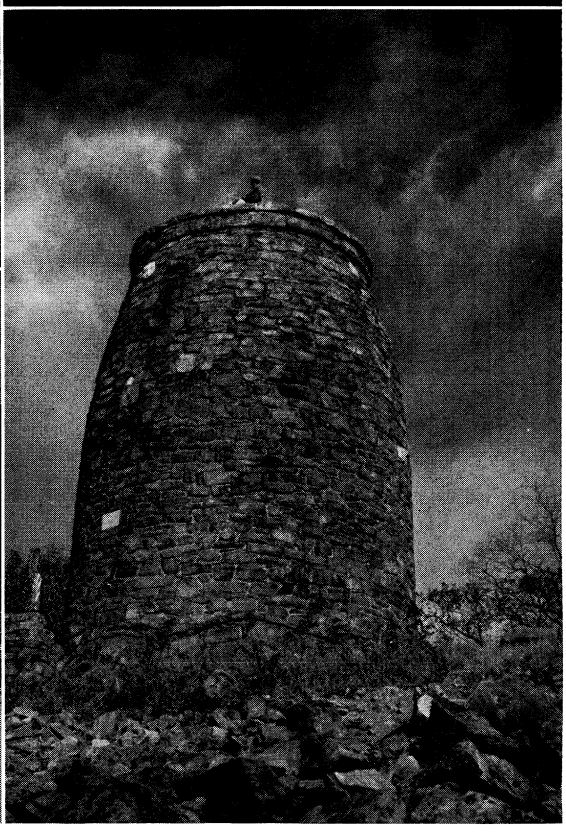
George Calvert died in 1632 before the charter was sealed. The king then made the grant to Calvert's oldest son, Cecil, second Lord Baltimore. The charter, which granted to Calvert the territory that lay between the Potomac river and the 40th parallel, also granted him broad powers and extensive rights such as were not conferred upon any other single proprietor. Nearly 200 colonists sailed from England in the "Ark" and the "Dove" in Nov. 1633, under the colony's first governor, Leonard Calvert, brother of the proprietor. They reached Maryland four months later, landing first at St. Clement's Island (now Blakistone Island) on March 25, 1634.

The colony was launched under favourable circumstances. For more than 60 years it centred around St. Mary's City. There was no great trouble with the Indians, no period of starvation or widespread disease and the climate was not severe. Maryland was well planned and profited from the experience of earlier colonies. Difficulties, however, arose with William Claiborne and other Virginians who regarded the Marylanders as trespassers upon soil originally granted to Virginia. Claiborne was interested in personal possession of Kent Island on the eastern shore where he had established a trading post and claimed also to have cultivated the soil. A phrase in the Maryland charter, *hactenus* inculta, per-









BY COURTESY OF A. AUBREY BODINE

HISTORIC SITES AND MONUMENTS OF MARYLAND

Top left: Reproduction of house at Frederick from which Barbara Fritchie **(1766-1862)** is said to have waved a Federal flag at Confederate soldiers en route to Harper's Ferry during the Civil War

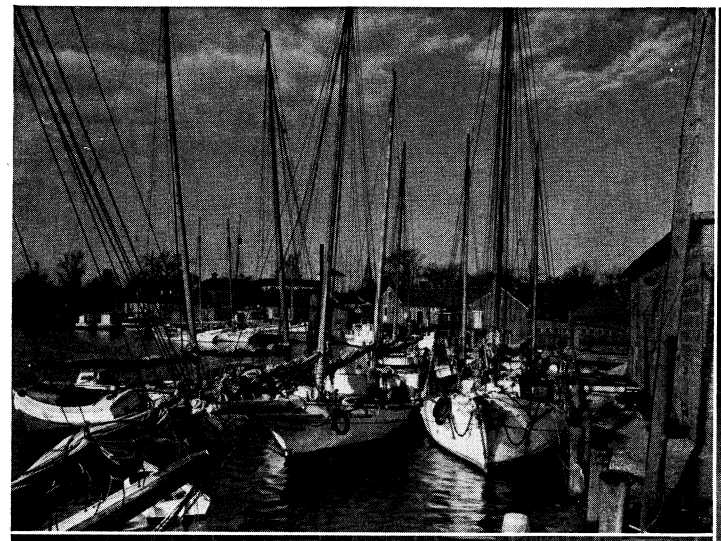
Centre left: Burnside bridge over Antietam creek, near Hagerstown, named in honour of Gen. Ambrose E. Burnside **(1824-81)** who led Federal troops over it during the battle of the Antietam, Sept. **16-17, 1862**

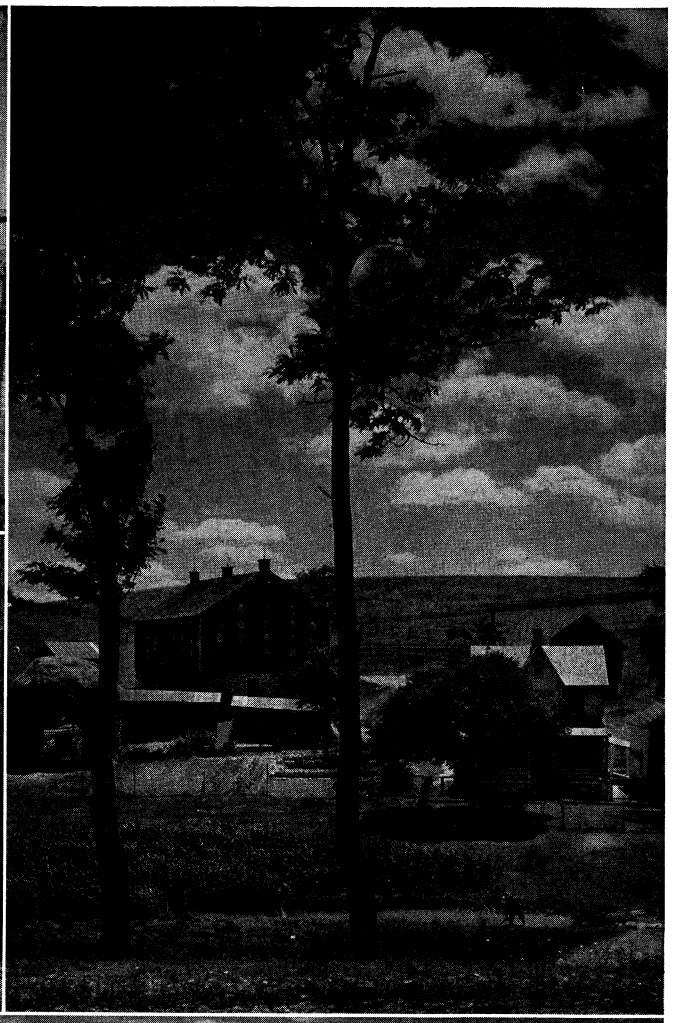
Top right: Hampton National Historic site, near Towson and north of Baltimore, was built by Charles Ridgely in **1783-90**

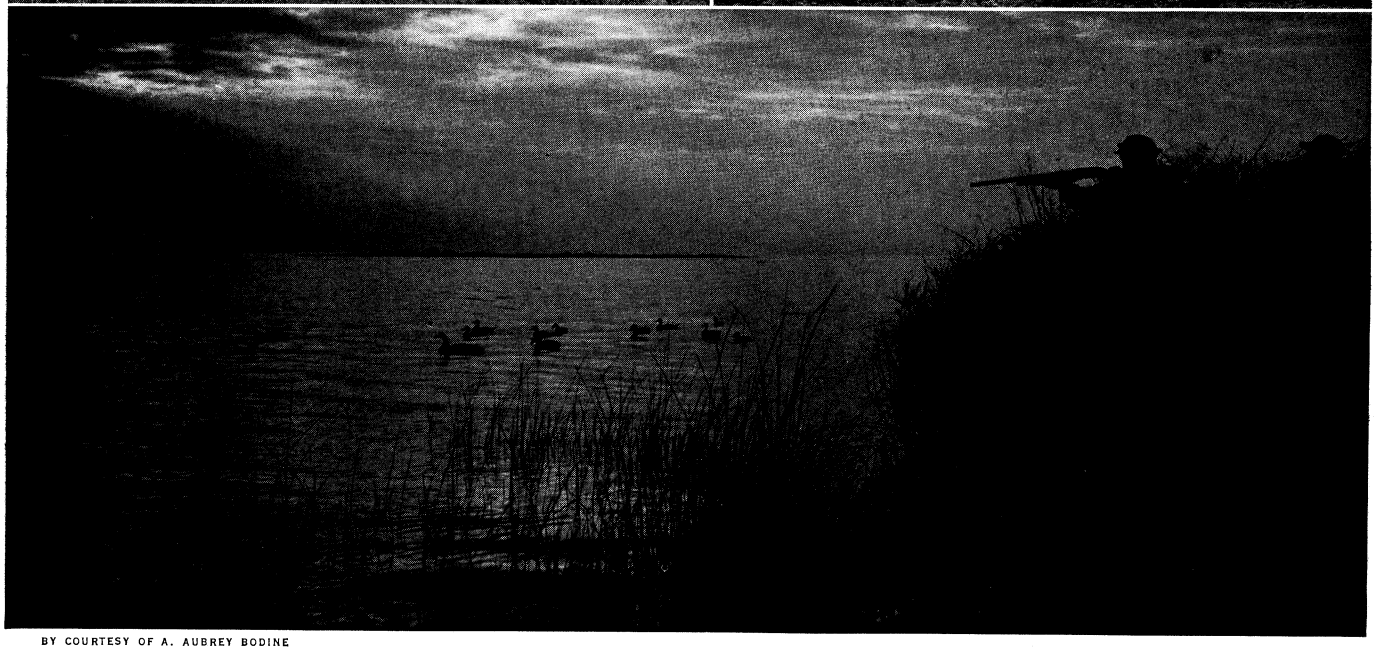
Bottom left: Midshipmen parading in front of Bancroft hall, dormitory at the U.S. Naval academy, Annapolis. The building was named for U.S. Secretary of Navy George Bancroft **(1800-91)** who founded the academy in **1845**

Bottom right: Restoration of first completed monument to George Washington at state park near Boonsboro. The original was completed in one day, July 4, **1827.** It was rebuilt in **1936**

MARYLAND







BY COURTESY OF A. AUBREY BODINE

VIEWS OF MARYLAND

Top left: Oyster dredges at anchor in Cambridge, southeastern Maryland. State law permits dredging only from sailboats

Centre left: Drying tobacco in southern Maryland, on the western shore of Chesapeake bay. Five counties on the western shore grow about 30,000,000 lb. of tobacco a year

Top right: View of rich dairy and wheat farmland in Frederick county, along the Piedmont plateau in the western section of the state

Bottom: Duck hunting on the eastern shore of Chesapeake bay

mitted Lord Baltimore to settle only territory that had not hitherto been cultivated. A series of petty conflicts, invasions and naval battles ensued. Claiborne was eventually dispossessed of Kent Island in 1638 when ruled against in England, but he remained a thorn in Maryland's side for several decades. Richard Ingle, a vigorous partisan of parliament, also offered trouble and temporarily seized St. Mary's City in the mid-1640s.

Maryland's Act Concerning Religion, passed by the assembly in 1649 and usually called the Toleration act, was a pioneer statute and gave Maryland claim to being the first civil regime in America to recognize freedom of conscience. From the beginning Marylanders had a large measure of freedom of conscience and the proprietor had endeavoured to separate church and state in the colony. Although the Toleration act limited tolerance to Christians, the record is bare of any persecution of Jews. However, with Cromwell seated firmly in England, zealous Maryland Puritans swept away toleration in 1654 when Lord Baltimore was deprived of his government and placed Anglicans, Catholics, Jews and all dissenters under disabilities as oppressive as any imposed in America.

The return of Charles II to the throne in 1660 and the reestablishment of Lord Baltimore's government inaugurated a period of surface tranquillity in Maryland that lasted for nearly 30 years. The proprietor's position was stronger despite the ordeal through which he had passed under the Commonwealth. The period 1660–89 witnessed the settlement of new areas along the Chesapeake bay and the principal rivers. Most of the great estates as well as the smaller plantations shipped their produce from their own wharves. All land was held feudally, each 100 ac. having a quitrent of four shillings imposed on it.

Despite surface quiet, a constitutional revolution was developing. It involved a conflict between the governor and his council on the one hand and the lower house representing the voters on the other. In essence, it was the proprietary party versus the popular party, the rights of the proprietor set against the rights of the people. Through his appointments, the proprietor was generally able to hold the upper hand. He had tactfully surrendered his claim to the sole right of initiating legislation in 1638. With opposition mounting, honever, Gov. Charles Calvert foolishly sought to strengthen the government by disfranchising all freemen who possessed less than 50 ac. or a personal estate of less than £40 sterling. The right to vote was thus limited to freeholders and was taken away from freemen. The plan of representation in the assembly also became the subject of heated controversy. Resistance in Charles and Calvert counties plus Indian molestations harassed the proprietor. Further, he was accused of prejudice against Roman Catholics and of resistance to royal customs collectors.

While Lord Baltimore sought to defend himself in England, boundary disputes flared in Maryland. The first involved the Maryland-Virginia line across the Potomac river and the Chesapeake bay to the mouth of the Pocomoke river on the eastern shore. This line was not clarified until 1785 and revised in 1877.

The other dispute was the bitter and prolonged one between the Baltimores and Penns over the Maryland-Pennsylvania boundaries and the boundaries of Delaware, which had originally been a part of the Maryland grant. In 1682 England transferred it to the Duke of Tork and in 1685 it was denied to Lord Baltimore on the grounds that Christians had inhabited it before the Maryland grant was made. After decades of disagreement and litigation, the fifth Lord Baltimore (the second Charles Calvert) came to an agreement nith the sons of William Penn. For reasons unknown, except possibly ignorance of the facts, he surrendered his claims to the three loner counties (Delanare). He also relinquished Maryland's northern boundary, specified in the charter as the 30th parallel, which ran north of Philadelphia, and agreed to a line 15 mi. south of Philadelphia. When he realized his error, Lord Baltimore repudiated his agreement but after more years of bickering, it was held binding in 1750 by Lord Chancellor Hardwicke who ruled that original boundaries were too uncertain to be relied upon. Frederick. the sixth Lord Baltimore, refused to accept the Chancellor's decision until 1760. Finally. after surveys by Charles Mason and Jeremiah Dixon between 1763 and 1767, the line was fixed at the parallel 39° 43' 26.3". At one point the distance between this line and the Potomac river, the state's southern boundary, is less than two miles.

In England Lord Baltimore was charged with mismanaging the customs situation. To make matters worse, in Baltimore's absence, the acting governor had murdered the royal customs collector. This and other problems — insurgent uprisings, poverty, religious friction, the uncertainty of the tobacco trade and the bothersome use of tobacco as a medium of exchange — led to the overthrow of proprietary government in Maryland in 1692. A royal government was established which alloned the proprietor to retain only his land rights.

The end of the 17th century saw the capital moved from St. Mary's City to Annapolis near the mouth of the Severn river on the western shore in 1694 and an act passed which led to the establishment of King William's school in Annapolis, the third oldest of its kind in the colonies. Eleven counties had been established. The chief commerce was in tobacco and the landed gentry were strong. During the royal period the Anglican Church mas established as the official church in Maryland, supported by the taxpayers. The period saw an increase in the powers of the lower house as the assertion of liberty was finding expression. The royal period ended in 1715 when the fourth Lord Baltimore, Benedict Leonard Calvert, who had renounced Roman Catholicism, had full proprietary rights restored to him.

Following the restoration and until about 1765 Maryland was generally well governed. The colony was not drawn heavily into the French wars, experienced only sporadic narfare with Indians and was left alone by England to manage its own affairs. However, there was no end to disputes as Maryland's distinguished lawyers were opposing proprietary prerogatives and insisting upon the privileges and rights of a free people. Daniel Dulany led the fight for the extension of English statutes to the colony. The proprietor contended that only those statutes directly mentioning the dominions were in force there.

There were numerous points of difference and most of them were economic at base. The agricultural classes attacked the privileged classes — the lawyers, the clergy and officers of state — many of whom were also large landowners. Fees and salaries came in for special criticism. The limitations of the one crop tobacco economy in Maryland were always pressing. The paper currency act of 1733 provided a second medium of exchange to supplement tobacco and also helped to diversify the Maryland economy and finance the colony's share of the French mars.

The American Revolution. — After gaining a victory over France in 1763, Great Britain tightened the reins upon the colonies. Debts to British merchants. the lack of a proper colonial currency and taxes on imports led Maryland citizens to action. When the Stamp act of 1765 mas imposed, Maryland cited the charter rights nhich exempted the colony from all taxes except those imposed by the colonial assembly. Resistance with other colonies helped define the colony's ideas of popular liberty, the rights of Englishmen and clarified its attitude toward England.

The Boston Tea Party of 1773 had its counterpart in Maryland when a tea ship, the "Peggy Stewart," was burned in Annapolis harbour on Oct. 19, 1774. The Association of the Freemen of Maryland on July 26, 1775, one year before the Declaration of Independence. passed resolutions protesting against British practices and asserting colonial rights. The revolutionary movement in Maryland was led principally by the group that had fought proprietary prerogatives; it consisted of men of wealth and social position as well as those learned in the law. On the other hand, Maryland had a large body of loyalists, especially on the eastern shore.

Statesmen of Maryland played leading roles in both the First and Second Continental Congress and in signing the Declaration of Independence. while the colony's troops and individuals distinguished themselves in the war that followed. The first state constitution, adopted in Nov. 1776. replaced the colonial charter. It was far from democratic by modern standards. It established property qualifications for voting which were not abolished until

1810. The Maryland general assembly refused to ratify the Articles of Confederation when they were adopted by congress in 1777, holding out until 1781 when other colonies agreed to surrender to the federal government their claims to western land.

Problems of Independence. — Postwar problems included the disposition of confiscated loyalist property: the struggle for paper money and debtor relief. Maryland's controversy with Virginia over the use of the Potomac and loner Chesapeake bay resulting in the compact of 1785 was a step leading toward the constitutional convention. Such was also the Annapolis convention (*q.v.*) of 1786 at which, however, Maryland was not represented. Luther Martin distinguished himself as a representative of Maryland at the Philadelphia convention of 1787. Maryland ratified the constitution on April 28, 1788. and became the seventh state to do so. It also ceded territory and advanced money for public buildings to help form the District of Columbia (1791).

As a member of the union, Maryland was confronted with questions of slavery, agriculture, education, religion and others which required diligence and wisdom in their solution. The Constitution of 1776 allowed free Negroes to vote for members of the lower house of the legislature, but this privilege was cancelled by an amendment in 1810. The Napoleonic wars adversely affected the state's commerce and during the War of 1812 Maryland was the scene of several engagements, at Havre de Grace, Caulk's Field in Kent county. Bladensburg and at Baltimore.

After 1815, Maryland was absorbed in its own problems but still active in the affairs of the nation. The national road was completed to the Ohio river in 1818. and 11 years later the Chesapeake and Delaware canal was opened. In 1329 work was begun on the Baltimore and Ohio railroad and the Chesapeake and Ohio canal. The state suffered severely in the depression of the 1830s.

Civil War and Reconstruction. — In 1860 as the Civil War approached, Maryland was a sharply divided state for it had social, economic and political ties with both North and South. Its population included approximately 87,000 Negro slaves and 84,000 free Negroes. As the state's geographical position made its adherence to the Union a necessity, President Lincoln and the military authorities prevented its secession by suspending the writ of habeas corpus, establishing martial law, controlling elections, suppressing pro-Southern newspapers and by making arbitrary arrests and imprisonments. Members of the legislature were arrested and imprisoned to prevent steps that might lead to secession. The majority of the people were Union sympathizers but opposed coercion of the South. The state was invaded several times during the war. (See AMERICAN CIVIL WAR.) Frederick was occupied by Lee's forces, and the battles of South Mountain. Monocacy and the crucial engagement at Xntietam (*q.v.*), were fought with heavy loss. In 1864 Maryland adopted its third constitution; it freed all slaves in the state and provided an iron-clad loyalty oath. Lincoln, whose vote in the state was negligible in 1860, carried the state in 1864.

Problems of education and the administration of justice characterized the period of self-reconstruction in Maryland. The Democratic party regained power and held dominance for many years but did little before the turn of the century to effect civil service reforms, ballot reform and stricter corporation control. There was a boom in industry and commerce. with rail and water facilities increasing. Large philanthropic gifts were made by George Peabody for a conservatory of music, Johns Hopkins for a hospital and university and Enoch Pratt for a library.

Two-party government was restored in 1896 when the Democratic Gorman-Rasin machine was defeated. A period of extreme conservatism followed, but even the Baltimore fire of 1904 (see BALTIMORE), did not retard economic development. The Progressive movement in Maryland was expressed in the administration of Gov. Austin L. Crothers, 1908–12, when a direct primary law, an improved corrupt practices act. a good roads bill and the important Public Utilities commission act were passed.

20th Century. — In the 20th century, shipbuilding and steel manufacturing replaced the manufacture of men's clothes, boots and shoes as chief concerns. Agriculture progressed but the seafood and fisheries industry began to decline because of inadequate conservation measures due in part to the continuing boundary disagreement with Virginia over the Potomac river and Chesapeake bay. In 1956 the Maryland legislature abrogated the compact of 1785 and Virginia carried the matter to the U.S. supreme court. On Dec. 20, 1958, representatives of the two states signed an agreement to set up a commission to regulate the removal of oysters from the Potomac river and thus put an end to the so-called oyster war between the two states. The Maryland legislature, however, refused to ratify the agreement.

Among the notable military, naval and air force establishments in the state are the U.S Naval academy, Xberdeen Proving Ground, Ft. George C. Meade, the Army Chemical centre. the Naval Ordnance laboratory, the Naval Medical centre and Andrews air force base. Among noted civilian government establishments in Maryland are the National Institutes of Health in Bethesda and the Agricultural Research centre at Beltsville.

Throughout the 1920s, and until 1935, the governor of Maryland was Albert C. Ritchie, a Democrat, who served for four terms. He won national acclaim for his administrative ability, for his opposition to prohibition and for various steps he took to improve the efficiency and economy of the state government.

A notable post-World War II development was construction of the Chesapeake bay bridge after many years of delay and frustration. William Preston Lane, Democratic governor from 1947 to 1951, laid the groundwork for this mammoth project which crosses from the mainland to Kent Island and the eastern shore. He also instituted the retail sales tax that aided greatly in coping with the state's fiscal problems and he extended its road-building program. Gov. Theodore Roosevelt McKeldin, his successor. saw many of these projects through to completion and inaugurated others. The Baltimore harbour tunnel was opened in Nov. 1957. As the fourth Republican governor since 1860, McKeldin served two terms and greatly expanded state services. In the election of 1958 McKeldin was succeeded by the Democratic candidate, J. Millard Tawes.

GOVERNMENT

Maryland is governed by the constitution of 1867 which succeeded constitutions of 1776, 1851 and 1564. This constitution gave the governor increased powers, including a veto over acts of the legislature, called the general assembly. This veto may be overridden by a three-fifths vote of the members of each house. The governor is elected by popular vote for a four-year term. An amendment adopted in 1948 limited the governor henceforth to two terms. Maryland has no lieutenant governor. A vacancy in the governorship is filled by the legislature, with the president of the senate serving during the interim. The constitution may be amended by a three-fifths vote of all members of each house of the legislature and a majority of votes cast in a state referendum.

The constitution of 1867 established a general assembly consisting of a senate of 29 members and a house of delegates of 123 members. all of whom now serve four-year terms. Each county elects one senator and the city of Baltimore elects six. After the U.S. supreme court ruled (March 26, 1962) that metropolitan residents were entitled to court hearing of complaints against denial of representation in legislatures, the assembly temporarily increased house membership from 123 to 142. with the new seats going to the metropolitan areas. The establishment by 1066 of a plan of reapportionment on the basis of 123 seats granting representation in accordance with population was left to the 1963 assembly. From 1948, the legislature met annually, with a 90-day session in even years. The short session is limited to budgetary matters and emergency legislation for the general public welfare.

In 1922 the administrative branch of the state government was completely reorganized. A merit system was established and by the mid-20th century more than 70% of the state employees were in the classified service. The Maryland state planning commission was established in 1933 to prepare a long-range capital improvements program as well as to recommend a program of needed improvements each year. A legislative council was created in 1939 to give continuous study to the state government and to sponsor a legislative program for each session of the assembly.

Other notable advances include the creation of the department of public improvements to lend technical advice and assistance to the board of public works

Justice is administered by the court of appeals (supreme court), four appellate circuits, intermediate circuit courts in the counties and the city of Baltimore. orphans' courts. trial magistrates' courts and peoples' courts. The state is divided into eight judicial circuits, one comprising the city of Baltimore and the other seven comprising two or more counties. In each circuit there is a chief judge and a varying number of associate judges, all elected for 15-year terms. Under the reorganization act of 1943, the court of appeals consists of five judges, one elected from each of three appellate circuits and two from the fourth appellate circuit (Baltimore) for 15 years. The chief judge of the court of appeals is the administrative head of the state's judicial system. Judges of the court of appeals have no original jurisdiction.

In 1916, by constitutional amendment, Maryland became one of the first states to adopt the executive budget. Under this system the governor submits the budget to the legislature in the form of a budget bill. The legislature can reduce or eliminate appropriations for executive and administrative purposes, increase but not decrease judicial appropriations and either increase or decrease legislative appropriations. The budget bill becomes law as soon as passed by the legislature.

A separate agency, the department of budget and procurement, was established in 1939 to assist the governor in preparing the budget. The form of the budget remained unchanged until 1951 when the recommendations of the commission on administrative organization of the state were submitted and then approved. During fiscal year 1953. the change was effected from the then line-item budget to a program or performance-type budget, which for the first time included in one comprehensive budget all funds—general, special, federal and capital collected and disbursed by the state. The first budget adopted under the new system was for fiscal year 1954. The comptroller's department administers most revenue of the state. Exceptions are the property tax. which is administered by the state tax commission through Baltimore City and the counties. and certain fees and licenses.

The 1960 budget for the state provided for receipts and expenditures of nearly $500,000,000. Principal sources of income were the state income tax, 21.4% ; federal funds, 21.3% ; gasoline taxes and motor vehicles revenues, 19.6%; and the state sales and use tax, 15.3%. Expenditures in order of importance were for public education, 29.5% ; highways and nonhighway transportation, 26.9%; payments to civil divisions of the state, 12.2%; health, hospitals and mental hygiene, 10%; and public welfare and employment security, 7.7%.

*Maryland: Places of 5,000 or More Population (1960 census)**

Place	Population				
	1960	1950	1940	1920	1900
Total state	3,100,689	2,343,001	1,821,244	1,449,661	1,188,044
Aberdeen	9,679	2,944	1,525	1,067	600
Annapolis	23,385	10,047	13,069	11,214	8,525
Arbutus-Halethorpe Relay	22,402	—	—	—	—
Baltimore	939,024	949,708	859,100	733,826	508,957
Bethesda	56,527	—	—	—	—
Cambridge	12,239	10,351	10,102	7,467	5,747
Catonsville	37,372	—	—	—	—
Cheverly	5,223	3,318	996	—	—
College Park	18,482	11,170	—	—	—
Cumberland	33,415	37,679	39,483	29,837	17,128
District Heights	7,524	1,735	392	—	—
Dundalk	82,428	—	—	—	—
Easton	6,337	4,836	4,528	3,442	3,074
Elkton	5,989	5,245	3,518	2,660	2,542
Essex	35,205	—	—	—	—
Frederick	21,744	18,142	15,802	11,066	9,296
Frostburg	6,722	6,876	7,659	6,017	5,274
Greenbelt	7,479	7,074	2,831	—	—
Hagerstown	36,660	36,260	32,491	28,064	13,591
Havre de Grace	8,510	7,809	4,967	4,377	3,423
Hillcrest Heights	15,295	—	—	—	—
Hyattsville	15,168	12,308	6,575	2,675	1,222
Langley Park	11,510	—	—	—	—
Lansdowne-Baltimore Heights	13,134	—	—	—	—
Laurel	8,503	4,482	2,823	2,239	2,079
Lexington Park	7,039	—	—	—	—
Loch Raven	23,278	—	—	—	—
Middle River	10,825	—	—	—	—
Mount Rainier	9,855	10,989	4,830	2,462	—
Overlea	10,795	—	—	—	—
Parkville-Carney	27,236	—	—	—	—
Pikesville	18,737	—	—	—	—
Rockville	26,090	6,934	2,047	1,145	1,110
Salisbury	16,302	15,141	13,313	7,553	4,277
Seat Pleasant	5,365	2,255	1,553	—	—
Silver Spring	66,348	—	—	—	—
Sparrows Point-Fort Howard-Edgemere	11,775	—	—	—	—
Stoneleigh-Rodgers Forge	15,645	—	—	—	—
Suitland-Silver Hills	10,300	—	—	—	—
Takoma Park	16,799	13,341	8,938	3,168	756
Timonium-Lutherville	12,265	—	—	—	—
Towson	19,090	—	—	—	—
Westminster	6,123	6,140	4,692	3,521	3,199
Wheaton	54,635	—	—	—	—
Woodlawn-Rockdale-Millford Mills	19,254	—	—	—	—

*Populations are reported as constituted at dare of each census.
Dash indicates place did not exist during reported census, or data not available.

POPULATION

Maryland's population, approximately 200 in 1634, increased to 8.000 by 1660, to 43,000 by 1710, to 319,728 by 1790, to 687.049 by 1860, to 1.295.346 by 1910, to 2,343.001 by 1950 and to 3,100,689 by 1960. The population per square mile by 1960 was 293.1 as compared with 49.7 for the United States as a whole. The urban population was 2,256,634 or 72 8%, while the rural population was 844.055. or 27.2%. The state has one standard metropolitan statistical area, Baltimore. This area had a total population of 1,706,076 or 55% of the total population of the state in 1960.

Maryland's population was distributed by color and nativity in 1950 as follows: 79.8% native white; 3.6% foreign-born white; and 16.5% nonwhite, practically all Negro. There were 99 males per 100 females in the native white population and 99.5 in the Negro population; 6.9% of the population was 65 years old or older; and 55.7% of the population 14 years old or over was in the labour force.

EDUCATION

Maryland's public school system was established in 1865 and completely revised in 1916. It is headed by a state board of seven lay members appointed by the governor for seven years. Their principal function is to formulate policy and provide leadership to local units. The state board appoints a state superintendent for a four-year term. He directs the department of education and administers the school system in general.

In 1947 a comprehensive program was launched for building schools, increasing salaries, raising standards and improving the curriculum. In 1951 complete transition to a 12-year system was effected. During the 1950s approximately $280,000,000 was expended for public school buildings, with about 900 new classrooms added each year. Local taxes and funds from the state school building incentive fund (which provided over $6,000,000 a year), made this expansion possible. At the same time Maryland made rapid progress. particularly in Baltimore, in integrating white and Negro pupils in its public schools in accord with the supreme court decision of 1954.

The University of Maryland, dating from 1807, was enlarged in 1920 by the merger of the university, consisting of the schools of law, medicine, nursing, pharmacy and dentistry at Baltimore nith Maryland State college (formerly known as Maryland Agricultural college) at College Park. The Negro branch, Maryland State college. at Princess Anne, was also included.

The university made rapid strides after World War II, increasing from 10.104 students in 1951 to nearly 15,000 by 1960. There was an additional increase in off-campus enrollment, including overseas branches. from 16,737 to nearly 34.000. Capital improvements and many valuable services were pushing the university toward top rank among the nation's land-grant institutions. Approximately $4.500 000 was authorized for future construction, including $1,000.000 for the purchase of new building sites in cooperation with the Urban Renewal agency in Baltimore. The gross operating income of the university was over $35,000.000.

Johns Hopkins university in Baltimore. often described as the first true university in America, was established from a fund of nearly $7,000,000 bequeathed by Johns Hopkins, a wealthy Balti-

more merchant, in 1873 for the founding of a university and hospital. A leading educational institution, it comprises the hospital, the school of medicine, the school of hygiene and public health, the faculty of philosophy (conferring A.B.. M.A., and Ph.D. degrees), school of engineering, school of business and industrial management, McCoy college, the school of advanced international studies and other units.

Other institutions of higher learning in Maryland are: Washington college (nonsectarian), Chestertomn (dating to 1707 as a secondary school and chartered in 1782 as a college); St. John's college (nonsectarian), Annapolis (established as King William's school in 1696 and chartered as a college in 1784); Western Maryland college (Methodist) in Westminster (established in 1865); Mount St. Mary's (Catholic, 1808) and St. Joseph's college (Catholic, 1809), both in Eminitsburg; and in Baltimore, St. Mary's seminary and university (Catholic, 1791). Loyola college (Catholic, 1852), College of Notre Dame of Maryland (Catholic, 1873), Mount St. Agnes (Catholic, 1890), Goucher college (nonsectarian, 1885), Morgan State college (founded in 1867 as a private Negro college, taken over by the state in 1939); Hood college in Frederick (United Church of Christ, 1893); Woodstock college at Woodstock (Catholic, 1867).

State teachers' colleges are located at Towson, Salisbury, Frostburg, Bowie and Baltimore (Coppin state). Junior colleges are at Baltimore, Takoma Park, Hagerstown, Frederick, Bel Air, Catonsville and Essex. Other institutions include the University of Baltimore and miscellaneous business and professional colleges.

Other outstanding institutions of an educational and cultural nature are Peabody Conservatory of Music (1868), Maryland Institute for the Promotion of Fine and Mechanic Arts (1825) and the Enoch Pratt free library (with numerous branches), established in 1866.

PUBLIC HEALTH AND WELFARE

The state department of health, governed by the state board of health, administers Maryland's public health program. Each county also has its health board and health officer. The county is the functional unit. Some municipalities in the counties also make financial contributions to the health program.

The department operates four tubercular hospitals (the Victor F. Cullen, Henryton, Mount Wilson, and Pine Bluff state hospitals) and three chronic disease hospitals (Montebello, Deer's Head, and the Western Maryland state hospitals). The department of mental hygiene controls mental hospitals at Cambridge, Sykesville, Catonsville, Crownsille and Owings Mills. In 1955 the Patuxent Institution for Defective Delinquents was opened. Two other institutions were authorized in the late 1950s: the Institution for Criminally Insane at Jessups and the Long Term Care colony near Pikesville.

The state department of public welfare co-ordinates and directs all welfare activity in the state. It supervises and controls the county welfare boards; investigates public and private institutions, organizations and agencies of a charitable nature; administers the child labour laws; and licenses agencies and institutions having care and custody of minors. It controls the state's four training schools—Boys' Village. Maryland Training school, Barrett school and Llontrose school. Other state agencies in welfare activities are the state industrial accident commission, the department of employment security and those supervising the state penitentiary and other penal institutions.

THE ECONOMY

Occupations and Employment.— The total labour force in Maryland exceeds 1,000,000, about 6% of whom are agricultural workers. Non-agricultural employment is as follows: manufacturing employs about 28%; trade about 18%; public administration about 13%; service industries about 10%; and all others, 31%. Total personal income in Maryland rose steadily during the 1950s and approached $7,000,000,000 by the end of the decade. Thousands of men and women in Maryland, particularly in the rapidly growing suburbs of Washington, D.C., such as Chevy Chase, Bethesda, Silver Spring and Takoma Park, are employed by the federal government in a great variety of occupations.

Agriculture.— Although its small size and the diversity of its farm crops prevent Maryland from becoming an important factor in the national agricultural picture, the state nevertheless has a thriving farm population. The state has a variety of good soils and a climate adaptable to a wide range of production. There are also excellent transportation facilities, readily accessible markets and fine agricultural services of the University of Maryland.

Tobacco production predominates in southern Maryland. Hay, grain, livestock and dairy production typify the central counties, while the eastern shore excels in poultry raising and truck farming. In the state as a whole, the 1950s saw a marked decline in the production of corn, Irish potatoes, horses and sheep, but the decade brought a steady increase in the production of milk, eggs and chickens. Maryland ranks high nationally in commercial broiler production, and in its output of tomatoes and strawberries. The state produced approximately 400,000,000 eggs annually in the late 1950s.

Of the 6,323,840 ac. of land area in Maryland, about 61% is in farms. The harvested acreage totals about 1,500,000. The number of farms declined from about 42,000 before World War II to 32.000 in the second half of the 20th century. The number of acres in farms declined for the same period from about 4,000,000 to fewer than 3,900,000. Meanwhile, the average size of farms increased from approximately 100 to 120 ac., while the average farm increased in value from about $6,500 to more than $20,000. The value per acre jumped from $65 to $177. Principal crops are corn, wheat, oats, barley, rye and hay. Crops rank first in terms of income, followed by livestock and livestock products, dairy products and commercial broilers. Also important are cattle, calves, eggs and tobacco.

Manufacturing.— Maryland's leading source of wealth, manufacturing, steadily increased in importance during and after World War II. Although centred mainly in Baltimore substantial industrial gains were made in Cumberland, Hagerstown, Frederick, the central counties generally and at Salisbury and Cambridge on the eastern shore. Extensive vegetable, poultry and fish processing developed on the eastern shore. The number of industrial establishments in Maryland increased rapidly during the 1950s. In terms of number of employees, Maryland's major industry groups nere food and kindred products, textile mill products, apparel and related products, lumber and wood products, furniture and fixtures, paper products, printing and publishing, and some mining.

Fisheries.—Maryland is known everywhere for its seafood and has developed a substantial fishing industry. The commercial fish catch from the Atlantic ocean and the Chesapeake bay and its tributaries exceeds 17,000,000 lb. annually. The leading types of fish are striped bass, roe shad, menhaden and river herring. The commercial catch of shellfish exceeds 42,000,000 lb. annually. The most valuable catch is that of oysters, which totals approximately 2,250,000 bu. The oyster industry, after a marked decline due to lack of proper conservation measures, has made a comeback as a result of shell planting or seeding and other measures. Approximately 280.000 bu. of seed oysters were made available to private planters by the state during the 1950s, and 1,400 additional acres of barren bottom were leased to private planters. The annual hard crab catch exceeds 20,000,000 lb. The new soft shell clam industry made rapid progress during the 1950s.

Trade and Finance.— With a constantly expanding economy, Maryland developed a large retail and wholesale trade. By 1960 it had approximately 25,000 retail establishments with an annual sales volume of about $3,500,000,000. More than half of this total was accounted for in the Baltimore metropolitan area. Wholesale trade was conducted by about 3,000 establishments.

During the 1950s Maryland had more than 150 active banks (including national, state, commercial, savings, and private banks) with total deposits of more than $2,600,000,000. The state also had many chartered credit unions and industrial finance companies.

Transportation and Communication.— Maryland was a pioneer in road building in the early 20th century, but fell behind

other states during the 1930s and was compelled to begin a great road and bridge building program at the end of World War II. The Chesapeake bay bridge was built between 1949 and 1952 at a cost of $45,000,000, financed by a bond issue. By Dec. 1952, the Washington-Annapolis freeway was partly opened. A new Severn river bridge filled the last gap in a direct link between the Chesapeake bay bridge and the freeway. The Baltimore-Washington expressway was opened in its entirety early in 1954. Dual highways were built between the Delaware line and Washington. between Washington and Frederick and between Baltimore and Frederick. In 1957 an under-harbour tunnel from Fairfield to Canton, costing $130,000,000 including approach roads, further facilitated traffic through Baltimore.

By 1960 there were more than 1,000,000 motor vehicle registrations in the state and about 19,000 mi. of roads and highways. There were no toll roads in Maryland, but tolls were paid to use the Chesapeake bay bridge, the Baltimore harbour tunnel, the Susquehanna river bridge at Havre de Grace and the Potomac river bridge in southern Maryland.

The state is traversed by three main railroads. Altogether, 13 railroads operate more than 2,800 track miles within the state. Bus lines serve all parts of the state and major airlines serve Baltimore and other parts of the state.

The state's first radio station began to operate in 1922 and its first television station in 1947, both in Baltimore.

Maryland has 74 weekly newspapers, the oldest being the *Maryland Gazette-Glenburnie News* (Annapolis, 1727), first published as the *Maryland Gazette*. The *Baltimore Sun* is the oldest daily newspaper.

See also references under "Maryland" in the Index volume.

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Current statistics on production, employment, industry, etc., may be obtained from the pertinent state departments; the principal figures, together with the current history, are summarized annually in the *Britannic~Book of the Year,* American edition. (C. B. CL.)

MARYLEBONE: *see* SAINT MARYLEBONE.

MARY MAGDALENE, a woman mentioned in the Gospels, first in Luke viii, 2, as one of a company who, "healed of evil spirits and infirmities . . . provided for [Jesus and the apostles] out of their means." It is said that seven demons were cast out of her. Mary came from Magdala (el-Mejdel, 3 mi. northwest from Tiberias). She went with Jesus on the last journey to Jerusalem, witnessed the Crucifixion, followed to the burial and returned to prepare spices. John xx gives an account of her finding the tomb empty and of her interview with the risen Jesus. Mary of Magdala has been confused (1) with the unnamed fallen woman who in Simon's house anointed Christ's feet (Luke vii, 37); (2) with Mary of Bethany, sister of Lazarus and Martha.

MARYSVILLE, a city of northern California, U.S., is located in the centre of the Sacramento valley, 42 mi. N. of Sacramento. It has been the seat of Yuba county since 1850. Its climate is dry and warm in the summer, and rainy and moderate in the winter. Lying at the confluence of the Yuba with the Feather river, the region is subject to periodic flooding; but Marysville itself, through the efforts of its citizens, especially in 1907 and 1955, and the protection of 7 mi. of high levees, has not been flooded since 1875.

Settlement dates from 1842, when Theodore Cordua leased from Gen. John A. Sutter the present site of Marysville and established a trading post. Named for Mary Murphy Covillaud, a survivor of the tragic Donner party of 1846 and wife of Charles Covillaud, a founder of the town, Marysville was incorporated in 1849. Being at the head of river traffic, it was an important wholesale and retail centre for the northern gold mines. As agriculture developed in the Sacramento valley, a prolonged controversy, 1875–84, occurred between the farmers and the miners over the disposal of hydraulic mining debris. Marysville citizens, because the debris was filling the rivers and contributing to frequent flooding, sided with the victorious farmers. After 1884 mining gradually declined as the mainstay of the economy and was replaced by farming. Fruit production, mainly of peaches and pears, is the most important form of agriculture, and Marysville is a centre for the processing and packing of the region's produce. For comparative population figures *see* table in CALIFORNIA: *Population.* (C. F. McI.)

MASACCIO (TOMMASO DI GIOVANNI DI SIMONE GUIDI) (1401–1428), the first and greatest Florentine Renaissance painter, was born at San Giovanni Valdarno, near Florence, on Dec. 21, 1401. His father, a notary ser, Giovanni di Monte Vassai, died in 1406. In 1422, Masaccio was enrolled in the Arte dei Medici e Speziali in Florence, and in 1424 became a member of the Compagnia di S. Luca. According to Giorgio Vasari, he owed his early training as a painter to Masolino da Panicale (*q.v.*) and this is probable, since Masolino came from the same region and Masaccio's earliest surviving work was painted in collaboration with the older artist. This is the "Virgin and Child with St Anne" painted about 1420 and now in the Uffizi gallery, Florence, to which Masaccio contributed the uppermost angel on the right, the foreshortened left hand of St Anne, and the seated Virgin and Child. The marked contrast between the contributions of the two artists, one soft and lyrical, the other recessive and sculptural, continues throughout their whole collaborative careers. About 1424 they again worked side by side on a double-sided altarpiece, commissioned from Masolino for Sta. Maria Maggiore in Rome, to which Masaccio contributed at least one lateral panel with SS. Jerome and John the Baptist, now in the National gallery, London.

ALINARI.

"EXPULSION FROM PARADISE," FRESCO BY MASACCIO. BRANCACCI CHAPEL, THE CARMINE CHURCH, FLORENCE, IT.

In Dec. 1426, Masaccio completed an altarpiece for the church of the Carmine at Pisa, of which a central panel, of the Virgin and Child enthroned, is in the National gallery, London; a central pinnacle of the Crucifixion is in the Museo di Capodimonte at Naples; two panels of saints in half-length are in the Lanckoronski collection, Vienna, and the Raiser Friedrich museum, Berlin; and four pilaster panels and three predella panels are also in the latter gallery. By this time, Masaccio, despite his youth, was a mature artist, and the altarpiece is the first panel painting in nhich a Renaissance style is fully employed. Among the many novel features of this revolutionary painting may be noted the accomplished use of linear perspective in the central panel, the Brunelleschan architecture of the throne, and the illusionistic modeling of the figures, in which the forms are suffused in light. At the same time, the work far transcends what is normally understood by the term naturalism, and the panel in Naples is one of the most moving representations of the Crucifixion in Italian painting. A fresco

of the Trinity. commissioned for Sta. Maria Novella in Florence. probably in 1427, shows a barrel-vaulted hall, closed on its outer face by columns and pilasters, nith a representation of the crucified Christ supported at the back by a standing figure of God the Father and accompanied by the Virgin and St John: the two donors kneel to right and left outside the scene. The spatial scheme is the first example of the application of linear perspective to the art of fresco painting. The fresco is without precedent also in its iconography. which recalls certain works executed by the sculptor Donatello.

Masaccio's most important work is the decoration of the Brancacci chapel in the Carmine church in Florence. for which he executed what are possibly the greatest Italian frescoes and certainly the greatest frescoes of the 15th century. There are no documents relating to Masaccio's activity in the Brancacci chapel, and a number of widely differing hypotheses respecting it have been advanced. It seems probable that this decoration (which consisted of scenes from the life of St. Peter) was first entrusted to Masolino, who about 1425 executed the frescoes in the upper register (destroyed). After an interval. work was resumed in the summer of 1427 jointly by Masaccio and Masolino. Masaccio is generally agreed to have been responsible for the frescoes of the "Expulsion from Paradise." the "St. Peter and the Tribute Money," and "St. Peter enthroned" (unfinished) on the left wall, and for the "Baptism of the Neophytes," the "Distribution of the Goods of the Community" and "SS Peter and John healing the Sick with their Shadows" on the altar wall The contrast between the styles of Masaccio and Masolino appears most forcibly in the magnificently virile "Expulsion from Paradise" of Masaccio and the fresco of "Adam and Eve" by Masolino on the wall opposite. The most impressive of these astonishing frescoes is the "Tribute Money," where the figures, with their heavy drapery, are set against a background of seemingly limitless depth in a foreground area defined by a receding building on the right. In this and in the other frescoes the effect of overwhelming grandeur is partly induced by the rapt absorption of the participants in the event that is portrayed. The portrayal of the sick men in "SS. Peter and John healing the Sick with their Shadows" and of the dead Ananias in the "Distribution of the Goods of the Community" forms one of the most momentous advances in representation in western art.

In about 1428. Masolino began work on the decoration of the Branda chapel in S. Clemente in Rome. The frescoes in this chapel were ascribed by Vasari to Masaccio, and it is possible that he accompanied Masolino to Rome, where he died, at the age of 27, in the autumn of 1428. Since his death the supreme importance of Masaccio's contribution to the development of painting has never been in doubt, and his frescoes in the Carmine have been copied by Michelangelo and countless bther artists. Though all of his known works were produced in a period of eight years, he occupies in his own art a position analogous to those of Brunelleschi in architecture and Donatello in sculpture.

See J Mesnil, *Masaccio et les débuts de la Renaissance* (1927); *M.* Pittaluga, *Masaccio* (1935); *M.* Salmi, *Masaccio* **(1948).**

(J W. P.-H.)

MASAI. The most important members of the Nilo-Hamitic group are the Masai, Nandi, Keyo, Suk, Turkana, Iteso, Karamojong. Dodoth. Didinga, Topotha and Ajie. While they are, generally speaking, homogeneous the following distinctions have to be noted: (1) the Suk and the tribes to the south and east, the Masai, the Nandi and their neighbours, practise circumcision and clitoridectomy, while the tribes north of the Suk do not. (2) The Masai. Turkana and Ajie are nomadic; the Nandi, Keyo and Iteso are sedentary and have adopted agriculture in addition to the pastoral life; the rest are seminomadic.

The Masai are a tall, well-built, slender people with good features and well-defined noses. The two lower incisors are removed. The heads of the women are shaved, as are the heads of married and of uninitiated men. The warriors wear their hair plaited into queues hanging down the back and over the forehead. The women are scrupulously clothed from girlhood to old age with dressed skins and leather petticoats. Beads, metal armlets, necklets and bracelets, are popular with both sexes.

Their dwellings are of a peculiar type, long, continuous houses (not more than 6 ft. in height) which are built around the inside of a circular thorn fence. They are flat roofed and are divided into separate compartments for families, each with a door. During their period of service the warriors, who may not yet marry, live in separate barracks or villages. where they are visited by the unmarried girls. The Masai keep cattle (of the humped Zebu type), sheep and goats. donkeys and dogs, and the cattle cult is a feature of their culture. The Masai are divided into a number of patrilineal, exogamous clans grouped into four endogamous sections. and inheritance is normally to the eldest son who has to support his father's wives and his own brothers and sisters.

The system of initiation and age grades is the basic feature of Masai social life and has produced a most effective military organization. The tribe is divided into young men or boys and groups of initiated men who pass through successive stages as warriors and elders, difterentiated by duties, privileges and details of costume. The centre of political gravity is with the warrior class and there are no chiefs. The elders whose ranks are replenished by time-expired warriors act as advisers and with the tribal magician form the judicial and legislative authority, but the executive authority remains with the warriors. The magician (oloiboni). a hereditary office, is the chief adviser. *(See* AGE SET.)

Religion is a mixture of ancestor worship and the worship of Engai, the "sky." The ancestor cult is associated with certain trees, notably the fig, and a reverence for snakes.

See also references under "Masai" in the Index volume.

(J. H. D.)

MASANIELLO, properly TOMMASO ANIELLO (1620?–1647), an Amalfi fisherman, who became leader of the revolt against Spanish rule in Naples in 1647. A revolt had broken out at Palermo in Sicily in May 1647, and the people of Naples followed this example. The immediate occasion of the Neapolitan rising was a new tax on fruit. the ordinary food of the poor, and the chief instigator of the movement was Masaniello. On July 7, 1647, there was a riot at the city gates between the fruit vendors and the customs officers, and the customs office was burned. The rioters then poured into Naples and forced their way into the palace of the hated viceroy, the duke of Arcos, who fled.

Masaniello, himself illiterate, became a figurehead for educated reformers and was elected "captain-general." The revolt was spreading to the provinces when, on July 13, through the mediation of Cardinal Ascanio Filomarino, a convention was sworn between the viceroy and Masaniello as "leader of the most faithful people of Naples," by which the rebels were pardoned. the more oppressive taxes removed and the citizens granted certain rights. Elated by success, Masaniello began to show signs of madness and was murdered by his own supporters on July 16. 1647.

MASARYK, JAN GARRIGUE (1886–1948), Czech statesman, the son of T. G. Masaryk (*q.v.*), was born in Prague on Sept. 14, 1886. He went to the United States in 1907 and undertook a variety of jobs; he returned to Prague before the outbreak of war. During World War I he served in a Hungarian regiment, mostly in Poland. He then went into the Czechoslovak foreign office; before the end of 1919 he was sent as Czechoslovak chargé d'affaires to Washington, but was soon transferred to London where he became counselor of legation until 1921, when he returned to Prague to become secretary to E. Benes.

In 192 j Masaryk was appointed Czechoslovak minister in London; he resigned after the Munich agreement of Sept. 30. 1938. When, after the fall of France. the Czechoslovak government was provisionally reconstituted in London in July 1940, Jan Masaryk became foreign minister. His broadcasts to occupied Czechoslovakia from London throughout the war made him for the first time a tremendously popular figure in his own country from which he had been so long absent. In spring 1945 he accompanied Benes to Moscow, then went to San Francisco for the inauguration of the Cnited Nations, returning to Prague in July. He remained foreign minister until his death He was one of the three non-Communist ministers to whom bombs were sent by post on Sept. 11, 1947. After the Communist coup d'état of Feb. 25, 1948, at Benes' request he remained at his post. His dead body was found on

March 10; it appeared that he had thrown himself out of the window of his room at the foreign office.

See Sir R. H. Bruce Lockhart. *Jan Masaryk* (London, 1951); Robert Pon-ell, "Jan Masaryk" in *The Slavonic arid East European Review* (London, April 1950). (E. Wi.)

MASARYK, THOMAS GARRIGUE (1850–1937), first president of Czechoslovakia. was horn on March 7, 1850, near the Moravian border town of Hodonin. His father was a coachman employed on one of the Austrian imperial estates a native of Kopcany in Slovakia (Slovakia then being a part of Hungary): his mother came from a semi-Germanized Czech family of Hustopece, in the Moravian plains. In his boyhood Masaryk was taught Czech and a smattering of German. and was educated at a Czech school in Cejkovice. His parents sent him for tn-o years to the lower German *realschule* of Hustopece. with the intention of making him a teacher.

This object being abandoned. he became at the age of 14 a locksmith's apprentice in Vienna. then a blacksmith at Cejc. In 186j his former schoolmaster induced his parents to resume their idea of making him a teacher. and in that year Masaryk passed the entrance examination to the second grade of the *gymnasium,* and began studying at Brno. He supported himself. as did many poor students. by tutoring. He developed a rebellious disposition. disagreed with some of the dogmas of the Roman Catholic Church and refused to go to confession. As a result he had to leave the *gymnasium,* but continued his studies in Vienna. where he graduated from the *gymnasium* with honours, then obtained his doctor's degree in 1876 from the university, returning in 1879 to become a lecturer in philosophy. a great Platonist. He had spent a year in Leipzig, where he met his future wife, Charlotte Garrigue, who was studying music; she was a daughter of the president of the Germania Insurance company of New York city In 1881 he published in German his first great sociological work. *Der Selbstmord als soziale Massenerscheinung der modernen Zivilisation* (Suicide as a Mass Phenomenon of Modern Civilization). In 1882, when the University of Prague was divided into tn-o parts. Czech and German. he was appointed to one of the Czech professorships. In 188; he published his larger work on *Concrete Logic.*

The Forged Manuscripts and "Realism."—In 1883 Masaryk founded a critical monthly review *The Athenaeum,* which soon sprang into prominence by becoming the battleground on which the famous manuscripts of Kralovy Dvur and Zelena Hora (Koeniginhof and Gruenberg) were attacked and proved to be forgeries manufactured in the early 19th century by two well-meaning men, whose object was to provide texts to prove that in the Middle Ages there had been a high standard of literary culture in Bohemia. The authenticity of the manuscripts had already been doubted by Slav philologists. but it was not until 1886. when Masaryk invited the great Czech philologist Jan Gebauer to analyze the manuscripts philologically. himself analyzing them sociologically, that they were conclusively proved to be forgeries.

The fight over the manuscripts marked the beginning of the so-called "realist" revolution in Czech politics, literature and philosophy, the guiding principle of which was the application of the scientific method to letters and politics. While at Prague university. Masaryk founded in 1893 a monthly review *Nase Doba* (Our Epoch). He became a member and instructor of the Sokols. He started lecturing in Prague clubs and societies on unconventional subjects and published unpopular books. His sociological work led him to a study of Marxism, whose historical materialism he criticized in Tlze *Social Question* (in Czech and German. 1898).

Masaryk's political career started in the early 1880s. In 1887 his friends founded a fortnightly paper *Cas* (Time), which two years later he took over and transformed into a political weekly. At that time the so-called Old Czech (Conservative) party was losing ground, and Masaryk, invited by the Young Czech (Liberal) party to be a candidate. was elected to parliament in 1891. He soon resigned his seat (1893) to devote himself to a crusade of moral education among the Czech people.

Although his opinions on nationalist questions were unpopular—an unpopularity which increased when in 1899 he fearlessly withstood a popular anti-Semitic superstition as manifested in the so-called ritual murder trial of a Jew named Hilsner—his ideas made a deep impression. They became the rallying cry of the younger generation not only of the Czechs. but of the Yugoslavs and other Slavs who flocked to Prague.

Political Leadershim— In 1900 his followers founded a political party which was officially named the Progressive party, but which continued to be known popularly as the Realist party. The program was founded on the principles enunciated in Masaryk's books. As a candidate of the Realist party he was re-elected to parliament in 1907. In parliament he soon began to criticize Austria's passive subjection to Germany and its own aggressive policy in the Balkans. especially as manifested in the annexation of Bosnia-Hercegovina. In the notorious "high treason" trial of Zagreb (1909), by which the Austrian foreign minister. Count Aehrenthal. tried to justify his annexation policy, and in the Friedjung trial (1909) which followed, Masaryk played a decisive part. He proved. on the basis of his private investigations. that the case for the crown rested on documents forged at the Austro-Hungarian legation in Belgrade. His fearless disclosures in the Austrian *Reichsrat* (May 1909) and in the Xustro-Hungarian delegations (1910) forced the proceedings in the Zagreb trial to be quashed, compelled Heinrich Friedjung to retract his accusations against the Serbs. and unmasked the methods of Austro-Hungarian diplomacy. Masaryk incurred the intense displeasure of the official and court circles in Vienna, but made a reputation abroad.

Propaganda.— During World War I he developed his case against Austria-Hungary in detail, and in the end, in his work *The New Europe,* characterized it as a corrupt, imperialist, militarist, pretentious and senseless relic of the middle apes.

When the war broke out he was still a member of the Austrian parliament. In Dec. 1914 he escaped from Austria, and in the iollowing iour years conducted a political and propagandist campaign in Switzerland, France, Britain, Italy, Russia and the United States on behalf of Czechoslovak liberation from Habsburg rule. He founded the propagandist journals *La Nation Tchèque,* which was edited in Paris bi- Ernest Denis, and *Ceskoslovenska Samostatnost* (Czechoslovak Independence), which was produced in the small town of Xnnemasse in Savoy, and he was one oi the original board of R. W. Seton-Watson's *The New Europe,* which was founded in London in 1916.

Masaryk's stand against Austria was publicly proclaimed in his Jan Hus anniversary speech made in Zurich, Switz., in July 1915, and reaffirmed in his revolutionary maniiesto, issued by him with the sanction of the Czech political leaders at home, on Nov. 14, 1915, in Paris. The signatories of that manifesto, who included representatives of Czech residents in France, Great Britain, the United States and Russia, formed (1916) a central revolutionary committee called the Czechoslovak National council, of which Masaryk acted as president and E. Benes as secretary. Finding his work in Switzerland hampered by enemy spies, he settled in London, where, at the invitation of Ronald Burrows, the principal, he joined the staff of King's college in Sept. 1915. There he worked for tn-o years combating, with the help of his friends, Wickham Steed and R. W. Seton-Watson, German-Magyar propaganda, and familiarizing western opinion with Czechoslovak aspirations.

The Russian revolution of 1917 enabled him to go to Russia. Several thousand Czech soldiers—prisoners of war—had gone over to the Russians, and wanted to organize themsrlves into active military units. After some difficulty- Masaryk induced the revolutionary Russian government to agree to the formation and equipment of an independent Czechoslovak army (92,000), whose exploits as they marched eastward from Siberia to Vladivostok were one of the impressive later episodes of the war. Masaryk transferred some units to the western iront.

President.— He went to the United States in May 1918. The result was the Lansing declaration (May 29, 1918) of sympathy with the cause of Czechcslovak and Yugoslav independence. The Allied governments associated themselves with that declaration on June 3, 1918. The ice being thus broken, the Allied powers and the U.S. recognized Masaryk's national council as the de *facto* government of the future Czechoslovak state. Masaryk was elected first president of the Czechoslovak republic on Nov. 14, 1918, re-elected on May 27, 1920, in May 1927, and again in May 1934, but in Dec. 1935 he resigned. Having seen his beloved pupil. Benes, elected to succeed him, he died on Sept. 14, 1937, mourned by the nation. His wife had died in 1923. For his work irom 1918 *see* CZECHOSLOVAKIA.

Masaryk ranks equally high as a philosopher and as a statesman. His philosophical treatises were the result of his study of Czech history. His pronounced realism was a reaction both against the Teutonic idealism which developed moral speculation without reference to the practical affairs of life and against the Tolstoyan Slav philosophy of nonresistance to evil. Masaryk, as philosopher, stood for a unified conception of life, in which the spiritual and religious took their place with the intellectual and the political as aspects of an integral whole.

The following are the chief of his many philosophical! sociological and political works: *O Hypnotismu* (On Hypnotism, 1880); *Der Selbstmord als soziale Massenerscheinung der modernen Zivilisation* (Suicide as a Mass Phenomenon of Modern Civilization, 1881; Czech version! 1904); *Theorie Pravdcpodobnosti a Humeova Skepse* (The Theory of Probability and Hume's Scepticism, 1882; Ger. trans., 1884); *Blaise Pascal* (1883); *Theoric dezin dle zasad T. H. Buckle* (The Theory of History according to T. H. Buckle, 1884); *Zakladove Konkretni Logiky* (Essay on Concrete Logic, 1885; Ger. trans., 1886); *Slavjanofilism I. S. Kirejevskeho* (1889); *Ceska Otazka* (The Czech Question, 1895); *Karel Havlicek* (1896); *Otazka Sociální; Zaklady marxismu filosoficke a sociologike* (The Philosophical and Sociological Foundation of Marxism, 1898, also in German); *Jan Hus* (1899); *Rusko a Evropa* (1913, Eng. trans., *The Spirit of Russia*, 1919, reprinted with additions, 1955): *The Problem of Small Nations in the European Crisis* (1916); *The Sew Europe* (1918; French trans., 1918; Czech, 1919; German. 1922); *Svetova Revoluce za valky a ve valce, 1914–1918* (1925; German trans., 1927; Eng. trans., *The Making of a State: Memories and Observations 1914–18*, 1927; French trans., 1930).

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MASAYA, the smallest department in Kicaragua (area 232 sq.mi.), located northwest of Lake Nicaragua, and the name of its capital city. The department is the most densely settled in the country; pop. (1959 est.) 101.273. With fertile soils derived chiefly from volcanic ash and lava. Masaya is important agriculturally, producing especially tobacco. corn. beans and other vegetables. flowers and. on the slopes of Masaya volcano. coffee.

The city of Masaya, pop. (1959 est.) 29.119. on the shore of a crater lake of the same name. is famous for its flower gardens. It is on the main line of the Pacific railway of Nicaragua: branch roads and railways connect the city with rich agricultural districts. It manufactures foodstuffs, leather. footwear. cigars. soaps. starch, rugs and hats. (C. F. J.)

MASBATE, an island in the Philippine archipelago. centred 30 mi. S.W. of the southern tip of Luzon. Area 1.262 sq.mi. The island is adz-shaped with mountain ranges along each axis. probably representing the intersection of the two main lines of Philippine faulting. Gold was mined for centuries near Aroroy in the north. Before World War II this area produced about 12% of the Philippine output; operations had ceased by the 1960s. The province of Masbate includes the much smaller Burias and Ticao islands. Pop. (1960) 336.709. The capital and principal trading town is Masbate (pop. [1960] 31.580). on the northeast; Cataiñgan, on the southeast. is also a trading centre. (R. E. HE.)

MASCAGNI, PIETRO (1863–1945), Italian operatic composer. was born at Leghorn on Dec. 7, 1863. A symphony by him was performed in 1879, and an uncle helped him to study at the Milan conservatory. But Mascagni went off with a touring operatic company. He leaped into fame by the production at Rome in 1890 of his one-act opera *Cavalleria Rusticana,* to a libretto based on a peasant story by Giovanni Verga (*q.v.*) containing a tuneful intermezzo. which became widely popular. He died in Rome on Aug. 2. 1945.

MASCARA, chief town of an *arrondissement* in the *département* of Mostaganem. Algeria, 60 mi. S.E. of Oran. Among the public buildings are two mosques, in one of which Abd-el-Kader preached the *jihad.* The principal industry is the making of wine. There is also trade in grains and oil. Mascara (*i.e.,* "mother of soldiers") was the capital of a Turkish beylik during the Spanish occupation of Oran from the 16th to the close of the 18th century. On the removal of the bey to Oran its importance rapidly declined; in 1832 Abd-el-Kader chose it as the seat of his power. It was laid in ruins by the French in 1835, reoccupied by Abd-el-Kader in 1838 and again captured in 1811 by the French.

MASCARENE ISLANDS (occasionally MASCARENHAS), the collective title, derived from their discoverer, a Portuguese navigator Garcia Mascarenhas, of a group in the Indian ocean east of Madagascar. viz., Mauritius, Réunion and Rodrigues (*qq.v.*).

MASCARON, JULES (1634–1703), French Roman Catholic preacher, the son of a barrister at Aix, was born at Marseilles in 1634. He early entered the French Oratory and obtained a great reputation as a preacher. In 1666 he was asked to preach before the court, and became a favourite with Louis XIV, who said that Mascaron's eloquence was one of the few things that never grew old. In 1671 he was appointed bishop of Tulle and in 1679 bishop of Xgen. He continued: however, to preach regularly at court, being especially in request for funeral orations. A panegyric on Turenne. delivered in 1675, is considered his masterpiece. Mascaron died at Xgen on Dec. 16. 1703.

Six of his most famous sermons were edited, with a biographical sketch of their author. by the Oratorian Borde in 1704.

See J. Lehanneur, *Mascaron d'après des documents inédits* (1878).

MASCART, ÉLEUTHÈRE ÉLIE NICOLAS (1837–1908), French physicist. who applied photography to the mapping of spectra. was born on Feb. 20. 1837, near Valenciennes. He was educated at the École normale, obtaining his doctorate in 1864 and taught physics in *lycées* at Metz, Paris and Versailles. He became director of the central bureau of meteorology in 1871 and in 1872 succeeded Henri V. Regnault as professor of physics at the Collège de France. He also served as permanent secretary of the Academy of Sciences. Mascart retired in 1907 and died at Poissy on Xug. 26, 1908.

His early investigations were on optics; he constructed a quartz spectograph and investigated a number of spectra farther into the ultraviolet. He also made determinations of standard wave lengths. His memoir on the effect of the proper motion of the earth on optical phenomena was awarded the grand prix des sciences mathématiques in 1874. Mascart made a number of determinations of electrical units and determined the electrochemical equivalent of silver. He was interested in the teaching of practical electricity and in its application to industry, and acted as adviser to the government in many matters. He wrote *Éléments de mécanique* (1866); *Traité d'électricité statique* (1876); *Traitk d'optique,* 4 vols. (1889–93); *Leçons sur l'électricité et le magnétisme,* with J. J. Joubert (1882–86); and *Traité du magnétisme terrestre* (1900).

MASEFIELD, JOHN, O.M. (1878–), British poet and novelist. was born in Ledbury and spent his youth in many countries and occupations, serving before the mast at sea, and earning a living as best he could in America. The activity of these years was reflected in his work from the first. as *Salt-Water Ballads* (1902) or *Ballads* (1903) show. His early novels, *Jim Davis* (1911), *Captain Margaret* (1908) and *Multitude and Solitude* (1909), were excellent tales of action and spirit, but he found his natural expression in narrative poetry and drama. *The Everlasting Mercy* made something of a sensation in 1911; it was followed quickly by *The Widow in the Bye Street* (1912); *Dauber* (1913); and *The Daffodil Fields* (1913), all narrative poems in a key of stern realism. Meantime Masefield had written two plays. *The Tragedy of Nan* (1909) and *Pompey the Great* (1910), the first allied in subject and setting to his long poems of village life, the second historical in theme. *Lollingdon Downs* (1917) included a noteworthy sonnet sequence, and *Reynard the Fox* (1919) proved one of the most successful of his verse narratives. Here the country life that he knows so well is reflected faithfully and vividly, without the somewhat excessive gloom of *Nan* and the *Everlasting Mercy.* The gradual awakening of the village on the morning of the meet, followed by the gathering of the hunt, the stir and movement of horses and hounds, make a picture among the best things he has ever done. *Right Royal* (1920), a similar poem, is less successful. Later work includes the novels *Sard Harker* (1924), *The Hawbucks* (1929) and *Badon Parchments* (1947); *A Macbeth Production* (1945); and a book of new verse, On *the Hill* (1949). He published some able prose war sketches in *Gallipoli* (1916) and *The Old Front Line* (1917). He succeeded Robert Bridges as poet laureate in May 1930.

MASER, a device used for the amplification or generation of radio waves, usually in the microwave region. X device analogous to the maser, but which operates at optical frequencies, is called

the laser (*q.v.*). The maser takes its name from an acronym coined by C. H. Townes from the descriptive phrase, "microwave amplification by stimulated emission of radiation." As the phrase implies, the operation of the device depends on radiant energy emitted from a suitably activated material, the material being stimulated by incident energy at the same wave length.

A solid-state maser can be activated by storing energy supplied by a microwave source in a paramagnetic crystal (*see* PARAMAGNETISM). The stored energy is released from the crystal by the triggering action of an incoming resonant signal. Satisfactory performance ordinarily requires operation at low temperatures (−270° to −200° C.).

A gaseous maser can be activated by an electric field arranged to remove ground-level (unexcited) particles that would absorb incident energy from a molecular stream passing through it. (For an explanation of energy levels of atoms. *see* ATOM.) The remaining excited-level particles are then stimulated to emit energy as they pass through a resonant cavity. The power corresponding to the rate at which energy is emitted is greater than the power lost in the cavity, resulting in a net power gain (*see* ATOMIC AND MOLECULAR BEAMS).

The quantum-mechanical description of the properties of matter prescribes both discrete energy levels and the average number of particles occupying those levels. Normally. lower energy levels have a greater occupancy than do higher levels; therefore. matter absorbs a net amount of energy as a result of induced transitions from lower to higher levels (absorption) in excess of the amount of energy involved in transitions from higher to lower levels (emission). Maser activation produces greater occupation in the higher levels. Spontaneous emission, a source of random noise, also occurs, but the relative improbability of this at very short wave lengths accounts for the desirable low noise characteristic of maser amplifiers.

Because the energy-level spacing of certain gases is little affected by external forces, the gaseous maser produces power at a precisely maintained frequency corresponding to that spacing, a property that is useful for accurate measurement of time (*see* TIME MEASUREMENT). Since paramagnetic energy levels are more easily affected. solid-state masers have been more important as tunable preamplifiers for supersensitive microwave receivers used, for example. in radio telescopes.

See J. R. Singer, *Masers* (1959). (J. W. M.)

MASERU, the capital town of Basutoland, Africa, is situated 4,950 ft. above sea level on the eastern bank of the Caledon river and near the territory's western border with the Orange Free State. Pop. (1956) 5,739 including 590 Europeans. The annual rainfall is about 30 in. Only a few of the early mud-walled buildings remain, many having suffered in the "Gun War" of 1880. The residency, the home of the resident commissioner of Basutoland, incorporates the pre-1880 building but was extensively enlarged. The octagonal National Council chamber, erected in 1910 when the council was first established, is the best known architectural feature. There are several churches and schools including an African high school and a technical school which was opened in 1906, and a well-equipped hospital. The high court of Basutoland is housed in an imposing sandstone building. Maseru is linked to the South African railway system and by road to the various district headquarters, or "camps," in the western and northern lowland border country of Basutoland; it also has air services to administrative and trading centres in the mountainous interior.

The town is one of the oldest and most historic capitals in southern Africa, having been established in 1869 when the famous paramount chief of the Basuto, Moshesh, asked for the capital to be moved there from Mokema. (Js. W.)

MASHAM, ABIGAIL, LADY (d. 1734), favourite of Anne, queen of England, was the daughter of a London merchant; and cousin of Sarah Jennings, duchess of Marlborough, who procured her an appointment in the queen's household about 1704. The queen's presence at Abigail's private marriage to a gentleman of the royal household named Samuel Masham, first led the duchess to suspect that Abigail was supplanting her in the queen's favour. This suspicion was confirmed in 1710 when the queen compelled Marlborough to give an important command to Col. John Hill, Abigail's brother; and when Sunderland, Godolphin, and the other Whig ministers were dismissed from office. In the following year the duchess was also dismissed from her appointment at court, and Abigail became keeper of the privy purse, shortly before her husband was created a peer. Finally, in July 1714, Anne, influenced by Lady Masham, dismissed Oxford from his office of lord high treasurer, and gave the staff to the duke of Shrewsbury. When the queen died on Aug. 1, Lady Masham retired into private life. She died on Dec. 6, 1734. See ANNE, QUEEN; MARLBOROUGH.

MASHAM, SAMUEL CUNLIFFE LISTER, 1ST BARON (1815–1906), English inventor of wool-combing and silk-combing machines, was born on Jan. 1, 1815, at Calverley Hall, near Bradford, Yorkshire, the son of a wealthy manufacturer. Starting at Manningham in 1838 with his elder brother John as spinners and manufacturers: Samuel devoted considerable attention to devising efficient mechanical wool-combing methods. He finally produced and patented a machine which performed this operation remarkably well. In time he had nine combing mills operating at once—five in England, one in Germany and three in France. In 1855 he turned his attention to finding a way of working up waste silk (*i.e.*, the residue remaining after reeling silk cocoons). After spending about ten years and an enormous amount of money, he perfected means by which silk yarn could be made from a cheap raw material and sold at many times the cost. His velvet loom was another important textile machinery development.

He was awarded an Albert medal in 1886 and created a baron in 1891. Lord Masham died at Swinton Park, Yorkshire, on Feb. 2, 1906. (A. DR.)

MASK is a form of covering for the face employed as a protective screen or disguise; the term also refers to a facial portrait in three dimensions. As a protective device, the mask has been used by medieval horsemen, by fencers, by welders and, in modified form, by participants in competitive athletic events. The practice of reproducing the features of memorable living or dead persons by a mask molded directly from the subject's face has been reported among ancient Phoenicians, Egyptians, Greeks and Assyrians. The Romans are reported to have invented a technique of casting in wax. During the 19th century, three-dimensional portraiture enjoyed great popularity in the United States and Europe. With liquid plaster of Paris, a negative cast of the human face could be produced which in turn acted as a mold for the positive image. The features of such notables as Henry Clay, De Witt Clinton and Presidents Adams, Madison and Van Buren have been preserved in life masks. Death masks of Newton, Cromwell, Bonaparte, Keats, Schiller, Washington, Lincoln, Beethoven and other well-known figures are in existence.

The principal use of the mask, however, has been as a device of disguise, serving: (1) as part of the paraphernalia in primitive ritual; and (2) as a convention in theatrical representation.

PRIMITIVE RITUAL

Primitive men believe that spirits govern the world. Spirits in the living and in the dead, animate and inanimate, human and bestial, real and mythological, must be cajoled, exorcised, fooled, coerced, soothed, frightened and worshipped. They must be propitiated and given concrete form by idolization. To accomplish this, elaborate rituals and ceremonies, in which masks play a dominant role, have been invented.

The origin of the mask is obscure. It may have existed first as a grotesque symbol on battle shields to frighten enemies. Some authorities point to the hunt, claiming that disguise masks were first used in stalking prey and, later! to house the slain animal's spirit in the hope of placating it. Some Africans maintain, however, that the first mask was an admonitory one. A child, repeatedly told not to, persisted in following its mother to fetch water. To frighten and discipline the child, the mother painted a hideous face on the bottom of her water gourd. Others say the mask was invented by a secret African society to escape recognition while punishing marauders.

Primitives have designed masks of innumerable varieties from

the simplest of crude "false faces" held by a handle, to complete head coverings with ingenious movable parts and hidden faces. Masklike carvings, expected to accomplish the mask function, range in size from tiny amulets to huge totem poles and house posts. Native mask makers have shown great resourcefulness in selecting and combining available materials. Among the substances utilized are woods, metals, shells, fibres, ivory, clay, horn, jade, onyx, stone, feathers, leather, furs, paper, cloth, and corn husks. Surface treatments have ranged from rugged simplicity to intricate carving, from polished woods and mosaics to gaudy adornments.

Because everything was believed to possess a spirit, it was natural for primitive man to become selective, to find authority for himself and his family by identifying with a specific nonhuman spirit. He adopted, therefore, an object of nature as the resting place for his own spirit, and mythologically tracing his ancestry back to the chosen object, he pre-empted the leopard or elephant, the hawk or serpent as the emblem of himself and his clan. This is the practice of totem. and it is the basic religious conception of the primitive hunter. He puts a taboo on his totem, forbids himself and his totem brothers to kill or eat it, makes masks to house the totem spirit, dances for it and invents ritual to honour it. The totem ancestor, he believes, actually materializes in its mask; so masks are of the utmost importance in securing protection and bringing comfort. Totemism consolidates family pride and distinguishes social lines.

The Papuans of New Guinea build mammoth totem masks attaining 20 ft. in height. Made of wood or bark cloth. these man-animal masks are given large, painted eyes and a frightening aspect. When placed against the mall of the men's secret clubhouse they serve to protect the members of the totem clan. Similar is the practice among the Indians of the American northwest coast where painted masks three or four feet long signifying the clan are placed before individual members' homes. The totem pole of the Eskimo and British Columbian Indian fulfills the same function. The African totem mask is most often carved from ebony or other hard woods, designed with graceful lines and showing a highly polished surface. Deer, antelope, gorilla, elephant, panther and leopard masks, their features elongated and beautifully formalized, are common. Generally, the South Pacific masks are more grotesque than the African, less attention being given to realism in concept or execution. Dried grass, woven palm fibres, coconuts and shells, as well as wood, are employed in the masks of New Guinea, New Ireland and New Caledonia. Represented are fanciful birds and animals with distorted or exaggerated features.

The high priest among most primitives was the *shaman* or medicine man. Frequently he had his own very powerful totem, in nhose mask he could exorcise evil spirits, punish enemies, locate game or fish, predict the weather and, most importantly, cure disease. Usually, the medicine man's mask was sacred, more mythological, elaborate and fantastic than others.

The northwest-coast Indians in particular devised mechanical masks with movable parts to reveal a second face—generally a human image. Believing that the human spirit could take animal form and *vice versa,* the makers of these masks fused man and bird or man and animal into one mask. Some of these North Pacific articulating masks acted out entire legends as their parts moved. One, called the mask of the first dawn, represents night when its black wings are closed. When the wearer pulls a string and the nings open, a red, beaked sun appears; another string, and the sun mask rises on small iron rods to reveal the face of the light-maker painted nhite. A device on top scatters tiny feathers to represent mist or fog.

The *shaman* of the North American Pueblo Indians, the Hopi, the Zuñi and Keres, is primarily concerned with rain making. Together with masked dancers representing clouds, rain spirits, stars, Earth Mother, sky-god, etc., he takes part in elaborate ceremonies designed to assure bumper crops. Spirits, called *Kachinas,* who first brought rain to Pueblo tribes, are said to have left their masks behind when sent to dwell in the bottom of a desert lake. Their return to help bring the rain is incarnated by the masked dancer. Cylinder- and post-like masks, covering the entire head and resting on the shoulders, are of a primal type. They are made of leather, old saddles or rawhide, humanized by hair and a variety of adjuncts. Eyes are represented by incisions or by buckskin balls filled with deer hair and affixed to the mask. The nose is commonly of rolled buckskin or corncob. Frequently the mask has a projecting wooden cylinder for a bill or a gourd stem cut with teeth for a snout. Horns are attached to some masks and the datura, a flower which has the power to induce hallucinatory visions, is generally a part of the adornment. Many colours are used in their painting; plumes and beads are attached and the sex of the mask is distinguished by its shape: round head for male and square for female.

The magic of the mask has been employed extensively to cure sickness, usually by the medicine man wearing a mask representing the fever or specific disease; he devil dances the illness out of the patient into the mask. Chinese children have long been made to wear measle masks to protect them from that common ailment, and both the Chinese and Burmese have had cholera masks. The disease mask reached its zenith in Ceylon where 19 distinct disease devil masks were devised. Even deafness was thought curable by use of the mask. The Sinhalese disease masks are of ferocious aspect, fanged, and with starting eyes. Sometimes having articulating jaws and, gaudily coloured, they present a dragonlike appearance.

In some primitive cultures, secret societies, whose members were masked, could drive disease demons from entire villages and tribes. Most familiar is the False Face society of the Iroquois Indians from the American northeast coast. These professional medicants wear long-haired, grimacing, twisted masks representing the *Gahadogoka gogosa,* demons who plague the Iroquois. Violent pantomimes are performed to exorcise them. According to legend the False Face masks must be carved from a living basswood tree, so they will possess life. Permission, which is sought through incantations and ritual, must be granted by the tree.

Like disease-curing, the art of demon-chasing and of admonishing women, children and criminals has had wide practice. Discipline masks are common in China, Africa, the South seas and North America. Towering false faces, Mumbo-Jumbo, screaming giants and identically masked men maintain order and exact punishment among tribes in the Congo. The Dukduk, a secret society in New Britain, appear in their monstrous five-foot masks once a month to police, to judge and to execute offenders.

The Dukduk, like other secret societies, also preside at initiation ceremonies, an important function throughout the primitive world. Totem and spiritualistic masks are donned at these ceremonies, and some elaborate, precious masks of gods and demons are reserved for appearance only at initiation, the most important ceremony in the male's life. The Great Cannibal Spirit dominated the Kwakiutl Indians' initiation rites in British Columbia, a strange, heavily carved wooden face with four pipelike eyes and horns and an extended pipe as mouth. Most impressive of initiation masks are the exquisitely carved human faces of the west coast Africans. Among the Bapendes of the Belgian Congo, after a lengthy ordeal of teaching and rites of initiation, the youth appears in a mask representing the ghost of his childhood. The mask is later cast aside and replaced by a small ivory duplicate which is worn as a charm against misfortune and as a symbol of his manhood.

Ceremonies associated with the dead and with departing spirits exist in every known culture. Totem ancestors, demon spirits, benevolent shades and mythological characters are all represented by masks at funerals and spiritual festivals. Primitive men believed it necessary to entice or force spirits of the newly dead to depart for the spirit world. Money, food, means of transportation and other travel accessories were placed with the body to assist the spirit to the nether world. Obstreperous and obstinate spirits had to be exorcised with masks designed to frighten and coerce. The Donegon tribe of Africa has a six-day funeral ritual performed by masked dancers to drive away reluctant spirits. Curiously, some of these African masks have white complexions and non-Negroid features.

Some primitives, particularly those of the South seas and Africa, set aside certain times of the year to honour and placate departed

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ANCIENT MASKS

1. Egyptian tragic masks made of faience (*c.* 100 A.D.). From Medinet-el-Fayum
2. Female tragic mask of terracotta; Greek, of the Hellenistic period. From Thebes
3. Colossal tragic mask of marble; Roman period
4. Ancient Tibetan Mask; probably used by a devil dancer
5. Bronze helmet found at Ribchester, Lancashire. In the Townley Collection, British Museum

MASK

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ANCIENT MASKS

1. Fire God mask. Zuni Indians, New Mex. 2. Ant bear mask. Senufo, Ivory Coast. 3. Rainbow mask. Keres Indians, New Mex. 4. Yeibichai mask. Navaho Indians, New Mex. 5. Congo mask of carved wood. 6. Gorilla mask. Dan-Guere, Liberia and Ivory Coast. 7. Antelope mask. Guro, Ivory Coast. 8. Japanese war mask. 9. Elephant mask. Baii, Camcroors. 10. Carneo mask. Ibo, Nigeria. 11. Yoruba mask. Nigeria and Dahomey. 12. Kcyemci mask. Zuni Indians. 13. Long horn mask. Zuni Indians. 14. Mask of Wupamu. Hopi Indians, New Mex. 15. Tobodzistsini, Navaho War God mask. 16. Crown dancer mask. Western Apache Indians, Ariz.

spirits. On these occasions recognizable masks of dead chieftains, relatives, foes and friends are worn or exhibited. Gifts are made to the spirits incarnated in the masks while professionals, wearing stylized mourning masks, dance the ritual. In parts of Africa spiritualism flourishes much like a sport. The youths of the tribe do not even need a funeral in order to make "juju," the practice in which the community is presented with returning spirits, in the form of masks, who exact gifts from relatives as the price for re-departure.

Burial masks to protect spirits and guide them on their way have been widely excavated. In Mycenae were found seven of beaten gold which appear to be portrait masks. Gold masks were regularly placed on the faces of dead kings in Cambodia and Siam, and burial masks of silver and gold, bronze and terra cotta have been discovered in Japan, Greece, Italy, the Crimea, Mexico, South American countries, Phoenicia, Mesopotamia, France, Britain and in the Danube valley, suggesting that similar practices were universal. For 3,000 years, the Egyptians placed a stylized, impersonal mask of painted plaster, gold or silver upon the face of important dead persons in order that the spirit might find its final resting place, the mask serving to guide the spirit back to the body. In Mexico masks were often placed upon idol statues to animate them. Made of jadeite or onyx, the Toltec and Aztec masks, whether of idols, chieftains, or village leaders, are marked by great simplicity, formalism and symbolic realism. They seem to be generic representations of the tribe rather than portraits of individuals, and they are still carved by Indian craftsmen. Masks made from skulls have been found in Mexico and in Melanesia. Believing that the skull was the home of the spirit, the Aztecs took great care of those inhibited by important personages. Like their wooden masks, the Aztec skull masks are inlaid with turquoise mosaic bands alternating with bands of lignite. Eye sockets were filled with pyrites, and holes were drilled in the back so the mask might be hung as an idol.

In Melanesia ornamented skull masks were often hung in front of a dead man's statue to give it life, just as ashes of a dead Alaskan chief were put in the abdominal hole of his ancestor post to animate it and give it potency.

Among the special uses of masks other than those mentioned are the widely used war masks, worn not for protection but to frighten the foe. War masks are now ordinarily worn only in dances and rituals, especially among the Africans, Javanese and northwest coast Indians. The primitives of New Ireland devised "peace masks" worn at victory festivals in which even the enemy participated.

Still another special mask is the Dionysiac mask of fertility. Often out-and-out clowns such as the "Mud Heads" of the American Pueblos, masks of this sort are common in *fiestas* and are among the forerunners of Hallowe'en, Mardi gras and other festival masking. Ludicrous, grotesque or superficially horrible, festival masks are usually conducive to good-natured licence, release from inhibitions. and ribaldry.

Not to be overlooked are the masks used throughout Mexico for storytelling and caricature, such as those seen in the Dance of the Old Men and the Dance of the Moors and the Christians. Many "art for art's sake" masks, made with no religious connotations but simply for decorative purposes, are made available to tourists. Japan and Mexico, Kenya and Indonesia are among the leading producers of these handsome artifacts.

THEATRE

Greek and Roman. — The mask as a device for theatre first emerged in western civilization from the religious practices of ancient Greece. In the worship of Dionysus, god of fecundity and the harvest, the communicants' attempt to impersonate the deity by donning goat skins and by imbibing mine eventually developed into the sophistication of masking. When a literature of worship appeared, a disguise, which consisted of a white linen mask hung over the face (a device supposedly initiated by Thespis), enabled the leaders of the ceremony to make the god manifest. Thus symbolically identified, the communicant was inspired to speak in the first person; thereby giving birth to the art of drama. In Greece the progress from ritual to ritual-drama was continued in the highly formalized theatrical representation, which, although still concerned with religious and semireligious subjects and performed in connection with religious exercises, was maintained by the state and performed by professionals and is understood as the beginning of secular drama in the west. Masks used in these productions became elaborate headpieces made of leather or painted canvas and depicting an extensive variety of personalities, ages, ranks and occupations. Heavily coiffured and of a size to enlarge the actor's presence, the Greek mask seems to have been designed to throw the voice by means of a built-in megaphone device and, by exaggeration of the features, to make clear at a distance the precise nature of the character. Moreover, their use made it possible for the Greek actors — limited by convention to three speakers for each tragedy — to impersonate a number of different characters during the course of the play simply by changing masks and costumes.

In his encyclopaedia, *Onomasticon,* Iulius Pollux, Greek sophist and grammarian of the 2nd century A.D., described in detail the catalogue of comic and tragic masks used in the earlier Greek theatre. but no clear visual picture of these masks emerges. Several manuscripts of the plays of Terence contain illustrations of masks used by comic actors of the Roman theatre, a theatre heavily influenced by the style and practices of the Greek. Their comic mask appears to have been a grotesque affair with the mouth fashioned in the form of a huge bivalve generally fringed with a stylized beard. Details from frescoes, vase paintings and fragments of stone sculpture complete what is known of these ancient theatrical masks. The tendency of the early Greek and Roman artists to idealize their subjects throws doubt, however, upon the accuracy of these reproductions. Some authorities, such as Olive L. Riley, maintain that the masks of the ancient theatre were crude affairs with little aesthetic appeal.

Medieval. — After the interval of the Dark Ages, the mask makes its appearance again in the mystery plays of the late middle ages. In plays dramatizing portions of the Old and New Testaments, grotesques of all sorts, such as devils, demons, dragons and personifications of the seven deadly sins, were brought to stage life by the use of masks. But again, no reliable pictorial record has survived. Costume and property lists for the English cycle plays contain scattered references. For example, the Norwich *Creation* play notes "a face [mask] and hair for the Father." Other references suggest that Lucifer wore a false head painted black and that actors impersonating God and probably Christ had masks covered with gilt. Masks used in connection with present-day carnivals and *Mardi gras* and those depicting dragons still used by Tyrolean peasants are most likely the inheritors of the tradition of medieval masks. Constructed of papier-mâché, the masks of the mystery plays were evidently marvels of ingenuity and craftsmanship, being made to articulate, and to belch fire and smoke from hidden contrivances.

Renaissance. — The Renaissance in Italy nitnessed the rise of a theatrical phenomenon that spread rapidly to France. to Germany and to England, where it maintained its popularity into the 18th century. Comic plays improvised from scenarios based upon the domestic dramas of Plautus and Terence and upon situations drawn from anonymous Roman mimes flourished under the title of *Commedia dell' Arte.* Adopting the Roman stock figures and situations to their own usages, the players of the *Commedia* characterized types such as Pantelone, Dottore, El Capitano, young lovers and a variety of Zannis with such names as Arlechino, Brighella, Scaramuccia, Scapino, Pedrolino and Pulcinella. Most of these characters were masked. Sometimes the masking was grotesque and fanciful; but generally a heavy leather mask, full or half face, with beaked nose and wrinkles, with a wart on the forehead to distinguish particular Zannis disguised the *Commedia* player. Excellent pictorial records of both *Commedia* costumes and masks exist; some sketches show Harlequin and Columbina wearing black masks covering merely the eyes from which the later masquerade mask is certainly a development. Mask making has remained a fine art in Italy.

Modern. — Except for vestiges of the *Commedia* in the form of

puppet and marionette shows, the drama of masks all but disappeared in western drama during the 18th, 19th and first half of the 20th centuries. In revivals of Greek plays masks have occasionally been employed, and such plays as Gerhart Hauptmann's *The Sunken Bell* and dramatizations of *Alice in Wonderland* have required masks for the performers of grotesque or animal figures. But the mask as a convention has lost its importance. W. B. Teats revived the convention in his *The Dreaming of the Bones* and in other plays patterned upon the Japanese *nō* drama, and in 1926 theatregoers in the United States witnessed a memorable use of masks in Eugene O'Neill's *The Great God Brown,* wherein actors wore masks of their own faces to indicate changes in the internal and external lives of their characters.

Japanese.— In many ways akin to the Greek drama in origin and theme, the *no'* drama (*q.v.*) of Japan has remained a significant part of national life since its beginnings in the 14th century. Inspired by the Buddhist priests of the Zen sect and by the pleasure-loving Shogun Uoshimasa, 210 *nō* dramas are still in existence. The *no'* mask, of which there are about 125 named varieties, are rigidly traditional and are classified into five general types: old persons (male and female), gods, goddesses, devils and goblins. The material of the *nō* mask is wood with a coating of plaster lacquered and gilded. Colours are traditional. White is used to characterize a corrupt ruler; red signifies a righteous man; a black mask is worn by the villain who epitomizes violence and brutality. No' masks are sharply characterized and exquisitely carved by highly respected artists known as *Tenka-ichi* "the first under heaven." Tranquility, wrath, cunning and mirth, as well as more subtle shades of feeling, are portrayed with beautifully sublimated realism. It is said of these masks that when in movement they appear to change in expression.

Tibetan.— In Tibet, sacred dramas illustrating the former births of Buddha and similar events are performed by masked lay actors. A mystery play with manifestations of gods and demons by awe-inspiring masks is performed exclusively by the priests or Lamas at fixed seasons of the year and is still called "Dance of the Red Tiger Devil." This play appears to have been originated by a devil-dancing cult and is performed for the exorcising of demons. Masks employed in this play are made of papier-mâché, cloth and occasionally gilt copper. In Sikhim and Bhotan, where wood is abundant and the damp climate destructive, they are carved of durable wood; in all cases they are fantastically painted and provided with a wig of yaktail in various colours. They take the forms of hideous tusked ogres, animals, ghouls and skeletons; the jester or buffoon have a blue mask and cowls.

Chinese.— Masks, usually made of papier-mâché, are employed in the religious or admonitory drama of China, but for the greater part the actors in popular or secular drama make up their faces with cosmetics and paint to resemble masks. The sacred drama, which in China is highly didactic, is peopled with devils. madonnas, kings and court attendants of the ten purgatories; all are masked fancifully and grotesquely. Akin to this "morality" drama are the congratulatory playlets, pageants, processions and dances of China. Masks employed in these ceremonies include animal gods, sky-gods, mythological heroes, dragon kings and ancestors. They are highly ornamented masks, with jeweled and elaborately filigreed headgears. In the lion dance of both China and Japan, a red mask of a lion is carried on a pole by itinerant players whose bodies are concealed by a dependent red cloth. The mask and cloth are manipulated violently, as if the animal were in pursuit, to the taps of a small drum. The lower jaw of the mask is movable and is made to emit a loud continuous clacking by means of a string.

Javanese.— In Java, wooden masks, *tupeng,* are used in certain theatrical performances that are extremely popular. These plays developed from the shadow puppet plays of the 18th century and are performed not only as amusement but as a safeguard against calamities. The stories are in part derived from ancient Sanskrit literature, the *Mahabbarata* and the *Ramayana,* although the Javanese are now Moslems. The masks are ordinarily held in the teeth by means of a strap of leather or rattan fastened across the inside. Occasionally an actor interrupts the unseen Dalang who is speaking the play. The mask is then held in front of the face while the player says his line. The use of masks in Java is exceptional; for masks, being forbidden under the prohibition of images, are practically unknown in the Islamic east. *See* also Index references under "Mask" in the Index volume.

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MASKELYNE, NEVIL (1732–1811), 5th English astronomer royal, whose chief aim was the practical improvement of the art of navigation, was born in London on Oct. 6, 1732. He mas educated at Westminster school and Trinity college, Cambridge, where he graduated as 7th wrangler in 1754. He was ordained in 1755, but his interest in astronomy had been aroused by the eclipse of July 25, 1748, and in 1761, on James Bradley's recommendation. he was deputed by the Royal society to observe the transit of Venus in St. Helena. During the voyage he experimented upon the determination of longitude by the method of "lunars," and introduced this method into navigation by publishing in 1763, *The British Mariner's Guide.* In 1765 Maskelyne succeeded Nathaniel Bliss as astronomer royal. In 1766 he published the first volume of the *Nautical Almanac.* He continued the superintendence of this. his greatest work, until his death on Feb. 9, 1811.

Maskelyne's first contribution to astronomical literature was "A Proposal for Discovering the Annual Parallax of Sirius," published in 1760 *(Phil. Trans.,* li, 889). Subsequent volumes of the same series contained his observations of the transits of Venus (1761, 1769). on the tides at St. Helena (1762), on various astronomical phenomena at St. Helena (1764) and at Barbados (1764). In 1772 he suggested to the Royal society the famous Schiehallion mountain experiment for the determination of the earth's density and carried out his plan in 1774 *(Phil. Trans.,* li, 495). From Maskelyne's observations Charles Hutton deduced a density for the earth 4.5 times that of water *(Phil. Trans.,* lxviii, 782).

MASKS, GAS: *see* GAS MASK.

MASOLINO DA PANICALE (TOMMASO DI CRISTOFORO FINI) (1383–after 1435), one of the principal Florentine painters of the early Renaissance, was born at Panicale near San Giovanni Valdarno in 1383. He thus came from the same district as his younger contemporary Masaccio (*q.v.*), with whom his career was closely linked. Trained in a Florentine studio, possibly that of Gherardo Starnina, he appears before 1407 to have been a member of the workshop of Lorenzo Ghiberti. He was enrolled in the Arte dei Medici e Speziali in Florence in 1423. In 1424 he received payment for frescoes in S. Stefano at Empoli (in large part destroyed); a half-length "Virgin and Child With Two Angels" in S. Stefano and a "Pietà" in the Collegiata at Empoli also date from this time. A panel of the "Virgin and Child" in the Alte Pinakothek at Munich was probably painted before 1420, and a "Virgin and Child" in the Kunsthalle at Bremen is dated 1423.

The earliest work executed in collaboration by Masolino and Masaccio, a "Virgin and Child With St. Anne" (Cffizi, Florence), painted about 1420, illustrates the fundamental antithesis between the decorative late Gothic style of Masolino and the more progressive style of his pupil Masaccio. In this work Masolino was responsible for the cartoon and for executing the figures of St. Anne and four of the five angels.

A double-sided altarpiece for Sta. Maria Maggiore in Rome (now distributed between the Pinacoteca Nazionale in Naples, the Philadelphia Museum of Art and the National gallery, London) seems also to have been commissioned from Masolino about 1424 and was executed in conjunction with Masaccio. The two central panels of this altarpiece, representing the foundation of Sta. Maria Maggiore and the Assumption of the Virgin, are Masolino's most distinguished panel paintings.

The influence on Masolino of the stronger and more decisive personality of hlasaccio reached its climax in the frescoes of scenes from the life of St. Peter in the Brancacci chapel in the church of the Carmine in Florence. There have been many opinions about the respective shares of the two artists in this important cycle. It is likely that the frescoes were commissioned from Masolino about 1425 and that at this time he painted some lost scenes in the upper register of the chapel walls. Thereafter he worked in Hungary, from which he returned in 1427 to undertake, jointly with Masaccio, the remaining frescoes in the chapel. By this time the balance of emphasis within the studio had shifted toward Masaccio. and Masolino was responsible for only one fresco. that of "St. Peter Preaching." on the altar wall and three scenes on the right wall, the "Fall of Adam and Eve," the "Healing of the Lame Man" and the "Raising of Tabitha," where the perspective scheme seems to have been worked out and in part realized by Masaccio. The figures in the latter fresco reveal Masolino as an artist of great suavity and as a consummate colourist.

Work on the Brancacci frescoes was abandoned in 1428, and probably at this time Masolino received the commission for a fresco cycle in the Branda chapel in S. Clemente in Rome. The death of Masaccio in Rome in the autumn of 1428 marks a turning point in Masolino's career, and the story of his later development is that of a progressive return to the international Gothic idiom of his youth. This is evident initially in the S. Clemente frescoes (where the space construction is once more decorative) and subsequently in a frescoed "Virgin and Child" in S. Fortunato at Todi (1432) and in fresco cycles in the Baptistry and Collegiata at Castiglione d'Olona (Lombardy). The decoration of the Baptistry (nhich contains scenes from the life of St. John the Baptist) was completed in 1435, and makes use of the same deep but imperfectly systematized space constructions as the S. Clemente frescoes. The extensive panoramas in the backgrounds of the "Crucifixion" on the altar wall in S. Clemente and the "Baptism of Christ" at Castiglione d'Olona are milestones in the history of landscape painting. An important landscape fresco by Masolino also exists in the Palazzo Castiglione at Castiglione d'Olona. With their light tonality and elegant, rhythmical figures, the scenes by Masolino in the Baptistry and Collegiata form two of the most fascinating fresco cycles of the 15th century. Like the sculptor Ghiberti, Masolino achieved a compromise between the Gothic past and the advanced style of his own day. and owes his prominence in the history of Florentine art not to his innovations but to his lyrical style and his unfailing artistry. Masolino's death is generally assigned to the year 1447, but may have occurred at any time after 1435.

See P. Toesca, *Masolino da Panicale* (1908); *M*. Salmi, *Masaccio* (1948). (J W. P.-H.)

MASON, GEORGE (1725–1792), American statesman, was born in Fairfax county, Va., in 1725. His colonial ancestors held official positions in the civil and military service of Virginia. Mason was a near neighbour and a lifelong friend of George Washington. His large estates and high social standing, together with his personal ability, gave Mason great influence among the Virginia planters, and he became identified with many enterprises, such as the organization of the Ohio company and the founding of Alexandria (1749).

He became a member of the Virginia house of burgesses in 1759. In 1769 he drew up a series of nonimportation resolutions, which were presented by Washington and adopted by the Virginia legislature. In July 1774 he wrote for a convention in Fairfax county a series of resolutions known as the Fairfax resolves, in which he advocated a congress of the colonies and suggested nonintercourse with Great Britain, a policy adopted by Virginia and later by the continental congress. He was a member of the Virginia committee of safety from Aug. to Dec. 1775, and of the Virginia convention in 1775 and 1776 In 1776 he drew up the Virginia constitution and the famous Bill of Rights. a radically democratic document which had great influence on U.S. political institutions. The federal government laid claim to the hinterland, *i.e.,* to territory north and northwest of the Ohio river, which Virginia conceded in 1780 on the basis of a plan worked out by Mason. He was a member of the Virginia house of delegates (1776–88). He took an active part in the Constitutional Convention in Philadelphia in 1787. Particularly notable was his opposition to the compromises in regard to slavery and the slave trade. Indeed, like most of the prominent Virginians of the time, Mason was strongly in favour of the gradual abolition of slavery. He objected to the large and indefinite powers given by the completed constitution to congress, so he joined with Patrick Henry in opposing its ratification in the Virginian convention (1788). Failing in this, he suggested amendments, the substance of several of which was afterward embodied in the present Bill of Rights. Declining an appointment as a U.S. senator from Virginia, he retired to his home, Gunston hall (built by him and named after the family home in Staffordshire, Eng.). A radical republican, he believed that local government should be kept strong and central government weak; his democratic theories had much influence in Virginia and other southern and western states. He died on Oct. 7, 1792, at Gunston hall.

See Kate Mason Rowland, *Life and Writings of George Mason* (1892).

MASON, JAMES MURRAY (1798–1871), U.S. political leader, whose seizure with John Slidell (*q.v.*) precipitated the famous "Trent affair" during the American Civil War, was born in Fairfax county, Virginia, on Nov. 3, 1798. He was a member of the Virginia house of delegates (1826–32) of the state constitutional convention of 1829, of the national house of representatives (1837–39) and of the U.S. senate from 1847 until the outbreak of the Civil War when he resigned to take part in the Virginia secession convention. A staunch Democrat, he upheld state's rights and slavery and was the author of the Fugitive Slave act of 1850.

In Aug. 1861 he was appointed commissioner of the Confederate states to Great Britain. The British ship "Trent," upon which he and John Slidell. the commissioner to France, sailed, was intercepted by a C.S. ship-of-war, and the two commissioners were seized and carried as prisoners to Boston but were released two months later through the demands of Great Britain. Arriving at London, Mason was unable to secure official recognition, and his commission to Great Britain was withdrawn late in 1863.

He died at Alexandria, Va., on April 28, 1871.

See Virginia Mason, *The Public Lije and Diplomatic Correspondence of James M. Mason, with some Personal History* (1903).

MASON, JOHN (1586–1635), founder of New Hampshire, was born in King's Lynn, Norfolk, Eng. He was governor of the English colony in Newfoundland (1615–21) and published the first map of that region. In 1622 he obtained from the council for New England a grant of the territory (Mariana) between the Salem and Merrimac rivers, and with Sir Ferdinando Gorges, a grant of the region between the Merrimac and Kennebec rivers extending 60 mi. inland (Province of Maine).

In 1629 Mason and Gorges agreed upon a division of their joint holdings, hfason receiving the tract between the Merrimac and the Piscataqua, which he named New Hampshire. With Gorges and a few associates, he also secured a grant of the region named Laconia, including Lake Champlain, and in 1631 the Pescatamay grant, bordering on the Piscataqua river.

He was vice-president of the council for New England in 1632, and in 1635 was appointed vice-admiral for New England, but died in London in Dec. 1635, before he could return to North America. He was buried in Westminster abbey.

See Captain John Mason, the Founder of New Hampshire, published by the Prince Society (1887).

MASON, JOHN YOUNG (1799–1859), U.S. political leader and diplomat who helped frame the Ostend manifesto (*q.v.*) calling for the annexation of Cuba by purchase or war, was born in Greensville county. Virginia. on April 18, 1799. He served in the Virginia house of delegates (1823–27), the national house of representatives (1831–1837), and as judge of the U.S. district court for Virginia (1837–44). From 1844 to 1849 he was a member of the cabinets of Presidents Tyler and Polk, as secretary of the navy, and served for a time as attorney-general. He was president of the Virginia constitutional convention of 1850, and from 1853 was minister to France.

In 1854 Mason joined with James Buchanan and Pierre Soulé,

ministers to Great Britain and Spain respectively, in drawing up the manifesto, which was disavowed by the U.S. state department. He died at Paris Oct. 3, 1859.

MASON, MAX (1877–), U.S. mathematician and educator, president of The University of Chicago from 1923 to 1928. was born at Madison, Wis., on Oct. 26, 1877. He completed his undergraduate work at the Gniversity of Wisconsin in 1598 and received the Ph.D. degree from the L'niversity of Gottingen in 1903. His special interests and contributions lay in mathematics (differential equations, calculus of variations), physics (electromagnetic theory), invention (acoustical compensators, submarine detection devices) and administration of universities and foundations. Following brief appointments in mathematics at the Massachusetts Institute of Technology and Yale university, Mason taught mathematical physics at the University of Wisconsin (1908–25). In 1923 he turned to administration, first as president of The University of Chicago, then as director of natural sciences of the Rockefeller foundation (1928–29) and as president of the foundation (1929–36). In 1936 he joined the California Institute of Technology as chairman of the observatory council and member of the executive council, retiring in 1949. (J G H.)

MASON, WALT (1862–1939), U.S. humorist and writer, was born on May 4, 1862, at Columbus, Ont. He worked as a reporter on various newspapers in the middle west until William Allen White gave him a job on the *Emporia* (Kan) *Gazette* and encouraged his fondness for writing poetry. His homespun "prose poems," first contributed to the *Gazette,* were later syndicated throughout the United States. Mason also wrote *Uncle Walt* (1910), *Rippling Rhymes* (1913), *Horse Sense* (1915) and *Terse Verse* (1917). He died at La Jolla, Calif., June 22, 1939.

MASON, WILLIAM (1725–1797), English poet, friend and first editor of Thomas Gray, was born in Hull, Feb. 23, 1725, and educated at Hull grammar school and St John's college, Cambridge. At Cambridge he published *Musaeus* (1747), a lament for Pope. and in 1749 was made a fellow of Pembroke college through the influence of Gray, whom he admired. Mason's poem *Isis* (1749), attacking Jacobitism in Oxford university, provoked Thomas Warton's *Triumph of Isis* (1749), generally considered superior. His two pseudoclassical plays *Elfvida* (1752) and *Cavactacus* (1759) were performed in 1772 and 1776 respectively. Horace Walpole called *Caractacus* "laboured, uninteresting and no more resembling the manners of Britons than of Japanese": Gray wrote that he had read it "not with pleasure only but with emotion." Gray also said that Mason, nhose verses he corrected and whom he nicknamed "Scroddles," "reads little or nothing, writes abundance, and that with a design to make a fortune by it."

Ordained in 1754, Mason received many preferments, including a canonry of Tork and a royal chaplaincy (1757–73). On Gray's death in 1771 Mason, his literary executor, began to edit and in 1775 published *Memoirs . . . and Poems of Mr. Gray,* including only such poems as he thought fit for a definitive edition. Contemporaries described this as an "inimitable edition," "a new species of biography," but modern editors have condemned his silent mutilation of Gray's letters. He had been helped by Walpole, with whom he corresponded regularly until 1784, when they quarreled, but the correspondence was later renewed. Mason died at Aston, April 3, 1797. His collected works, in four volumes, were published in 1811; his correspondence with Gray was edited by T. Mitford in 1853.

See W. S. Lewis (ed.), H. *Walpole's Correspondence,* vol. 28 and 29 (1955); J. W. Draper, *W. Mason* (1924).

MASON AND DIXON LINE, in the United States, the boundary line (approximating lat. 39° 43' N.) between Maryland and Pennsylvania; popularly the line separating "free" and "slave" states before the Civil War, and also distinguishing in popular parlance the "North" from the "South," east of the Ohio river. The line derives its name from Charles Mason (1730–87) and Jeremiah Dixon. two English astronomers, whose survey of it to a point about 244 mi. west of the Delaware river between 1763 and 1767 marked the close of the protracted boundary dispute (arising upon the grant of Pennsylvania to William Penn in 1681) betneen the Baltimores and Penns, proprietors respectively of Maryland and Pennsylvania.

The dispute arose from the designation, in the grant to Penn, of the southern boundary of Pennsylvania mainly as the parallel marking the "beginning of the 40th degree of northerne latitude," after the northern boundary of Maryland had been defined as a line "which lieth under the 40th degree of north latitude from the equinoctial."

The eastern part of the line as far as Sideling hill in the western part of the present Washington county, was originally marked nith milestones brought from England, every fifth one of which bore on one side the arms of Baltimore and on the other those of Penn; but the difficulties in transporting them to the westward were so great that many were not set up.

The use of the term "hlason and Dixon line" to designate the boundary betneen the free and the slave states (and in general betneen the north and the south) dates from the debates in congress over the Missouri compromise in 1819–20. As so used, it may be defined as not only the Mason and Dixon line proper, but also the line formed by the Ohio river from its intersection with the Pennsylvania boundary to its mouth, thence the eastern, northern and western boundaries of Rfissouri, and thence westward the parallel 36° 30'—the line established by the Missouri compromise to separate free and slave territory in the Louisiana Purchase, except as regards Missouri. (S. LE.)

MASON BEE, the name given to bees of the subfamily Osmiinae (fam. Megachilidae), which construct earthen cells, sometimes mixed with sand, pebbles or wood, each cell containing a single egg, together with honey and pollen as food for the larva. Ten to 20 cells are usually found together. In Europe the commonest genus is *Chalicodoma,* in the United States. *Osmia.*

See BEE.

MASON CITY, a city of north-central Iowa, U.S., the seat of Cerro Gordo county, is located on the Winnebago river. midway betneen Des Moines and the tnin cities of Minneapolis-St. Paul, Minn.

An 80-mi. radius of rich corn belt farm land produces large quantities of livestock, dairy products, poultry, eggs and a variety of farm crops.

The school system includes Iowa's first and largest junior college. Mason City junior college. founded in 1918. There are 270 ac. of public parks and two golf courses. Excellent recreational facilities are also found at Clear lake and at two state parks 10 mi. W. There are adequate accommodations for tourists and conventions.

Underlain by deposits of clay and limestone 30 ft. deep, and with sand and gravel available. hlason City supports a substantial cement industry and has one of the largest brick and drain tile plants west of the Mississippi. Other industries include meat packing, beet sugar refining, creameries, soybean processing, fertilizer processing, millwork, founding and natural gas and gasoline pipelines.

Mason City owes its name to settlement (1853) by Freemasons. First platted in 1855. it was incorporated as a town in 1570 and as a city in 1851. For comparative population figures *see* table in IOWA: *Population.* (HU. H. S.)

MASONRY, the craft of building with stone. The English word "mason" is from the French, which appears in two forms, *machun* and *masson* (from the last comes the modern French form *macon,* which means, indifferently, a "bricklayer" or "mason"). This article deals with the history of masonry and illustrates the work of the craftsman and his tools, the machinery and processes used in modern masonry production, technical terms and types of stone.

HISTORY

The period at which wrought stone was first used architecturally is quite unknown; the earliest records of masonry worthy of the name are found in the ancient temples of Egypt, Chaldaea, Phoenicia, India, China, Babylon, Assyria and Crete.

The remains of the Egyptian pyramids and vast temples are proof that the craft of masonry was in a very advanced state, hardly to be surpassed by modern craftsmen. The skill of the

early Egyptian masons was quite incredible. For example,' the masonry joints of the stones on the great pyramid of Cheops are under 1/100 in. thick and some of the stones weigh up to 60 tons. Their great size and the fact that they were quarried some 140 mi. from the site indicates that vast armies of labourers were employed on the pyramid's construction, which, it has been calculated, required the continuous labour of 100,000 men for more than 20 years.

From Egypt the craft of masonry passed into Phoenicia, Asia Minor, the Aegean Islands and Greece. Greece developed the mason's craft and gradually the three well-known orders of architecture, Doric, Ionic and Corinthian, were evolved, culminating in the buildings on the Acropolis at Athens around 450 B.C. *(See* ORDER). In this period we find the highest standard of masonry. The Greek architectural style, as that of Egypt, is knonn as *trabeated; i.e.,* horizontal beams and upright posts. The arch was known at this time but never used above ground.

The Romans had little original architectural style and copied Greek forms, but used stone for surface, nonconstructional treatment. However, they developed the Etruscan semicircular arch, the vault and the dome, which enabled them to increase the open span of their buildings. Being a practical people! they devised institutions, known as *collegia,* to foster and protect their arts and crafts, including masonry. These *collegia* are believed to be the parent bodies from which medieval trade guilds derived their origin. The Roman conquest of Britain probably began the history of real masonry in England and the spirit of building encouraged by the Romans so increased the numbers of masons that in 296 A.D. the rebuilding of the city of Autun in Gaul was chiefly carried out by craftsmen from Britain and at the end of the 3rd century British masons were used in the rebuilding of Constantinople.

With the departure of the Romans from Britain in the early 5th century A.D. and under the domination of the Saxon invaders the use of wrought stone for building was discontinued and it was not until some 200 years later with the revival of Christianity that efforts were made to reintroduce the craft of masonry. Masons from Italy and France were induced to come to Britain to reestablish the craft. In 926 King Athelstan granted a charter to the masons at York and in the reign of Henry II, no fewer than 157 abbeys, priories and other religious buildings were founded. This period saw the beginning of the Gothic style of building which reached its zenith during the 14th and 1 jth centuries. The many beautiful cathedrals built then are evidence of the supreme skill of the craftsmen of that time, and undoubtedly the climax of the mason's craft was the introduction of the fan vault where the stonework hangs down like stalactites in inverted cone shapes. One of the finest examples of vaulting in the world can be seen in Henry VII's chapel in Westminster abbey, London.

From the 15th century onward stone was used extensively as a building material and masonry played an important part in an expanding building program. The introduction of large-scale brick production reduced the demand for stonework, but it opened up another field for masonry in the form of stone dressings in brick facades, the best examples being perhaps in Georgian architecture. Brick was also used, and indeed still is, as a backing to masonry in solid wall construction. *(See* BRICKWORK.) In time stone became an ornamental veneer and not a constructional part of the building.

In modern construction, where steel or reinforced concrete forms the frame of the building, masonry is essentially a thin veneer, supported on the frame. With style tending toward plain and unadorned façades, the need of the mason's craft has been reduced. Much work can be produced by machines and indeed, were it not so, the high cost of working stone manually would prohibit its use almost completely. There still is, however, a demand for skilled masons. In fashioning stone it is not possible to mechanize every operation, however plain the work may be, and there is always repair and maintenance work to be carried out on historical and similar buildings. This work, particularly, requires skilled craftsmanship, if the heritage left by earlier generations of builders is to be preserved.

APPRENTICESHIP AND TRAINING

The skill essential to a good mason can only be acquired through years of practice. The requirements are a sound basic education, manual dexterity, an "eye" for line and contour and an aptitude for creative work.

Initial training in most countries is by way of apprenticeship for a period of five years. Under the British National Apprenticeship scheme, for example, boys usually enter the trade from school at the age of 15 or from technical college at 17, and one day and two evenings a week are then spent at technical school where the apprentice pursues studies in workshop practice, building construction, craft science, solid geometry and draftsmanship. His practical training with the master mason includes, in addition to working stone, the use of machines and mechanical aids, fixing the worked stones on the building and instruction in the drawing office and setting-out shop.

The apprentice is encouraged to take the craft examinations set by the City and Guilds of London institute, after which he has a nide choice of further studies and examinations fitting him for foremanship or management responsibility within the building industry.

MASONS' TOOLS

There is a great variety of masons' tools according to the type of stone to be worked. For convenience they may be classified under five heads: granite tools; hard-stone tools; soft-stone tools; marble tools; and fixing tools. Certain of the tools are common to two or more of the classifications.

Masons tend to specialize on particular types of stone depending on the locality of their initial training. A mason from the granite districts, for instance, would not ordinarily be trained to work on hard stone or soft stone. A mason trained on hard stone would get some instruction on working soft stone, but he would not be expected to work granite. A marble mason is usually trained on that material only and develops a technique which would be unsuitable for either granite, hard stone or soft stone. Some masons are competent on all classes of stone, but they are the exception rather than the rule. Fixers are mostly masons who, having trained with the tools, then specialize on the fixing of worked stone on the building.

The following descriptions are of tools normally used by masons, but inevitably each craftsman accumulates special tools for carrying out difficult operations such as intersections and undercut moldings.

Hammer. — This is made in various sizes and weights. The weight for granite is about three pounds; for hard stone between

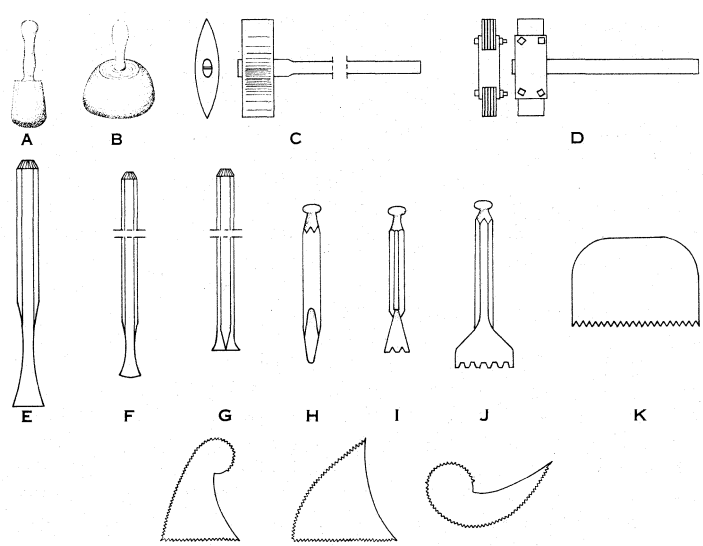

FIG. 1. — EXAMPLES OF MASONS' TOOLS: (A) DUMMY: (B) MALLET: (C) AXE: (D) PATENT AXE OR BUSH HAMMER: (E) LEWISING TOOL; (F) JUMPER FOR GRANITE: (G) STAR JUMPER; (H) POINT OR CLOURER; (I) WASTER: (J) CLAW CHISEL; (K) DRAG; (L) COCKS' COMBS

four and six pounds; for marble about two pounds. The head is of cast steel and the striking face inclines toward, instead of being parallel to, the handle. A malleable iron hammer, used in conjunction with "cup-headed" chisels for carving, letter-cutting and delicate enrichments, has a short head and large striking faces. A spall hammer, used for removing large quantities of rough stone and also for breaking up stones, has faces that are concave to form cutting edges; it is made of cast steel and weighs from 10 to 1 j lb.

Mallet. — This is made of hickory or beech wood or sometimes of selected pear wood. It is used in conjunction with mallet-headed chisels and weighs from three to six pounds. It forms a very important item of a mason's kit and a good mallet will last almost a lifetime and is a prized possession (fig. 1[B]).

Dummy. — This is for use with wooden-handled chisels on soft stone and is made of a mixture of zinc and lead. Dummies are made in different weights up to three pounds (fig. 1[A]).

Axe. — This tool is used on granite for reducing surfaces to the correct level. It is made of cast steel and has a long handle for two-handed operation (fig. 1[C]).

Patent Axe or Bush Hammer. — This is used on granite to form the final or "dressed" surface. The head is fitted with a series of four to ten chisel plates and, according to the grading of these plates, different types of finish are obtained; *i.e.*, "fine axed," "medium axed," etc. (fig. 1[D]).

Hammer-Headed Tools. — These tools are used in conjunction with the mason's steel hammer in working granite, marble and hard stone. They are made of cast steel and in various sizes.

The *punch* is used for roughly shaping a stone prior to tooling. When sharpened for granite or marble it is drawn out to a definite point, hut for use on hard stone a narrow cutting edge is formed instead of a point. The *drafting chisel* is usually $\frac{3}{4}$ in. to 1 in. wide and used for working drafts or margins on a stone preparatory to punching and tooling. The *pitching tool* is made with a beveled cutting edge and in various widths and weights. It is for cutting off superfluous stone in fairly large pieces. The *lewising tool* (fig. 1[E]) is made in the form of a mortising chisel, the cutting edge being wider than the stem. It is used for forming undercut slots to accommodate the two-legged or three-legged type of lifting lewis. The *quirking tool* is similar in design to lewising tools. hut small and lighter. The cutting edge ranges from $\frac{1}{4}$ to $\frac{3}{4}$ in. wide and the tool is used for cutting narrow grooves. *Jumper* (fig. 1[F] and 1[G]), two tools, are used for forming holes in stone. They are lifted and turned with one hand and struck with the hammer after each turn. The type shown in fig. 1(F) is mainly used on granite; the type in fig. 1(G), known as a star jumper, is used on hard stone. The *cup-headed chisel* is used in conjunction with the iron hammer on delicate work such as carving: letter-cutting, etc. It is made in various shapes and sizes: points, chisels and gouges from $\frac{1}{16}$ to 1 in. wide. *Marble tools* are similar in shape and detail to the cup-headed tools but made with hammerheads for use with a light (two pounds) steel hammer.

Mallet-Headed Tools. — These are made for use with the mallet for working on hard stone. They must never be used with a steel hammer as the mushroom head mill snap off. They are made of cast steel, hardened, tempered and sharpened to a knife edge.

The *point,* or *clourer* in Scotland (fig. 1[H]), is sharpened to a narrow cutting edge and is used for taking off, almost to the level required, the rough stone in a series of furrows. The *waster* (fig. 1[I] has its cutting edge formed into a series of teeth and is used as an alternative to the point. The *Claw chisel* (fig. 1[J]), from $1\frac{1}{2}$ to 2 in. wide and formed with teeth, is used for forming drafts on the surface of the stone after roughing down with the point or the punch. The toothed cutting edge prevents the stone "plucking" or "pitting." The *chisel* is made in widths of from $\frac{3}{4}$ to 2 in.; the wider types are known as boasters. They are used for forming margins or drafts and for finishing the surface of the stone to a comparatively smooth texture.

A batting tool, or *broad tool,* is similar *to* a boaster but is made up to $4\frac{1}{2}$ in. nide. It is for forming a finish known as "batted." on the surface of a stone. This comprises a series of regularly spaced parallel cuts or grooves. The *gouge* is a chisel with a curved cutting edge. Gouges of various sizes and curves are made and used for working moldings. The *patent claw tool* is similar in shape to a chisel but has a slotted end into which fits a toothed steel cutter. The cutters can be changed and are of various widths up to two inches. They are used for the same purpose as a claw chisel.

Wood-Handled Chisels and Gouges. — These are similar to carpenters' chisels but are stouter at the neck. They are used in conjunction with the dummy for working soft stone and are made in a variety of widths and shapes.

Other Mason's **Tools.**—*Drags* (fig. 1[K]), are used for producing a finished surface on soft stone. They are made from plate steel varying in thickness from 8 B.G. (Birmingham Gauge) for "coarse" to 18 B.G. for "fine" and are half eliptical in shape, varying in length up to eight inches and have teeth along the straight edge. They have 4 to 5 teeth per inch for "coarse," 8 to 10 for "medium," and 16 to 20 for "fine." They are also made with convex, toothed edges for finishing circular work. *Cocks' combs* (fig. 1 *[L]*)are thin steel plates with finely toothed edges in various shapes and are used for cleaning up the face of molded work on soft stone. *Masons' saws* are used for cutting soft stone and are similar to carpenters' saws but of heavier gauge and with coarser teeth. There are three main types: the crosscut saw, of various lengths for sawing large blocks of stone (worked by two men); the hand saw, available in different sizes, for sawing smaller blocks and ordinarily used by the mason; the whip saw, a narrow saw of flexible steel from $2\frac{1}{2}$ to 4 ft. long and from 1 to 2 in, wide with a wooden handle at each end in line with the blade. It is used for sawing around curves. The *bevel,* or *shiftstock,* consists of a double stock between which is inserted a thin blade which can be set at any desired angle and secured with a thumb screw. It is used for testing bevels, chamfers, sinkings, etc. The *sinking square,* is a tool in which a blade passes through the stock and can be adjusted. It is used for gauging the depth of sinkings. With the addition of an extra blade the tool becomes a double sinking square. The *mitre square* is made of thin steel plate or hard wood with one edge formed at an angle of 45° and 135° with the long edges. This tool is used for positioning a straightedge at the correct angle for marking out the line of mitres. The *plumb rule* is a wooden straightedge with a pear-shaped hole at one end. A thin cord to which is attached a bob is fixed to the end of the rule so that the bob hangs in the hole. The mason-fixer uses the plumb rule for testing whether the stonework he is fixing is upright.

In addition to the above tools, the mason and the fixer need such items as folding rule: steel squares, steel set-squares, steel wing compasses, scriber, steel straightedges, trowels, rasps, brace and bits, pinch bars and spirit level.

Lifting Appliances. — There are various types of equipment for handling stone. which by virtue of its weight usually has to be lifted by mechanical means. In the ordinary way, cranes of different sorts are used at the quarry and masonry works for moving the large blocks of rough stone. On building sites: the worked stone is unloaded from transport by cranes and hoisted to the various floor levels, but thereafter the individual stones are handled by different forms of light hand tackle. It is necessary to provide attachments to the stone for hooking on to the crane or tackle and these take different forms to suit the size and type of stone to be lifted:

Sling chains are made in varying lengths and capacities. They are mostly used at the quarry or masonry works for lifting large unwrought blocks of stone weighing up to 20 tons or more. At one end is a ring and at the other a hook. The chain is placed around the block, so that it passes through the hook; the ring is attached to the lifting apparatus. If sling chains are used on wrought masonry the clean edges of the stone must be protected with slats of wood to prevent chipping and damage.

Webbing slings are used in the masonry works during the various stages of processing. They comprise two endless solid woven cotton straps attached to shackles which are fitted with rollers to allow the straps to rotate. They prevent damage to edges of stones that are being lifted and they also enable the stone to be

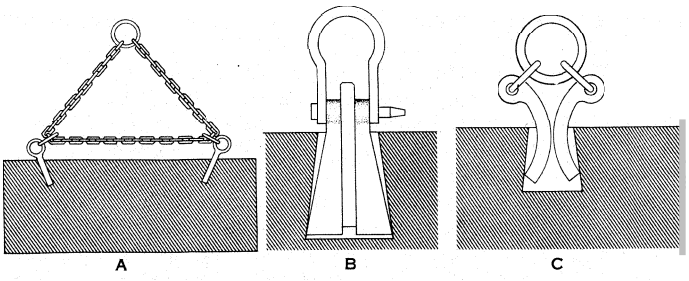

FIG. 2.— THREE TYPES OF LIFTING APPLIANCES: (A) LIFTING PINS; (B) THREE-LEGGED LEWIS: AND (C) CHAIN LEWIS

turned over while suspended. They are capable of handling loads of up to two tons and range from 10 to 20 ft. in length.

Dogs comprise two steel hooks with rings attached, and are designed so that the greater the weight the tighter they "bite." They are used in conjunction with a chain. A small "dog-hole" is cut at each end of the stone to be lifted to receive the point of the hook. Normally dogs are limited to handle stones weighing not more than six tons.

Lifting pins are single steel pins with rings connected by a chain (fig. 2[A]) which are used for heavy stones. Holes to accommodate the pins are drilled inclined so that the pins cannot pull out. A similar type has the pins connected by a ring and is used on smaller stones.

Three-legged lewis comprises two dovetailed pieces and a centre parallel piece connected together by a shackle and pin (fig. 2[B]). The two dovetailed pieces are first inserted into an undercut mortise in the stone and then the centre piece is placed in position. The shackle and pin are then assembled ready for lifting.

Chain *lewis* has two curved legs linked by three rings. The legs are placed into a slightly undercut mortise in the stone (fig. 2[C]). The design is such that the rings tend to pull the top portions of the legs together, thus opening out the bottom portions which bite into the stone. These lewises are only suitable for comparatively light stones.

Split-pin *lewises* are used for light stones and fit into a single round hole in the stone. The cranked legs, connected by three rings, act on the scissor principle and spread at the bottom, thus gripping the sides of the hole.

STONE-WORKING MACHINERY

Machines play an important part in the conversion of the rough quarry block into finished masonry. They can be classified into the following types: primary saws; secondary saws; molding machines; surfacing machines; lathes; light hand tools (pneumatic or electric).

Primary Saws.—These are used for the initial cutting of block into slabs of required thickness. They are of three types: frame saw; large circular saw; and wire saw.

Frame Saw.—This machine has a heavy steel frame which is made to swing or reciprocate horizontally by a power-driven crank via a connecting rod. The frame is suspended on four corner pendulum arms or four slides, which in turn are mounted on four vertical pillars suitably braced for rigidity. The frame, while swinging or reciprocating, can be lowered or raised mechanically on the pillars. Into the frame, thin steel blades are tensioned and positioned to suit the thickness of stone slab to be cut. The blades do not have teeth, the cutting being obtained by abrasion. Sharp sand or steel shot is fed, either by hand or mechanically, on to the blades and sprayed with water and the action of the blade rubbing on these abrasives forms a thin cut.

Any number of blades can be mounted in the frame and the speed of cutting can vary between 1 and 12 in. an hour according to the material being cut and the number of blades being used. Blocks measuring up to 12 ft. long, 6 ft. wide and 6 ft. high can be handled by the frame saw.

Large Circular *Saw.*—There are two types of machine in this category: (a) where the block of stone is made to travel against a revolving circular saw blade; (b) where a revolving circular saw blade is made to travel against a stationary block of stone—this is known as a beam or crosscut saw (see fig. 5). The circular saw blades range from 5 to 11½ ft. in diameter and revolve at a peripheral speed of between 8,000 and 10,000 ft. per minute.

The cutting agent is industrial diamonds and these are used in two forms: either single diamonds of about one-half carat each, or crushed diamonds. The single diamonds are welded into steel sockets, nhich are in turn fixed around the periphery of the saw blade about 1½ in. apart. The diamonds are set in different positions in the steel sockets and the sockets fixed in the saw blade in a sequence that will give a coverage of diamond cutting points over the width of the blade.

Crushed diamond, in various grades, is sintered into a metal bond and formed into segments. These segments are fixed around the periphery of the saw blade at regular intervals. As the segments are impregnated with crushed diamonds they cut over their full width and do not have to be set in sequence as with the single diamond type of socket. High-pressure water is fed on to the blade to wash away the stone dust and to keep the blade cool.

These large circular sawing machines are capable of very fast cutting on most hard and soft stones, but they are not suitable for sawing granite, the primary sawing of which is usually done on the frame saw or the wire saw.

Wire Saw.—This comprises a long length of stranded steel wire traveling over pulleys so that a length of the wire is free to rub on the top of a block of stone. An abrasive, mixed with water, is fed automatically on to the wire at the point of contact with the stone and the pulleys over which the wire travels are mechanically lowered very slowly, so that a cut is gradually formed.

Secondary Saws.—These are used for cutting the slabs from the primary saws to the required sizes; for cutting the joints of stones which have been worked on the molding machines; for cutting notches and checks and for all other smaller sawing operations.

These machines are all of the circular saw blade type and have movable tables, either hand- or power-operated, for traversing the stone against the saw blade, or alternatively they can be smaller versions of the beam or crosscut machines described under primary saws. The cutting agent on the saw blade can be either silicon carbide (carborundum) in a continuous rim or crushed diamond segments.

Molding Machines.—As their name implies these machines are used for forming molded or profiled surfaces such as cornices, string courses, etc. A power-driven table, on slides, moves the slab of stone against cutting tools mounted in a toolbox on a cross head. The toolbox is adjustable vertically and horizontally. After "roughing out," steel plates shaped to the profile required are mounted in the toolbox to form the correct contour on the stone. The cutting tools are usually tipped with tungsten carbide to give a better and longer-lasting performance. These machines are used on all soft and hard stones, but not on granite. Molded work on granite is invariably done by hand.

Another type of molding machine works on the same principle as the secondary saw, but instead of a saw blade a wide silicon carbide (carborundum) drum is fitted. This drum can be formed to the required profile and, when rotated at high speed, grinds the stone to shape.

Surfacing Machines.—These are used for producing different surface finishes on plain face stonework. There are three main types: rubbing table; jenny lind; and dunter.

Rubbing Table.—This comprises a large cast-iron circular disk, up to ten feet in diameter, which is power-rotated on a vertical axis. Water and sharp sand are fed on to the table and the stone is placed face downward against a stop so that the action of the rotating disk with the sand and water rubs a smooth face on the stone. It is used on granite and marble as well as hard stone.

Jenny *Lind.*—This machine is used for rubbing and polishing stone, marble and granite. It consists of a head nhich is power-rotated on a vertical axis and to nhich circular disks, fitted with different forms of abrasive, can be attached. The head is mounted on a double hinged arm nhich allows it to be moved freely over a horizontal surface on the pantograph principle.

Dunter.—A machine used on granite for working large surfaces roughly level and straight. It comprises an arm, capable of mov-

ing over the surface of the stone, to which is fixed a percussion tool actuated by compressed air.

Lathes. — These are similar to machinists' and wood-turning lathes, but are more sturdily constructed. Stone columns are turned nith the aid of a toolbox mounted on a saddle as in metal turning, but stone balusters are normally turned with hand tools using a tool rest as with wood turning.

Light Hand Tools. — Power-operated hand tools are widely employed in masonry production. Chipping hammers are extensively used by masons on hard stone, marble and granite and conziderably speed up their work. High-speed rotating heads are used for rubbing and polishing, and pneumatic and electric percussion and rotary drills are used for forming holes in all types of stone.

PRODUCTION AND FIXING

Before stonework for a building can be produced and fixed, much planning by the masonry contractor is necessary. **A** time program must be worked out to fit in with all other trades, availability of labour determined, supplies of raw stone from the specified quarry secured, drawings made and approved, and transport and plant for fixing arranged. The usual routine is for the masonry draftsman or setter-out, as he is called, to prepare working drawings, normally to a scale of † in. to 1 ft., from details supplied by the architect. Where the building has a steel or reinforced concrete frame, details of this would be required from the consulting engineer so that details can be worked out for attaching the stones to the frame. These working drawings also have to be agreed with other specialist firms such as window-frame suppliers, etc.

It is important to ensure that the design of the stone jointing allows for proper bonding, *i.e.*, that a proportion of the individual stones are of sufficient depth, front to back, to get support from, and be built into, the brick or concrete backing to the stonemork. (This condition would not apply to solid masonry walls, but such construction is now rarely used.) Where it is not possible to provide bonding, metal ties and supports must be used. (See Metal *Ties and Supports,* below).

It is also important with the majority of stones, and particularly with stratified stones, that they are worked and fixed on their natural bed; *i.e.,* with their laminae horizontal. Doing so ensures greatest strength and durability. There are exceptions to this rule: in arch stones the natural bed should be at right angles to the face and parallel to the centre line of the voussoirs; in cornices with large projection, the natural bed should be vertical and at right angles to the face, except for corner stones, which should be fixed on the natural bed.

When all details have been verified, each individual stone in the building is given an identification number on the working drawing, the necessary templates cut out of sheet zinc and a schedule, giving a full description of each stone, issued to the works' foreman, who then marks out the raw stone as economically as possible. The stones are sawn and passed through the various processes and on completion the identification number is cut into each stone and the stone stacked in proper sequence ready for delivery to the building.

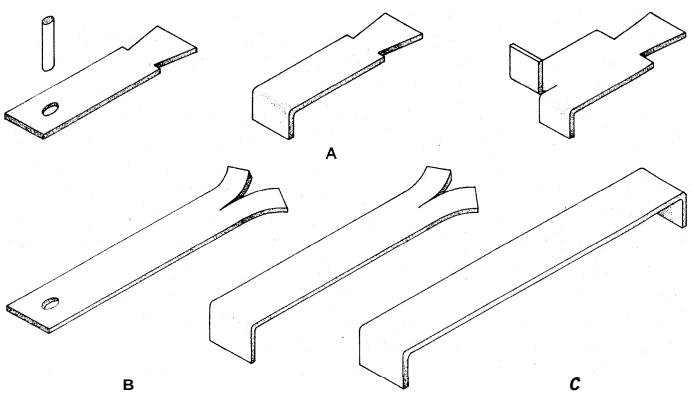

FIG. 3 — METAL TIES AND SUPPORTS USED IN PRODUCTION AND FIXING: (A) CRAMPS FCR FIXING STONE TO CONCRETE: (B) CRAMPS FOR FIXING STONE TO BRICKWORK; AND (C) GENERAL PURPOSE STANDARD CRAMP

Fixing. — The mason-fixer is responsible for setting the stones on the building in their correct order and position. He is issued a copy of the working drawings on which all relevant information is given and calls for delivery of stone from the masonry works in the required sequence.

Stones are set into position with the aid of light lifting appliances, usually of the endless chain tackle variety, and must be perfectly level and upright. For setting arch, lintel and similar stones, wooden supports knonn as centres have to be provided as a support for the stones until the mortar in the joints has set and the stones are capable of supporting themselves. The centres are then removed.

Stones are never fixed directly in contact with each other; they always have a mortar joint separating them. This joint can vary from $\frac{1}{16}$ to $\frac{1}{4}$ in. wide according to the architect's design and the type of stone. In addition to this mortar joint, the vertical joints of the stones have a V-shaped groove cut into them, called a joggle, so that when two stones are fixed the grooves correspond. Cement grout is poured into the joggle to lock the stones together.

When an area of stonemork has been fixed, it is usual to protect the exposed face from damage and dirt until such time as the whole building is completed. This protection is given by brushing on a thick coating of slurry composed of stone dust and lime mixed uith water. (This treatment does not apply to granite, marble and certain soft stones). On completion of the building. this protective coating is washed off and the exposed face of the stonework rubbed down either by hand using abrasive blocks such as sharp grit stone or carborundum, or by mechanical spinners — a high-speed rotating head with a flexible abrasive pad.

The scaffolding, from which the mason-fixer works, has to be designed as an independent structure; it must have no fixings into the wall of the building as in the case of scaffolding for brickwork. It is known as a mason's independent scaffold.

Metal Ties **and** Supports. — In modern building construction it is very frequently necessary to use metal ties and supports for securing the stonework to the structure. The design of these has to be norked out to suit individual cases, but there are certain stock designs which have wide application *(see* fig. 3).

In all cases, metal fixings should be made of nonferrous metal or, if made of iron or steel, should be galvanized, sheridized or in some other way treated against rust and corrosion. Rusting iron fixings are the cause of much damage to stonemork in many older buildings. Cramps and dowels are used for anchoring together stone copings, cornices, mullions and similar items. Slate is sometimes used for these purposes.

Mortars. — The mortars used for masonry vary according to the kind of stone and the structural requirements.

Wrought stonework, by virtue of the bonding arrangements of the stones and the large true joint surfaces, does not depend on the mortar for strength and, generally, the mortar when set should be no harder than the stone.

For most hard and soft stones, the mortar should be a mixture of crushed stone, hydrated lime and cement. Washed sand can be used in place of crushed stone. For granite the mortar is usually a mixture of uashed sand and cement, while for marble, plaster of Paris is normally used. Pointing to the masonry joints should be done with the same mortar and at the same time as fixing. For filling joggles, neat cement is normally used.

TECHNICAL TERMS, SURFACE FINISHES AND TYPES OF STONE

Technical Terms. — The following are some **of** the terms used in masonry and not explained in the article *(see* fig. 4).

Apex stone is the top stone of a gable, spire or pediment.

Arch is a method of spanning an opening with masonry consisting of a series of wedge-shaped stones, known as voussoirs or arch stones, which are supported by lateral pressure induced across the radial joints. The three types are: *flat arch,* in which the voussoirs are arranged **to** provide a horizontal soffit; *joggled arch,* in which adjacent stones are interlocked by means of rebates or tongues and grooves; and ***skew*** *arch,* whose face is not at right angles to its supports.

Arris is the line or edge made by the junction of two surfaces, forming

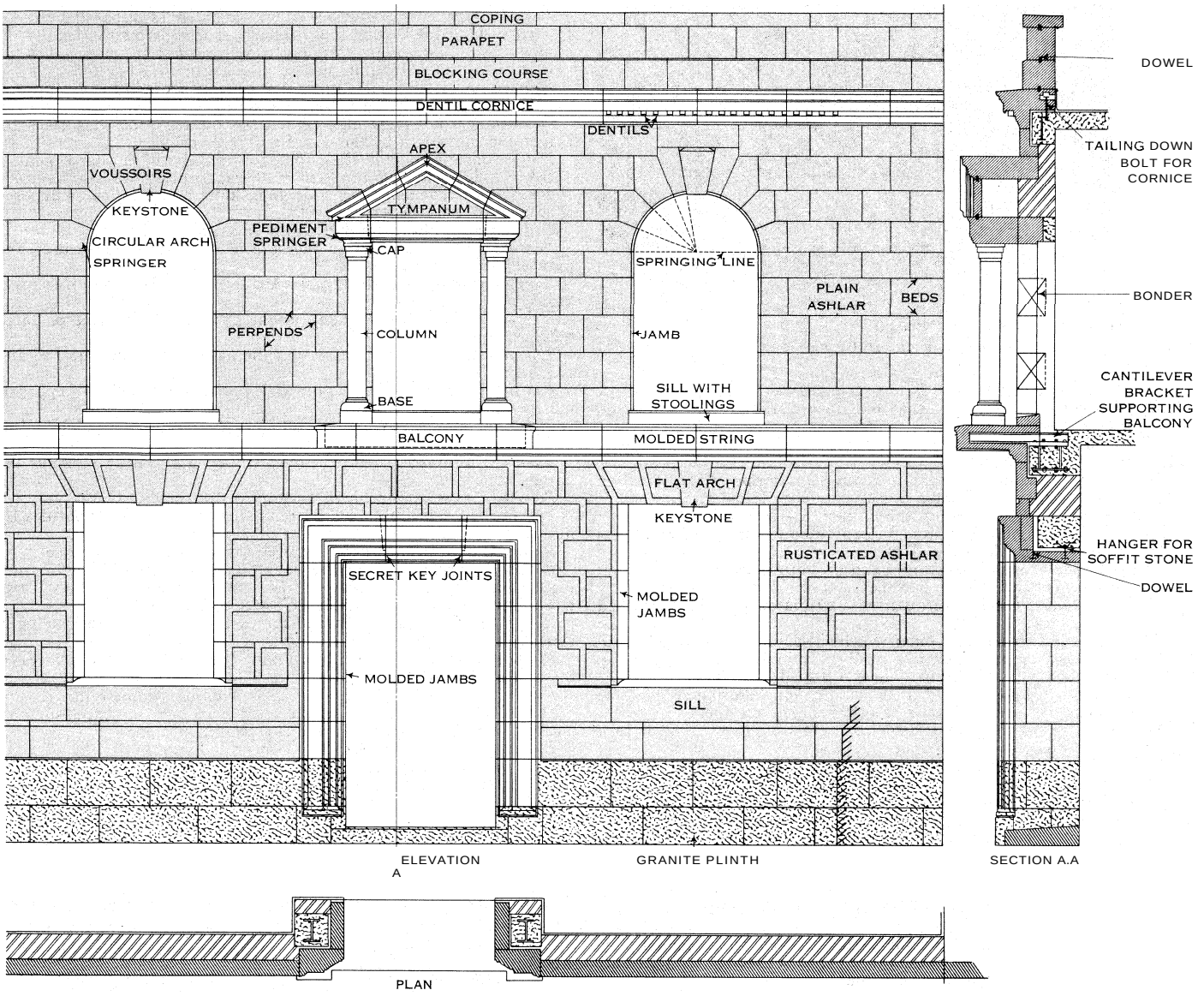

FIG. 4.— ARCHITECTURAL TERMS ILLUSTRATED IN ELEVATION, SECTION AND PLAN

an external angle.

Baluster is a short pillar, usually circular on plan, the characteristic feature of which is the bulging-out or swell of the lower part.

Band course is a plain course of stone continued horizontally along the face of a building.

Banker is a mason's workbench, made of heavy timber or blocks of stone.

Barge is a projecting stone drip at the base of a chimney stack to throw off water.

Batter is an inward inclination of the exterior face of a wall.

Bed is the lower and upper surface of a block of stone. The term *natural bed* is used to indicate the way sedimentary rocks were originally laid down or deposited. Also, a bed is the line of cleavage between the laminae of stratified rocks.

Bed nzold is the lowest molded member of a cornice.

Birdsmouth is a notch cut on the edge of one piece of stone to receive the square edge of another.

Blocking course is a plain course of masonry over a cornice.

Bonder is a stone whose longer dimension is in the thickness of the wall.

Cladding consists of thin slabs of stone used externally as a nonload-bearing covering to the structure of a building.

Closer is a stone placed in a course of masonry to fill or close a gap.

Column is a free-standing vertical member usually circular on plan.

Coping, or *capping,* is the topmost course of masonry on a wall usually made wider than and arranged to overlap the wall and having a sloping top to throw off rainwater.

Corbel is a stone or series of stones which project from a wall, often used as a bracket or support.

Czisp is the projection from the inner face of the curves of Gothic arches.

Damp-proof course is a layer of impervious material interposed in the bed joint of a wall to prevent the passage of moisture.

Dentil is a series of small rectangular blocks cut in the bed mulding of cornice? giving the appearance of a row of teeth

Dressings is a general term used for all wrought masonry.

Entasis is the outward curvature of the shaft of a column to counter an illusionary concave appearance.

Finial is a finishing ornament at the top of a gable, a pediment or pinnacle.

Gablet is a small gable-shaped carved panel, frequently used in Gothic stonework for apex stones and in spires, etc.

Galleting, small pebbles or chips of flint pressed into the murtar, while still soft, in the joints of rubble or flint walling.

Gargoyle is a projecting stone formed as a waterspout for throwing rainwater from gutters clear of the walls In early work it was often carved into grotesque shapes of animals and other forms.

Hoodmold, or *dripstone* or *label,* is a projecting molding or canopy over a door or window opening to throw off rain from the walls of the building

Impost is the top member of a pier or pillar from which an arch springs

Jambstone is one of a number of stones forming part of the vertical surface at the sides of a door or window opening

Joggle consists of adjacent recesses in vertical joints of stones for filling with cement grout, and also a projection on one stone which fits into a corresponding recess in another stone.

Keystone is the central stone of an arch

Kneeler is a stone bonded into the wall and forming an intermediate length of the coping to a gable wall.

Linings are thin slabs cf stone, marble or granite used internally as a nonload-bearing covering.

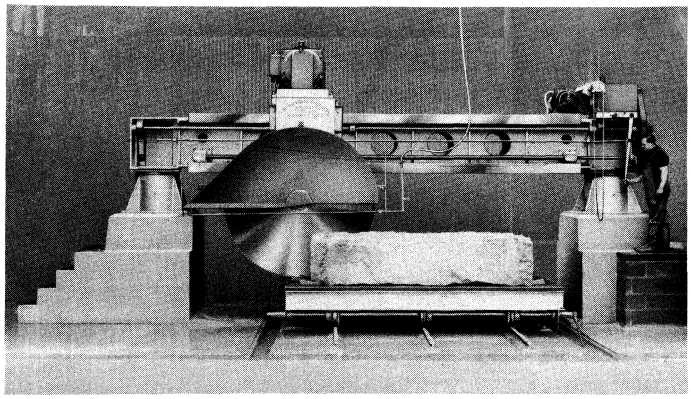

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FIG. 5.—CIRCULAR CROSSCUT SAW FOR STONE

Lintel is a stone which spans in one piece the top of an aperture.

Mason's mitre is a mitre worked out of a single piece of stone and not forming a joint at the mitred angle as in a joiner's mitre.

Modillion is an ornament bracket worked out of the solid at regular intervals in the molded member under the corona of a cornice.

Mortice is a sinking in a stone to receive a corresponding projection on another stone, or to receive a dowel, cramp, rail, lug, etc.

Mullion is a vertical member subdividing a window.

Padstone, or *template,* is a stone incorporated in the structure to distribute a concentrated load.

Parpend is a through bondstone faced on both sides.

Perpend is a vertical joint in masonry.

Pier is any load-bearing vertical mass of masonry, either detached from or attached to a wall.

Pilaster is a flat rectangular pillar which slightly projects from a wall.

Plinth is the projecting base of a wall or column.

Quoin is a stone at an external angle of a wall.

Rebate is a continuous rectangular sinking along the edge of a stone to receive window or door frames or other similar members.

Respond is a half pillar or pilaster corresponding to another or to a pillar opposite to it.

Returned end is the termination of a stone worked to match the face with an external mitre.

Reveal is that part of the jamb of a window or door opening which is not covered by a frame.

Sill is the lower horizontal member of a window opening and certain external door openings.

Skewback is an inclined or splayed surface of an abutment from which an arch springs.

Soffit is the under surface of a lintel or arch, or the lower surface of a vault.

Spandril, or *spandrel,* is a triangular space enclosed, approximately, by the curve of an arch with a horizontal line drawn through its apex and a vertical line drawn through its springing.

Springer is the stone from which an arch springs.

Springing line is the level from which an arch commences.

Stool is a seating such as that on both ends of a sill on which a jambstone is fixed.

Stopped end is the termination of a molding worked in the solid.

String course is a narrow molded or plain projecting course of stone continued horizontally along the face of a building.

Throat is a groove worked in the under surface of overhanging stonework to prevent rainwater flowing back to the wall.

Transom is a horizontal member subdividing a window or other opening.

Voussoir is a wedge-shaped stone forming a unit of an arch.

Walling: ashlar (qv.) is masonry consisting of plain blocks of stone, finely dressed to given dimensions and laid in courses; *block in course* is roughly squared blocks of stone which may vary in length, having worked beds and hammer-dressed faces and joints and set in courses which may vary in height not exceeding 12 in. (used in heavy engineering masonry); *brought to courses* is walling, similar to uncoursed rubble, which is roughly leveled up to courses at intervals usually to correspond with the heights of the quoin and jambstones; *coursed rubble* is roughly squared stone walling to courses to suit the heights of corner stones; *dry walling* is walling without mortar; *polygonal (rag walling)* is walling built of stones of irregular shape which may be roughly worked to fit adjacent stones; *snecked* means a rubble wall in which the stones are squared but of irregular size, with small stones, known as "snecks" introduced to break the line of the courses.

Weathering is working the top face of a stone to an inclined plane for the purpose of throwing off rainwater.

Surface Finishes.— There is a wide range of different finishes used in masonry and the following are the more common

Axed is used for granite only, having a surface obtained by using an axe or a patent axe. "Fine-axed" is when the surface has been chopped with he-axe marks. "Once-axed" is the term used when the surface has been roughly chopped with an axe.

Batted means having a surface comprising a series of parallel grooves formed with a wide batting tool regularly spaced across the face of the stone. The number of grooves may vary from five to ten per inch.

Boasted means a stone finished by dressing with a boaster.

Boasted for carving refers to a stone roughly worked to the approximate form required by the carver or sculptor.

Combed means having all irregularities on the exposed surfaces of soft stones worked off by the use of a drag or comb.

Dabbed means fine and close sparrow-pecked with a sharp point.

Dressed means having any kind of worked finish; of slate, having a rough beveled edge as left by a dressing knife or guillotine as opposed to a sawn edge which is not beveled.

Eggshell means having a dull polish or a matt surface.

Face-bedded, a stone cut so that the natural bed is vertical to and parallel with the face.

Fluted means having a surface worked into a regular series of concave grooves.

Hammer-dressed (for granite) means having a rough face prepared with a hammer.

Joint-bedded is a stone cut so that the natural bed is vertical-to and parallel with the joints.

Pencil-arrissed means having the arris rounded to a radius of approximately $\frac{1}{8}$ in.

Picked, or *pecked,* is a dressing obtained by means of a point tool or pick.

Pitched is a surface produced by a pitching tool so as to resemble the natural rock face.

Polished means having a high-gloss mirrorlike finish.

Punched is a finish obtained by removing the larger irregularities by means of a point tool.

Reeded is a surface worked into a regular series of convex ridges.

Reticulated means an irregular network of bands worked on a true-faced stone, the sinking between the bands being about # in. deep, worked true to a gauge and "picked" with a fine point.

Rock-faced is the natural face of the rock or a dressing resembling it *(see* also "Pitched").

Rubbed is a finish obtained by rubbing the surface with abrasives to the degree of smoothness required.

Rusticated refers to a stone which has a sunk dressed margin.

Shotted is the face which results from grinding with steel shot by means of a heavy steel ring used in a polishing machine.

Tooled is a surface showing the mason's tool marks.

Vermiculated is a surface which has a dressing taking the form of irregularly shaped sinkings resulting in winding wormlike ridges.

Types of Stone.— There are five main classifications of natural stone used in masonry. They are: *granite,* a holocrystalline plutonic rock composed of quartz, feldspar, mica, or hornblende and accessories; *marble,* a granular limestone, recrystallized by heat or pressure; *slate,* a rock derived from argillaceous sediments or fine-grained volcanic ashes by metamorphism and characterized by a cleavage along planes independent of the original bedding; *limestone,* a bedded rock consisting essentially of calcium carbonate; *sandstone,* a bedded rock composed of grains of quartz sand naturally cemented together.

The use of the different types of stone depends largely upon the geographical situation of the source of supply, transport facilities, availability of skilled labour and costs. Granite is the hardest and most durable of all the building stones and is widely used for architectural, civil and marine engineering and decorative purposes. It comes in a wide range of colours and textures and is generally capable of being polished. Marble is used mainly for internal

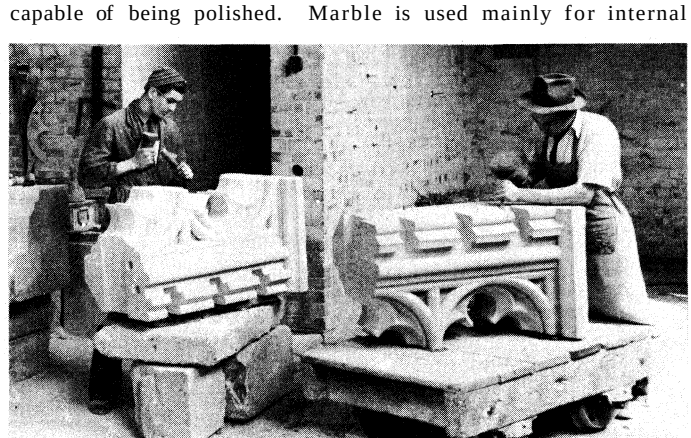

FIG. 6.—MASONS CARVING GOTHIC TRACERY HEAD

wall linings, staircases, floors and decorative work. It is also used externally, mostly in thin cladding to walls and, where supplies are abundant such as in Italy, as solid masonry. There is an endless variety and combination of colours which are considerably enhanced when the material is polished. Slate is used extensively as a roofing material and also for floors, stair treads, shelves and decorative work. In the second half of the 20th century, it has found favour as an external cladding material in some modern buildings. This particularly applies to the green variety of slate, which is used as panels in conjunction with other stone dressings. Limestone and sandstone are the most widely used stones for general masonry work. There is a considerable variety of colour, texture and quality and special care is needed in selecting the type to be used to ensure that it will withstand the climatic conditions prevailing in the locality of the building. *See* BRICKWORK; *see* also Index references under "Masonry" in the Index volume

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MASPERO, GASTON CAMILLE CHARLES (1846–1916), French Egyptologist, was born in Paris on June 23, 1846, his parents being of Lombard origin. He was in his second year at the École Normale in 1867 when he met Mariette, who was then in Paris as commissioner for the Egyptian section of the exhibition. Mariette encouraged his studies, and in 1869 he became a teacher (*répétiteur*) of Egyptian language and archaeology at the Ecole des Hautes Etudes; in 1874 he was appointed to the chair of Champollion at the Collège de France.

In Nov. 1880 Professor Maspero went to Egypt as head of an official archaeological mission, which ultimately developed into the well-equipped Institut Français de l'Archéologie Orientale. Maspero then succeeded as director-general of excavations and of the antiquities of Egypt. He held this post until June 1886; in these five years he had organized the mission, and had discovered the great cache of royal mummies at Deir el-Bahri in July 1881. Maspero now resumed his professorial duties in Paris until 1899, when he returned to Egypt in his old capacity as director-general of the department of antiquities. He found the collections in the Cairo museum enormously increased, and he superintended their removal from Gizeh to the new quarters at Kasr en-Nil in 1902. The vast catalogue of the collections made rapid progress under Maspero's direction. Twenty-four volumes or sections were already published in 1909. The repairs and clearances at the temple of Karnak led to the most remarkable discoveries in later years (*see* KARNAK). He died in Paris on June 30, 1916.

Among his best-known publications are: *Histoire ancienne des peuples de l'Orient classique,* 3 vol. (1895–97), displaying the history of the whole of the nearer east from the beginnings to the conquest by Alexander; a smaller *Histoire des peuples de l'Orient,* 1 vol., of the same scope, which has passed through six editions from 1875 to 1904; *Études de mythologie et d'archéologie e'gyptiennes* (1893, etc.), a collection of reviews and essays originally published in various journals, and especially important as contributions to the study of Egyptian religion; *L'Archéologie égyptienne* (latest ed., 1907), of which several editions have been published in English. Maspero also wrote: *Les Inscriptions des pyramides de Saqqarah* (1894); *Les Momies royales de Deir el-Bahari* (1889); *Les Contes populaires de l'Égypte ancienne,* 3rd ed. (1906); *Causeries d'Égypte* (1907), translated by Elizabeth Lee as *New Light on Ancient Egypt* (1908).

MASQUE, a band of masked persons of the same sex who, accompanied by torchbearers, arrived at a social gathering to dance with the guests. It could either be a procession introduced by a presenter or an elaborately staged show in which a brief lyrical drama heralded the appearance of masquers who, having descended from their pageant to perform figured dances, reveled with the audience until summoned back into their pageant by farewell speech and song. The masque theme was usually mythological and symbolic and complimentary to the noble or royal host. The dramatic business was performed by professionals, the masquers remaining mute until they consorted with the guests. Traditional festivals and social events were celebrated by masques and the Twelfth Night court masque was so diplomatically important that foreign ambassadors intrigued for positions in the auditorium.

Origin and etymology are obscure. The masquerade, a popular carnival amusement akin to mumming (*see* MUMMERS), was transformed by Lorenzo de'Medici into a performance designed to illustrate a theme and accompanied by songs explaining the meaning of costume and pageantry. By the time it reached France it had become very spectacular and toward the end of the 16th century provided material for the French and Italian humanists who, attempting to revive classical drama, invented opera and ballet de cour. The English court masque was continuously influenced by its continental analogues.

In 15th-century Ferrara, young men in masks and dominoes paraded the streets at carnival time and penetrated uninvited into festive gatherings. The fashion reached France in the 16th century. Henry VIII introduced it into England on Twelfth Night 1512, when he and 11 others, disguised in masks and Italian dominoes, entered the banqueting hall and invited ladies to dance and converse. Some refused, scared possibly by the rumoured licentiousness of continental masquers. Dominoes were soon discarded and the masque, combining with other kinds of entertainment, became increasingly dramatic. The earliest extant example of a developed masque, *Proteus and the Adamantine Rock* presented by gentlemen of Gray's Inn, London, in 1594, complimented Elizabeth as empress of hearts and of the ocean.

The production of *Of Blacknesse* in 1605 marked the beginning of the partnership of Ben Jonson and Inigo Jones and the introduction of Italian methods of staging. Instead of dispersed decorations, a scene in perspective was presented on a raised stage. Later, Jones introduced methods of instantaneous scene-changing. In 1609, the *Masque of Queenes* opened with an antimasque of witches who symbolized evil and vanished at the appearance of the virtuous masquers. Jonson used the antimasque as foil to the main masque; but it gradually ceased to be functional and became a series of entries of grotesque or realistic types with little relevance to the central theme. The sacrifice of poetic unity to variety and spectacle led to a quarrel between Jones and Jonson and after 1631 the libretti were composed by more subservient poets. The term "masque" was sometimes used sufficiently loosely to include entertainments such as Milton's *Comus.*

The performance of *Salmacida Spolia* in 1640 closes the history of the court masque, which was too intimately bound up with social life to survive the fall of the monarchy.

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MASQUERADE, a form of entertainment or a costume ball where the personages are masked or disguised. The abbreviated form of the word, "masque" or "mask," applies more particularly to certain varieties of drama which flourished during Elizabethan times. *See* DRAMA.

MASS, the common designation in western Christendom for the celebration of the Eucharist. From the Latin *missa* ("dismissal"), it referred originally to the ceremony which terminated the rite. The Eucharistic sacrifice is treated in the article EUCHARIST; an account of music at Mass is given in the section *The Music of the Mass.* Here is offered a summary of the process by which the name of what is now an insignificant detail came to stand for the rite itself; this is followed by the more important uses of the term in Roman Catholic worship.

The Scriptural terms for this rite, "Breaking Bread," "the Lord's Supper" and "Communion," were in the course of time

supplemented by numerous other terms, assembly (*synaxis, collect~*), sacrifice and the like.

In oriental Christianity the term that gradually won commonest acceptance was "the sacred liturgy"; in western, or Latin, Christianity. from the end of the 4th century (Ambrose, *Ep.* 20,4; *Peregrinatio Silviae,* 27,8) there was a tendency to apply the name of a part of the whole and call a service, having as a striking feature a dismissal, a *missa.* After the prayers and Scripture readings preceding the Eucharist proper the nonbaptized were solemnly dismissed: as St. Augustine said: "After the sermon occurs the dismissal of the catechumens *(fit missa catechumenorum),"* (*Serm.* 49,8). Again, at the end of the whole rite there was a dismissal of the participants, which by analogy was known as the *missa fidelium.* The full Eucharist therefore had a dismissal of the nonbaptized halfway through and a dismissal of the faithful at the end. Little by little people, who had spoken of remaining *until* the *missa,* began to talk of remaining *for* the *missa,* from which it was a short step to calling the service itself a *missa.* From the 5th to the 7th centuries the new and old "meanings" of *missa* competed; by the 8th *missa* had practically ceased to mean "dismissal" and was the ordinary name for the Eucharist.

Mediaeval authors often applied an accommodated meaning (*missa* = transmission) : the sacrifice was called *missa* because its victim was first sent us by the Father and in turn sent by us to the Father. But it was usually remembered that this explanation was not historical. Similarly in modern trends Catholic (Herwegen, Parsch) and non-Catholic (Kattenbusch) authors tend to explain the primitive *Ite missa est* figuratively as a Christian's commission, "Go. carry out your mission."

In Roman Catholic worship a *low* Mass is one in which no part is sung by the celebrant; a *high* Mass is one in which celebrant and choir sing their respective parts; a *solemn* Mass is a high Mass in which the celebrant is assisted by deacon and subdeacon; a *pontifical* high Mass is a solemn Mass celebrated by a bishop or higher prelate with special ceremonial.

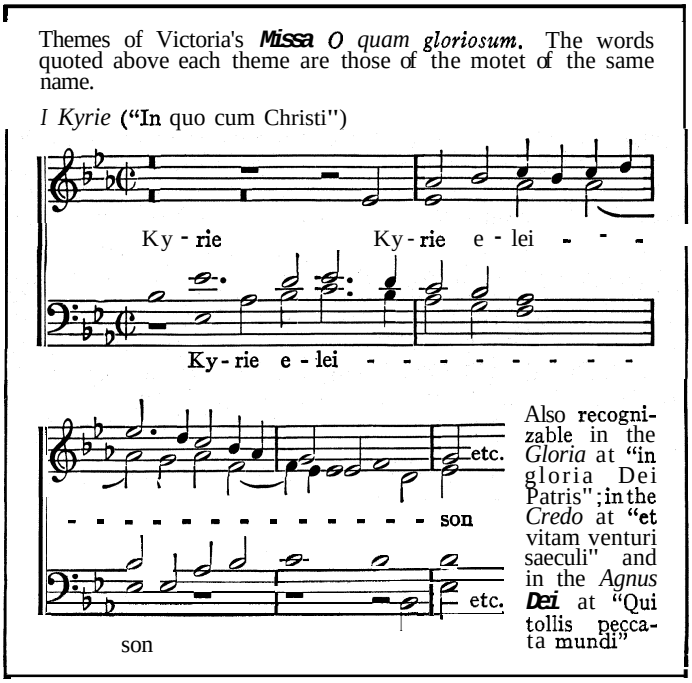
A *parochial* Mass is one celebrated by all pastors for their parishioners on Sundays and holydays; a *nuptial* Mass is celebrated in connection with weddings; a *Requiem* Mass, for the repose of the faithful departed.

See DuCange, *Glotsarium, s.* v *'Missa';* Eisenhofer, *Handbuch der Katholischen Liturgik* II, 3–7 (1933), Fortescue, *The Mass: a Study of the Roman Liturgy* 397–401 (1937). (G. ED.)

THE MUSIC OF THE MASS

The commonly known music of the Mass consists of the *Kyrie, Gloria, Credo, Sanctus* and *Agnus Dei.* They are more commonly known as the Ordinary of the Mass in contradistinction to the other sung portions which comprise the Proper of the Mass. This latter is of equal if not greater importance: it includes the *Introit,* Gradual, Alleluia (sometimes Tract or the Sequence), Offertory and Communion. The Proper was the first part of the Mass to receive polyphonic treatment. The examples that survive of the 12th-century choirmasters of Notre Dame, Leonius and Perotinus, are classic. Since the text of the Proper, unlike that of the Ordinary, changes from day to day and from church season to church season. the composers found it more renarding to write settings for the Ordinary which might be often repeated. Nevertheless we find numerous settings for the Proper among the 16th-century composers, such as G. P. da Palestrina's *Offertories* for the entire church year and Byrd's *Gradualia.* There is also a collection of 114 Graduals by the 18th-century Michael Haydn. The most outstanding collection of the Propers for the church year is the monumental *Choralus Constantius* of Heinrich Isaac *(c.* 1450–1517) for four voices, with the plain song in the tenor. Conditions changed very little in the 20th century, for Gregorian settings if not sung are supplanted by the simple adaptation of the text to a psalm tone or simple recitative, in order to fulfil the liturgical prescription which orders the singing of the Proper.

The settings of the Ordinary of the Mass include such idioms as Gregorian chant, polyphony and the concerted Masses of the later centuries. Pope Pius X in his *Motu Proprio* of 1903 on church music mentions Gregorian chant and the sacred polyphony of the 16th century, especially that of Palestrina, as the types of music best suited to liturgical functions. The concerted Masses of the 18th and 19th centuries, which emphasize music per se rather than as part of the liturgy, are not appropriate, but modern compositions in keeping with the ideals of the *Motu Proprio* are acceptable.



Themes of Victoria's ***Missa O quam gloriosum.*** The words quoted above each theme are those of the motet of the same name.

I Kyrie ("In quo cum Christi")

Also recognizable in the *Gloria* at "in gloria Dei Patris"; in the *Credo* at "et vitam venturi saeculi" and in the *Agnus Dei* at "Qui tollis peccata mundi"

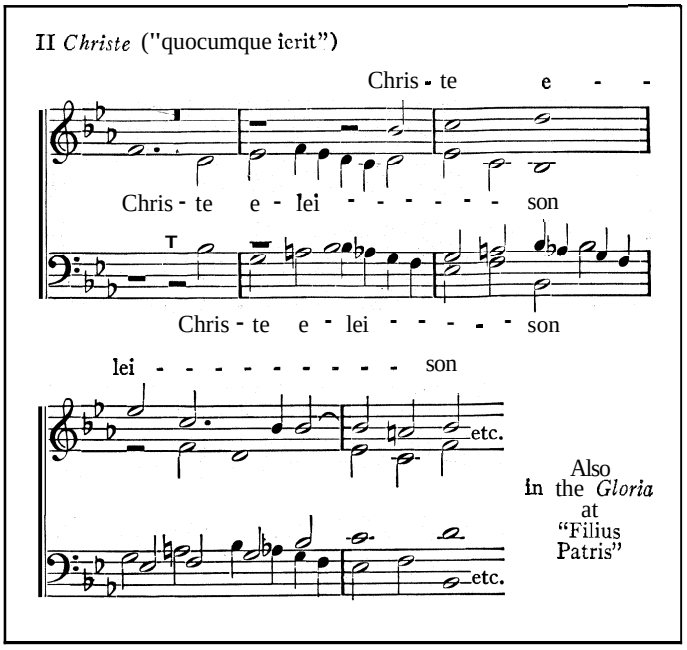
Gregorian Masses. — These 18 Masses with the *Missa pro defunctis,* dating from the 10th to the 16th centuries, are collected in the *Kyriale,* a name derived from the *Kyrie.* They range in scope from the florid melodies for solemn feasts to the simpler ones for minor feast days. For convenience they are designated by Roman numerals: thus the popular *Missa de Angelis* is VIII and the *Missa Marialis* IX. Another means of differentiation is by the trope formerly associated with each *Kyrie* melody; *i.e., Lux et origo,* I, and *Fons bonitatis,* II.

Polyphonic Masses. — The Mass as an art form was of central importance in the history of music in the 15th and 16th centuries. In the last half of the 16th century it reached its most perfect development in the compositions of Palestrina and his contemporaries, Orlando Lasso, Tommasso da Victoria and Da Monte. The earliest Mass to contain the whole Ordinary is the 14th-century *Messe de Tournai,* but the first to unify the sections by a central theme is that of Guillaume de Machaut, composed for the coronation of Charles V. The Masses of the Netherlander Josquin des Prés are the high point of the 15th-century composers and a connecting link with those of the 16th century. To these masters the *Kyrie, Sanctus* and *Agnus Dei* were a delight, for the brief textual phrases did not encumber the melodic thought. They could be written as glorified motets with vocal phrases of soaring quality and spiritual significance. To set the numerous phrases of the *Gloria* and *Credo* presented a difficult problem if the church service was not to be lengthened. Victoria solved this by adopting a style midway between the extended phrases of the motet and the recitative style. Palestrina likewise adopted this idiom in many of his later Masses.

Possibly the best-known Mass of the 16th century is Palestrina's *Missa Papae Marcelli.* Besides being seemingly the only Mass titled with the name of a pope, it set a precedent in Palestrina's early career, for he essayed a style that he returned to in his most fruitful period from about 1580. Although these Masses were designed for *a cappella* singing and scored for two and three choirs for the more solemn occasions, instruments gradually came into use to duplicate the voice parts. A favourite theme for the Mass in the last half of the 16th century was the motet to which the words of the Mass were adapted (Parody Mass). In order to

achieve unity, this might be a motet appropriate to the feast day or a successful motet chosen with the hope that its gracious phrases would yield an equally inspiring Mass. Palestrina's six-part *Missa Assumpta est* and Victoria's *Missa O quam gloriosum,* founded on the motet for the feast of All Saints. are superb examples. The *O quam gloriosum* shows the relation between the themes of the Mass and the motet.

See also *MOTET.*

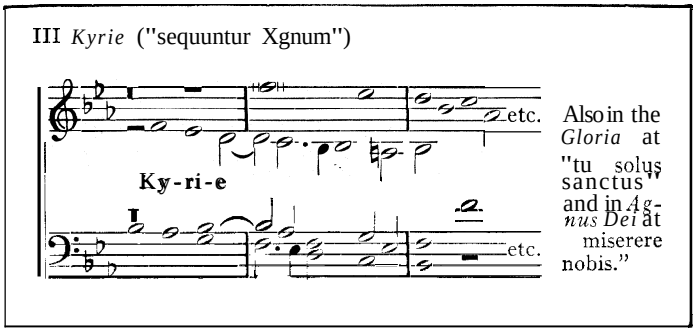


Instrumental and Symphonic Masses.—The style created by the Neapolitan masters who gave us classic tonality and the instrumental art forms of the 17th century finds its maturity in the Masses of Franz Joseph Haydn and Wolfgang Amadeus Mozart. So unfavourable were the conditions of the 19th century to the formation of an ecclesiastical style that only a small part of the music of this era can be called religious music at all. The approach to the form and the musical content of the *Gloria* and *Credo* resulted in overbalancing the whole scheme. Mozart's terse *Mass in F,* written when he was only 17, exemplifies the tradition although such contrapuntal richness was not achieved by the Neapolitan composers. It was scored for a four-part chorus and solo voices accompanied by the organ, a largely independent bass and free parts for two violins. Other Masses added trumpets and oboes and probably drums as was customary in the 18th-century orchestra. The old polyphony did not entirely disappear, G. B. Martini and Johann Joseph Fux helped to keep at least the shell of the tradition. Fux's *Missa canonica* enjoyed a well-deserved popularity for many years.

Beethoven's *Missa Solemnis in D* (op. 123) was intended for the installation of the archbishop of Olmütz in 1820 but was not completed until 1823. It is perhaps the most dramatic setting ever penned and exemplifies the enormous growth of symphonic music. Subsequent Masses in this style gave less thought to composition for church use. More frequently they are written with the intention of a public performance. Franz Schubert's Masses show evidence of the style of both Mozart and Beethoven although they are less dramatic. Where it was possible, Schubert turned to limpid lyric passages rather than the older contrapuntal idiom. The brilliant Masses of Carl Maria von Weber are overshadowed in substance by those of Franz Liszt and the more stolid Masses of Luigi Cherubini. In one of his finest vocal scores, the *Mass in F Minor,* Anton Bruckner voiced again the Viennese tradition of Schubert.

Lutheran Masses.—Although chorals were provided to supplant the Ordinary of the Mass, music with Latin words was not excluded from the Lutheran Church. The *Kyrie* and *Gloria* were sung and entitled a short Mass. Bach's four "short" Masses, which are largely traceable to his church cantatas, are in reality lengthy. as each sentence has a separate movement. His complete Mass, the overpowering, monumental score in B *Minor,* has in reality the stature of an oratorio. for it is too long to fit any liturgy.

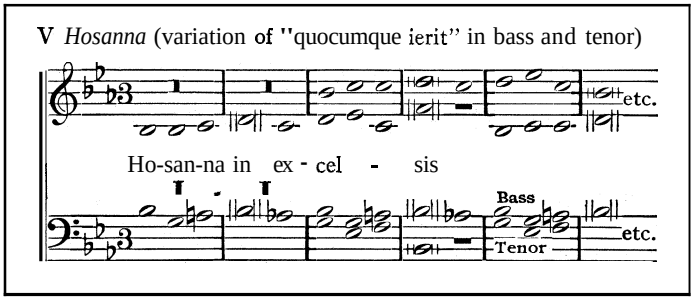
The Requiem.—The traditional use of Gregorian chant for the *Missa pro defunctis* or Requiem Mass discouraged the composition of choral settings until the 17th century. Although we find



numerous examples from this time onward, one investigator has catalogued only about 50 examples before that time. Instead, as early as Charlemagne's day composers turned to the *tombeau* or funeral ode written on the death of kings, high-ranking princes and important personages. The *Deploration on the Death of Okeghem* by Josquin des Prés, with the *Requiem aeternam* theme as *cantus firmus,* provides a well-known example. The *Requiem* of Eustache du Caurroy (1549–1609), the *maître* of the Sainte-Chapelle, deserves special mention for it was used at the funerals of the French kings down to the 18th century and yearly on All Souls' day at Notre Dame. Palestrina's five-part setting and the two examples of Victoria each employ the plain song melody in the soprano voice. This conservation in the late 16th century points

to the hold of the traditional plain song setting. The *Dies Irae* (Sequence) is generally left to the plain song melody, but, as in that of G. M. Asola, it is often made to alternate its phrases with those composed in the polyphonic idiom.

Although not liturgical in spirit, other important examples include the sublime work of the dramatic and pompous *Messe des Mortes* of Hector Berlioz, Giuseppe Verdi's towering but operatically conceived score and the touching but less well-known Mass of Gabriel Fauré. The Brahms *Deutsches Requiem,*



a profoundly moving choral setting inspired by the death of his mother, is founded on a text compiled by the composer from the Bible.

Later Masses.—The mid-19th century interest in the revival of plain song, especially under the direction of the abbot of Solesmes, Dom Prosper Louis Guéranger, and the scholarly work of Dom Joseph Pothier and Dom André Mocquereau, resulted in the restoration of the ancient melodies of the Ordinary and the

Proper. These appeared in the Vatican Gradual of 1908. which became the official chant book of the Catholic Church. The revival of the 16th-century polyphony was initiated in the first quarter of the 19th century by Kaspar Ett. Johann Aiblinger and later by Karl Proske. whose first volume of the *Musica Divina* made available several of the older Masses. The Masses of Victoria were edited by Felipe Pedrell, and many of Palestrina's by Franz Xaver Haberl and in a new edition by Msgr. Raffale Casimiri, completed shortly before his death in 1943. Only a few of the Masses of Lasso are available in modern editions. The Masses of Lorenzo Perosi may be taken as an indication of the contemporary approach to the composition of the Ordinary. His *Missa Te Laudamus,* although one of his simpler Masses, is a gem of the modern repertoire.

The modern setting of Ralph Vaughan Williams' *Mass* in G, first performed in 1923, is written in the polyphonic idiom and dauntlessly turns to the sterner tonal tenets of mediaeval polyphony. (J. V. H.)

MASSA-CARRARA, a province in northwestern Toscana. Italy. largely mountainous, lies between the Tuscan Apennines and the Tyrrhenian sea. Area 446 sq.mi., pop. (1951) 204.377. In the centre are the Apuan Alps, a small massif. world-famous for their marble quarries. The northwestern corner, the valley of the Magra river, is known as the Lunigiana district. The province mas originally created in 1938 and was known as the province oi Apuania until 1945 when it received its present name. The Cybo Malaspina family, long the feudal rulers of the area. built the splendid 16th-century fortress of Massa and a handsome palace in the city itself. Massa is now the capital (pop.. 1951, 38,432). Carrara (pop.. 1951, 27,207), besides being synonymous with the best marble of the world, has a fine Romanesque-Gothic cathedral (12th–14th century), built in the Pisan style. The Rome-Genoa railway passes through the short coastal section of the province; there are also rail and road connections with Parma and Lucca. (G. KH.)

MASSACHUSET, the Algonkin tribe formerly about Boston, from whom the bay and state of Massachusetts were named. They may once have numbered 3.000 and in the early 11th century were said to live in more than 20 villages. distributed along the Massachusetts coast from Plymouth at least as far as Salem and possibly nearly to the northern boundary of what is now the state of Massachusetts. Before colonial settlement began, however. they were greatly reduced in number by intertribal warfare arid by the pestilence of 1617, followed, in 1633. by an epidemic of smallpox which wiped out most of the few remaining members of the tribe, including its chief.

Toward the end of the first half of the 17th century the Massachuset became Christians and soon lost their tribal identity altogether.

MASSACHUSETTS, popularly known as the Bay state or Old Bay state, was the sixth of the 13 original Colonies that formed the United States. Its name! meaning "large hill place" or "at or about the Great Hill." came from the Massachuset Indian tribe. The official motto of the state is *Ense petit placidam sub libertate quietem* ("By the sword we seek peace, but peace only under liberty"). The state flower is the trailing arbutus, commonly called the Mayflower. The state tree is the American elm and the bird is the chickadee.

The state of Maine—larger than the other five New England states combined—was part of Massachusetts until 1819. Vermont and New Hampshire now form the northern boundary of Massachusetts. To the east is the Atlantic ocean. On the south is the ocean, Rhode Island and Connecticut. New Tork forms the western boundary. Because of its peculiar form, these boundaries are only approximate in the east. Its main portion forms a parallelogram about 130 mi. from east to west and 46 mi. from north to south. its straight southern boundary being almost coincident with the parallel of 42° N. In the east. the state spreads out. extending considerably south and somewhat north of the lines of the parallelogram, the counties of Plymouth and Barnstable forming the peculiar southeast "pothook" of Cape Cod. The state extends approximately between the extremes of 41° 11' and 42° 53' N. Boston, the capital and principal city, is in about the same latitude as Rome. The total area is 8.257 sq.mi., of which 390 sq.mi. are water. Massachusetts ranks 45th in size among the states.

PHYSICAL GEOGRAPHY

Physical Features. — These can be understood in their full significance only by reference to those of New England as a whole. The Appalachian mountain barrier, which extends from southwest to northeast parallel to most of the eastern coast line of the United States, continues through western New England in the Berkshire hills and the Green and White mountains. From the base of these ranges a gently sloping upland descends south and eastward to Long Island sound and the Atlantic ocean. The only large river navigable for any considerable portion is the Connecticut, which flows southward from the Green mountains of Vermont to the sound. As Massachusetts in form is a long narrow strip extending westward from the ocean, it runs at right angles, so to speak, to these principal New England features of mountains and river. Its eastern two-thirds is mostly made up of the sloping upland. West of that the state is divided by the Connecticut valley, the best portion and maritime outlet of which is in Connecticut, and west of that again lie the mountainous western counties.

There are several small ranges, each with local names, in the Berkshires. The more eastern is that known as the Hoosac hills. which have an elevation of only 2.100 to 3,041 ft. and divide the valley of the Connecticut river from that of the smaller but more picturesque Housatonic. Bordering the 101%-landsof the Connect:-cut a few well-known hills rise to a marked height above the general level. such as Mt. Tom (1,202 ft.), Mt. Holyoke (954 ft.) and Mt. Toby (1,269 ft.). West of this. in what is known locally as more particularly the Berkshire region, are found such peaks as Mt. Williams (2.951 ft.) and Greylock (3.491 ft.), the highest point in the state. From the Connecticut valley eastward the elevations steadily decrease to the coast and the extreme southeastern portion is low lying and sandy. There are a few exceptions, such as Mt. Lincoln (1,238 ft.), Mt. Wachusett (2,006 ft.) and the Blue hills. These, like those mentioned in the western section, appear to be residual peaks of an original mountain range that covered the entire state in the geological era before the whole had been leveled to the plain which was then carved into its present features. The existence of this original mountain range is also indicated by the structure and extremely complicated disordrr of the gneiss and crystalline schist of the uplands. On the other hand, the valley of the now much shrunken Connecticut river is composed mainly of shale and soft sandstone. The evidences oi the glacial period occur everywhere, the entire state having been covered by the ice sheet. with resultant glaciation of the rocks, as far as the Cape Cod peninsula, where are found traces of the terminal moraine.

The eastern part of the state can be described almost wholly in terms of the junction of sea and land, though there is one small river, the Merrimack, important not because of its very short navigable portion but for the water power it provides by its fall. The coast line extends for about 250 mi., with a number of good harbours. The enormous water area included between the two points of Cape Ann and Cape Cod is known as Massachusetts bay, with the designation Cape Cod bay for its southern portion. Among the harbours, all of which are excellent, and popular yachting resorts, may be mentioned those of Salem. Cloucester. Marblehead, Boston and Provincetown on the east, and Buzzards Bay on the south. The northern part of the eastern shore is somewhat rocky and picturesque, whereas the long pothook or encircling arm of Cape Cod peninsula (Barnstable county, is low and sandy. Almost the entire coast is lined with summer resorts. Those within a 30-mi. radius of Boston. however. were rapidly becoming year-round towns in the second half of the 20th century. Modern highways coupled with population growth are the main reasons.

At Woods Hole on Buzzards bay is the U.S. fish and wildlife service station with a marine biological laboratory. Leaving the mainland, there are several islands to the south, two of them. Martha's Vineyard and Nantucket, being of considerable size and importance. Martha's Vineyard, a little the larger (about 9 by

20 mi.), has a good harbour which, aside from summer yachting. is resorted to by stormbound vessels avoiding the dangerous shoals that lie to the southeast of the state.

The physical features thus briefly described have had a marked effect upon the history of Massachusetts at every period. In the colonial days. when waterways provided the only means of travel. the absence of any large river leading to the interior retarded development of the sections lying back of the coast, prevented the development of the fur trade and led the people to look to fisheries and commerce for their livelihood, an influence that was strengthened by the rather poor soil of most of the state. The climate (see below) was another factor that prevented the growth of large estates and a slave economy as in the south. The broken character of the eastern upland has had a marked effect also the richer valleys having afforded moderate ease and comfort, which resulted in conservative politics. whereas the "hill towns" were poorer, radical in politics and largely abandoned nhen a changed economic situation and western expansion opened new opportunities for their dwellers. The fact that the Connecticut river merely ran through the state, flowing thence into another. led the inhabitants of this richest of all sections to ally themselves rather with their neighbours to the south in Connecticut than with their own fellow citizens to the east. To the west of this, the mountainous and somewhat rugged land gave special character to its inhabitants. who have always shown themselves more democratic and radical than those in the mercantile towns of the seaboard. As a whole, the mountain barrier to the west long tended to isolate New England from the rest of the country, to preserve certain New England characteristics that included a certain provinciality of outlook in which Massachusetts shared. Although railways overcame this isolation to some extent. the great traffic from the west goes to New York city rather than to Boston, and both commerce and manufactures declined relative to those in competing states. hlassachusetts lost much of its textile industry in the 20th century, but it rapidly diversified and attracted new firms in the electronic and chemical industries. The beautiful scenery and changing seasons attracted more and more people and the automobile brought unexpected prosperity to villages that shortly after 1900 seemed doomed.

Climate. — Massachusetts has four distinctive seasons. It is a rare winter that does not have at least one severe snowstorm throughout the state. It is not uncommon, however. for the western part of the state to have severe storms while the southern section — Cape Cod and the islands — enjoy moderate weather with little or no snow. Spring often brings the extremes of winter and summer with generous amounts of rain. July and August are the hottest months, with September offering relief with dry, crisp air. Mean averages in the middle of the 20th century at Boston were 30.4" F. in the winter and 70.3° F. in the summer. Extremes recorded were 106° F. on July 4. 1911, in Lawrence, and —34" F. on Jan. 18, 1957, at Burch Hill dam. The average annual precipitation for the state is 43.06 in. along the coastal area, 44.64 in. in the central area and 45.14 in. in the western area.

Vegetation and Animal Life. — There is little that is distinctive in either animal or plant life as differentiated from New England as a whole. The state is a meeting place, however, for many southern and northern species of which it forms, respectively, the northern and southern limits. It is, for example, the northern limit of such trees as the holly and tupelo, the latter occasionally found in southern New Hampshire also. There is a small colony of prickly pear cactus in Nantucket. It is also the northern limit of many insects, notably the 17-year locust. Among the birds likewise limited are the seaside sparrow, blue-winged warbler, prairie warbler and quail. On Martha's Vineyard there was a colony of the heath hen, until 1929 or 1930, but it is now extinct.

Most remarkable from the standpoint of its fauna and flora is the influence of Cape Cod, which stretches out to sea and deflects the current of the Gulf stream. To the south of the cape are found many southern fishes and other marine creatures including the Portuguese man-of-war. On the north side of the cape the fish and invertebrates are entirely different; it is said that no other barrier makes so sharp a dividing line in ocean animal life.

Museums, Historic Places and State Parks. — Massachusetts has a wealth of museums and historic houses and buildings. The Museum of Fine Arts in Boston (1870) has what many consider the most important collection of Asian art in the western world. The Boston Museum of Science (1949) is an outgrowth of the Museum of Natural History (1830) Other Boston museums include the Isabella Stewart Gardner museum, the Institute of Contemporary Art, the Children's museum and the Children's Art Centre Inc.

More than 175 museums and houses in the state are of historic interest. They reflect not only early life in New England but the interest created in the rest of the world during the days of the clipper ships that carried Rlassachusetts commerce to all parts of the globe. At Plymouth is the Plimoth Plantation, which contains the "Mayflower II" and has early Pilgrim dnellings on exhibition. At Sturbridge village in the western part of the state is a reproduction of a New England village of 1790. It contains old homes, shops and mills. There are demonstrations of spinning, weaving, cabinet making, furniture finishing pottery, metalwork, printing. grist milling and blacksmithing There also are exhibits of the period At West Springfield in southnestern Massachusetts there is another New England colonial village. Other historic sites and places of special interest are covered in articles on Cambridge, Concord (the home of Emerson. Thoreau and other literary figures), Deerfield. Gloucester. Lexington. Marblehead, Martha's Vineyard, Nantucket, North Adams (the site of Fort Massachusetts). Provincetown, Quincy. Salem, Saugus (site of the first colonial iron works; restored in 1954) and Stockbridge. There are more than 100 state parks, forests and other state reservations. October Mountain state forest. with 13,723 ac. in western Massachusetts south of Pittsfield is the largest in the state. Savoy state forest (10,956 ac.), farther north on the Hoosac range offers scenic attractions and various camping and recreational facilities; Myles Standish state forest covers about the same area in the eastern part of the state south of Plymouth State parks include Clarksburg (near Mt. Greylock), Cochituate (includes the lake of the same name west of Boston) and the Pilgrim Springs park, noted as the first watering place of the Pilgrims after leaving the "Mayflower."

HISTORY

Exploration and Early Colonization. — Itis uncertain when Xlassachusetts was first visited by Europeans. In spite of conjecture of visiting Norsemen around A.D. 1000, there is no proof of anyone's having been there before 1602, when the English navigator Bartholomew Gosnold visited Massachusetts bay and named it Cape Cod. Two years later Samuel de Champlain explored the coast and in 1614 John Smith also did so, naming many of the points along it. After that, visits became more frequent, but it was not until many years after other settlements had been made in America that a permanent colony was planted there at Plymouth. in 1620. Certain separatists from the Church of England had fled from England to the Netherlands several years before and from there decided to migrate to the new world. After considering Guiana and other places, they determined to try the territory owned by the Virginia Company of London. and financial assistance was received from colonizing speculators in London. The London promoters provided the money and, when the "Mayflower" sailed. of its 102 passengers only 35 came from the Leyden religious group and 67 from London. Before landing, the leaders of the Pilgrims drew up the famous Mayflower Compact to serve as the basis of government. There was no intention of making a new departure in the direction of a democratic constitution, and the short document was merely a modification of the customary form of church covenant to meet the temporary crisis in an unfamiliar situation. Because of stress of weather or some other unknown cause. the colonists landed in Massachusetts instead of Virginia. They had no other government than this formed by themselves, and the pure democracy thus inaugurated and later modified was accidental. It became. however, the precursor of innumerable other written covenants in New England. forming the basis of town and church government there.

The troubles of the first winter were severe and half the colony

died, including Gov. John Carver, whose place was taken by William Bradford. Indian tribes in the Plymouth area had been decimated by illness a fen. years earlier and the settlement had little trouble on that score. Fields earlier cultivated by the Indians were of considerable help to the colonists. who were ill-fitted to carve farm land from the forests. The contract with the London promoters had called for ownership of property in common, but this was soon modified in favour of individual property. Although the colony managed to survive its initial difficulties and become modestly comfortable, it was never financially successful and eventually all connection with the English company was terminated. After the adjustment of accounts with its financial sponsors. the colony succeeded in getting grants defining its territorial boundaries, and gradually the village of Plymouth threw off other little settlements, such as Scituate (incorporated 1636) and Duxbury (incorporated 1637). but was finally absorbed into the larger and more powerful Colony of Massachusetts Bay in 1691.

Soon after the Plymouth settlement was made others were established along the coast. mostly by individuals, a number of whom from 1625 onward settled around Boston harbour. A small fishing company tried to establish a foothold and business on Cape Ann, which mas the forerunner of a much more important colonizing movement than any yet made in North America. In England it was a time of much change and unrest. quite as much political and economic as religious. The Puritans were drawn to a great extent from country gentlemen and middle-class businessmen. all of whom were feeling the stress of the times severely (see PURITANISM). There was a great migration of the discontented to the new world. a migration by no means confined to New England. Between 1620 and 1632, for example. 18.600 persons went to Barbados as compared with only 14.000 to Massachusetts. and 18.000 went to other West Indies islands as compared with fewer than 3.000 to the rest of New England. The Massachusetts settlement was thus merely an episode in a much broader movement.

The Massachusetts Bay Colony.— Certain Puritans in England became interested in an attempt to revive the defunct fishing company at Cape Ann, and in 1628 a patent was received from the Council for New England and a number of settlers were sent out under John Endecott as governor. Meanwhile the number in England interested in a Massachusetts venture had increased, and in 1629 a rather strong group, including John Winthrop, obtained a charter as "The Governor and Company of the Massachusetts Bay in New England." The grant was similar to that of the Virginia company in 1609. the patentees being joint proprietors, with rights of ownership and government. The intention of the crown was evidently to create merely a commercial company with what, in modern parlance. would be called stockholders, officers and directors. but by a shrewd and legally questionable move the patentees decided to transfer the entire management and the charter itself to Massachusetts, thus paving the way not only for making the management local. but also for the unwarranted assumption. pregnant with most important consequences, that the charter for a commercial company was in reality a political constitution for a new government with only indefinable dependence upon the imperial one at home.

The religious motive was but one among others inducing even the leaders to emigrate to America. It was undoubtedly important, but even it looked merely to the establishment of a community in which the emigrants would he free to worship as they themselves wished, not to establish in any way a refuge for those who might wish to worship differently. Indeed, throughout the whole colonial period, the leaders of the colony fought religious liberty with every weapon in their power. The economic motives were also strong (as Winthrop clearly indicated in writing in his own case), the sudden increase in the cost of living in England. with consequent unsettlement of established habits and social position, being a leading factor.

In the summer of 1630 a fleet of ships carried over nearly 1,000 emigrants. including Winthrop as governor and Thomas Dudley as deputy go\-ernor. to Massachusetts bay, where they settled the towns of Boston. Charlestown. Dorchester. Medford. Watertown, Roxbury and Lynn. Such leaders as Winthrop, Dudley, Endecott and the Rev. John Cotton were strongly opposed to democracy. were zealous to prevent any independence in religious views and had no trust in the people at large. Opposition showed itself now and then in the case of individuals. the general court or even a town (as Watertown, which protested a tax levy).

Religious Disputes.——The first of the more noted cases was that of Roger Williams. who was banished from the colony and settled in Rhode Island (1636). Almost simultaneously occurred the so-called Antinomian controversy in which Anne Hutchinson (*q.v.*) and Henry Vane the younger were the protagonists and which ended in the banishment of Mrs. Hutchinson and the return of Vane to England. There was much criticism in England, even among the friends of the colony. of the policy of repression adopted by the leaders, lay and clerical. but they pursued their course until halted by royal authority a generation later.

The harshness of rule. narrow-mindedness and self-satisfaction. which became characteristic of the Massachusetts colony. cannot be ascribed wholly to Puritanism. Much of it was motivated by a desire for profit. As has been said, it was a period of great Puritan emigration and all the colonies both on the American mainland and in the Nest Indies were strongly Puritan in tone at first. In the south and on the islands. differing climatic and other conditions induced modifications in cultura! life and thought, but even in New England both Rhode Island and Connecticut were far more liberal than Slassachusetts.

Extension of settlements brought on troubles with the Indians and in 1637 there occurred the war with the Pequots in which that people was practically annihilated. In the same year a synod of the clergy. held at Boston. listed 82 blasphemous, erroneous or unsafe opinions held in the colony. In 1643 a loose confederation of the four colonies of Massachusetts, Connecticut. Plymouth and New Haven was effected under the title of the United Colonies of New England. It performed some useful work but its policies were largely doininated by Massachusetts and it gradually lost influence.

In 1644 laws were passed against the Baptists and several of them were cruelly dealt with. The Quakers also were persecuted. more particularly from 1656 to 1662, four being put to death and many others whipped, imprisoned. branded or banished. Finally, owing partly to a revulsion of public feeling and largely to action by the English crown, a stop was put to the worst forms of persecution. During the Civil War and Cromwellian period in England, the colonies had for the most part been left to go their own way and Massachusetts had arrogated to itself an almost complete independence of the home government. It was obvious according to the ideas of the time that if the colony were to remain part of the empire a closer dependence would be essential, and after the Restoration it was decided to send out a royal commission to in\-estigate conditions. In 1665 the commission visited New England, and the following year the king sent a circular letter to all the colonies, expressing dissatisfaction with Massachusetts only. There was, indeed, a considerable and respectable party in the colony itself that was opposed to the extreme pretensions of the local government. That government. however. trusting to distance and the preoccupation of England with the European war, pursued its course.

In 1675 there occurred a second and much more serious Indian war, known as King Philip's War. caused by the grasping land policy of the colonies and the desperation oi the Indians at seeing themselves more and more hemmed in by the whites. It was an inevitable conflict. and although the whites were victorious they suffered severely. It was said that 1 man in every 16 of military age was killed and it was long before the frontier recovered. Meanwhile the case of Massachusetts was again taken up by the English government. The colony adopted the method of evasion and delay in meeting charges and complying with orders. 'This policy resulted in the annulment of the charter in 1684. in leaving the colony defenseless again-t the king and with few or no friends in England to defend the course it had taken. In some respects, such as the end of the exclusion oi nonchurch members from the franchise. the cause of liberty gained by the change.

Royal Government.— In 1686 a royal government was inau-

gurated by the arrival of Joseph Dudley, a native Massachusetts man, as president of a provisional government until a new one could be devised. He was soon supplanted by Sir Edmund Andros, whose government extended over all New England and Sew York. Although he nas by no means the "tyrant" whom the earlier patriotic historians painted, he mas lacking in tact and in the qualities of wise statesmanship. and his situation was an extremely difficult one. When word came that the Stuart dynasty had been overthrown in England in favour of William of Orange, a mild revolution occurred in Boston, and Andros and most of his government were imprisoned. Finally, in 1691 a new charter was procured for Massachusetts, to whose territory it added the province of Maine and the former colony of Plymouth.

Although the new charter provided for a royal governor and in other ways greatly diminished the power of the old theocratic party, it was a more reasonable governmental instrument than the anomalous commercial charter which the colony had for so long tried to twist into a political constitution. The first royal governor was a Ken England man. Sir William Phips, aho had led an unsuccessful attack on Quebec in 1690. Massachusetts had carried out an easy raid upon Acadia, which had inspired hopes of a larger conquest of French territory. with the sole result of almost bankrupting the colony by a debt of £200,000.

The last decade of the 17th century was also marked by the witchcraft delusion, mainly in Salem village, during 1691–92. In all about 32 persons were executed, one by the horrible medieval penalty of being pressed to death under heavy weights. After the end of that delusion, the life of Massachusetts took on a more modern tinge. Not until 1957. however. was a resolve passed by the state legislature declaring that the proceedings convicting one Ann Pudeator and certain other persons in 1692 of witchcraft to have been shocking and the result of a wave of hysterical fear of the devil, even if lawful under the province charter. Connecticut had shown the way to civil and Khode Island to religious liberty. If the far more powerful colony of Massachusetts cannot lay claim to having been a leader in either of these directions, its founders had established the strongest colony in Sorth America in their search for profits, had made creditable beginnings in public education, had developed the system of town government and laid the foundation for the Congregational Church. Although the results of the intellectual repression of its first century were long to be felt. with the opening of the new century the colony swung more and more into the growing liberalism of thought of the 18th century.

18th Century. — The colony also shared more in the larger life of the empire. Several times, notably in the unfortunate expeditions against Jamaica (1702), against Canada (1709–11) and Cartagena (1740), Massachusetts troops played an honourable part, and to that colony must be given the main credit for the capture of Louisburg from the French in 1745. In the French and Indian War its soldiers also took part in the expedition against Osnego, took the chief part in the capture of Acadia and also shared in the Crown Point and second Louisburg attacks. Meanwhile, the colony had been making rapid strides in uealth and was becoming markedly self-conscious politically. There had been serious trouble with the currency earlier in the century. due to the colonists' insistence, perhaps necessary, upon the use of large amounts of paper money, in which it was opposed by the English government. This trouble culminated in a crisis, including rioting, under Gov. Jonathan Bclcher in 1740, but the repayment to the colony by England of about £183.000 in sterling to cover its expenses in the capture of Louisburg enabled it to retire about £2,000,000 of its depreciated bills and establish itself on a firm money basis, a fact of great importance in its subsequent commercial development. Fortunes were accumulating, business operations were growing much larger in scale, Harvard had become liberal in thought and Connecticut, not Massachusetts, had become the last stand of the old religious ideas.

During the war there had been much smuggling and trading with the enemy, and the British government became more stringent in trying to enforce trade regulations. In 1756 it introduced a system of general search warrants, such as Massachusetts itself had had in force for eight years. Merchants who saw their profits endangered protested, and in 1761 James Otis made his famous and impassioned attack in court upon these writs of assistance, the strict legality of which was hardly open to question. Following the peace of 1763 and the need for readjusting the cost of maintaining and defending the empire, came the attempts to solve the problem.

Pre-Revolutionary War. — In 1765 Massachusetts was prominent among the Colonies which resisted the Stamp act. Samuel Adams of Boston, one of the ablest agitators and propagandists any country has produced, set himself to keep alive the flames of discontent, having made up his mind that the Colonies should be wholly independent of England. In his skillful manipulation of public opinion and emotion, and in his organization of the committees of correspondence, he probably did more than any other man to arouse the opposition of certain elements against England and to prevent the possibility of any reconciliation.

In 1768 royal troops were stationed in Boston and on March 5, 1770, a clash occurred between them and some citizens. of whom five were killed. The soldiers had been constantly subjected to taunts and abuse and on the whole had behaved well. In this incident a small mob had been the aggressors. Officers and men at once surrendered to the civil authorities and upon trial by the local court were acquitted, except two who received slight penalties for technical homicide. Samuel Adams and his party made the most possible of the "atrocity" and dubbed it the "Boston massacre."

In 1773 occurred the Boston Tea Party in which a band of citizens disguised as Indians boarded the ships carrying the tea and threw it overboard. In retaliation for this wanton destruction of private property (not considered necessary in any other colony), parliament passed the Boston Port bill, closing the port to commerce. The increasing agitation and violence of the mobs during this decade presaged more serious armed conflict.

Revolutionary War and After. — Gen. Thomas Gage was made governor and in April 1773 sent an armed force to Lexington and Concord to destroy military stores gathered at those places by the opposition. The force was attacked and completely routed by the country people, and Gage was practically besieged in Boston. In an effort to release himself the battle of Bunker hill was fought — actually on Breed's hill — June 17, resulting in a costly but psychologically complete victory for the Americans. The British loss was exceedingly heavy. In July Washington arrived at Cambridge to take command of all the troops, and soon after the scene of war shifted from Massachusetts and no important military action occurred within it for the rest of the struggle. During the whole of it blassachusetts contributed more liberally than any other colony in men and money, though military leadership. except for Gen. Henry Knox and Gen. Benjamin Lincoln, passed to other hands.

Two years of prosperity following the signing of peace in 1783 soon gave place to serious financial difficulty. particularly among the poor and heavily taxed farming class. Violence occurred in most counties and became especially serious in the western ones. Owing largely to the failure of the legislature either to suppress the insurrection or to redress grievances, the revolt gained headway. Many former Revolutionary soldiers and officers took part in it, among others Capt Daniel Shays. and because of his leadership the movement became known as Shays's rebellion. It was finally put down by aid of heavy forces under General Lincoln.

The incident was important as frightening the moneyed classes into accepting more readily the new federal constitution. This was ratified by only a very small majority in Massachusetts, which was considered a "pivotal state." After its adoption the state became strongly Federalist in politics.

19th Century.—A group of leading politicians, known as the "Essex Junto" and including such men as Fisher Ames. George Cabot, Timothy Pickering. John Lowell and others (all opponents of democracy and strongly reactionary), long dominated the politics of the state. They were utterly out of sympathy with the principles of the party in national power after 1800 and with the policy of war against England in 1812. As a commercial community the state suffered heavily from the embargo measures preced-

ing the war and it was characterized by extreme sectionalism and antinationalism during the war. Although New England held most of the specie of the country, it refused, in the main. to subscribe to the mar loans and Boston took only $75,000 of that of 1813 as compared with $7,000,000 subscribed in Pennsylvania. Although great numbers of its citizens supported the government, the policy of the state as a whole was distinctly obstructionist. Rumours of secession, which had been heard at intervals from 1800, seemed to find confirmation with the convening in 1814 of the Hartford convention to consider grievances against the federal government; it was mainly dominated by Massachusetts. The convention adjourned! however, doing little harm except to the reputations of those who had attended. The state also opposed the Mexican War of 1846–48 as it had the policy leading to it.

The period 1830–40 witnessed great social changes, among others the rise of the factory system and the substitution to a great extent of imported foreign for native American labour. It was a period of intellectual ferment and of social experiment. Utopian communities. such as Brook farm, were undertaken, and although they all ended in failure they left their mark on the thought and idealism of the times.

Under the lead of William Lloyd Garrison and Wendell Phillips, Massachusetts was in the van of the abolitionist movement. Such citizens as C. F. Adams and Charles Sumner took leading parts in the formation of the Free-Soil party, and when at last the Civil War came the state rallied to the support of the federal government in a spirit utterly different from that which had marked the two preceding ones. It has been stated that of the 159,165 men (including re-enlistments) whom the state sent to the war fewer than 7.000 were drafted.

Post-Civil War and Later History. — After the war the Republicans maintained a fairly continuous control until 1911. The industrialization of the state and the increasing domination of the cities by immigrant peoples strengthened the Democrats, and, except for the period 1916–28, they dominated the state in national elections. In 1928 Massachusetts was among the few supporters of Alfred E. Smith, and in all presidential elections from 1932 through 1948 continued to vote Democratic. Dwight D. Eisenhower won the state for the Republicans in the presidential elections of 1952 and 1956. As Republican governor in 1919, Calvin Coolidge (elected U.S. vice-president in the following year) came to national prominence when he put down with state troops a strike by the Boston police. Republican governor Christian A. Herter (1953–57) was named U.S. secretary of state by President Eisenhower in 1959. Herter was succeeded as governor by Democrat Foster Furcolo in 1957. In 1960 Sen. John F. Kennedy of Massachusetts, the Democratic presidential candidate, carried the state and the country in the general election.

Massachusetts Men and Women. — The influence of Massachusetts in life of the nation has been out of all proportion to its size and population. The roll of historians has been notable, including John Winthrop and William Bradford in the settlement period. Thomas Hutchinson in the Revolutionary one and culminating with Bancroft, Sparks, Prescott, Motley, Parkman, Thayer, Henry Adams (historian and philosopher) and Rhodes by adoption. In poetry Massachusetts produced R. H. Dana, Bryant, Longfellow. Whittier, Lowell! Holmes and Amy Lowell; in philosophy and theology. Jonathan Edwards, Channing, Emerson, Theodore Parker, William James and Mary Baker Eddy; in fiction, Harriet Beecher Stowe and Hawthorne; in education, Horace Mann, Charles W. Eliot and James Conant; in oratory and statesmanship. James Otis, John Adams: John Quincy Adams. Webster, Choate, Everett, Sumner and Wendell Phillips; in social reform, S. G. Howe and B. F. Sanborn; and in law, Story, Parsons, Shaw, Holmes, Gray, Brandeis and Frankfurter.

GOVERNMENT

The first government, other than that of the Plymouth settlement. was based upon the charter of 1629, which was intended to be merely the charter for a commercial company but mhich was twisted by the colonists into a political constitution.

The system of "towns" created became the most characteristic feature of the New England system. The word meant a "township," an area of considerable extent that might include several settlements. villages, etc. Each township had the right of sending deputies to represent it in the general court, as the legislature was styled. The affairs of the towns, including election of officers and representatives, were conducted in town meetings at which all citizens had the right to speak although the franchise was for long limited by religious requirements. The town meeting was a political school of prime importance and although the system has less significance now it has been abandoned slowly and with reluctance even in the larger places; Boston, for example, refused incorporation as a city until 1822, when it had a population of 47,000. There still remained. however, over 300 towns compared with only 39 cities in 1960. Among the larger towns, based on 1960 population figures. were Brookline, Arlington, Weymouth, Watertown and Framingham.

Representative government dates from 1634 and the general court (the legislative body) was divided into two chambers in 1644. The old charter was annulled in 1684 and a royal one, with a governor appointed by the crown. substituted in 1691. The government functioned under this until the Revolutionary period when, first, committees and, next, a provincial congress took over the duties. The constitution, adopted in 1780 and which calls the state a commonwealth, is the oldest of all state constitutions still in force. It has been amended frequently. Townships ceased to be represented as such after 1856. The franchise is enjoyed by citizens over 21 years old.

The last religious test even for officeholders was abandoned in 1821 and the last remnant of a property qualification in 1891 and sex distinction in 1924. A slight educational test can still be enforced. Massachusetts was the first state to adopt the blanket ballot in which the names of candidates are arranged alphabetically without party columns. A relic of colonial times is the council, a body elected to represent divisions of the state to assist the governor in executive functions. Its major power lies in its veto over gubernatorial appointments and pardons. In 1916 the jurisdiction of district or municipal courts was extended to run throughout the state.

Massachusetts has been a leader in the creation of boards and commissions whose functions extend to almost every department, such as the board of education (1837), of agriculture (1852), of railroad commissioners (1869), of health (1869), of statistics of labour, fisheries, game and charity (1879), of insanity (1879) and the dairy bureau (1891). Others have to do with prisons, highways, insurance, banking. ballot laws. voting machines, gas and electric companies, conciliation and arbitration in labour disputes, registration in dentistry, medicine and pharmacy, inspection of food and drugs, etc.

Almost all state employees are under civil service regulations, even in the smaller political subdivisions. There are rigid laws to prevent stock watering in all corporations of a semipublic sort. The Torrens system of land registration was adopted in 1898 and a court created for its administration. Municipal ownership of public utilities, particularly gas and electric light works, is permitted. There were more than 40 publicly owned utilities after mid-20th century. The state did notable work for municipalities in such matters as roads, docks, parks and water supply.

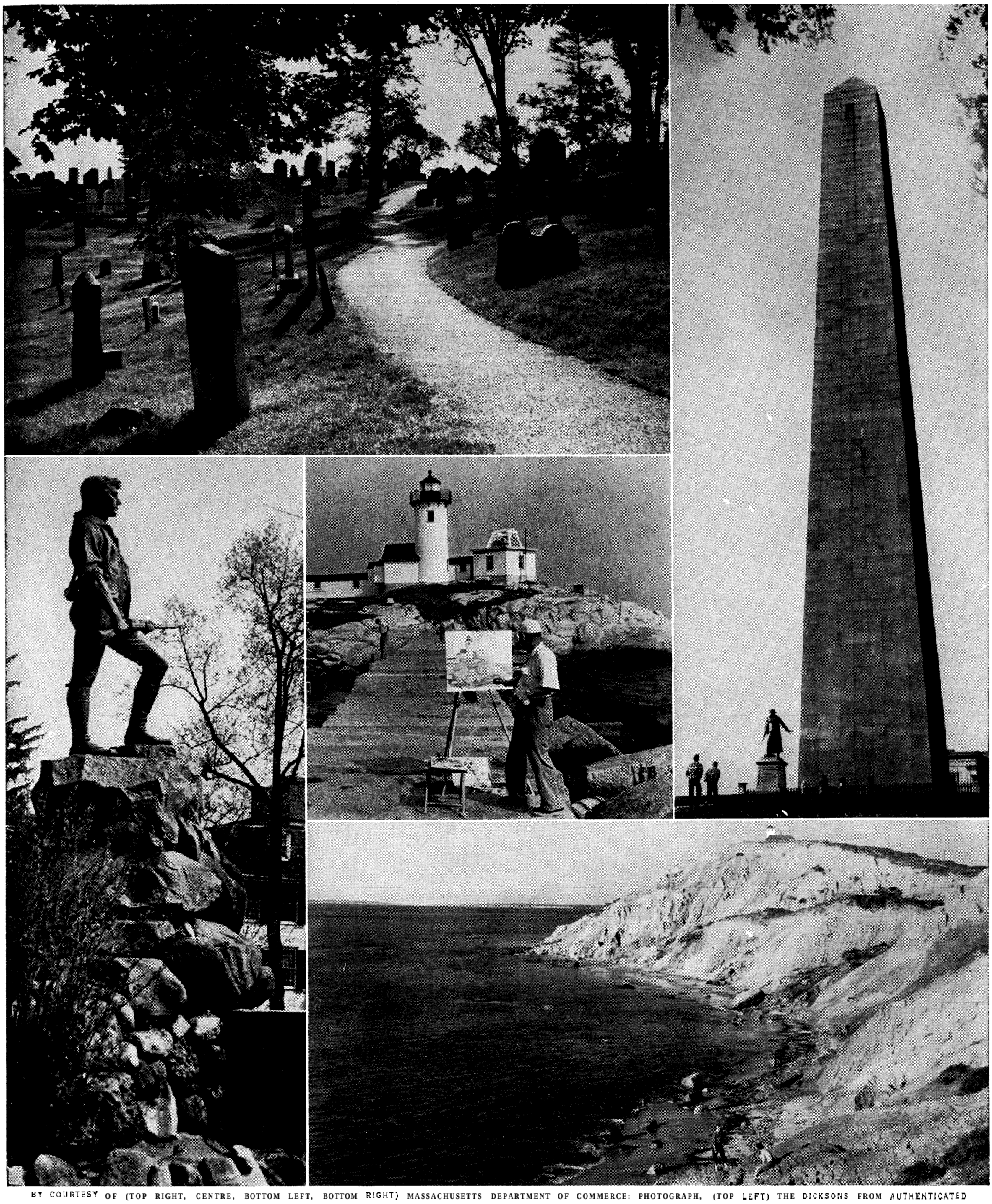
Finance. — In addition to real and personal property taxes, major sources of revenue in the 1960s were the state income taxes, corporation taxes, and motor-vehicle and trailer excise taxes. In 1959 the state began a payroll withholding system for state income taxes similar to that for federal income taxes.

POPULATION

In 1790 the population was 378.787. It grew to 994,514 by the census of 1850. and to 2,805,346 fifty years later. It was 4,316,721 in 1940, 4,690.514 in 1950 and 5,148,578 in 1960. The population in 1960 was nearly twice what it was in 1900.

In 1960 the state had 11 standard metropolitan statistical areas; Boston. Brockton. Fall River. Fitchburg-Leominster, Lawrence-Haverhill. Lowell, New Bedford, Pittsfield, Providence-Pawtucket, Springfield-Chicopee-Holyoke, and Worcester. These areas had a

MASSACHUSETTS



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HISTORIC AND SCENIC VIEWS OF MASSACHUSETTS

Top ieft: Burial hill, Plymouth, once the site of a fort and a church. Several of the Pilgrims are buried there

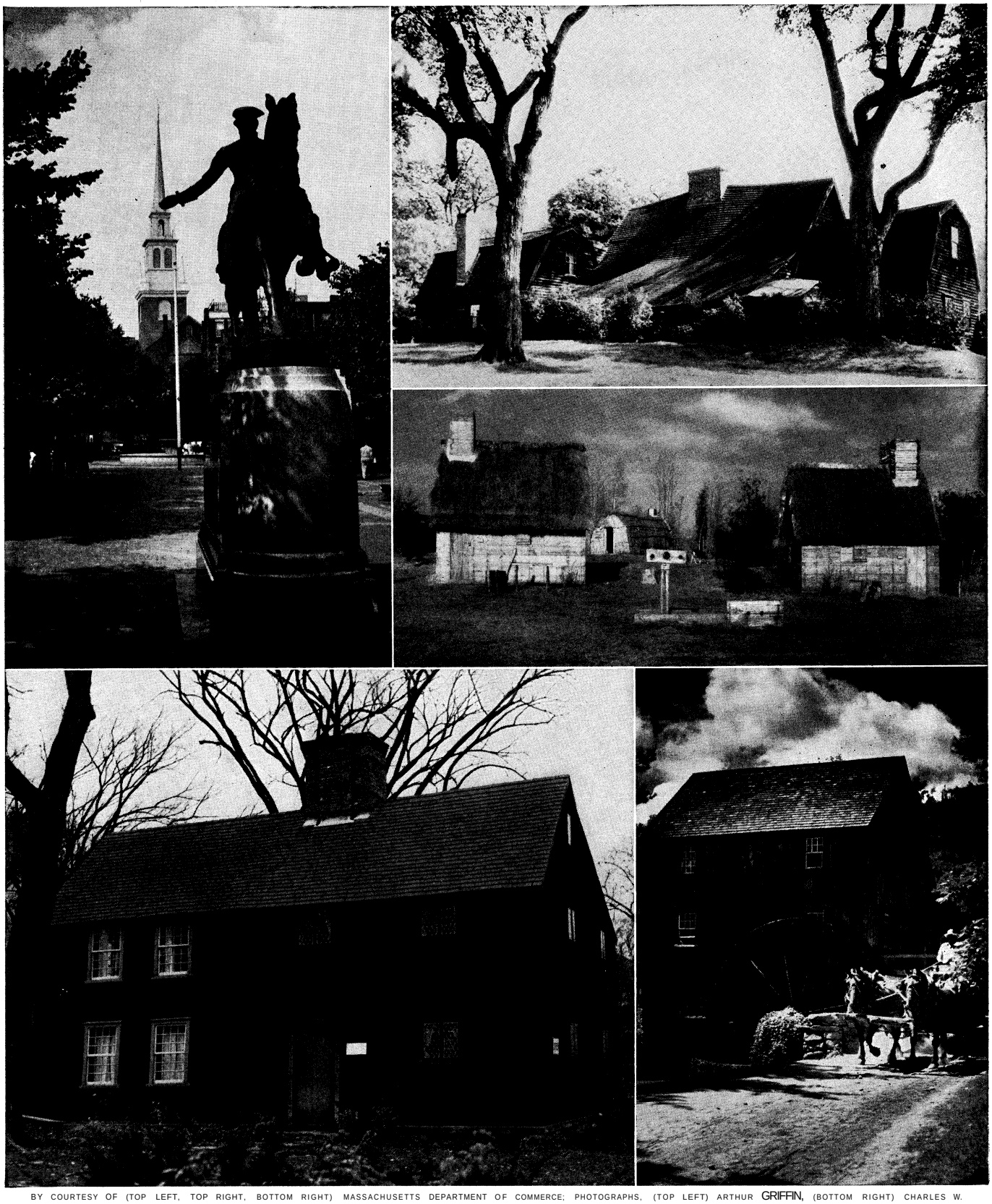
Top ***right:*** Bunker Hill monument at Charlestown, Boston, on the approximate site of the battle of Bunker Hill (1775). It is about **220** ft. high and **30** ft. square at the base

Centre: Artist from Gloucester summer art colony painting the Eastern Point lighthouse

Bottom left: Minute Man statue by H. H. Kitson on Lexington green, a level triangular area where the battle of Lexington was fought in 1775

Bottom right: Gay Head cliffs on Martha's Vineyard

MASSACHUSETTS



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SOME HISTORIC BUILDINGS OF MASSACHUSETTS

Top left: Paul Revere Mall and Hanover street, Boston, with statue of Paul Revere and restored steeple of Old North church in background

Top right: Shaded by giant elms, Fairbanks house at Dedham is one of the oldest wooden houses still standing in the United States. Its central structure was built in 1636

Centre right: Open-air museum at Salem shows pillory and stocks used for public punishment and thatched-roof houses similar to those built by 17th-century settlers

Bottom left: John Howland house, built in 1666, Plymouth

Bottom right: Grist mill at Old Sturbridge village

total population of 4,387,101 or 85.2% of the total population of the state.

The table gives comparative population figures for towns and cities over 5,000.

In 1960 the population per square mile was 623.5 compared with 568.1 in 1950; in 1950 it was 50.7 for the United States as a whole and in 1960 it was 49.6. In 1960 the population breakdown for Massachusetts was 4,308,044 urban, and 840,534 rural. There were 1,696,448 households in 1960. Ten years before there were 1,307,450 households with an average of 3.9 persons per household.

Of the total population there were 2.5% nonwhites in 1960. A breakdown of the six leading groups of the 576,452 foreign born in 1960 showed 26.6% from Canada. 15.1% from Italy, 13.4% from Ireland, 9.4% from the United Kingdom, 6.7% from Poland, 6.3% from the U.S.S.R. There were 2,663,101 females and 2,486,216 males in 1960. Of the total, 10.9% were over 65 years of age and 41.4% of those over 14 years of age were in the labour force.

*Massachusetts: Places of 5,000 or More Population (1960 census)**

Place	Population				
	1960	1950	1940	1920	1900
Total State	5,148,578	4,690,514	4,316,721	3,852,356	2,805,346
Adams	11,949	11,633	12,608	12,967	11,134
Amesbury	9,625	9,711	10,862†	10,036†	9,473†
Amherst	10,306	17,900	6,410†	5,550†	5,028†
Andover	15,878†	12,437†	11,122†	8,628†	6,813†
Arlington	49,953†	44,353†	40,013†	18,665†	8,603
Athol	10,161	9,708	11,180†	9,792†	7,061†
Attleboro	27,118	23,809	22,071	19,731	11,335†
Belmont	28,715†	27,381†	26,867†	10,749†	3,929†
Beverly	36,108	28,884	25,537	22,561	13,884
Boston	697,197	801,444	770,816	748,060	560,892
Braintree	31,069†	23,161†	16,378†	10,580†	5,981†
Brockton	72,813	62,860	62,343	66,254	40,063
Brookline	54,044†	57,589†	49,786†	37,748†	19,935†
Cambridge	107,716	120,740	110,879	109,694	91,886
Canton	12,771†	4,739	6,381†	5,945†	4,584†
Chelsea	33,749	38,912	41,259	43,184	31,072
Chicopee	61,553	49,211	41,664	36,214	19,167
Clinton	12,848†	12,287	12,440†	12,979†	13,667†
Concord	12,517†	8,623†	7,972†	6,461†	5,652†
Danvers	21,926†	15,720†	14,179†	11,108†	8,542†
Dedham	23,869†	18,487†	15,508†	10,792†	7,457†
Everett	43,544	45,982	46,784	40,120	24,336
Fairhaven	14,339†	12,764†	10,938†	7,291†	3,567†
Fall River	99,942	111,963	115,428	120,485	104,863
Fitchburg	43,021	42,691	41,824	41,029	31,531
Framingham	44,526†	28,086†	23,214†	17,033†	11,302†
Franklin	6,391	5,348	7,303†	6,497†	5,017†
Gardner	19,038	19,581	20,206	16,971†	10,813†
Gloucester	25,789	25,167	24,046	22,947	26,121
Greenfield	14,389	15,075	15,672†	15,462†	7,927†
Haverhill	46,346	47,280	46,752	53,884	37,135
Holyoke	52,689	54,661	53,750	60,203	45,712
Hudson	7,897	8,211†	8,042†	7,607†	5,454†
Hull	7,055†	3,379†	—	—	—
Hyannis	5,139	4,235	—	—	—
Ipswich	8,544†	6,895†	6,348†	6,201†	4,6581
Lawrence	70,933	80,536	84,323	94,270	62,559
Leominster	27,929	24,075	22,226	19,744	12,392†
Lexington	27,691†	17,335†	13,187†	6,350†	3,831†
Lowell	92,107	97,249	101,389	112,759	94,969
Lynn	94,478	99,738	98,123	99,148	68,513
Malden	57,676	59,804	58,010	49,103	33,664
Marblehead	18,521†	13,765†	10,856†	7,324†	7,582†
Marlborough	18,819	15,756	15,154	15,028	13,609
Maynard	7,695†	6,690	6,812†	7,086†	3,142†
Medford	64,971	66,113	63,083	39,038	18,244
Melrose	29,619	26,988	25,333	18,204	12,962
Methuen	28,114†	24,477†	21,880†	15,189	7,512
Middleborough	6,003	5,889	9,032†	8,453†	6,885†
Milford	13,722	14,396	15,388†	13,471†	11,376†
Milton	26,375†	22,395†	18,708†	9,382†	6,578†
Natick	28,831†	19,838†	13,851†	10,907†	9,488†
Needham	25,793†	16,313†	12,445†	7,012†	4,016†
New Bedford	102,477	109,189	110,341	121,217	62,442
Newburyport	14,004	14,111	13,916	15,618	14,478
Newton	92,384	81,994	69,873	46,054	33,587
North Xdams	19,905	21,567	22,213	22,282	24,200
Northampton	30,058	29,063	24,794	21,951	18,643
Norwood	24,898†	16,636†	15,383†	12,627†	5,480†
Oxford	6,985	3,238	—	3,820†	2,677†
Peabody	32,202	22,645	21,711	19,552	11,523†
Pittsfield	57,879	53,348	49,684	41,763	21,766
Plymouth	6,488	10,540	13,100†	13,045†	9,592†
Quincy	87,409	83,835	75,810	47,876	23,899
Randolph	18,900†	9,982†	7,634†	4,756†	3,993†
Reading	19,259†	14,006†	10,866†	7,439†	4,969†
Revere	40,080	36,763	34,405	28,823	10,395†
Salem	39,211	41,880	41,213	42,529	35,956
Saugus	20,666†	17,162†	14,825†	10,874†	5,084†
Sharon	5,888	2,815	—	—	—
Somerset	12,196†	8,566†	5,873†	3,520†	2,241†
Somerville	94,697	102,351	102,177	93,091	61,613
Southbridge	15,889	16,748	16,825†	14,245†	10,025†
Spencer	5,593	5,259	6,641†	5,930†	7,627†
Springfield	174,463	162,399	149,554	129,614	62,059
Stoneham	17,821†	13,299†	10,765†	7,873†	6,197†
Swampscott	13,294†	11,580†	10,761†	8,101†	4,548†
Taunton	41,132	40,109	37,395	37,137	31,036
Wakefield	24,295†	19,633†	16,223†	13,025†	9,290
Waltham	55,413	47,187	40,020	30,915	23,481
Ware	6,650	6,217	7,557†	8,525†	8,263†
Watertown	39,092†	37,329†	35,427†	21,457†	9,706†
Webster	12,072	12,160	13,186†	13,258†	8,804†
Wellesley	26,071†	20,549†	15,127†	6,224†	5,072†
Westfield	26,302	20,962	18,793	18,604	12,310
Weymouth	48,177†	32,690†	23,868†	15,057†	11,3241
Whitinsville	5,102	5,662	10,242‡	10,174‡	7,036‡
Whitman	10,485†	8,413†	7,759†	7,147†	6,155†
Williamstown	5,428	5,015	4,294†	3,707†	5,013†
Winchester	19,376†	15,509†	15,801†	10,485†	7,248†
Winthrop	20,303†	19,496†	16,768†	15,455†	6,058†
Woburn	31,214	20,492	19,751	16,574	14,254
Worcester	186,587	203,486	193,694	179,754	118,421

*Populations are reported as constituted at date of each census. †Township
‡Northbridge township, which includes the population of Whitinsville.
Note: Dash indicates place did not exist during reported census, or data not available.

EDUCATION

In the colonial period Massachusetts took the lead in popular education and was the first colony to found a college, but at no time in that period could Harvard compare with other new world universities such as those at Mexico City or Lima, Peru. The quality of New England colonial education has been greatly overestimated.

The real beginning of the state's modern system dates from about 1840, when the extremely bad situation everywhere in the schools of the country had aroused great criticism. At that time 29 of the richest towns in the state maintained no schools at all as they should have in accordance with the law. The school board was organized in 1837, and under the leadership of Horace Mann conditions improved rapidly. The system was still conducted in the second half of the 20th century under the general laws relating to education passed in 1920, with amendments.

There is a department of education "under the supervision and control of a commissioner of education. and an advisory board of education of six members, of whom at least two shall be women and one shall be a school teacher." The commissioner is appointed by the governor and council. The system includes common, high and normal schools, and all have a high reputation. Manual training from 1893 was part of the curriculum in all municipalities of more than 20,000 population. The state agricultural college at Amherst (incorporated 1863) became the University of Massachusetts in 1947. The first normal school (teachers' college) in the country was that founded at Lexington in 1839; a number of others were established later.

There are many private secondary schools of high standing, such as Phillips academy in Andover, and schools in Groton and Mount Hermon. The Roxbury Latin school, founded in 1645, is one of the oldest in the United States. Of the higher institutions of learning, besides Harvard (1636), may be mentioned Williams college (1791) at Williamstown, Amherst (1825) near Northampton, Boston university (Methodist Episcopal) at Boston (1839), Tufts university (1852) at Medford, Clark university (1887) at Worcester and Brandeis university (1947) at Waltham. For women there are Mount Holyoke (1837) at South Hadley, Smith college (1871) at Northampton, Wellesley college (1870) near Boston, Simmons college (1899) in Boston and Radcliffe college (1879) in connection with Harvard. Technical instruction is at Worcester Polytechnic institute (18651, Worcester, the Massachusetts Institute of Technology (1861). Cambridge, and other schools.

Libraries. — The Boston Public library (first city public library to be entirely supported by taxation) is one of the great scholarly libraries of the country open to the public and is the largest municipal free library in the world, specializing in Shakespeare, Americana and Spanish literature. Other notable libraries are the Massachusetts Historical society's library, rich in Americana manuscripts; the state library, with one of the finest collections in the world of the laws of foreign countries; the Boston Athenaeum, including Washington's library; the New England Historic Genealogical society library. mainly devoted to family history; various libraries connected with Harvard university; Essex institute library, Salem; and the American Antiquarian society library, Worcester, with the finest collection of bound newspapers in the United States as well as the blather library. There are other important technical libraries and rnany general ones of 100,000 or more volumes scattered throughout the state.

HEALTH, WELFARE AND CORRECTIONS

Many private charitable corporations report to the state department of public welfare and a large number of private infirmaries are subject to visitation by an inspector from the department. The Perkins Institution for the Blind is particularly notable for its historical association with Samuel Gridley Howe. Under the department of public welfare is the state infirmary at Tewksbury for dependents (1866). Under the department of public health are four tuberculosis sanatoriums at Rutland, Westfield, North Reading and Lakeville. The Pondville hospital is for cancer patients. The Massachusetts Hospital school is for the care and education of crippled and deformed children. The Lemuel Shattuck hospital is a chronic disease institution. Under the department of mental health are state hospitals for the insane at Worcester, Taunton, Northampton, Danvers, Westborough, Boston. Graiton, Medfield, Waltham and Foxborough, and a colony at Gardner; a hospital for epileptics at Monson; schools for the feeble-minded at Waverly, Wrentham and Belchertown; the Walter E. Fernald State school; and the Boston Psychopathic hospital.

The department of correction has a reformatory for women at Framingham, a state reformatory at Concord for men, a state prison at Walpole, a prison camp and hospital at Rutland, a state farm for petty criminals, defectives, delinquents and insane criminals at Bridgewater and a state prison colony at Norfolk. A modern state prison at Walpole replaced an ancient prison at Charlestown; many other penal plants. however, were in need of repair or replacement in the second half of the 20th century.

THE ECONOMY

Agriculture.—Conditions of soil and climate in Massachusetts are favourable for the raising of apples, small fruits, berries, potatoes, onions, market-garden vegetables and some kinds of tobacco. The average yield per acre ior potaloes, oats and tobacco is higher than the national average. In the mid-1950s the 17,000 farms in the state were less than half the number at the end of World War II, and the total acreage decreased to 1,440,000 as compared with 2,100,000 ac. in 1945. The average value per farm more than doubled in that period, however, increasing from about $7,000 to more than $16,000. Dairy products and eggs are the leading farm products in the state.

Industry.—There was little manufacturing in Massachusetts before the American Revolution. The state has always been the leader in the textile industry as well as other industries of importance. The first cotton mill was established at Beverly in 1788 and the first woolen mill at Byfield in 1794. The first power loom was set up in 1814 at Waltham.

With the improvement in machinery and the development of water power, the great centres of Lowell, Lawrence and Fall River arose in the 1830s. In the 20th century vast changes occurred in the industry of the state as a result of the transfer of much of the textile business to the south.

The leading industries in the 1960s were machinery, including electrical machinery manufacture; textile mill products; food and kindred products; and leather and leather goods. The state is noted for its footwear industry. After mid-20th century over one-third of the persons employed worked in manufacturing industries; the next largest field for employment was wholesale and retail trade.

Minerals. — The chief products of quarries in the state are building stone, monumental stone, trap rock and limestone. The principal granite quarries are in Quincy, Rockport, Westford and Milford, although granite is a common rock in Massachusetts and is found in every county except Barnstable, Dukes and Nantucket.

Commerce. — The cod fisheries have always been of prime importance in the economics of the state and formed one of the bases of the earliest commerce to Europe. Until 1785 when trade was opened with China and 1788 when trading began with the American northwest coast, trade was mainly with Europe, Africa, and the West Indies and American coast ports. Shipbuilding was always an important industry and with the rise of the clipper ships and the rich trade to the orient, merchants of Salem and Boston grew rapidly in wealth. Oning to great changes in the United States and in transportation facilities to the interior, Massachusetts fell behind many other states in foreign commerce.

Transportation and Communication. — In the 1960s the state was served by over 2,500 mi. of railroad track. 2,350 mi. of paved state highways and 25,700 mi. of all roads within the state. There were more than 100 municipal, commercial and private airports, of which Logan International airport in Boston was the most important.

In addition to separate articles on most places and persons of historical interest, mentioned under History, see also Index references under "Massachusetts" in the Index volume.

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Current statistics on production, employment. industry, etc., may he obtained from the pertinent state departments; the principal figures, together with the current history, are summarized annually in the *Britannica Book of the Year,* American edition.

(J.T.A.; L. SL.; R. C. BE.)

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, a U.S. institution of higher education and a research centre, was incorporated in 1861. It opened in Boston in 1865 and moved to Cambridge. Mass., in 1916. See CAMBRIDGE.

MASSAGE, meaning "to knead." constitutes one of the oldest forms of therapy. It depends for its influence upon controlled pressure and is generally accomplished by a "laying on of hands," although isolated applications afford few evidences of its full influence, From the 1920s physical therapy, of which massage constitutes a part, experienced an inquiry and development that gave it an important place in medical procedures.

The chief immediate influence of massage is in effecting a redistribution of fluids in the vascular and lymphatic channels. Normally the body exercises upon itself a form of automassage well illustrated in the muscles oi the legs which. during contraction, favour the return flow of blood by their pressure on the veins.

Massage partakes partly of the nature of exercise but one of its beneficial features is the fact that it is not accompanied by all the consequences of exercise. Exercise produces a systemic acidosis referable to the production of lactic acid by the muscles. Massage is not accompanied by acidosis and can be used even after exercise to expedite removal of those products that characterize acidosis. an influence widely appreciated by trainers of athletes and even of horses.

Heat is nidely used preparatory to massage to render the tissues hyperaemic and better adapted to response; but if applied suffi-

ciently to induce a systemic response, heat will cause alkalosis because of heightened respiration and elimination of carbon dioxide from the blood. Massage does not significantly influence respiration and therefore does not induce the alkalosis following the application of heat. Positive results of massage, however are dilatation of the vessels of the capillary beds and liberation of red cells and other blood elements from stagnant areas of the circulation.

Inspection under the microscope of the capillaries in a rabbit's ear subjected to massage. reveals sticking of many leucocytes to the vessel wall and passage of some into the tissues beyond. The lymphatics, in which the flow of lymph is normally very sluggish, also experience under massage an increase of flow sometimes of great significance in regions which are the site of chronic disease. The influence on the finer blood vessels is partly the result of pressure, but also of stimulation of the sympathetic nervous system and the liberation of acetylcholine or histamine. nhich cause dilatation of the capillaries. Systemic massage is accompanied by diuresis, particularly if the abdomen is included There may then occur an increase in the excretion of nitrogen, inorganic phosphorus and sodium chloride.

The lightest form of massage, with which most treatment should begin, is known as effleurage. This consists of light stroking, centripetally, and should proceed to the heavier stroking which constitutes massage proper. Another form, known as pétrissage, consists of a seizure by the hands of muscles or other tissues which are then subjected to a process of kneading. A form of massage in which the tissues are struck sharp blows is known as tapotement.

The widest applications of massage, which should always be under medical supervision, are probably to local injuries s ~ as sprains or fractures. Following fracture, even into a joint, massage can be instituted a day or two after the accident with the result that limitation of motion and deformities are less likely to occur.

Systemic application of massage is practised less frequently but the fullest benefit can be achieved only when the body as a whole is subjected to it. Dilatation of various capillary beds, both superficial and deep, determines redistribution of blood in many parts of the body, and may induce lassitude. Rest following treatment constitutes an essential feature of massage of any kind.

Massage is indicated in a variety of disease states. General debility in the elderly, secondary anaemia, cardiovascular decompensation and certain forms of arthritis and muscular rheumatism may be favourably influenced by skilful massage. In pitting oedema massage may be useful in helping to restore tissue fluids to the vascular channels. In flaccid paralysis massage may be helpful in maintaining better tone of the muscles. In local use, great care must be exercised lest it operate as an additional irritant to already traumatized or diseased tissues. In systemic massage care must be exercised lest in disturbing stasis of blood and lymph in various regions, or in displacing tissue fluids present in increased amounts, there occurs undue absorption of accumulated detritus.

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(RH. P.)

MASSASOIT (1580–1661), chief of the Wampanoag Indians, was born in the present limits of Massachusetts about 1580. His tribe of several thousand had been almost destroyed by an epidemic, supposed to be yellow fever, just before the arrival of the Mayflower. In March 1621, an Indian, Samoset, appeared at Plymouth and to the surprise of the Pilgrims spoke to them in English. He arranged for a meeting between his chief, Massasoit, and Governor Bradford. Massasoit appeared a week later, and signed a treaty of peace with the white men which remained inviolate for 54 years. In 1623, when he had been very ill, Edward Winslow visited him and effected a cure. In return for this kindness Massasoit revealed the plot of a neighbouring tribe to destroy the white men. See *A. G.* Weeks, *Massasoit of the Wampanoags* (1919).

MASSAWA, or MASSOWAH, chief port of Eritrea, in 15° 36' N. and 39° 28' E. Pop. (1956 est.) 26,627. It stands at the north end of the bay of Massawa and is built partly on a small coral island of the same name and partly on the islets of Tautlub and Sheik Said, and the neighbouring mainland. The harbour, which affords good anchorage, was greatly improved by the Italians. Fifteen vessels can be anchored simultaneously. The town possesses many good buildings. chiefly built of coral. After 1912 a railway connected Massawa with Asmara, the capital of the colony. Massawa is the port for northern Ethiopia, of which Eritrea after 1952 was a part.

The trade consists normally in exporting hides, butter, cotton, coffee and civet, and importing textiles, foodstuffs and manufactured goods. In 1935 Massawa became the base for the Italian expedition against Ethiopia (See ERITREA). In 1937, 976 ships used the port, landing 1,078,711 tons of cargo and embarking 81,622 tons. It was at Massawa (Matzua, as it is called by the Portuguese chroniclers) that Christopher da Gama and his comrades landed in July 1541 on their way to aid the Ethiopians against the Moslem invaders. Captured by the Turks in 1557, the island remained a Turkish possession more than 200 years, although James Bruce found in 1769 that the governor was paying half the customs receipts to the negus of Ethiopia in return for the protection of that monarch. At the close of the 18th century Massawa was held by the sharif of Mecca, and it afterward passed to Mohammed Ali of Egypt. The Turks were reinstated about 1850, but in 1865 they handed the island back to Egypt for an annual tribute of 2,500,000 piastres. In Feb. 1885 Massawa was occupied by an Italian force, the Egyptian garrison stationed there being withdrawn in the November following. It was the capital of the colony until 1900 when the seat of administration was removed to Asmara. It was captured by the British on April 7, 1941, when it was found that much of the port equipment had been destroyed and 23 ships and three dry-docks had been sunk in the harbour.

(P. W. I.)

MASSÉNA, ANDRÉ, duke of Rivoli, prince of Essling (1756–1817), the greatest of Napoleon Bonaparte's marshals, was the son of a small wine merchant. He was born at Nice on May 6, 1756 and began life as a cabin boy, but in 1775 he enlisted in the Royal-Italien regiment. He quickly rose to be under-officer-adjutant; but he left the army in 1789, retired to his native city, and married. He left Italy, and joined the 3rd battalion of the volunteers of the Var in 1791, and by February 1792 was a lieutenant-colonel. He served in the army which occupied Nice, and in the advance to the Apennines which followed, his knowledge of the country and of the people was so useful that in December 1793 he was already a general of division. He won the battle of Saorgio in August 1794, and after many successes, on Nov. 23, 1795, he had the greatest share in the victory of Loano, won by Schérer over the Austrians and Sardinians. In Bonaparte's great campaign of 1796–97 Masséna was his most trusted general of division and won the crowning victory of Rivoli. During this campaign Bonaparte gave him the title of *enfant chéri de la victoire,* which he was to justify till he met the English in 1810. In 1798 he commanded the army of Rome for a short time, but was displaced by the intrigues of Berthier. Masséna's next important service was in command of the army in Switzerland, which united the army in Germany under Moreau, and that in Italy under Joubert. The archduke Charles and Suvórov, who had each been successful in Germany and in Italy, now turned upon him. He held his ground well against the archduke, and then suddenly, leaving Soult to face the Austrians, he transported his army to Ziirich, where, on Sept. 26, 1799, he entirely defeated Korsakov. This campaign and battle placed his reputation on a level with that of his compatriot Bonaparte, and he might have made the revolution of Brumaire, but he was sincerely attached to the repubiic, and had no ambition. Bonaparte, now First Consul, sent him to command the débris of the army of Italy, and he defended Genoa from February to June to the very last extremity, giving time for Bonaparte to strike his great blow at Marengo. He now went to Paris, where he sat in the Corps Législatif in 1803, and

actually defended Moreau without drawing upon himself the ill-will of Napoleon, who well knew his honesty.

Marshal of France.— In 1804 he was made one of the first marshals of France of the new régime, and in 1805 was decorated with the Grand Eagle of the Legion of Honour. In that year Napoleon chose Masséna to keep in check the archduke Charles in Italy, while he advanced through Germany with the grand army. Masséna kept the archduke occupied till he received news of the surrender of Ulm, and then on Oct. 30. defeated him in the battle of Caldiero. After the peace of Pressburg, Masséna was ordered to take possession of the kingdom of Naples, and to place Joseph Bonaparte on the throne. He then distinguished himself in Poland. In 1808 he was made duke of Rivoli. In the campaign in 1809 at the battle of Aspern-Essling his magnificent leadership made what might have been an appalling disaster into a mere reverse of which the enemy could make no use. At Wagram Masséna, too ill to ride, directed from his carriage the movements of the right wing He was created prince of Essling, and given the castle of Thouars.

Campaign in **Spain.**—Masséna was then ordered to Spain to "drive the English into the sea." (For campaigns of 1810 and 1811, the advance to and the retreat from Torres Vedras *see* PENINSULAR WAR) Masséna himself, with some justice, ascribed his failure to the frequent disobedience of his subordinates Ney, Reynier and Junot. Though unsuccessful Masséna kept his army for five weary months close up to Wellington's impregnable position before retiring. His retreat through a devastated country was terrible, but his force of character kept his men together, and Ney showed his best side in brilliant rear-guard actions, until dismissed for a new act of insubordination. Soon Masséna was again ready to try his fortune, and he nearly defeated Wellington at Fuentes d'Oñoro, though much hampered by Bessières. His recall soon followed this and he returned home to find his prestige gone. The old marshal felt he had a right to complain of Ney and of Kapoleon himself, and, it is said, opened communications with Fouché and the remnant of the republican-party. Kapoleon gave his greatest marshal no more employment in the field, but made him a territorial commandant at Marseilles. Louis XVIII. :confirmed him in this command. When Napoleon returned from Elba, Masséna, probably by the advice of Fouché, kept Marseilles quiet to await events, the greatest service he could do the royalists, but afterwards imputed to him as a fault. After the second restoration Masséna was summoned to sit on the court-martial which tried Marshal Ney, but refused. He died on April 4, 1817, and was buried in Père-la-Chaise, with only the word "Masséna" upon his tombstone.

See Thiebault's *Éloge funèbre,* and Koch's *Mémoires de Masséna* (4 vols., 1849), a valuable work, carefully compiled. In more modern times E. Gachot has produced several important works dealing with Masséna's campaigns.

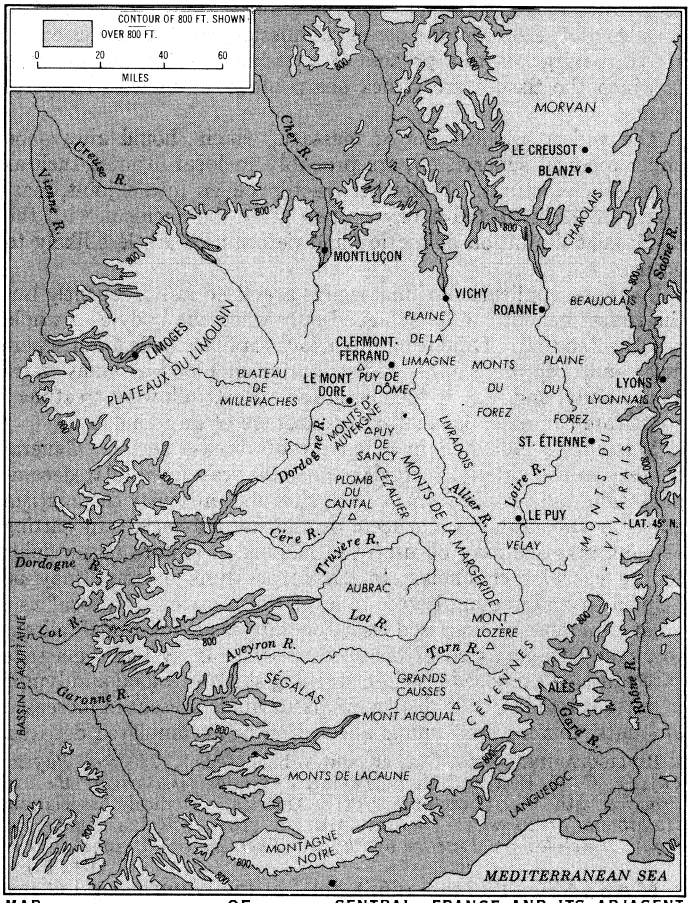
MASSENET, JULES EMILE FREDERIC (1842–1912), French composer, was born at Montaud, on May 12, 1842. He studied at the Paris Conservatoire, where he obtained the Grand Prix de Rome in 1863 with the cantata *David Rizzio.* Massenet's operas include *Hérodiade,* five acts (Brussels, 1881); *Manon,* five acts, opéra comique (1884); *Le Cid,* four acts, opéra (1885); *Esclarmonde,* four acts, opéra comique (1889); *Le Mage,* five acts, opéra (1891); *Werther,* four acts (Vienna, 1892); *Thai's,* three acts, opéra (1894); *Le Portrait de Manon,* one act, opéra comique (1894); *La Navarraise,* two acts (Covent Garden, 1894); *Sapho,* opéra comique (1897); *Le Jongleur de Notre Dame* (Mentone, 1902). hlassenet also wrote oratorios, orchestral suites. and songs. He was professor of composition at the Conservatoire from 1878 to 1896. His opera *Panurge* was written just before his death in Paris on Aug. 13, 1912.

A full bibliography of his works is given in Séré, *Musiciens français d'aujourd'hui* (2nd ed. 1921). *See* also J. E. F. Massenet, *My Recollections* (Boston, 1919); R. Brancour, *Massenet* (1922); L. Schneider, *Massenet 1842–1912* (1926).

MASSEY, WILLIAM FERGUSON (1856–1925), New Zealand statesman, was born at Limavady. County Derry. Ire., on March 26. 1856. His parents emigrated to New Zealand when he was six, and eight years later he joined them at Tamaki. He went on the land. and later: as president of the huckland Agricultural and Pastoral society, began to play a prominent part in public life. He entered parliament in 1894 as member for Waitemata. and in 1903 became leader of the Conservative opposition to Seddon and Sir Joseph Ward. In 1912 he defeated the ministry and formed a cabinet. Thereafter he played a dominating part in the dominion's affairs. During World War I, at the head of a strong coalition ministry. Massey led New Zealand with conspicuous ability and foresight, and. when peace came. enforced unpopular economies. In 1919 he was the representative of New Zealand at the peace conference in Paris. He died on May 10. 1925.

MASSIF CENTRAL, an upland area in the south-central part of France. It is bordered by the lowlands of Aquitaine and the Loire basin on the west and northwest. and by the valley of the Rhône and Saône rivers on the east and its southern edge overlooks the Mediterranean coastlands of Languedoc. It is conventionally demarcated by the 1,000-It. contour and in area it occupies about one-sixth of France (33,000 sq.mi.). The highest peak is the Puy de Sancy (6.188 ft.), while to the south of this lies the Plomb du Cantal (6,096 it.). The greater part of the massif, however, consists of plateaus lying between 2,000 and 3,000 ft.

About three-quarters of the region is underlain by crystalline



MAP SHOWING REGIONS OF MASSIF CENTRAL, FRANCE AND ITS ADJACENT AREAS

rocks, mainly granite, gneiss and schist. The structures found in this basement were produced by the Hercynian earth movements. and in this respect the massif may be compared with certain other European regions. *e.g.,* Britanny or the Vosges. Resting on the crystalline basement in some areas are sedimentary deposits of a later age, such as the Jurassic limestones of the Causses or the Tertiary sands and clays of the upper Allier and Loire valleys. One of the most recent episodes of geological history in the massif was characterized by volcanic activity. continuing into the early Quaternary period and giving rise to the great volcanic cones and

lava plateaus of Auvergne, Velay, etc. All the volcanoes are now extinct.

For long periods of geological time much of the massif was exposed to denudation; this resulted in the formation of extensive plateaus at various altitudes. The older of these are now deeply dissected by river valleys. The highest parts of the massif have also been glaciated; small cirques and moraines occur in Mt. Dore and in the Cantal.

In the Massif Central are the sources of several of the larger French rivers: the Loire and the Allier rise in Auvergne; the Cher. Creuse and Vienne originate in Limousin; the Dordogne. Lot and Tarn flow westward into Aquitaine; and numerous smaller rivers in the east contribute to the Rhône-Saône drainage.

Physiographic Regions.—The diversity of geological structure is reflected in the variety of regions found nithin the massif. Four broad divisions can be recognized.

The Eastern Margins overlook the Rhône-Saône trough and Languedoc in a marked fault-line scarp and consist mainly of crystalline uplands. Morvan in the north reaches 2,959 ft.; southward, in order, lie the divisions of Autunois, Charolais (the lowest part of the eastern margins, averaging only 1,500 ft.). Beaujolais (up to 3,320 ft.), Lyonnais and Vivarais (5,089 ft.). The last tuo are separated by the St. Étienne depression. The Cévennes continue the region southward from Vivarais; their eastern scarp face is intensely dissected and they rise to the granite summits of Mt. Aigoual (5.141 ft.) and Mt. Lozère (5,584 ft.). Heath and moorland occupy the higher parts of the eastern margins and the scenery at such elevations is characterized by bleakness. Snow often lies for several months of the year. At lower levels, especially in Morvan and the Citvennes, considerable areas are forested. The natural forest of beech, oak and chestnut has been greatly depleted by clearing, but more recently there has been extensive development of state forests, mainly of the conifers. On the slopes of the Citvennes below 1,500 ft., Mediterranean scrub forest occurs, with mulberries and olives planted on the lowest parts.

The emphasis in farming throughout the whole region is pastoral; cattle are especially important in Charolais and Lyonnais, reared for both meat and milk. In the Cévennes, sheep are dominant and large numbers move up to the higher pastures from Languedoc in the summer. Vineyards and orchards are found on the loner eastern slopes from Charolais southward; the orchards produce peaches, apricots, plums and cherries, and the vineyards of Beaujolais and Charolais are the source of many of the famous Burgundy wines.

The *Western Margins* bordering the Aquitaine lowlands include Limousin in the north where a plateau bevels the crystalline rocks at 1,500–2,500 ft., but rises to 3,209 ft. in the Millevaches plateau. Rough grassland and heath are extensive on the exposed plateaus and the relatively high rainfall coupled with the impermeable bedrock is responsible for the frequent occurrence of peat bogs and pools of water. Sheep and hill cattle are kept on the poorer areas, while the more favoured parts support increasing numbers of the famous Limousin cattle which are bred for beef and veal. In the southwest of the massif lies Ségalas, another crystalline plateau similar in elevation to Limousin and named after rye (*seigle*) which was formerly its main crop. The Montagne Noire and the Monts de Lacaune, projecting from the southwest of the massif, are prominent crystalline massifs rising to almost 4,000 ft.

Arable farming in the western margins is limited by low temperatures on the uplands and by poor soils on the crystalline rocks, though liming and fertilizing have in places made great improvements (*e.g.*, in Ségalas). Wheat, potatoes and fodder crops are generally the main products.

The Central Region consists mainly of Auvergne and has a greater diversity of scenery than the other regions. Three basic types of structure can be recognized: first, the crystalline massifs, such as Forez. Livradois and Margeride (up to 5,380 ft.); secondly, the volcanic regions of Les Puys (a chain of recent ash or lava cones, culminating in the Puy de Dôme, 4.806 ft.), Mt. Dore and Cantal (large volcanic cones, originally comparable in size with Vesuvius and Etna respectively, but greatly dissected by subsequent erosion), Cézallier and Aubrac (basaltic plateaus rising to over 4,500 ft.), and Velay (consisting of lava plateaus flanking the basin of Le Puy with its striking volcanic hills); thirdly, the down-faulted Tertiary basins of Limagne, the Forez plain and Roannais.

These variations in relief and geology are among the factors responsible for the different types of land use in Auvergne. Rough pasture and moorland occupy the high ground; forest is not usually found above 4,000 ft., though it is extensive at lower levels in many areas. Considerable numbers of cattle ark kept, mainly for dairy produce, and full use is made of the higher mountain pastures in summer. Many distinctive cheeses, such as Cantal and St. Nectaire, are produced in Auvergne. There is also much arable farming in the valleys; wheat, barley, oats, potatoes and sugar beet are important crops and market gardening is practised near the large towns. Vineyards and orchards occupy favoured slopes, particularly around the basins of Forez and Limagne.

The *Limestone Regions* principally in the south of the massif have distinctive characteristics associated with the permeability of the limestone and the resultant general lack of surface moisture and drainage. The largest of the limestone regions is the Grands Causses, where the Jurassic limestones are beveled by extensive peneplained surfaces at 2,500–3,500 ft. On these uplands, the scenery is unattractive, with scanty vegetation, except for some recent forest plantations. The area is, however, trenched by the imposing gorges of the Tarn, Lot and their tributaries, in some places up to 2,000 ft. in depth. The Tarn and Lot rise outside of the limestone region and maintain a continuous flow of water, though the volume is much reduced in summer.

The main economic importance of the Causses lies in the sweet but scanty pasture on the limestone plateaus, which supports fair numbers of sheep and some cattle. Roquefort cheese, made from ewes' milk! is a well-known product of the region. Arable farming is confined to depressions in the plateau surface where some soil has collected. Small orchards and vineyards are found on south facing slopes within the deep gorges.

Mining and Industry.—Coal is the most important mineral produced in the massif, but the deposits are comparatively small and scattered since only restricted patches of Carboniferous rocks have survived subsequent periods of erosion. The coal fields at St. Etienne, Ales and Blanzy each produce between 2,500,000 and 3,500,000 tons a year. Small-scale mining of metal ores is associated with the crystalline rocks, such as lead and haematite in the Cévennes, zinc (refined at Viviez) in Ségalas and pyrites in Lyonnais. At St. Yrieix, south of Limoges, there are china clay deposits worked since 1755.

The coal fields have given rise to important steelworks, now using pig iron from Lorraine. The development of steelworks in the massif has been helped by strategic considerations, the sites selected being less vulnerable than those near France's north-eastern frontiers. Manufacture of armaments, locomotives, machinery and other metal goods is carried on in the St. Étienne region, at Le Creusot and Montluçon. The second most important industry is that of rubber, established by Michelin at Clermont Ferrand and employing about 18,000 workers. A smaller Dunlop rubber factory is located at Montluçon. At Limoges, the porcelain industry has long been famous for its fine products. Various textile industries are widespread in the massif: those connected with silk and rayon are of considerable importance in towns within 30 mi. of Lyons (including St. Étienne) and at Roanne. Other industries are concerned with the manufacturing of bricks and tiles, furniture, paper, leather goods, glass, lace, etc., often using local raw materials.

Electricity for industry and other consumers comes both from thermal power stations and from hydroelectric installations. In the latter 1950s, one-third of France's hydroelectricity was generated in the massif, mainly from large plants on the Dordogne, Cère, Truyère, Lot and Tarn, whose gorgelike valleys provide ideal dam sites. Problems of seasonal variation in river discharge have been partially overcome by the construction of barrages in series.

Population.—The population is unevenly distributed over the massif. The largest conurbation is centred around St. Étienne, this area as a whole containing about 300,000; Clermont Ferrand

and Limoges come next in size. In contrast, there are areas which are virtually uninhabited including some plateaus over 3,000 ft. and parts of the Causses. Lozère has the lowest population of any *département* in France. The more agriculturally productive areas possess a more' dispersed population and numerous market towns. There are also tourist centres, such as Vichy, La Bourboule and Royat.

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MASSILLON, JEAN BAPTISTE (1663–1742), French bishop and preacher, was born at Hyères on June 24, 1663, his father being a royal notary of that town. At the age of 18 he joined the Congregation of the Oratory and taught for a time in the colleges of his order at Pézenas and Montbrison and at the seminary of Vienne. In 1693 he was placed at the head of the famous seminary of St. Magloire. He soon gained a wide reputation as a preacher and mas selected to be the Advent preacher at the court of Versailles in 1699. He was made bishop of Clermont in 1717, and two years later was elected a member of the French Academy. The last years of his life were spent in the faithful discharge of his episcopal duties; his death took place at Clermont on Sept. 18, 1742. Massillon enjoyed in the 18th century a reputation equal to that. of Bossuet and of Bourdaloue, and has been much praised by Voltaire, D'Alembert and kindred spirits among the Encylopaedists. He has usually been contrasted with his predecessor Bourdaloue, the latter having the credit of vigorous denunciation, Massillon that of gentle persuasiveness. Besides the *Petit Carême,* a sermon which he delivered before the young king Louis XV in 1718, his sermons on the Prodigal Son, on the small number of the elect, on death, for Christmas day and for the fourth Sunday in Advent may be perhaps cited as his masterpieces.

The first edition of Massillon's complete works was published by his nephew, also an Oratorian (Paris, 1745–48), and upon this, in the absence of manuscripts, succeeding reprints were based. A modern edition is that of the Abbé Blampignon, 4 vol. (Paris, 1865–68; new ed., 1886).

MASSILLON, a city of Stark county, eastern Ohio. U.S., on the Tuscarawas river. 8 mi. W. of Canton. It is an important manufacturing centre! its principal products being electric furnace alloy steels, stainless steels, cold-drawn steels, evaporators, household wares, surgeons' rubber gloves, lock washers and automobile parts. It is also a major centre for the production of mass advertising materials.

Massillon was founded in 1826 with the advent of the Ohio and Erie canal and became the greatest "wheat city" of the state. It was incorporated as a city of second class in 1853 and as a city of first class in 1868. The public library, housed since 1937 in a structure of modified Georgian design, is connected architecturally and administratively with the Massillon museum, which occupies the oldest building in Massillon, the remodeled residence of James Duncan, founder of the city. The city was named after Bishop Jean Baptiste Massillon of France. A state hospital for the insane is located there. For comparative population figures *see* table in OHIO: *Population.* (E. T. HE.)

MASSIMO or MASSIMI, a Roman princely family of great antiquity, said to be descended from the Maximi of republican Rome. The name is first mentioned in 1012 in the person of Leo de Maximis, and the family played a considerable part in the history of the city in the middle ages. The brothers Pietro and Francesco Massimi protected the German printer Ulrich Hahn, who went to Rome in 1467.

In the 16th century the Massimi were the richest of the Roman nobles. A marquisate was conferred on them in 1544, and the lordship of Arsoli in 1574. Two branches of the Massimi survived, viz., the Principi Massimo, descended from Camillo Massimiliano (1770–1840), and the dukes of Rignano, descended from Francesco Massimo (1773–1844). The Palazzo Massimo, one of the finest Renaissance buildings in Rome, was built by Baldassare Peruzzi for Pietro Massimo, on the ruins of a palace destroyed in the sack of Rome in 1527.

MASSINE, LEONIDE (1896–), Russian dancer and choreographer noted for the wit and style of his characterizations, was born in Moscow on Aug. 9. 1896.

He developed the symphonic ballet, as in *Les Présages* (Tschaikovsky's Fifth) and *Choreartium* (Brahms's Fourth), and excelled in staging light, sparkling ballets such as *Gaîté Parisiènne* and *Le Beau Danube.*

Massine graduated from the Imperial Ballet school, but had almost decided to renounce dancing for acting when Sergei Diaghilev. seeking a replacement for Vaslav Nijinsky, whom he had just dismissed. invited him to join his company. After further training under Enrico Cecchetti, Massine made his debut in *La Légende de Joseph* in 1914.

Diaghilev supervised Massine's artistic education, taking him to museums and concerts, and encouraged his choreographic talent. His first ballet was *Le Soleil de Nuit* (1915). For the Diaghilev company he created such masterpieces as *Le Tricorne* and *La Boutique Fantasque.*

From 1932 to 1938, Massine was principal dancer and choreographer of the Ballet Russe de Monte Carlo. Disagreements with its director, Col. Wassily de Basil, led Massine to resign and form the new Bzllet Russe de Monte Carlo, which he headed until 1942. Later he appeared with the American Ballet Theatre and the Royal Ballet of England.

In 1960 he produced *Commedia Umana,* a ballet version of Boccaccio's *Decameron,* for the Nervi festival, in Italy. (LN. ME.)

MASSINGER, PHILIP (1583–1640), English dramatist, son of Arthur Massinger or Messanger, was baptized at St. Thomas', Salisbury, on Nov. 24, 1583. He entered St. Alban hall, Oxford, in 1602. His father was attached to the household of the 2nd earl of Pembroke, but on the succession of William Herbert in 1601 it has been suggested that the patronage ceased. On the other hand, a Wood says that he went to Oxford at Lord Pembroke's expense. Massinger left Oxford without a degree in 1606. His father had died in 1603, and he was perhaps dependent on his own exertions. He went to London to work as a dramatist, but his name cannot be definitely affixed to any play until 15 years later, when *The Virgin Martyr* (entered at Stationers' hall, Dec. 7, 1621) appeared as the work of Massinger and Dekker. During these years he worked in collaboration with other dramatists. From 1613 Massinger apparently worked regularly with John Fletcher. although in editions of Beaumont and Fletcher's works his co-operation is usually unrecognized.

Sir Aston Cokayne, Massinger's constant friend and patron, refers in explicit terms to this collaboration in a sonnet addressed to Humphrey Moseley on the publication of his folio edition of Beaumont and Fletcher *(Small Poems of Divers Sorts,* 1658). After Philip Henslowe's death in 1616 Massinger and Fletcher began to write for the King's Men. Between 1623 and 1626 Massinger produced unaided for the Lady Elizabeth's Men then playing at the Cockpit three pieces, *The Parliament of Love, The Bondman* and *The Renegado.* With the exception of these plays and *The Great Duke of Florence,* produced in 1627 by the Queen's Servants. Massinger continued to write regularly for the King's Men until his death. S. R. Gardiner, in an essay on "The Political Element in Massinger" (*Contemp. Review,* Aug. 1876), maintained that Massinger's dramas are before all else political.

In 1631 Sir Henry Herbert, the master of the revels, refused to license an unnamed play by Massinger because of "dangerous matter as the deposing of Sebastian, King of Portugal," calculated presumably to endanger good relations between England and Spain. There is little doubt that this was the same piece as *Believe as You List,* in which time and place are changed, Antiochus being substituted for Sebastian, and Rome for Spain.

Massinger seems to have supported the democratic views of his patron, the earl of Montgomery, who was an enemy of Buckingham. In *The Bondman,* dealing with the history of Timoleon, Buckingham is satirized as Gisco. The servility toward the crown displayed in Beaumont and Fletcher's plays reflected

the temper of the court of James I. The attitude of Massinger's heroes and heroines toward kings is very different. Camiola's remarks on the limitations of the royal prerogative (*Maid of Honour*, act iv, sc. v) could hardly be acceptable at court.

Massinger died suddenly at his house near the Globe theatre, and was buried in the churchyard of St. Saviour's, Southwark, on March 18, 1640.

The supposition that Massinger was a Roman Catholic rests upon three of his plays, *The Virgin Martyr* (licensed 1620), *The Renegado* (licensed 1624) and *The Maid of Honour* (*c.* 1621). *The Virgin Martyr*, which deals with the martyrdom of Dorothea in the time of Diocletian, cannot be relied on. It is not entirely his work, and the story is early Christian, not Roman Catholic. In *The Renegado*, however, the action is dominated by the beneficent influence of a Jesuit priest, Francisco, and the doctrine of baptismal regeneration is enforced. In *The Maid of Honour* a complicated situation is solved by the decision of the heroine, Camiola, to take the veil. His plays have generally an obvious moral intention. He sets himself to work out a series of ethical problems through a succession of ingenious and effective plots. In the art of construction he has, indeed, few rivals. But the virtue of his heroes and heroines is rather morbid than natural, and often singularly divorced from common sense. His *dramatis personae* are in general types rather than living persons, and their actions do not appear to spring inevitably from their characters, but rather from the exigencies of the plot. The heroes are too good, and the villains too wicked to be quite convincing. Moreover their respective goodness and villainy are too often represented as extraneous to themselves. This defect of characterization shows that English drama had already begun to decline. He contributed, however, at least one great and popular character to the English stage. Sir Giles Overreach, in *A New Way to Pay Old Debts*, is a sort of commercial Richard III, a compound of the lion and the fox, and the part provides many opportunities for a great actor. He made another considerable contribution to the comedy of manners in *The City Madanz.* In Massinger's own judgment *The Ronzan Actor* was "the most perfect birth of his Minerva." It is a study of the tyrant Domitian, and of the results of despotic rule on the despot himself and his court.

Massinger was a student and follower of Shakespeare. The form of his verse, especially in the number of run-on lines, approximates in some respects to Shakespeare's later manner. He is rhetorical and picturesque, but rarely rises to extraordinary felicity. His verse is never mean, but it sometimes comes perilously near to prose, and in dealing with passionate situations it lacks fire and directness.

The plays attributed to Massinger alone are: *The Duke of Milan, a Tragedy* (*c.* 1618, produced 1623 and 1638); *The Unnatural Combat, a Tragedy* (c. 1619, pr. 1639); *The Bondman, an Antient Storie* (licensed 1623, pr. 1624); *The Renegado, a Tragaecomedie* (lic. 1624, pr. 1630); *The Parlianzent of Love* (lic. 1624; ascribed, no doubt erroneously, in the Stationers' Register, 1660, to W. Rowley; first printed by Gifford from an imperfect manuscript in 1805); *A New Way to Pay Old Debts, a Comoedie* (*c.* 1625, pr. 1632); *The Ronzan Actor, A Tragaedie* (lic. 1626, pr. 1629); *The Maid of Honour* (dating perhaps from 1621, pr. 1632); *The Picture, a Tragecomedie* (lic. 1629, pr. 1630); *The Great Duke of Florence, a Comicall Historie* (lic. 1627, pr. 1635); *The Emperor of the East, a Tragaecomoedie* (lic. and pr. 1631), founded on the story of Theodosius the Younger; *Believe as You List* (rejected by the censor in January, but licensed in May, 1631; pr. 1848–49 for the Percy society); *The City Madam, a Comedie* (lic. 1632, pr. 1658), which Fleay *(Biog. Chron. of the Eng. Drama,* i, 226), however, considers to be a *rifaciamento* of an older play, probably by Jonson; *The Guardian* (lic. 1633, pr. 1655); and *The Bashful Lover* (lic. 1636, pr. 1655). A *Very Woman, or The Prince of Tarent,* licensed in 1634 as the work of Massinger alone, is generally referred to his collaboration with Fletcher.

Twelve plays of Massinger are said to be lost, but the titles of some of these may be duplicates of those of existing plays. Five of these lost plays were manuscripts used by John Warburton's cook for pie covers. The numerous plays in which Massinger's co-operation with John Fletcher is generally assumed are dealt with under BEAUMONT AND FLETCHER.

Massinger's independent works were collected by Coxeter, 4 vol. (1759; rev. ed. with introduction by Thomas Davies, 1779), by J. Monck Mason, 4 vol. (1779), by William Gifford, 4 vol. (1805, 1813); by Hartley Coleridge (1840), by Cunningham (1867), and selections by Arthur Symons in the "Mermaid Series" (1887–89). Gifford's remains the standard edition, and formed the basis of Cunningham's text. It contains "An Essay on the Dramatic Writings of Massinger" by John Ferriar.

For detailed criticism *see* A. W. Ward, *History of English Dramatic Literature*, iii, 1–47 (1899); F. G. Fleay, *Biographical Chronicle of the English Drama* (1891), under *Fletcher;* and Koeppel in *Canzbridge History of English Literature*, vol. vi; a general estimate of Massinger, dealing especially with his moral standpoint, is given in Sir Leslie Stephen's *Hours in a Library*, 3rd series (1879). Full discussion of the disputed plays will be found in A. H. Cruickshank, *Philip Massinger* (Oxford, 1928); *see* also the list which will be found at the end of ch. 5, *Cambridge History of English Literature*, vol. vi (1910).

MASSINISSA (*c.* 238–149 B.C.), king of Massylian or eastern Numidia, was educated at Carthage. His kingdom, though nominally independent of Carthage, was imbued to a very considerable extent with Carthaginian civilization; Massinissa, though a barbarian at heart, had a varnish of culture, and the craft and cunning in which Carthaginian statesmen were supposed to excel. While yet a young man (212) he forced his neighbour Syphax, prince of western Numidia, who had recently entered into an alliance with Rome, to fly to the Moors in the extreme west of Africa. Soon afterward he appeared in Spain, fighting for Carthage with a large force of Numidian cavalry against the Romans under the two Scipios. The defeat of the Carthaginian army in 206 led him to cast in his lot with Rome. Scipio Africanus is said to have cultivated his friendship. Massinissa now quitted Spain for a while for Africa, and was again engaged in a war with Syphax in which he was decidedly worsted, but after Scipio's arrival in Africa in 204 Massinissa crushed his old enemy Syphax and captured his capital, Cirta (Constantine).

Here occurs the romantic story of Sophonisba, daughter of the Carthaginian Hasdrubal, who had been promised in marriage to Massinissa but had subsequently become the wife of Syphax. Massinissa, according to the story, married Sophonisba immediately after his victory, but was required by Scipio to dismiss her as a Carthaginian and consequently an enemy to Rome. To save her from such humiliation he sent her poison, with which she destroyed herself. Massinissa was now confirmed by Scipio in the possession of his kingdom. In the battle of Zama (202) (*see* PUNIC WARS), he commanded the cavalry on Scipio's right wing. For his services he received the kingdom of Syphax, and thus under Roman protection he became master of the whole of Numidia, and his dominions completely enclosed the Carthaginian territories. It would seem that he had thoughts of annexing Carthage itseli with the connivance of Rome. In a war which soon followed he was successful; the remonstrances of Carthage with Rome on the behaviour of its ally were answered by the appointment of Scipio as arbitrator; but, as though intentionally on the part of Rome, no definite settlement was arrived at. Rome, it is certain, deliberately favoured its ally's unjust claims with the view of keeping Carthage weak, and it was Massinissa's policy, as soon as Carthage seemed to be recovering itself, to excite the fears of Rome, till at last the Third Punic War (149) ended in the final overthrow of Carthage. The king died soon after its commencement.

Massinissa converted a plundering tribe into a settled and civilized population. To his sons he bequeathed a well-stored treasury, a formidable army and even a fleet. Cirta *(see* CONSTANTINE, ALGERIA), his capital, became a famous centre oi Phoenician civilization. In fact Massinissa changed for the better the whole aspect of a great part of northern Africa. His fidelity to Rome was merely that of temporary expediency.

MASSON, DAVID (1822–1907), Scottish man of letters, was born at Aberdeen on Dec. 2, 1822, and educated at the grammar school there and at Marischal college. He studied theology at Edinburgh university under Thomas Chalmers. He gave up his intention to enter the ministry and became editor of the *Banner*, a weekly paper advocating Free Church principles. After two years he returned to Edinburgh, becoming a frequent contributor to *Fraser's Magazine*, *Dublin University Magazine* (in which appeared his essays on Chatterton) and other periodicals. In 1847 he went to London, where he became secretary (1851–52) of the Society of the Friends of Italy. In 1852 he was appointed professor of English literature at University college, London, and from 1858 to 1867 edited the newly established *Macmillan's Magazine*. From 1865 to 1895 he occupied the chair of rhetoric and English literature at Edinburgh and promoted the movement for university education of women. In 1879 he became editor of the *Register of the Scottish Privy Council*, and in 1893 he was appointed historiographer royal for Scotland. His magnum opus is his *Life of Milton in Connexion With the History of His Own Time*, 6 vol. (1859–80). He also edited the library edition of Milton's *Poetical Works*, 3 vol. (1874), and De Quincey's *Collected Works*, 14 vol. (1889–90). He died on Oct. 6, 1907.

Among his other publications are *Essays, Biographical and Critical* (1856; reprinted with additions, 3 vol. 1874); *British Novelists and Their Styles* (1859); *Drummond of Hawtkornden* (1873), *Chatterton* (1874); and *Edinburgh Sketches* (1892). *See* the autobiographical *Memories of London in the Forties* (Edinburgh, London, 1908) and G. A. Macmillan (ed.), *Letters of Alexander Macmillan* (Glasgow, 1908).

MASSON, FRÉDÉRIC (1847–1923), French historian and academician, was born in Paris on hlarch 8, 1847. He is best knonn for his books on Napoleon. In *Napoléon inconnu* (1895), Masson, with Guido Biagi. brought out the unpublished writings (1786–93) of the future emperor; these were notes, extracts from historical, philosophical and literary books and personal reflections.

His other works include several books on Josephine; *Napoléon et* sa *famille,* 9 vol. (1897–1907); *Napoléon et son fils* (1904); and *Autour de l'ile d'Elbe* (1908). Masson died in Paris on Feb. 19, 1923 A bibliography of his uorks, including anonymous ones and those under an assumed name, was published by G. Vicaire, *Manuel de l'amateur des livres du XIX^e siècle,* tome v (1904).

MASS PRODUCTION. The term mass production refers primarily to methods of organizing manufacturing processes to attain high output rates. Typically, both mechanization of production processes — the substitution of machine operations for manual work — and application of appropriate systems of industrial administration are involved. Although some of the more striking examples of mass production are provided by giant enterprises, high output production techniques are not restricted to large industrial organizations. The essential features of mass production are: (1) manufacture of standardized commodities; (2) long production runs; (3) continuous plant operation; (4) use of specialized production and material-handling equipment; (j) plant arrangements minimizing material handling and based on the particular sequence of operations required for the production of the standardized product; (6) division of labour to the point nhere most production workers perform short and simplified operation sequences repetitively; (7) systematic planning, direction and control of manufacturing operations. When these characteristics are present. output per time period and per norker are both high compared with the output rates obtained by small-lot, custom production in plants having nonsequential layouts and little specialization of jobs and equipment.

EVOLUTION OF MASS PRODUCTION

While mass-production methods in the approximate iorm they are known today first began to be applied on a wide scale in the U.S. at the opening of the 20th century, their origins are much older and wider. Factory production with considerable division of labour existed in western Europe long before the general employment of powered equipment for manufacturing processes which began with the industrial revolution of the 18th and 19th centuries. There are even accounts of manufacturing methods from as early as the 13th century which indicate that arrangements much like the assembly line of the 20th century were then used for outfitting ships and making weapons.

Several streams of technical, managerial and social development culminated in modern mass production. Expansion of basic scientific knowledge and associated improvement of technology opened up new technical possibilities for invention and innovation in production in the form oi new and improved materials, more efficient manufacturing processes, and equipment designed to operate faster and more accurately while lasting longer. The coming to dominance of the corporate form of enterprise allowed aggregation of large amounts of capital in continuous and stable organizations able to conduct long-term programs of product and process development. Beginning with the scientific management movement of the early 20th century, industrial management increasingly emphasized conception and perfection oi methods for analysis of industrial operations leading to elimination of waste and promotion of efficiency. Many of the analytical tools available to managers of the late 1950s—motion and time study, job analysis, budgeting and cost accounting, equipment selection and replacement study, production planning and scheduling—basically are refinements of those used or suggested by the pioneers of scientific management. The philosophy of mass production which emerged, as managerial and technical proficiency increased, is that output expansion, quality improvement and cost reduction achieved through improvement of methods and investment in plant and equipment should be major goals of industrial enterprise. In mass-production economies which give expression to this philosophy, wage rates and living standards tend to rise in step with productivity increases so that expansion of output tends to be cumulative.

Clearly, mass production is as much a market phenomenon as anything else, for it implies mass consumption. Urbanization, widening of educational opportunity, reduction of inequalities in income distribution, social and geographical mobility oi the population and other influences which induce homogeneity in tastes and patterns of consumption both impel mass production for mass markets and are furthered by it. As individual manufacturing firms and industries concentrated on large-scale production, a system of pervasive industrial specialization evolved in which firms may mass produce and sell in industrial markets one or a few items used in turn as materiais or components by other producers whose products ultimately find their uay to consumers through a highly developed distributive system comprising several levels of wholesaling and retailing.

PLANNING FOR MASS PRODUCTION

In any variety of production a certain amount oi planning necessarily precedes conduct of operations. Time and effort must be devoted to determination of product characteristics, quantity of output, production methods, equipment to be employed and other aspects of the manufacturing process before work can begin. Thorough, oiten elaborate, planning must be completed in advance oi mass-production operations and it is the high ratio of long-range planning to planning for day-to-day operation which sharply differentiates representative mass-production enterprises irom other types, Manuiacturing establishments which produce mainly to customers' orders often shiit much of the burden of product conception and design to the buyer.

Similarly, small-lot producers escape inventory expense at the cost of convenience to purchasers of their products. Mass-production enterprises, in contrast, must anticipate the future flow oi orders both in respect to product varieties and quantities and oiten must produce to build up inventories. The flexibility of general-purpose equipment which permits quick production shifts must be sacrificed in large part for the efficiency which comes from use of special-purpose equipment. Because of the large investments which must be made in plant and equipment and because of the oiten lengthy intervals irom decisions to proceed with product development and plant construction to attainment of expected rates of production and to repayment of plant and equipment costs, a potentially high and stable demand permitting long production runs without major changes in products generally is regarded as necessary. Continuous and intensive use of plant ior reduction of fixed cost per unit of output requires that pronounced seasonal fluctuations or other variations in demand be at a minimum. The market risks in equipping for mass production of new products obviously are great. Even conversion to high-volume methods for established products is not without risk.

Standardization of products, materials, processes, equipment and other iactors of production is as integral a part of mass production as interchangeability of product components is a key requirement for specialization oi operations. The degree to which production processes can be broken down to simple operations which workers can periorm with increased speed and accuracy is determined by the final effect on total production time. Hand fitting, rework and repair of product components and multiple inspections must he eliminated as iar as possible ii gains from division of labour and mechanization are not to be offset. Elimination of needless product variety, reduction of the total number of individual parts that must be made in order to turn out a series of product sizes, maximum utilization of specialized and expensive equipment units, minimization of material and parts inventories and avoidance of repetitive design and manufacture of but slightly differing items are hut a few of the advantages which stem from well-conceived company, industry and national programs of industrial standardization.

Proper standards for dimensions and other properties of materials and parts are the basis ior sampling inspection and statistical control of quality, measures which can contribute to cost reduction in mass manufacture. Standardization, however, must be planned carefully in co-ordination with every other plan of production to assure that standards for products and processes are neither premature, overly rigid nor excessively narrow.

The visible results of the comprehensive planning for mass-production operations are production and assembly lines, combinations of work stations, machines and material handling equipment arranged for continuous flow oi units from raw material to finished product. In designing a production line, the sequences of operations for manufacture of each product component are determined, man-machine combinations for each manufacturing step are provisionally decided, and plans or models of proposed physical arrangements are prepared ior study. Each movement oi material is scrutinized in detail, simplified or shortened if possible and crossflows and backtracking eliminated. Operations are balanced by so setting work assignments, numbers of machines and operating rates that all stations along the line have the same production rate. Where their use is indicated, mechanical or gravity conveyors are selected to couple the work stations. Auxiliary departments and plant services are planned in conjunction with the production layout to maximize convenience and ease of maintenance. The end in view is a set of production facilities capable of performing as an integrated unit with no bottlenecks and with minimum flow times and distances.

Operation of an automobile assembly line epitomizes mass production. Starting with a bare chassis, components are attached successively as the growing assemblage moves along the conveyor which paces all operations. Feeder lines on which parts are matched into subassemblies intersect the main line to deliver body parts, running gear, engines and other assemblies. Each worker along the line performs his job as the units move past and each part and tool is delivered to its point of use in exact synchronization with the line. An intricate system of production scheduling and control ensures that

the right body type and colour, trim, engine and optional equipment arrive together for assembly, for a number of individual assembly combinations are on the line simultaneously. The automobiles driven off the end of the line under their own power consist of parts which a few weeks before were raw materials, a few days before were unfinished in a distant supplier's plant, and were starting down the line but a few minutes before

In the most modern automobile plants, as has been true in such continuous process industries as petroleum refining and chemical manufacture for some time, many of the production lines are almost completely mechanized and workerless, consisting almost entirely of automatic, self-regulating equipment. A new word, "automation," was coined to describe the process of making machines to run machines and the growing technology of automatic control is having a dramatic impact throughout the mass-production industries. As the promise of automation for high and sustained rates of output is made a reality, the terms automation and mass production are likely to become virtual synonyms.

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MASS SPECTROSCOPY. The term "mass spectroscopy" is used to denote that field of physics in which the motion of charged atoms and molecules in electric and magnetic fields is used to sort those atoms and molecules according to their atomic masses. The instruments used for this purpose are called mass spectrometers and mass spectrographs. The two instruments differ only in their method of rendering the sorted charged particles (ions) observable. In the mass spectrometer, the sorted ions are detected electrically; in the mass spectrograph, they are detected photographically or by other nonelectrical means. The term "mass spectroscope" is used in a loose sense to include both types of machines. A person who specializes in the use of these instruments is called a mass spectroscopist.

There are a number of quite different instruments which can also sort out atomic masses but which do not depend on the motion of ions in electric or magnetic fields. By the 1950s these instruments were also classed as mass spectrometers but with a prefix added; they included the microwave absorption mass spectrometer, the nuclear induction mass spectrometer, the molecular mass spectrometer and the optical mass spectrometer. These instruments will not be discussed further here, but it should be noted that many of the problems which the mass spectrometer has solved could also be solved through the use of these instruments.

There are a large number of problems to which the mass spectrometer has been applied. They include the identification of the isotopes of the chemical elements; the relative abundances of these isotopes; the precise masses of the isotopes; the radiations emitted by those isotopes which are radioactive; the electronic structure of the atom; the forces with which molecules are held together; the energy of transition from the solid or liquid to the gaseous state; surface chemistry; the dating of geological samples as related to the origin of mineral deposits and of continent growth; and isotopic tracers as tools in chemical, biological and medical research. Beginning about 1940 the methods of mass spectroscopy were applied on a large scale to the preparation of separated isotopes (U^{235}) and to chemical analysis of gases, particularly to hydrocarbons in the oil industry.

Historical Mass Spectroscopy. — In 1886 E. Goldstein, experimenting with electrical discharges in gases at low pressures (a neon light is a well-known example of such a discharge), observed that if a hole was placed in the negative electrode, the luminous discharge extended through that hole into the gas behind. He concluded that this luminosity was due to some sort of ray or beam which travelled through the hole from the discharge in the opposite direction from the then known cathode rays; and, by analogy to their method of production, he named them *Kanalstrahlen.* In 1898 W. Wien showed that these beams could be deflected by magnetic fields. This fundamental property served as the basis of a large part of the subject of mass spectroscopy. An ion beam, homogeneous as to energy or velocity, of small mass is deflected more sharply by the magnetic field than one of larger mass with the same energy or velocity (fig. 1); *i.e.,* the ions are sorted according to mass by deflection in a magnetic field alone.

A series of investigations was carried out from 1907–13 by J. J. Thomson using simultaneous parallel electric and magnetic fields. With this arrangement of fields an ion beam is resolved into a series of more or less complete parabolas. each characteristic of ions of one mass. The limitation of the simple magnetic deflection noted above (*i.e.,* that the energy or velocity of the ions in the beam be constant) is removed. With this "parabola" instrument Thomson investigated the ions formed by electrical discharges in a number of gases. He renamed the rays "positive rays" on the basis that most of the ions he observed had positive charges. Thomson's apparatus could separate ions differing in mass by 1 part in 15. His investigations in 1913 gave the first indication that the element neon was made up of a mixture of two kinds of atoms (isotopes) that differed in mass by two atomic mass units.

The equipment summarized above is all analogous to the pinhole camera in optics; *i.e.,* no focusing is involved and definition of the ion beams is only as good as the pinhole is small. The next advance

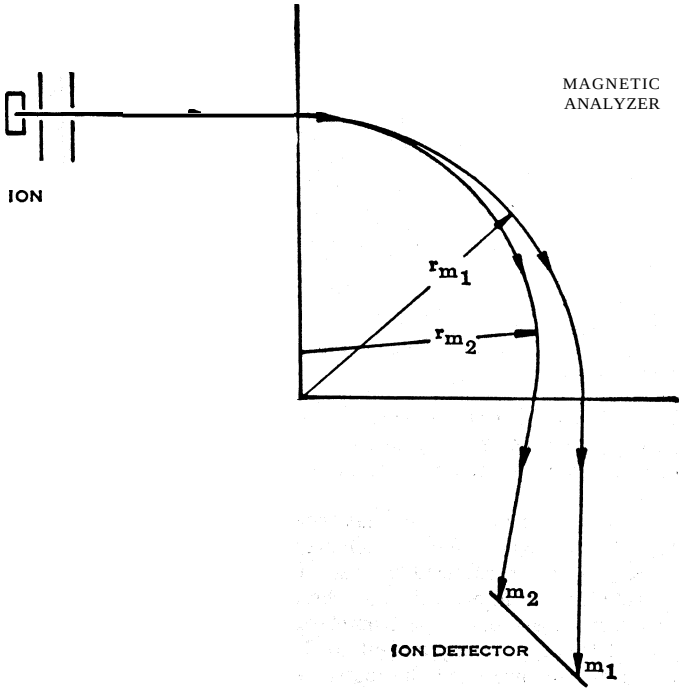

FIG. 1.—DIAGRAM SHOWING THE TRAJECTORIES IN A MAGNETIC FIELD OF TWO PERFECTLY COLLIMATED ION BEAMS HAVING THE SAME ENERGY BUT

came in the years 1918–19 with the introduction of focusing types of mass sensitive instruments. The use of ion lenses so improved the resolving power and sensitivity of the instruments that by 1920 the instruments had become practical tools for physical research. In 1918 A. J. Dempster introduced the first of these focusing analyzers. In his analyzer, magnetic deflection was used in such a way that an ion beam, homogeneous as to energy or velocity, diverging from a defining slit was refocused after passing through the magnetic field, different masses being brought to focus at different points (fig. 2). This type of focusing, analogous to a cylindrical lens in optics, is called direction focusing. In 1919 F. W. Aston introduced the second of these focusing analyzers. In his analyzer (fig. 3), successive electric and magnetic fields were oriented in such a way that all perfectly collimated ions of one mass were brought to focus independent of their velocity. This type of focusing is called velocity focusing. Because these machines recorded the different mass ions as a spectrum of lines on a photographic plate displayed as successive masses, Aston in 1920 introduced the term "mass spectrum" and termed the instruments "mass spectrographs." These designations, with some expansion, became the standard designations. With these two types of machines, which in 1920 were able to resolve masses that differed by 1 part in 100, the isotopic compositions of many of the elements

were investigated and the first measurements of precise atomic masses were made. By 1954 instruments based on the direction focusing principle were able to resolve masses differing by 1 part in 2,500 and had become the standard tool for isotopic abundance measurements.

In 1935–36 Dempster. K. T. Bainbridge and J. Mattauch introduced machines using successive electric and magnetic fields arranged in such a way that ion beams inhomogeneous in both direc-

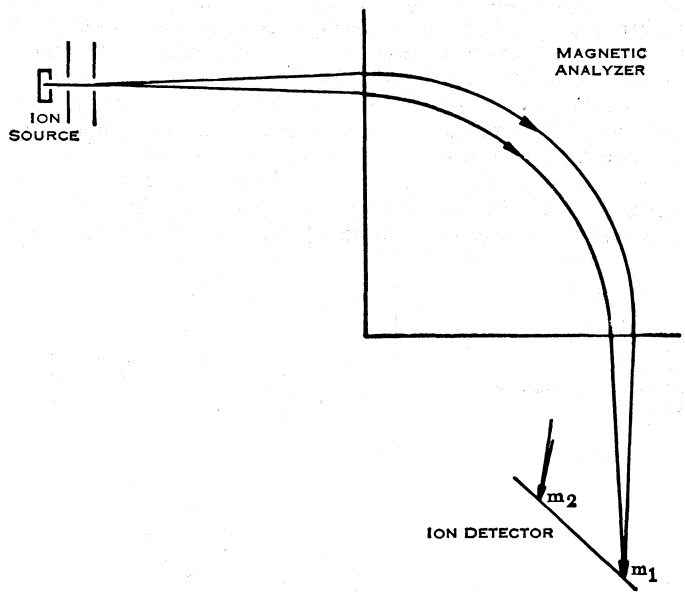

FIG. 2.— DIAGRAM SHOWING THE DIRECTION FOCUSING ACTION AND MASS SENSITIVITY OF A MAGNETIC FIELD FOR ION BEAMS HOMOGENEOUS AS TO ENERGY

tion and velocity were refocused. Such focusing is termed double focusing. By the mid-1950s instruments based on this principle were able to separate ions differing in mass by as little as 1 part in 60,000.

All the above methods of mass spectroscopy involve the use of electric and magnetic fields which are invariant with time. In 1932 W. R. Smythe introduced the use of alternating electric fields to separate ions of different mass. These instruments are called radio frequency or RF mass spectrometers. By the 1950s the development of this type of equipment by J. A. Hipple, S. Goudsmit and L. Smith had improved the instruments to the point where they could separate ions differing in mass by as little as 1 part in 100.000.

Experimental Mass Spectroscopy.— An experiment with a mass spectrometer involves: (1) the production of an ion beam characteristic of the sample under investigation with an *ion source;* (2) separating that ion beam into various mass components with a *mass analyzer;* and *(3)* rendering observable the resolved ion beams with an *ion detector.* There are a number of variations of each of the above parts and any combination of the three parts is classed a mass spectrometer. A typical combination is shown in fig. 2.

ION SOURCES FOR MASS SPECTROSCOPY

The production of an ion means in its simplest case the detachment of one or more electrons from a neutral atom. The production of an ion beam from such ions is accomplished by accelerating the ions with electric fields and directing them through small holes or slits. The beam which comes through the slit is thus collimated by the slit and has an energy or velocity which can be computed from the voltage through which the ions were accelerated. There are, however, a number of different mechanisms for producing the ions themselves and it is from this standpoint that different sources differ.

Gaseous Discharge Ion Source.— The gaseous discharge ion source was used almost exclusively until 1920. It was developed by Goldstein in 1886 and was improved by Wien, Thomson, Aston and others. In this source, ions are produced by a gaseous discharge maintained. in a gas at low pressures, by high voltage maintained betneen two electrodes. The ions so produced are accelerated by the field producing the discharge and pass through a hole located in the electrodes as an ion beam. Although this source is simple in concept and construction, no complete theoretical explanation has been made despite a great deal of work and numerous articles on the subject. By 1940 the source had been completely replaced by other sources which are simpler in theory and its place relegated to one of occasional special applications.

Solid Loaded Gas Discharge.— The source noted above is limited in application to the ionization of elements and compounds which have appreciable vapour pressures at room temperature. This limitation is removed by the methods introduced in alternate forms by E. Gehrcke and O. Reichenheim in 1906 and by Bainbridge in 1932. The method is based on the introduction of the solid material to be analyzed into small holes drilled in the anode or cathode of a gas discharge ion source. Operation of the gaseous discharge in the supporting gas evaporates and spatters the solid material into the discharge chamber as ions and as neutral atoms. Further ionization takes place in the discharge itself. Again the source depends on a gaseous discharge so that the limitations are quite similar to that of the simple gas discharge source.

Gaseous Discharge in a Magnetic Field.— The use of magnetic fields with gas discharges is based on a pressure-measuring device developed by F. M. Penning (1937). One useful arrangement of the source is shown in fig. 4. Ionization in this source is accomplished through electron bombardment of gases. It is different from the gaseous discharges noted above in the addition of a magnetic field which serves to trap the electrons in the discharge region. An electron appearing near the centre of the surface of one of the cathodes is accelerated toward the anode. The presence of the magnetic field, however, restricts the motion to follow the direction of that field. The electron, thereiore, passes completely through the anode and on toward the cathode on the opposite side. Since it is repelled by that cathode, it reverses its trajectory and returns to its original starting point. If at any point along that

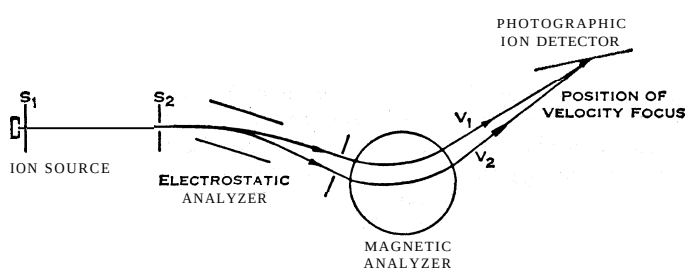

FIG. 3.—DIAGRAM OF THE MASS SPECTROMETER USED BY F. W. ASTON. SLITS S_1 AND S_2 DEFINE AN ION BEAM. THE ELECTROSTATIC DEFLECTION INTRODUCES A VELOCITY DIVERGENCE IN THE ION BEAM WHICH IS JUST CANCELLED BY THE MAGNETIC FIELD SO THAT VELOCITY FOCUS OCCURS AT THE PHOTOGRAPHIC ION DETECTOR

trajectory it collides with a gas molecule, it may ionize that molecule and the ion can be drawn out and formed into an ion beam by the collimating plates. The extra electron produced serves to further support the discharge. The discharge must be instigated by a chance electron appearing near the cathodes produced from radioactivity, cosmic rays or field emission. This source is more reliable than the simple gas discharges noted above since the long trajectories of the trapped electrons enable the source to work at much lower pressures. The source is useful for a few special problems.

Arc Discharge.-b he three sources noted above require only high voltages to maintain the discharge. If a hot filament is used as the negative electrode to supply a continuous stream of electrons, another type of discharge occurs called an arc discharge. This discharge can be operated at much lower voltages than can the simple gaseous discharges, yielding an ion beam more homogeneous as to energy and, hence, more useful in mass spectroscopy. The major advantage of such a source is that it produces an intense ion beam. Since isotopic separators require intense beams, it is clear that the arc discharge source is best suited for this application. Its instability, etc., make it undesirable for ordinary isotope

abundance work.

Surface Ionization. — The surface ionization source was discovered by Gehrcke and Reichenheim in 1907. It is based on the fact that when an atom or molecule is evaporated from a surface it has a probability of being ionized, given by the equation

$$\frac{n+}{n^0} = \exp\left[\frac{e(w-\phi)}{KT}\right]$$

where n+/no is the ratio of the charged to neutral constituents, e is the electronic charge, w is the work function of the surface, ø is the ionization potential of the constituent evaporated, K is the gas constant and T the absolute temperature. The theory behind this source is thus understood and the special requirements of the source are deducible from the equation. They are: (1) the ionization potential of the material to be analyzed must be low; (2) the work function of the surface from which evaporation takes place must be high; and (3) substances having ionization potential higher than the work function of the surface should be in refractory compounds in order to take advantage of the temperature sensitivity.

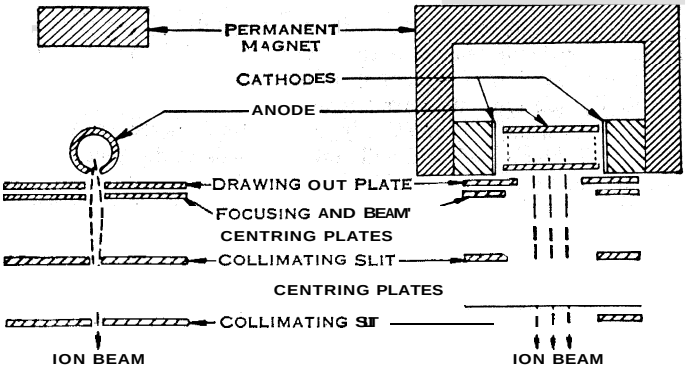

FIG. 4.—DIAGRAM SHOWING TWO VIEWS AT RIGHT ANGLES OF THE ION SOURCE BASED ON A GASEOUS DISCHARGE IN A MAGNETIC FIELD. THE IONS FORMED IN THE HOLLOW ANODE ARE DRAWN OUT OF THAT ANODE AND FORMED INTO AN ION BEAM BY THE SYSTEM OF PLATES SHOWN BELOW THE ANODE

Two variations of the surface ionization source are used. In one the material to be analyzed is deposited directly on the surface to be heated (filament), and ionization occurs when the material is re-evaporated in vacuum. In the second the sample is introduced as a gas and, upon striking the hot surface, it is ionized. A typical ion source of the former type is shown in fig. 5. It can be used with any type of mass analyzer since the ion energies are homogeneous.

For many of the elements this source is the most sensitive of all sources used in mass spectroscopy. Between 1945 and 1952 it became a standard tool in many laboratories.

Vacuum Spark. — The vacuum spark ion source was developed by Dempster in 1935. In this source a potential of about 50,000 v. is placed between two electrodes in order to instigate electrical breakdown. Electrical breakdown produces a hot spot on the electrodes from which the solid material of the electrode is evaporated and sputtered into the space between the electrodes. The electrons present in this space produce ions by electron bombardment. Further ionization is produced by the impact of ions against the electrodes themselves. A fraction of the ions is then accelerated out of the discharge and focused into an ion beam. In order to keep the electrode from melting, the voltages are applied to the electrodes as short pulses of a few microseconds duration, repeated at a rate of about **60** per second. The source must be used with a double focusing analyzer for mass resolution since the ion energies are not homogeneous.

The spark source is erratic since it depends on a chance electrical breakdown. Nevertheless, it is a useful source for the analysis of solid materials and by the 1950s had been applied to general chemical analysis of solids.

Electron Bombardment. — The electron bombardment source was introduced by Dempster in 1921. By the 1950s it was the most universally used of any of the ion sources. Its modern form was worked out by W. Bleakney and A. O. Nier. This source is based on the fact that when an electron collides with an atom or molecule it may loose a fraction of its energy to that atom or molecule in the form of ionization or excitation or both. The ions, whether they are atomic or molecular, are immediately usable In the case of excitation of an atom, the excitation is lost by radiation to the walls of the ionization chamber or by collisions of the second kind. It is only the second of these types of excitation which has any influence on mass spectroscopy since it is the only one which results in charged particles. In the case of excitation of a molecule, the excitation is often lost by dissociation of the molecule into i'onized fragments. Thus, the important characteristic of an electron bombardment source is ionization with or without fragmentization.

There are two variations of the electron bombardment source. In one the sample is introduced as a gas from an external sample handling system; in the other the sample is evaporated from a crucible placed in juxtaposition to the ion source itself. In either case, the sample enters the ionization chamber as a gas and the source itself is unchanged. The source shown in fig. 4 is typical. In this source electrons are produced at the filament by thermionic emission. The electrons so produced are accelerated and projected across the ionization chamber by a constant accelerating voltage maintained between the filament and the ionization chamber. Since the amount of ionization produced is a function of the electron current and electron energy, it is necessary to regulate both of these quantities. The ions produced by the electron beam are drawn out of the ionization chamber and focused electrically into an ion beam by the collimating slits. Since the ionization in this source occurs in an approximately field-free region, the ion beam is homogeneous as to energy and the source will work with any type of mass analyzer.

Ion Dipole. — The ion-dipole ion source, developed by W. A. Chupka in 1950, is based on the fact that in the gas phase in a closed furnace chemical equilibria of the following type occur:

$$RbCl + Rb^+ \rightarrow Rb_2Cl^+.$$

Thus, if an ion such as Rb' appears in the gas phase, it can attach itself to any dipole to form a complex ion with that dipole. In this way many elements can be analyzed—in the above example chlorine, which cannot be ionized by surface ionization itself. The ion energies from this source are homogeneous so that it may be used in conjunction with any type of mass analyzer. By the 1950s the main purpose of the ion-dipole ion source was the determination of chemical bond strengths in complex molecules.

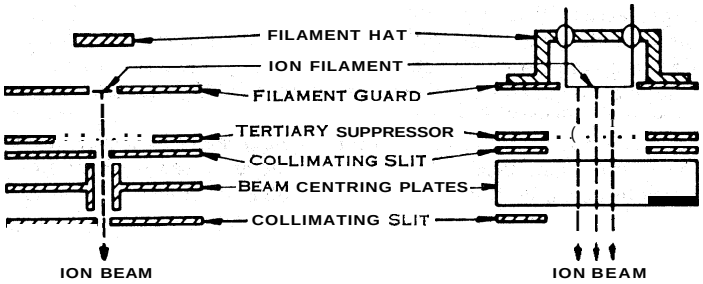

FIG 5 — DIAGRAM SHOWING TWO VIEWS AT RIGHT ANGLES OF A SURFACE IONIZATION SOURCE

Secondary Ion. — The first use of electron impact on surfaces to produce ions of the solid was that of Dempster in 1918. The use of ion bombardment of surfaces to produce secondary ions characteristic of that surface mas first tried by O H. Smith (1916). Experimentally it was found that, in most cases, secondary ion production by ions is many times more efficient than that produced by electron bombardment. The energy spread in the secondary ions produced is large, so that recourse to a double focusing is necessary. This source has been used largely for chemical analysis of solids and for studies of surface chemistry.

Electron Affinity. — The electron affinity ion source is based on the fact that when an atom or molecule is evaporated from a surface it has the probability of being evaporated as a negative ion

given approximately by the equation

$$\frac{n^-}{n^0} = \exp \quad e(A - w)$$

where the symbols have the same significance as in the equation under surface ionization, and A is the electron affinity of the evaporating species. It is clear on comparing this equation with the earlier one that this source is quite similar to the surface ionization

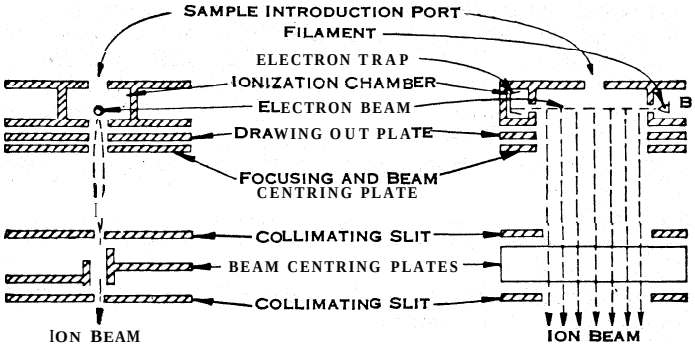

FIG. 6 — DIAGRAM SHOWING TWO VIEWS AT RIGHT ANGLES OF AN ION SOURCE BASED ON ELECTRON BOMBARDMENT IONIZATION

source except that it depends on electron affinity rather than ionization potential, and it produces negative ions rather than positive.

Field **Emission.**—The field emission ion source first applied by M. G. Inghram and R. Gomer in 1954 is based on the fact that when very high electrostatic fields are placed at a surface, the absorbed gases on that surface are pulled off as positive ions. Fields of the order of 10^8 v. per centimetre are necessary to draw such ions off the surface. The source is useful mainly in the study of surface chemistry. Since the ions are drawn from an equipotential surface, they are homogeneous as to energy and the source may be used with any of the various mass analyzers.

MASS ANALYZERS FOR MASS SPECTROSCOPY

The thousands of mass analyzers which have been constructed can be divided into ten classes depending on their field arrangements.

Parabola Mass Analyzer. — If a well-collimated pencil of ions is projected through parallel homogeneous electrostatic and magnetic fields, that beam will be resolved into a series of more or less complete parabolas each characterized by a particular mass to charge ratio (in almost all mass analyzers a doubly charged ion acts as a singly charged ion of half the mass, etc.). The completeness of the parabolas is a measure of the inhomogeneity in energy in the ion beam. This type of analyzer is no longer used for analytical isotopic purposes because, since it involves no focusing, it is inherently a low resolving power, low sensitivity machine. Its major use is in studying the characteristics of ion sources. A single record from the machine shows collimation, ion beam homogeneity, ion fragmentization, change of charge, etc. No other mass analyzer is so sensitive to all these parameters. Note, however, that it is just these parameters which are unimportant in most isotopic work.

First Order Velocity Focusing Mass Analyzers. — The first mass analyzer which achieved first-order velocity focusing was the successive electric and magnetic field machine constructed by Aston in 1919 (fig. 3). Though four machines involving first order velocity focusing have been constructed, they are no longer in use. This results largely from the fact that since no direction focusing is involved, the ionic transmission is low. The first order double focusing mass analyzer has replaced the velocity focusing analyzer for most purposes.

Velocity Selection Mass **Analyzers.**—The crossed homogeneous electric and magnetic field mass analyzer was developed by Wien (1898). If a beam of ions is projected at right angles into such fields, only ions of velocity

$$v_0 = \frac{cE}{B}$$

will traverse those fields without deflection. In this equation, c is the velocity of light, E is the electrostatic field strength and B is the magnetic field strength. If one uses an ion source producing a monoenergetic ion beam, the velocity is given by the equation

$$v_0 = \sqrt{\frac{2eV_0}{m}} .$$

In this equation e is the charge on the electron, V_0 the potential through which the ion was accelerated and m is the mass of the ion. On eliminating v_0 between these two equations

$$m = \frac{2eV_0B^2}{c^2E^2}$$

it is seen that, in combination with an ion source which produces an ion beam homogeneous as to energy, the crossed field arrangement may be used as a mass spectroscope. In addition to mass sensitivity, the cross field arrangement does have the property of direction focusing. Theoretically, an ion beam diverging from a slit within the crossed field will come to focus at distances which are any integral multiple of πa_m from the entrance slit. The quantity a, is the radius of curvature of the ion path in the magnetic field alone. This analyzer has been little used by itself. This results from the bulkiness of the equipment necessary to give the desired resolving power. Its main use is in conjunction with other types of analyzers where the property of velocity measurement is of fundamental importance.

Perfect Double Focusing Mass Analyzers.—The perfect double focusing trochordial mass analyzer was introduced by Bleakney and Hipple (1938). The fields in this analyzer are again crossed homogeneous parallel electrostatic and magnetic fields, but the trajectories are not straight lines as in the last case but trochoids as shown in fig. 7. This is one of the few analyzers in which perfect double focus occurs; *i.e.*, the focused image is a perfect image of the source slit and not an approximation. The image occurs for every multiple of $2\pi a_m$ along the x axis where a_m is the radius of curvature of the ion trajectory in the magnetic field alone. The mass scale is exactly linear. Though theoretically excellent, this type of analyzer is limited in use because of the bulkiness of the equipment necessary to produce the required fields.

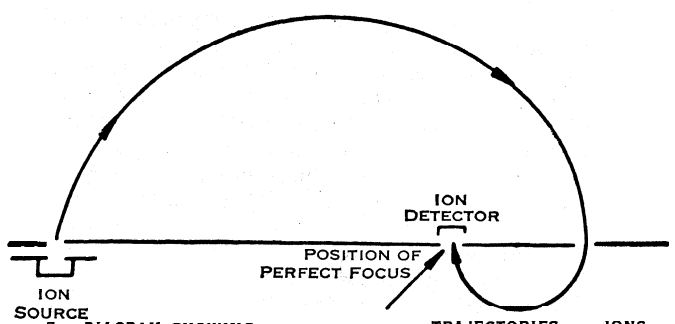

FIG. 7.—DIAGRAM SHOWING THE TROCHOIDAL TRAJECTORIES OF IONS IN THE PERFECT DOUBLE FOCUSING CROSSED-FIELD TYPE OF MASS ANALYZER. THE ELECTROSTATIC FIELD IS PLACED IN THE PLANE OF THE PAPER AND IN A VERTICAL DIRECTION. THE MAGNETIC FIELD IS PLACED NORMAL TO PLANE OF THE PAPER

First Order Direction Focusing Mass Analyzers.- he first order direction focusing mass analyzer was introduced in 1918 by Dempster. The extension of this principle to sector-shaped magnetic analyzers was made by Bainbridge and Nier in 1938. By the mid-1950s many hundreds of these analyzers were in use. In fact, all of the commercially available instruments were of this type.

In this analyzer an ion beam homogeneous as to energy is projected at right angles into a homogeneous magnetic field (fig. 8). After deflection, it again comes to focus. The relation between the lengths l'_m, l''_m, ϕ_m and a_m is given by the equation

$$(l'_m - a_m \cot \phi_m)\ (l''_m - a_m \cot \phi_m) = a_m^2 \csc^2 \phi_m .$$

a, is given by the equation

$$a, = \frac{m_0V_0C}{eB} .$$

It is clear from these equations that from the theoretical stand-

point all such machines are the same regardless of the angle of deflection. The problem of the deflection angle is dictated by constructional and other auxiliary considerations. There are, of course, more complicated equations governing the focal conditions in the case of ion beams which do not enter or leave the magnetic field at right angles to that field, but these are different only in detail.

First Order Double Focusing Mass Analyzers. — The successive field first order double focusing mass analyzer has been used extensively for precise mass determinations. After 1945 it was applied to the chemical analysis of solids. Since the machine is double focusing (*i.e.*, takes into account spreads in both velocity and direction in the initial ion beam) it will work with any ion source. A typical field arrangement is shown in fig. 9. In this machine ions are projected first into a radial electrostatic field which has an energy but no mass sensitivity, and then into a homogeneous magnetic field which has both mass and energy sensitivity. By properly arranging the fields, the magnetic field can be made to just cancel the energy sensitivity of the electrostatic field and so give an image which is independent of initial ion velocity. At the same time mass resolution does not cancel so that the combination is mass sensitive. Again, any angle of electrostatic and magnetic deflection can be used and the machines are not different in concept.

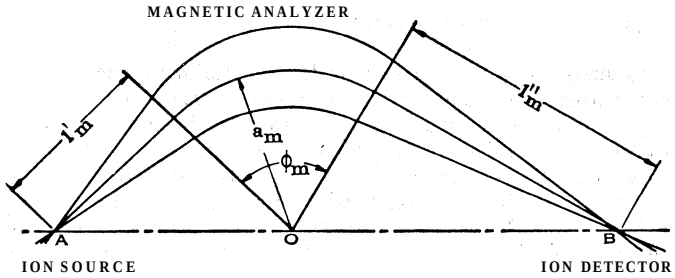

FIG. 8. — DIAGRAM SHOWING THE FOCUSING ACTION OF A VECTOR TYPE OF DIRECTION FOCUSING MASS ANALYZER

Higher Order Two Dimensional Focusing Mass Analyzer. —It is theoretically possible, by shaping the magnetic field pole faces in first order direction focusing mass analyzers to produce higher order focusing (*i.e.*, more perfect) images. The experimental realization of such improvement is difficult because of the fact that fields do not terminate abruptly as one assumes in such calculations but fringe out to give stray field effects. The shaping of such fields thus requires a detailed study of fringing fields and, when properly done, does improve the focusing action of a homogeneous magnetic mass analyzer. Such shaped fields were first used in lower order form by Smythe, L. H. Rumbaugh and E. West in 1934; and the higher orders have been treated theoretically by Bainbridge (1947).

Velocity Selection First Order Direction Focusing Mass Analyzer. — This type of machine is a combination of a velocity selection mass analyzer followed by a first order direction focusing mass analyzer. It was first used by Bainbridge in 1930. The mass discrimination (*i.e.*, sensitivity of the machine to ions of different mass) is very undependable since it combines two mass sensitivities. It is, therefore, not suitable for isotopic abundance measurements but is useful for special problems.

Time of Flight or RF Mass Analyzers. — A number of different types of mass analyzers have been constructed which depend on time dependent electrostatic fields for mass sensitivity. These machines can be subdivided into one of four subclasses depending on whether they use pulsed ion beams or sinusoidally varying fields, and whether they are focusing or nonfocusing analyzers. The simplest analyzer of this type uses a voltage pulsed grid to admit a pulse of ions homogeneous in energy to a long tube. Since the heavier ions move slower than the light ones they will arrive at the other end of the long tube at a later time than light ones; *i.e.*, the original pulse mill separate into a group of pulses each characteristic of a single mass. and mass resolution is observed as a function of time, not space as with most other analyzers.

All the RF analyzers up to the mid-1950s allowed collection of only one resolved ion beam at a time. Therefore the use of the null method (see *Ion Detectors*, below) for isotopic abundance measurements is impossible. The major purpose of these machines is thus one of very high transmission (W. E. Glenn, 1952) or very high resolving power (Hipple, 1950).

Composite Mass Analyzers. — In addition to the analyzers outlined above there are a number of combinations of those analyzers which are useful for special purposes. For example, two successive first order direction focusing mass analyzers have been used to achieve the advantages of a double achromat in optics. An energy selector followed by a direction focusing mass analyzer has been used as a tool in molecular energy level studies.

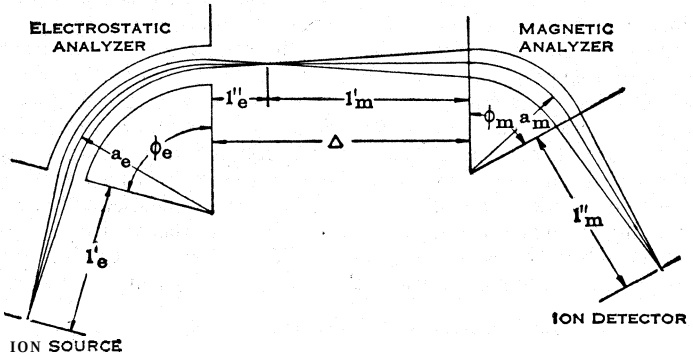

FIG. 9. — DIAGRAM SHOWING THE FIELD ARRANGEMENT USED WITH FIRST ORDER DOUBLE FOCUSING MASS ANALYZERS. THE DEFLECTION ANGLES ARE ARBITRARY. ANY ANGLES BEING USABLE. THERE ARE, HOWEVER, CERTAIN RELATIONSHIPS BETWEEN l'_e, l''_e, Δ, l'_m, l''_m, a_e AND a_m SUCH THAT DOUBLE FOCUSING TAKES PLACE

ION DETECTORS FOR MASS SPECTROSCOPY

Photographic Plate Ion Detectors. — The application of photographic plates to the detection of ion beams was due originally to J. Koenigsberger and J. Kutschewski. Unfortunately the action of fast-moving ions in forming a developable image is poorly understood. No single law has been found which satisfactorily describes the action. Among the factors involved are:

1. Breaking of chemical bonds of the silver halide molecule because of the energetic motion of an atom near or through that molecule.
2. Production of light by the atoms excited in the process of stopping the moving atom.
3. Production of secondary electrons.
4. Penetration of the ion through the emulsion.
5. Chemical effects of ionic molecules after stopping as evidenced by excessive sensitivity to some molecules.
6. Gross deposit of ion beam elements in the emulsion, effecting the rate of diffusion of developing solutions into that emulsion.
7. Charge on the ion.

The relative importance of these effects is a function of the particular emulsion used. For emulsions containing very little gelatin, item 1 is probably the most important; for emulsions containing a large amount of gelatin and having high light sensitivity. item 2 is the predominant factor. It is apparent from these considerations that the sensitivity of a photographic plate is a function of many variables — ionic mass, ionic energy, exposure, chemistry, etc. It is clear, therefore, that photographic plates should be used only where absolutely necessary or where qualitative information is sufficient.

Simple Electrical Ion Detector. — The first use of direct electrical detection of the resolved ion beams was due to Dempster (1918). To accomplish this detection the resolved ions are made to pass through a defining slit and impinge on a collector plate. There they are neutralized by electrons flowing to that plate. The flow of this current can be detected with a sensitive amplifier and recorded. The measurement of the relative intensities of two ion beams is thus simply a matter of reading a meter when first one and then the other ion beam is striking the final collector.

Dual Electrical Ion Detector. — The limitations in the accuracy of a mass spectrometer equipped with a simple electrical ion detector is usually one of ion current stability. One method of minimizing the effect of these fluctuations is to collect both beams

at once and balance one against the other electrically; *i.e.,* null detection. The use of dual collectors was first reported by H. A. Straus (1941). The arrangement shown in fig. 10 was developed by Nier, Inghram and E. P. Ney in 1947. In this collector one ion beam strikes the defining slit plate and the other passes through to the final collector. The "null" balance is accomplished with the electronic arrangement shown diagrammatically at the right in this figure.

Suppressive Electrical Ion Detectors. — The suppressive electrical ion detector is one which detects only those ions which have full or a known fraction of full energy, *i.e.,* those which have not lost part of their energy by gas collisions or by ion breakup in transit (metastable ions). These collectors are therefore used mainly in applications in which the spectrometer operates at relatively high pressures (leak detection) or where metastable ions are of importance (hydrocarbon analysis). There are three important methods of accomplishing this suppression: (1) by passing the ion beam over a potential barrier; (2) by placing the final collector at such a potential that the ion beam is decelerated after passing through the image slit and arrives at the final collector with essentially zero energy; or (3) adding a electrostatic analyzer after the image slit to select those resolved ions of the proper energy.

Electron Multiplier Ion Detection. — When extreme sensitivity or rapid or panoramic (oscilloscope) recording is of prime importance, the electron multiplier ion detector is advantageous. The system is avoided whenever possible since it is nonlinear with ionic mass. with ionic energy, with stray magnetic field, etc. In addition, with a sensitive spectrometer and most ion sources, background peaks are observed at many masses so that the added sensitivity is often useless. The use of electron multipliers can be illustrated from fig. 10. If the final collector plate is removed in that figure and the first stage of a standard electron multiplier placed in its place, the secondary electrons produced when the ion beam strikes that plate will be multiplied by the electron multiplier and detected as a much larger current increasing the sensitivity of the instrument. Such multipliers were first used in mass spectros-

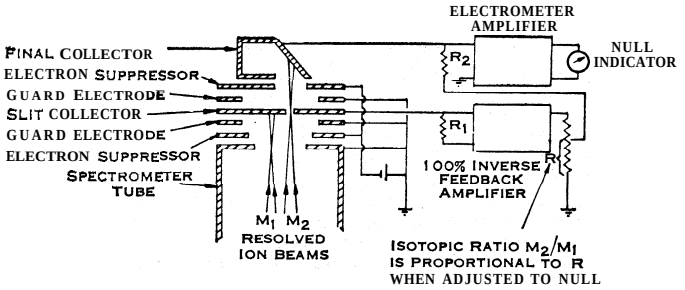

FIG. 10.— DIAGRAM SHOWING ONE ARRANGEMENT OF ION RECEIVING PLATES BY MEANS OF WHICH DUAL COLLECTION AND NULL MEASUREMENT OF ISOTOPIC COMPOSITION MAY BE ACCOMPLISHED

copy by A. Cohn in 1941. In his application they were used to count the individual ions striking the final collector.

Scintillation Ion Detector. — The scintillation detector is a detector in which the ion beam strikes a scintillator such as KI and the light pulse produced is amplified with a standard commercial photomultiplier. The scintillation detector has the advantage that the scintillator can be placed in a strong magnetic field and the light pulse piped out of the field to a photomultiplier. The scintillation detector does, however, have almost all of the difficulties associated with the electron multiplier detector. The pulse heights produced are a function of all variables listed above; in addition, because of deposits formed on the surface of the scintillator, its stability with time is considerably poorer than that of the internally placed electron multiplier.

AUXILIARY EQUIPMENT

In addition to the three major components of a mass spectrometer listed above, there are a number of auxiliary units. These include sample introduction systems, pumping systems and electronic supplies.

With regard to the design of sample introduction systems, it is necessary to take special precautions to ensure that the gas in the ionization region is identical or bears some known relationship to the sample being analyzed. Thus, if a gaseous sample is introduced to the machine through a leak in which viscous flow predominates, the sample in the source will be different in composition from that

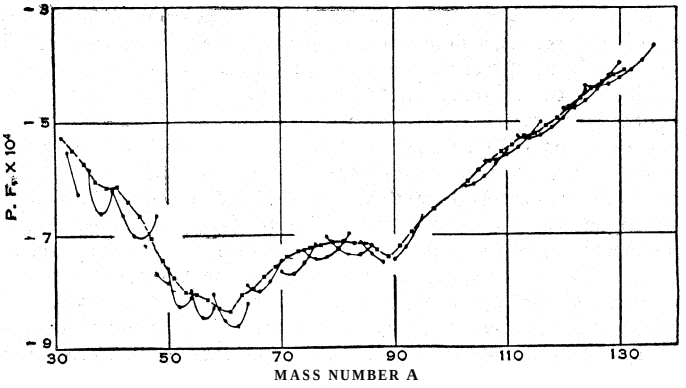

FIG. 11.— THE PACKING FRACTIONS (P.F.) OF THE ELEMENTS ACCORDING TO THE RESULTS OF A. O. NIER. THE DASHED CURVE CONNECTS THE ISOTOPES OF ODD MASS: THE PARABOLIC LOOPS REPRESENT THE EVEN MASS ISOTOPES OF EACH ELEMENT. THE LIGHT MASS ELEMENTS ARE MANY TIMES OFF SCALE IN THE UPWARD DIRECTION

being analyzed by the square root of the ratio of the masses. If, on the other hand, molecular flow is used throughout, there will be no difference. Again, if a sample is evaporated from a hot crucible placed in juxtaposition to an electron bombardment ion source a correction of the square root of the masses is needed if the evaporation is from a solid surface and no correction if from a liquid surface. Note that in the latter case, as is also true in molecular flow gas leaks, the composition of the sample itself changes with time. It is apparent that each problem should be considered separately.

The electronic units usually predominate in space over the three basic components themselves. The requirements on this equipment are so different in different machines that no general rules can be set up for specifying them for these units. They can, however, always be calculated starting from the requirements on the three basic units themselves.

APPLICATIONS OF MASS SPECTROSCOPY

It is impossible in a few pages to summarize even a fraction of the wealth of information which has been obtained through the application of the techniques of mass spectroscopy. The instruments are used in physics, in chemistry, in geology, in meteorology, in biology and in medicine. They are used to analyze microscopic crystals and to automatically control the operation of huge gas streams in industrial plants. This summary will, therefore, mention only a few of the many varied applications.

Isotopic Existence. — The first mass spectrometric evidence for the existence of isotopes was the two parabolas observed by Thomson in the element neon in 1913. The existence of these isotopes was verified in 1920 by Aston with his velocity selection mass analyzer equipped with a gas discharge ion source and a photographic plate ion detector. From that time the analysis of the isotopic composition of the chemical elements proceeded rapidly. Most of the elements were examined by Aston using either the gaseous discharge or the surface ionization type of sources. In this way he identified 202 isotopes in 71 elements. Other observers analyzed the remaining 12 stable elements and discovered many additional rare isotopes in the elements Aston had examined, to make up the final total of 282 naturally occurring isotopes in the first 83 elements in the periodic table. Of these 282 isotopes, 8 are radioactive with half lives of greater than 100,000,000 years. All the elements above element 83 are radioactive with relatively short half lives so the term "naturally occurring" looses its meaning.

The discovery that the chemical elements were made up of isotopes with integral values for their masses led to the revival of

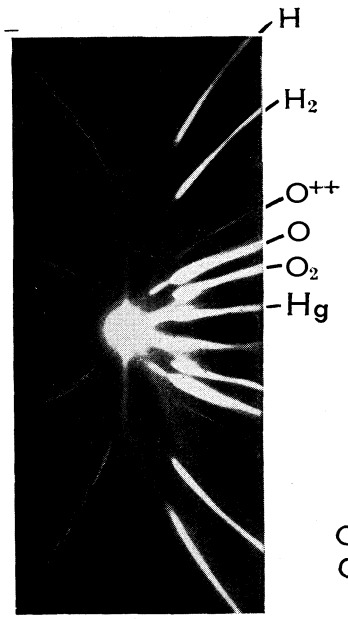

FIG. 1

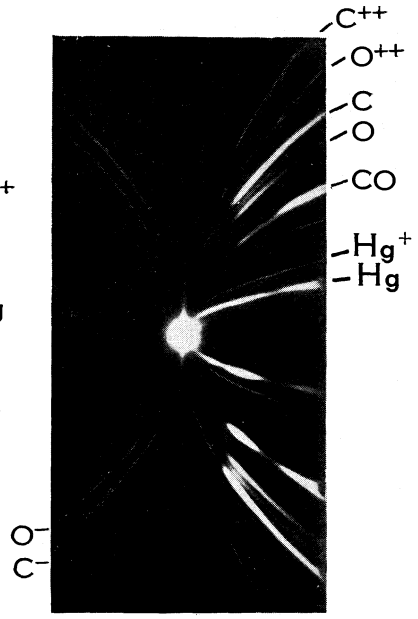

FIG. 2

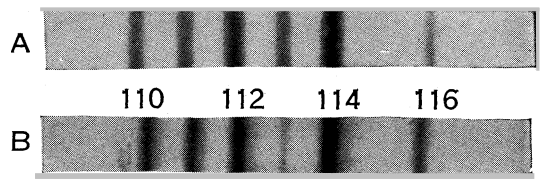

FIG. 3

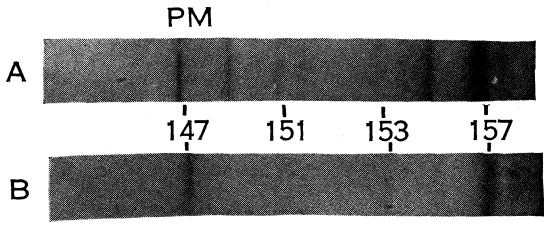

FIG. 4

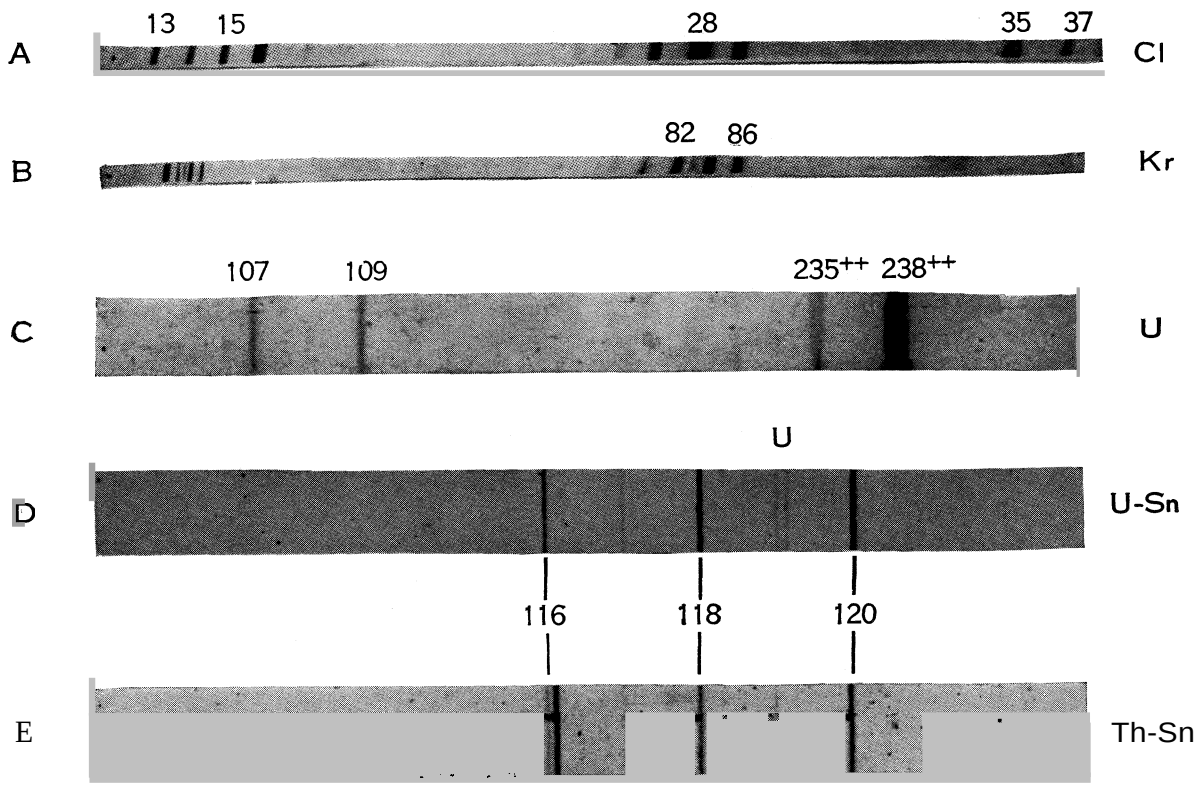

FIG. 5

(1, 2) PHOTOGRAPHS FROM DR. ASTON'S "ISOTOPES," BY COURTESY OF EDWARD ARNOLD AND COMPANY

1. Typical positive ray parabola. Particles of like mass and charge, but of different velocities, produce parabolic curves. The observation of H^{--} demonstrates that hydrogen can bind a second electron
2. Parabolas of carbon, oxygen, mercury, etc. The occurrence of C^- and O^{--} proves that these atoms can bind an extra electron
3. Mass spectra of cadmium: (A) normal cadmium and (B) neutron-irradiated cadmium Cd^{113} changed to Cd^{114}
4. Radioactive transfer method of determining the mass of radioactive atoms, (A) being the original and (B) a transfer in which only the radioactive lines appear. The samples shown were used to assign the four-year promethium isotope to mass 147
5. Typical spectra observed with mass spectrographs; (A) F. W. Aston's discovery of the two isotopes of chlorine; (B) Aston's first investigation of the isotopes of krypton; (C) the plate on which A. J. Dempstor discovered the isotope U^{235}; (D) a mass comparison of doubly charged uranium and tin; the location of the uranium line above that of tin shows that it can fission to two tin isotopes of mass 119 with the release of energy; (E) a mass comparison of doubly charged thorium and tin; fission is indicated as a possibility since thorium is more than twice as heavy as Sn^{116}

William Prout's theory of 1815, according to which the atoms of all the elements are different aggregations of hydrogen atoms. This theory had been abandoned toward the middle of the 19th century when precise measurements of the chemical atomic weights demonstrated that in many cases they are definitely not integers. When the nonintegral values were found to be due to the existence of two or more isotopes, it was again possible to think of the atomic nuclei as built up of different numbers of fundamental building blocks. These units were considered in 1920 to be protons and electrons, but after the discovery of the neutron by James Chadwick and the development of the theory of exchange forces by W. Heisenberg in 1932, the building blocks were supposed to be protons and neutrons, the number of protons being equal to the nuclear charge and the total number being equal to the isotopic mass.

More precise comparisons soon showed, however, that the values of the masses of even the individual isotopes departed slightly from exactly integral ratios, as will be discussed below. Physicists in 1947 considered that they had identified all the stable isotopes; *i.e.,* all the possible combinations of protons and neutrons that are capable of forming stable structures.

Radioactive Isotopes.—Isotopes were found to occur in the naturally radioactive elements as early as 1906. The chemical identity of several pairs and groups of radioactive products was well established by 1913, when the term "isotopes" was first introduced. Between thallium, mass 205, and uranium, mass 238, 40 different kinds of radioactive atoms were known which were classified in only ten groups with different chemical properties. The different groups constitute different elements with two to eight isotopes each.

The confirmation in 1934 by I. Curie and F. Joliot of the reality of the earlier claims of induced radioactivity, that stable isotopes of boron and aluminum could be transformed into radioactive forms by the impact of alpha-rays, led to an unexpected extension of know-ledge of isotopes. Protons. deuterons and especially neutrons also proved to be capable of producing radioactive isotopes. The number grew rapidly and by the late 1940s more than 500 so-called "active" isotopes had been produced (see RADIOACTIVITY). Their masses not only occupy the gaps between the stable isotopes but extend to lighter and heavier masses.

In many cases where a particular isotope, identified by its half life, can be formed in several ways from neighbouring elements, it is possible to deduce its mass from its relation to the stable isotopes. However, the occurrence of isomeric forms often introduces uncertainty.

The masses of many active isotopes have been observed directly by the methods of mass spectroscopy. For this purpose the radioactive sample mixed with stable isotopes is used in the source of a mass spectrograph. The isotopes separated by the mass analyzer are allowed to fall on a photographic plate or other collecting plate and the positions of the radioactive isotopes are identified, either by means of a counter-tube or by making a transfer in which the radiations from the radioactive isotopes give rise to images on a second photographic plate placed in contact with the original deposits.

Relative Abundance **of** Stable Isotopes.—The relative abundance of the isotopes of an element may be found either by comparing the relative ion currents in the resolved ion beams characteristic of each isotope or by photometric measurements of their images on a photographic plate. The latter method was used by Aston with the many elements he analyzed. Current measurements give more accurate values, and by mid-century this method had been used to measure the abundances of most of the isotopes. However, the values obtained were still subject to criticism and awaited refinement for many of the elements.

No general theory existed at mid-century to explain why the different elements should have the particular isotope patterns that they do. (See ATOM.) Regularities, however, exist, suggesting that a general theory should some day be found; for example, the odd-numbered elements never have more than two stable isotopes and these are always of odd mass except in the case of lithium and nitrogen. The even-numbered elements may have as many as ten isotopes with both odd and even masses, the even masses, however, predominating both in number and abundance. There are many cases of elements having isotopes of the same mass (isobars) when the mass is even, but only four with mass odd.

In the case of hydrogen, carbon, oxygen, sulphur and lead the mass spectrometer has detected slight differences in the relative abundances of the isotopes as they occur in nature. The carbon isotope at mass 13 is more abundant in organic samples (1:88.3) than in limestones (1:92.3). Lead samples from different sources vary markedly because of the admixture of some lead from radioactive decay. Water from various sources varies in density because of variations in the relative abundance of the oxygen isotopes (M. Dole, 1936). The strontium found in certain micas, formed by the radioactive decay of rubidium, consists almost entirely of an isotope at mass 87 (J. Mattauch. 1937).

Absorption of neutrons produces samples with very abnormal isotopic abundances, especially in the case of elements with large neutron absorption cross sections; for example, cadmium, samarium, gadolinium or mercury.

Exact Masses of the Isotopes.—The determination of the precise masses of the isotopes with the mass spectroscope was and is of fundamental significance for understanding the structure of nuclei. The measurements led to the discovery of the fundamental relation governing the energy released in nuclear transformations. It thus forms a most important chapter in the subject of mass spectroscopy.

The discovery by Aston, in 1920, that the mass of hydrogen was 1.008 when compared with oxygen defined as mass 16.0000 was of great importance; for, if we are to think of the nucleus of an element as built up out of hydrogen atoms—that is. protons and electrons—or, as was realized in 1932, out of protons and neutrons, the masses of all the nuclei above hydrogen are slightly less than one would calculate if these nuclei were just simple multiples of the hydrogen mass. One feature of the relativity theory formalized by Albert Einstein in 1905 was that the relationship between mass change and energy change, $\Delta E = \Delta mc^2$, entered in a very general way.

The mass of a material body could be regarded inherently as an aspect of a hypothetical energy content so that any change of the energy involved a corresponding change of mass. So as a result of the mass spectroscopic results of 1920 it could be assumed that the isotopes were built up out of hydrogen and that the loss of approximately 1.008 atomic mass units for each hydrogen atom was accounted for by the energy lost when the elements were formed. Conversely this is the energy which would have to be put in to the nucleus in order to remove a proton (hydrogen nucleus) from a heavier nucleus.

Further mass measurements were made by Aston between 1920–27 of the most abundant isotopes of 20 elements, enough to show the general nature of the nuclear binding energies throughout the elements: hydrogen 1.008, helium 4.004, sulphur 31.982, argon 39.975, mercury 200.61. All these numbers are very near integers. Because the difference between the exact mass and the nearest integer was always small Aston introduced the term "packing fraction," which is a measure of the deviation from integral masses. It is defined by the equation

$$\text{P.F.} = \frac{\text{M}-\text{I}}{\text{I}},$$

where M is the precise mass and I is the nearest integer to that mass.

The discovery by J. D. Cockroft and E. T. S. Walton in 1932 of the artificial disintegration of lithium by rapidly moving protons to form isotopes of helium presented the physicists with a new phenomenon from which they could hope to determine experimentally for the first time whether the change in mass in such a disintegration agreed quantitatively with the mass-energy equation noted above. It was immediately apparent, however, that the then available figures for the mass mere of such poor precision that the accuracy in the quantitative relation would be no better than 50%. It was evidently necessary to improve the accuracy of mass measurement to yield results accurate to five or six significant fig-

ures. It was this impetus that lead Dempster, Bainbridge and Mattauch to develop double iocusing mass analyzers. With the first of these machines Dempster, using the vacuum spark ion source, investigated the iour remaining elements which had been too difficult to do mith the older analyzers. In these elements and 13 other elements he iound 33 new isotopes which had been missed on the earlier machines, including the rare isotope of uranium U^{235}. The spark source iormed a great number of multiply charged ions and made possible 60 accurate mass determinations among the heavier elements. These determinations began to give detail to the shape of packing fraction curve (fig. 11). Bainbridge and E. B. Jordan mith their double focusing machine measured the mass of 14 of the light elements with great accuracy. Mattauch with his equipment made 12 comparisons and deduced seven precise masses. Other machines mere completed by T. Okuda (1939) and Jordan (1940), the latter having a resolving power of 30,000. Thus in eight years the resolving power of mass spectrometers had improved from 130 to 30,000; by 1954 it had improved to only 60,000 but the accuracy improved by a considerably larger factor because oi the introduction of electrometric methods oi mass comparison by Nier. A packing fraction curve taken irom his work up to 1954 is shown in fig. 11. The detailed mass information exhibited by this curve is remarkable.

These detailed experimental verifications of the mass-energy relation of the relativity theory constitute a major scientific achievement. What had been a grandiose theoretical formulation of 19th-century physics was shown to apply in one of its fundamental features to the partially explored field of nuclear phenomena.

Ionization Phenomena. — The subject of mass spectroscopy, as explained in the historical section, grew out of and includes the study of ionization processes that accompany the passage of electrons through gases at low pressures. Wien showed in 1900 that the particles which are formed by a gas discharge contain atoms of the gas in that tube. Thomson from 1910–13 carried out many investigations of ionization phenomena with his parabola analyzer. Many complex phenomena were observed. He found that molecular gases are dissociated, atoms with multiple changes occur, ions may suffer change of charge in colliding with other gas molecules and can in fact even become negatively charged; those which are neutralized appear as a central undeflected spot.

An important step in the study oi ionization phenomena was the introduction in 1916 of electrons of known energy. In 1922–30 H. D. Smyth and others. gradually reducing the velocity of the ionizing electrons, found the minimum potential at which ions appear from a given gas. This appearance potential is closely associated with the ionization potential of the elements, and it proved to be important in connection with the development of the quantum theory of atomic and molecular structure. In 1930 J. T. Tate and Bleakney observed the energies with which excited molecules dissociated and gave impetus to the study of quantum mechanical energy states in molecules. From 1933 to 1938 Tate and others carried out extensive measurements of the probability of producing singly and multiply charged ions of various kinds in a series of gases due to electron impact. This proved to be of particular practical significance in the case of hydrocarbons where the ion iragmentization pattern could be used to identify the hydrocarbons present.

Hydrocarbon Analysis. — The study oi Smyth, Tate and Bleakney concerning ionization phenomena in gases lead by 1940 to the use of the mass spectrometer on an industrial scale ior the analysis of hydrocarbon and other gaseous mixtures. In iact the first commercially available mass spectrometers were produced for exactly this application. In such applications the mass spectrum recorded by a hydrocarbon mixture can be represented as the sum oi the intensities of the pure components. Thus by measuring two peaks the relative concentration of a two-component system may be determined. By measuring ten peaks a ten-component system may be analyzed, etc. Such analyses require the solution of simultaneous equations since most peaks are an admixture of several components. In conjunction with these machines it is therefore important to have a special calculator for solving these simultaneous equations. Such calculators became commercially available in 1945. Using this mass spectrometric method, the analysis oi a ten-component hydrocarbon gas mixture takes, on the average, about half an hour; a similar analysis using the distillation methods mould require many hours of work. In addition to batch analyses as noted above, these instruments have been used directly on industrial plant streams for continuous analysis of plant operation. Instruments used for such purposes are more rugged and correspondingly somewhat less accurate than their laboratory counterparts. In some cases the instruments are connected directly to the plant controls to attain automatic plant operation.

Leak Detection. — Mass spectrometers can be used to detect the presence of extremely small amounts of gas even when mixed with large quantities of other gases. Using this property, Nier and A. Hustrulid in 1943 constructed a simple direction focusing instrument for the special purpose of detecting leaks in systems which must be airtight. With this instrument the system to be tested is evacuated and the leak detector is connected to sample the gas remaining in the system. If there is a leak that gas will be air. If a small jet of helium is now allowed to flow over the joints and suspected points in the equipment, as soon as that helium reaches a leak it will flow into the system and hence into the mass spectrometer which gives an immediate signal that the leak is located where the helium is flowing. Since the helium content of air is 1 part in 500,000, such a detector can locate 1 leak in the presence of 500,000 other equal leaks. In the mid-1950s there was no other leak detector known mith higher sensitivity. Leak detecting mass spectrometers became available commercially in 1945.

See J. J. Thomson, *Rays of Positive Electvicity*, 2nd ed. (1921); F. W. Aston, *Mass Spectva and Isotopes*, 2nd ed. (1942); M. G. Inghram, Advances in Electronics, edited by L. Marton, vol. i, p. 219–268 (1948); G. P. Barnard, *Modern Mass Spectrometry* (1953).

(A. J. D.; M. G. I.)

MASSYS (MATSYS, METSYS, MESSYS), QUENTIN (QUINTEN) (1466?–1530), Flemish artist and the first important painter of the Antwerp school, was born at Louvain. where he learned the trade of blacksmith. During the greater part of the 15th century the centres in which the painters of the Low Countries most congregated were Bruges, Ghent and Brussels. Toward the close of the same period Louvain took a prominent part in giving employment to workmen of every craft. It was not until the opening of the 16th century that Antwerp usurped the lead which it afterward maintained against Bruges and Ghent. Brussels, Mechlin and Louvain. Quentin Massys was one of the first men of any note who gave repute to the guild of Antwerp. A legend relates how the smith of Louvain was induced by affection for the daughter of an artist to change his trade and acquire proficiency in painting. Van Mander does not give us the name of Massys's master. Massys was ten years old when Dierik Bouts died at Louvain, and his style was probably formed by the Bouts tradition, which survived in the workshop of Dierik's son Albert. In 1491 Massys went to Xntwerp, and was there admitted into the guild of St. Luke. He was one of the first men of any note in the guild of that city, which was then rapidly becoming the most important commercial centre in the Netherlands.

Early works by Massys are two pictures of the Virgin and Child in the Brussels gallery. His most celebrated pictures are two large documented altarpieces, the triptych of the "Marys of Scripture Round the Virgin and Child," which was ordered for St. Peter's church in Louvain (1507–09), now in the Brussels gallery, and the triptych of the "Pieta" (c. 1508–11), which he executed for the joiners' company in the cathedral of Antwerp, now in the Antwerp gallery. These pictures display great earnestness in expression, strong religious feeling, great minuteness of finish and a general absence of light or shade. As in early Flemish pictures, so in those of Massys' excessive care is lavished on jewelry, edgings and ornament. There is a tendency to accentuate individual expression. This is illustrated in such pictures as "The Old Man and the Courtesan" in the Pourtales collection, Paris, and the "Market Bankers" in the Louvre, where an attempt is made to display cupidity and avarice. The "Ecce Homo" and "Mater Dolorosa," at Xntwerp, display serenity and dignity. Very attractive are his pictures with figures on a smaller scale! such as the polyptych in Munich, the scattered parts of which have been fitted together. and "The Virgin and Child" in the Xynard collection in Paris. His landscape backgrounds are often in the style of Patinir, who came to Antwerp in 1515 and is said to have painted backgrounds for some of Massys' pictures. "The Crucifixion," in the Liechtenstein collection, is believed to be the joint work of the two masters.

In 1517 Massys painted many great portraits, including those of Erasmus and Peter Gillis, to be sent to Sir Thomas More. The original of the Erasmus may be the portrait in the Corsini palace in Rome; the Gillis, in Lord Radnor's collection, drew from Sir Thomas More a eulogy in Latin verse. Other portraits are in the museums of Chicago and Oldenburg (Ger.) and in the collection of the prince of Liechtenstein. The man with a pair of eyeglasses in the Städel gallery at Frankfurt, Ger., is full of vitality; he seems to be speaking. The Musée André, Paris, has an expressive profile of a man, signed and dated 1513. The artist obviously aimed at depicting the desires and emotions of the men of his day.

When compared with portraits by Durer or Holbein, Massys' art appears subjective and personal. He came into contact with both German masters, for both in turn visited him in his house at Antwerp. Dürer's first call was made in Aug. 1520. The two men must have had much in common, for they were both humanists. The lost original of Massys' "St. Jerome in His Study," of which there is a copy in Vienna. owed something to Diirer's "St. Jerome,"

now at Lisbon. Holbein, as a young man. passed through Antwerp in 1526 on his way to England, and he carried an introduction from Erasmus to Gillis, uho was to send him to Massys' house. The question as to how much Massys was indebted to the Italian art of his time is difficult to determine. There is a picture by him from the Raczinski collection, in the museum at Posen (Pol.), representing the Virgin and Child playing with the lamb. These figures are obviously copied from Leonardo's famous "St. Anne, the Virgin and Child." now in the Louvre, except that the St. Anne is left out. and the group is placed on a landscape background in the style of Patinir.

Quentin Massys died at Antwerp in 1530. He had two sons who were artists

JAN MASSYS (1 jog–I575) was at first a weak imitator of his father. He became master in the guild of Antwerp in 1531, was banished for his heretical opinions in 1543 and stayed anay until 1558. During these years he is supposed to have visited Italy or France An early picture by him is the "Virgin Kissing the Child" in the church of St. James at Antwerp, which imitates the "Madonna Enthroned" by his father, non at Berlin. A half-length "Judith." now in the museum at Boston, is of a later date and seems to recall Italian or French influences. To the same class belongs the "Lot and His Daughters," at Vienna, dated 1563.

CORNELYS MASSYS (1513–1579) became a master painter in 1531. There is a signed picture of him at Amsterdam. dated 1538, representing the prodigal son; also a genre picture, signed and dated 1543, at Berlin. He painted landscapes in the style of his father, and he was also an engraver.

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MASTABA, in Egyptian architecture, a rectangular cut stone tomb. with sloping sides and a flat roof, usually containing three chambers. In the first chamber the walls were sometimes richly decorated with paintings, and there was a low bench of stone on which incense was burned. The second (*serdab*), containing the image of the deceased. was either closed, uith holes pierced in the wall separating it from the first chamber, or entered through a narrow passage, through which the fumes of the incense passed. A vertical wellhole descended to the third, in which the mummy was laid See EGYPTIAN ARCHITECTURE.

MASTER, one holding a position of authority, disposition or control over persons or things. The word is derived from the Latin *magister,* as in the title *magister equitum* which goes back to the early history of the Roman republic. Only some instances of the use of the word can be given.

The captain of a merchant ship is the master as is the officer entrusted with the navigation of a ship of war, who is now more usually styled the navigating officer. The title master is also used in the army. as in master sergeant. In the U S. navy. a master was the title formerly given to the rank of lieutenant junior grade.

The sovereign is the master of his ministers and officers, as is the employer of his servants and apprentices (*see* MASTER AND SERVANT); and the male head of a household is the master.

A teacher, tutor or preceptor is a master and so is he who has followers or disciples in religion, philosophy, art or scholarship; *cf.* the expression "Old Master" in painting. A workman on his own account or of approved skill is a master: *e.g.,* master builder or master mason. A fully qualified freemason who has passed the third degree is also termed a master mason.

In the academic sense the holder of a specific degree, which mav be. for example, a master of arts or of sciences. Master is the ordinary word for a teacher, generally used in the compound "schoolmaster."

The word is used as a title of office as applied to the heads of certain university colleges, guilds, corporations, livery companies, hospitals and religious orders. Master appears as the title of many judicial offices, for instance master of the rolls (*q.v.*). The master of the Temple is now the principal clergyman of the Temple church, London. his title being derived from that of the grand master of the Knights Templars (originally the priest-in-charge was termed the *custos,* but the act of Henry VIII which confiscated the property of Knights Hospitallers wrongly styled him master). The senior members of the four inns of court are known as masters of the Bench. and their names are still prefixed by the word Master (see INNS OF COURT AND CHANCERY). The chief officer of the archbishop of Canterbury in his court of faculties is the master of that court One of his duties is to grant special licences for marriage; another is to appoint notaries.

The title occurs in the royal household and survives in such titles as master of ceremonies. master of the queen's household, master of the jewel house, master of the queen's musick, master of the robes or wardrobe. The master of the mint is the chancellor of the exchequer.

"Master" is a title of rank or compliment prefixed to the name of a man. Probably under the influence of "Mistress" it was corrupted in sound to "Mister" and has now been abbreviated to "Mr." The word master. however, is still prefixed, especially by servants, to the name of boys and young men not old enough for "Mr.". The heir apparent to a Scottish peerage below the rank of earl is often known as the master of whatever the baronial title is. Puisne judges of the high court are properly referred to as "Mr. Justice." uhile the speaker of parliament throughout the commonwealth countries and the United States is addressed as Mr. Speaker. The president of the United States is always addressed as Mr. President. The prefix master to nouns appears in a large number of cases, such as master key (being a key that will open a number of different locks), masterpiece or masterwork, mastersinger, master stroke, master vein, etc.

MASTER AND SERVANT. This comprehensive term includes all forms of occupation in which a person for valuable consideration hires out his services in a subordinate capacity to another for the purpose of helping that other in the performance of some duty or object for which assistance is either necessary or desirable The contract need not be reduced into writing unless by the terms of the bargain the employment is to extend beyond a year, in which case a written agreement is necessary, under sec. 4 of the Statute of Frauds (*Dollar* v. Parkington, 1901, 84 L.J. 470). Consequently, a contract of service for a period of more than one year, terminable at any time by six months' notice, is unenforceable unless there is a memorandum in writing (Hanau v. *Erlich,* 1912. X.C. 39). Nor will part performance take the case out of the statute.

It seems. however, that a contract of hiring for a year certain need not be evidenced by writing unless it is to commence at a future date which would extend the term of employment beyond the year. Where the agreement is in writing. the consideration for the servant's promise to remain in the master's employ should appear on the face of the document and also the period during which the hiring is to continue and the length of notice necessary for its termination. But in a general hiring by parol the nature of the employment is a factor to be considered in determining alike the duration of the engagement and the length oi notice. In the case of a domestic or menial servant a general hiring will be construed as a hiring for a year terminable by a month's notice or by payment of a month's wages (with nothing additional for board and lodging) on the part of the master, and by a month's notice on the part of the servant. There is, however, no right of set off by a master ior accidental breakage of domestic utensils by a servant. A custom in domestic service that either party may determine it at the end of the first month by notice given at any time during the first fortnight has been held reasonable (*George* v *Davis,* 1911, 2 K.B. 445) Judicial decisions show that the rule as to a month's notice is not applicable in the case of an editor, a governess, a iarm bailiff, a steward. the housekeeper of a large hotel or a servant in husbandry. But it has been held to apply to a gardener and a huntsman.

Where the relation of master and servant clearly exists, the employer is responsible for injury occasioned by the negligent conduct oi the servant in carrying out his orders. And this rule is so extensive as to make the master liable for the careless, reckless and wanton conduct of his servant,, provided it be within the scope of his employment. But this responsibility does not prevent the servant from also being liable. A master is not, however, responsible for a wilful fraud outside the course of the servant's employment or for an act inconsistent with the nature of his duties.

If a servant wilfully disobeys any lawful order of his master or unlawfully absents himself from his work, or if he is guilty of moral misconduct, or takes a concealed commission, or proves grossly incompetent

in some particular service ior which he was engaged, he may be discharged without notice before the expiration of the period for which he was hired. Nor! in such case, is he entitled to any wages irom the date of his discharge, if they had not then accrued due. There is no legal obligation on the part of the master to give a "character" to a domestic or menial servant, but it is a common law misdemeanour for anyone to give a false character either verbally or in writing. A master need not, when dismissing a servant, allege any particular act on the part of the latter as the ground for his discharge, it being sufficient for such cause actually to exist. See LABOUR LAW; WORKMEN'S COMPENSATION. (W. W.-P.)

MASTER OF THE ROLLS, in England, originally chief of the 12 clerks or masters in chancery and as such keeper of the rolls, especially the register of original writs, and all patents and grants under the great seal. He was first called master of the rolls in the statute 11 Hen. VIII ch. 18. Before and after this date he is sometimes called vice-chancellor, since with the development of the chancery as a court, he was called upon to sit at first with the justices or with two or more masters; later, in the absence of the chancellor, by himself for judicial business. In fact he became the deputy of the chancellor. Meanwhile he had long ceased to be keeper of the records, but by the Public Record Office act, 1838, their custody was restored to him. He is now also chairman of the State Papers and Historical Manuscripts commissions. Under the Judicature act, 1875, and the Appellate Jurisdiction act, 1876, he always sits with the lords justices in the court of appeal, whose decisions can be questioned only in the house of lords.

(H. H. L. B.)

MASTERS, EDGAR LEE (1869–1950), U.S. poet and novelist, author of *Spoon River Anthology,* the first of the many works representing the "revolt from the village" in American literature. was born at Garnett, Kan., Aug. 23. 1869. He attended Knox college, Galesburg. Ill., for one year. was admitted to the bar in 1891 and developed a good law practice in Chicago. A volume of his verses appeared in 1898. followed by *Maximilian,* a drama in blank verse (1902); *The New Star Chamber and Other Essays* (1904); *Blood of the Prophets* (1905); and a series of plays issued between 1907 *(Althea)* and 1911 *(The Bread of Idleness).*

If Masters had continued to write along these lines, he mould not be remembered; but forces were at work on him that would soon induce him to write a work that stands as one of the most significant American books of the early 20th century. In 1909 his friend William Marion Reedy of St. Louis, Mo., editor of *Reedy's Mirror,* introduced him to *Epigrams From the Greek Anthology (see* ANTHOLOGY). Masters was seized by the idea of composing a similar series of free-verse epitaphs in the form of monologues spoken from the grave by former inhabitants of Spoon River, a fictitious village compounded of Petersburg and Lewistown, Ill., as he had known them as a boy. The result was *Spoon River Anthology.*

Though Masters continued to publish almost yearly during the rest of his life, the quality of his work never again rose to the level of the *Spoon River Anthology.* Other volumes of verse are *Songs and Satires* (1916); *The Great Valley* (1916); *Toward the Gulf* (1918); *Starved Rock* (1919); *Domesday Book* (1920); *The New Spoon River* (1924); *The Fate of the Jury* (1929); *Godbey* (1931); *Richmond* (1934); *Invisible Landscapes* (1935); *Poems of People* (1936); and *Illinois Poems* (1941).

Among his novels are *Mitch Miller* (1920) and *The Nuptial Flight* (1923). Masters wrote biographies of Lincoln (1931), Whitman (1937) and Mark Twain (1938); his best effort in this form is *Vachel Lindsay, A Poet in America* (1935), a study of his friend and fellow poet. Also notable are his autobiography, *Across Spoon River* (1936), and *The Sangamon* (1942), a volume in the "Rivers of America" series.

Masters died at Philadelphia, Pa., on March 5, 1950.

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MASTIC or MASTICH, a resinous exudation obtained from the lentisk, *Pistacia lentiscus,* an evergreen shrub of the family Anacardiaceae. The lentisk or mastic plant is indigenous to the Mediterranean coast region irom Syria to Spain but grows also in Portugal, Morocco and the Canary Islands. The production of the substance has been. since ihe time of Dioscorides, almost exclusively confined to the Greek island of Chios in the Aegean sea. The shrubs are about six feet high.

The resin is contained in the bark and not in the wood, and in order to collect it numerous vertical incisions are made, during June, July and August, in the stem and chief branches. The resin speedily exudes and hardens into oval tears, which are collected every 1 j days. The collection is repeated several times between June and September, a fine tree being found to yield about eight or ten pounds of mastic during the season. Mastic occurs in commerce in the form of roundish tears about the size of peas. They are transparent, with a glassy fracture, of a pale yellow or faint greenish tinge, which darkens slowly. It is used in making varnish.

Pistacia khinjuk and *Pistacia cabulica,* trees growing throughout Sindh, Baluchistan and Cabul, yield a kind of mastic. In Algeria, *Pistacia atlantica* yields a solid resin. Cape mastic is the produce of *Euryops multifidus,* the resin bush, or *harpuis bosch* of the Boers—a plant of the Compositae family. Dammar resin is sometimes sold under the name of mastic. The West Indian mastic tree is the *Bursera gummifera,* and the Peruvian mastic is *Schinus molle.* The name is also applied to a timber tree, *Sideroxylon mastichoderzdron,* family Sapotaceae, which grows in the West Indies and on the coast of Florida.

MASTIGOPHORA: *see* FLAGELLATA.

MASTODON, a generic name commonly applied to fossil proboscideans that lived during the Pleistocene epoch. By extension the word mastodon or mastodont is often used as a common noun, to indicate various proboscideans of middle and late Cenozoic Age.

The first mastodonts, which seem to have arisen during the Oligocene epoch. were the size of large pigs, and from them the mastodonts evolved during later Cenozoic times into giants, frequently as large as modern elephants. All of the mastodonts had elongated noses or trunks, long, heavy limbs, and massive skulls.

In these mammals certain incisor teeth were enlarged to form tusks. Early mastodonts were characterized by four tusks, two in the skull and two in the lower jaw, and this pattern of tusk development continued among many mastodonts of late Tertiary Age. In some of them the lower tusks were broadened to form together a sort of shovel or scoop. Among some of the later mastodonts the lower tusks were suppressed. and the upper tusks became very large. In all of the mastodonts the molar teeth were large and were frequently characterized by a multiplicity of cusps. In some of the mastodonts the cusps became connected to form heavy, transverse cross-crests.

In North America the word mastodon is most frequently applied to the American mastodon. a large, two-tusked mastodont of Pleistocene Age. Carbon-14 dating indicates that it survived until about 8,000 or 10,000 years ago. (E. H. CT.)

MASUDI, AL- (ABU-AL-HASAN 'ALI AL-MAS'UDI) (d. *c.* 956), Arab traveler and historian, known as "the Herodotus of the Arabs," was born at Baghdad toward the end of the 9th century. His travels extended to Palestine, Persia, Armenia, the shores of the Caucasus, India, Ceylon, the China seas, Madagascar, Zanzibar and Oman. He was in Antioch in 943 and in Damascus two years later. The last ten years of his life he spent in Syria and Egypt, dying at Fostat (old Cairo) in 956 or 957. Himself a rationalist (Mu'tazilite) he took his information, when necessary, from Persians, Jews, Indians and even the chronicle of a Christian bishop. His historical works included *Kitab akhbar al-Zaman,* in 30 volumes, and a supplement *Kitab al-Awsat,* a chronological sketch of general history. Only one volume of the former has survived but the two parts were epitomized in *Muraj al-Dhanab wa Ma'adin al-Jawahir* (French translation by C. Barbier de Meynard and P. de Courteille, *Maçoudi: les prairies d'or,* 9 vol., 1861–77). In the last year of his life he wrote *Kitab al-Tanbih wa-al-Ishraf* (French translation by B. Carra de Vaux, *Maçoudi, le livre de l'avertissement et de la revision,* 1897) in which he summarized, corrected and completed his former writings.

Masudi's historical works are somewhat superficial as he accepted many unauthenticated stories and seldom went to original sources, but they are enlivened by his boundless curiosity and interest in the world and marked by many anecdotes drawn from his travels and his observation of strange places, peoples and animals.

See C. Field, *Tales of the Caliphs* (1909), based on Masudi's history; R. A. Nicholson, *Literary History of the Arabs*, 2nd ed., pp. 352–354 (1930).

MASULIPATNAM (formerly Anglo-Indian MASULIPATAM; also BANDAR), a seaport and the administrative headquarters of Krishna district, Andhra Pradesh, India. It is between one of the Kistna river distributaries and a canal of the deltaic system, 215 mi. N.N.E. of Madras. Pop. (1951) 77,953. There are rice mills, cotton ginning and pressing factories. Weaving of chintzes, for which Masulipatnam was formerly noted, has declined. The port is a roadstead, vessels having to anchor 5 mi. out. Peanuts, castor seeds and oil cake are exported.

Masulipatnam mas the earliest English settlement on the Coromandel coast; its importance resulted from the fact that it was the bandar or port of Golconda. An agency was established there in 1611. In 1686–90 it was held by the Dutch. During the wars of the Carnatic, the English were temporarily expelled from the town, which was held by the French from 1750. In 1759 the town and fort were stormed and taken by Francis Forde.

MASURIUM: *see* TECHNETIUM.

MATABELE (MATEBELE), a term applied by the Sotho-Tswana peoples to invaders of Zulu stock. The two principal groups, not related to one another, are: (1) Manala, Ndzundza and several other tribes, collectively termed "Transvaal Ndebele," who number about 144,000 and have been in the Transvaal (Pretoria, Sebitiela, Potgietersrust and Pietersburg districts) for about three centuries; (2) the Rhodesian Ndebele, who emigrated from Zululand (c. 1820) and settled (1838) in Southern Rhodesia. Both groups speak dialects of Zulu. (I. S.; X.)

MATACO, the largest and most important Indian tribe of the Gran Chaco, living between the Bermejo and Pilcomayo rivers in northeastern Argentina. In 1945 they numbered about 20.000 out of the 68,000 total aboriginal population of the Chaco. Formerly known as Mataguayo, they were until relatively recently considered to form an independent linguistic family. Matacoan or Matacan. The relationship to Macá (Enimagá-Cochaboth) is generally accepted, however, and more distant relationship to the Guaicurú seems so probable that all have been suggested as forming a Macro-Guaicurú linguistic phylum. The Mataco of modern times practise considerable agriculture, growing principally maize, pumpkins, sweet manioc and beans, but they still rely on fishing, hunting and wild-food gathering, formerly of far greater importance. Classed as "foot Indians," they make slight use of boats or horses. (J. A. MN.; X.)

MATADOR: *see* BULLFIGHT.

MATAGALPA, a large department in the central highlands of Nicaragua, and its capital city. The population of the department (1950) was 135,401. Matagalpa is important in agriculture, mining and manufacturing, producing especially coffee (about 20% of the national output), corn, tobacco, potatoes and other vegetables, fruits, brown sugar (panela), cattle, swine, gold and silver, processed foodstuffs, furniture, leather goods and clay products.

The city of Matagalpa, pop. (1950) 10,323, is located in the north central part of the department in a highland valley at 2,131 ft. above sea level. It is one of the older picturesque cities of the country. Until well into the 20th century it could be reached only by horseback. A highway 20 mi. long connects Matagalpa with the Inter-American highway at Sébaco, giving it direct connections with Managua 103 mi. distant. The city is the leading trading and manufacturing centre of the department. (C. F. J.)

MATAMOROS, a town and border port in the Mexican state of Tamaulipas, 28 mi. from the mouth of the Rio Grande, on its south bank opposite Brownsville, Tex. Pop. (1950) 45,737. It is a commercial centre for the Mexican portion of the lower Rio Grande valley. Trade via the Gulf of Mexico is impeded by sand bars at the river's mouth. By international treaty effective Nov. 8, 1945, Mexico and the United States undertook to provide a series of dams and allied works across the river, chief of which is the international Falcón dam, 7½ mi. down river from Laredo, Tex.; and on the Mexican side, Anzalduas dam and canal, whose irrigation district of 540,000 ac. (a thriving cotton area) depends on Matamoros.

The city has rail outlets to Monterrey and Mexico City, and also has highway and air connections. It was the scene of bitter fighting in the U.S.-Mexican War, and was captured by U.S. troops (May 1846). Matamoros is one of Mexico's chief ports of entry for tourists and for the import and export of goods. (J. A. Cw.)

MATANZAS, a province and its capital city, in west-central Cuba. The province was established in 1879 between Havana province on the west and Santa Clara (now Las Villas) on the east and south. It is the smallest province in population (1953 census, 395,780), and next to smallest in area (3,260 sq.mi.). Its fertile plains have supported a prosperous sugar industry since colonial days. Various industries have been developed at Matanzas and Cárdenas, the port cities, and at Colón on the Central highway. The province's tourist attractions include Yumuri valley, Bellamar caves, and Varadero beach.

The city of Matanzas was founded in 1693 on an excellent open bay, which had been known to the Spanish since 1508 and had been used by pirates. By 1860 it was the second city of Cuba, having 30,000 inhabitants, but its growth thereafter was slow as the sugar industry expanded into the eastern part of the island. Pop. (1953) 63,916. In the mid-19th century Matanzas exported more than one-third of Cuban sugar. It has been called the Athens of Cuba because of its active cultural institutions, public library, and famous poets, sculptors and artists. The city has beautiful drives, plazas and monuments, as well as historic buildings, such as Castillo de San Severino and San Carlos, the oldest church, founded in 1730 and raised to the rank of cathedral in 1915. Monserrate shrine, located on La Cumbre hill, overlooks the Yumuri valley back of Matanzas.

Matanzas, about 50 mi. E. of Havana, is one of the chief ports of Cuba, exporting sugar from nine sugar mills of the province and henequen fibre. The establishment of a free zone in its spacious harbour has resulted in the expansion of industry, chief of which is a large rayon fibre factory. Other plants manufacture ropes, shoes, fertilizers and matches. Matanzas is linked to Havana by two railways, one of which is the electrified Hershey railroad, and by the Central highway. (D. R. D.)

MATARÓ (anc. *Iluro*), a seaport of northeastern Spain, in the province of Barcelona, on the Mediterranean sea and the Barcelona-Perpignan railway. Pop. (1950) 31,011 (mun.). The wine of the neighbourhood, which resembles port, is shipped in large quantities from Barcelona; the district furnishes fine roses and strawberries for the market. Industries include the manufacture of linen and cotton goods, especially canvas and tarpaulin, and of soap, paper and chemicals. The railway opened in 1848 was the first constructed in Spain.

MATCH. A splint of wood or cardboard or a piece of waxed thread provided with a combustible tip which ignites by friction.

Discovery of Phosphorus. — In 1669 Hennig Brand, a Hamburg alchemist, set off a train of events which was to lead to the friction match. Brewing an olio which he hoped would become precious metal, Brand discovered phosphorus. The glowing element was not used in matches for 161 years but it was the basis of widespread experimentation to devise ready methods for making fire. In 1680 Robert Boyle found that by coating coarse paper with phosphorus, fire was produced when sulphur-tipped splints were drawn through a pleat. Largely because of the prohibitive costs, interest soon died down, not to reappear until 1780, a century later, when there was a fresh flurry of inventiveness. Phosphorus unites with oxygen so readily that ignition results upon exposure to air, a principle utilized in an early device called the ethereal match or phosphoric candle. Produced in 1780 in France, the candle consisted of a sealed glass tube in which there was a piece of waxed string or paper tipped with phosphorus. When the tube was broken the inrushing air caused

combustion. Five years later the Italian pocket luminary appeared. This was a bottle containing partially oxidized phosphorus and was used in connection with sulphur splints. The phosphorus bottle of Cagniard de Latour (1810) made use of the same basic principle and François Derosne (1816) is said actually to have made phosphorus matches. The instantaneous light box (1805) was widely used for 40 years both in Europe and America. It consisted of a bottle containing sulphuric acid combined with splints tipped with potassium chlorate, sugar and gum arabic. In the U.S. a box with 50 splints retailed for $2 or 4 cents a light. One of the final novelties preceding the friction match was the electropneumatic fire producer in which a jet of hydrogen was directed upon a piece of charged resin in contact with the air. The famed chemist Johann W. Dobereiner (1823) invented the best known of the portable fire producers in which hydrogen was generated by the action of dilute sulphuric acid on zinc. The gas was then directed upon a platinum sponge in contact with the air. In one existing model a metal statuette of a man stands on the generating cylinder with the gas shooting from a cigar in his hands.

Later Novelties.—Even after the first practicable friction match was marketed in 1827 inventors continued to contrive unusual types of lights. In 1828 there was the Promethean match named for the Titan who stole heaven's secret of fire to give to man. It was a capsule of glass filled with sulphuric acid and coated outside with potassium chlorate, sugar and gum all wrapped in paper. When the glass was broken with the teeth, the chlorate would ignite firing the paper and endangering the user. Self-lighting cigars, with fancy caps or tips of combustible composition, were introduced in Austria in 1839. Pellet matches (1850) were exploded by a plunger machine. Another type of pellets came in strips like caps for a toy pistol. Wire fixed stars, chinese lights, Prussian war fuses and Latchford's bone stem cigar lights which will never fall off, break or burn the fingers are a few of the names of unusual matches of the mid-1800s. As late as 1882 the Diamond Match company patented the drunkard's match intended to save tipplers' fingers by killing the flame at midpoint of the splint. In 1932, Zoltan Foldi and Rudolf Koenig of Austria announced the "everlasting" or repeatedly ignitible match which was an elongated match head laced with fire retardents to make it burn more slowly.

Friction Matches.—The records of John Walker, a druggist of Stockton-on-Tees, England, report the sale on April 7, 1827 to a Mr. Hixon of "100 Sulphurata Hyperoxygenta Frict." These were the first friction matches. They were 3 in. long, tipped with antimony sulphide, potassium chlorate, gum arabic and starch. They lighted when drawn through a fold of glass paper. Ignition was accompanied by a series of small explosions and showers of sparks. Their odour was so offensive that Samuel Jones, who made similar matches a few years later, printed this warning on the boxes: "If possible, avoid inhaling gas that escapes from the combustion of the black composition. Persons whose lungs are delicate should by no means use Lucifers." The Walker matches were of the strike-anywhere type as were the matches invented by Charles Sauria of France in 1831, and which substituted phosphorus for the antimony sulphide. Sauria neglected to patent his phosphorus formula for match composition with the result that his creation was soon in use all over the world. In the U.S., Alonzo Dwight Phillips, Massachusetts powder maker, was granted a U.S. patent for phosphorus matches in 1836.

Sauria's formula had dreadful unforeseen consequences. Fumes of the phosphorus, entering the body through defective teeth, caused a disease called necrosis or "Phossy Jaw" which maimed and killed thousands of match workers before it was stamped out. In addition many innocent persons, particularly children, were poisoned by ingesting the phosphorus from match heads.

E. D. Cahen and H. Savene of Paris successfully substituted nonpoisonous sesquisulphide of phosphorus for the lethal element and were granted patents in Europe and the U.S. (1898). The Diamond Match company purchased the U.S. rights in 1900 for $100,000 only to find after three years of experiment that the formula, successful abroad, would not result in efficient matches in the U.S. because of the climatic differences. In 1911 William Armstrong Fairburn, a naval architect with no chemical training, adapted the formula to U.S. conditions. His methods were presented to all rival U.S. manufacturers, a gift which ended necrosis. Manufacture of matches aith phosphorus is outlawed by the agreement of an international convention at Berne.

Safety Matches.—The discovery of amorphous phosphorus in 1845 by Anton von Schrotte led to the development of the safety match in which only a part of the ingredients for combustion are in the head For this type of match, credited to J. E. Lundstrom of Sweden (1855), the amorphous phosphorus is painted into a striking surface on the box so that without the container the match is impotent.

Book Matches.—The paper book match, invented in 1892 by a Philadelphia attorney, Joshua Pusey, is characteristically American. These matches are packed, usually 20 to the book, in printed cardboard folders with a striking surface on the outside. The bulk of them carry advertising matter, the revenue from which so reduces costs that retail outlets in the U.S. can afford to give away 196,000,000,000 book matches a year as a good will gesture. Unpopular when first produced commercially in 1895. these matches now constitute about two-fifths of the U.S. annual output of 500,000,000,000 matches.

Water Resistant Matches.—World War II with the axis powers resulted in a fourth type of match, the water resistant or waterproof. When it became evident to the Allies that much of the war would be carried on in areas of heavy rainfall, the U.S. war department called on the match industry to create a match to meet wet conditions. Raymond Davis Cady of Oswego, N.Y , is credited with the first practicable formula for a coating which would withstand tropic humidity and water. Matches treated by his method still function efficiently after eight hours of complete submersion.

Match Manufacture.—At the outset every operation in the match industry was performed by manual labour and much of the work was done in the homes of the employees. At the time of the invention of the friction match the spunks or splints were split from wood blocks in single units and dipped in match composition in the same manner. The boxes were tediously made by hand also. This condition existed until the mid-1800s when slow mechanization of operations was begun. Probably the earliest effort to provide a speedier means of dipping the matches consisted in assembling splints in rows in a frame in which they could be dipped simultaneously. The matches were then dried and counted into boxes by hand.

Veneer Process.—All "square" matches made in England, the United States and elsewhere are manufactured by the veneer process. In order to prepare the splint, a log with bark still attached. 8 ft. or more in length and 10 in. or more in diameter, is crosscut to obtain suitable lengths for subsequent handling. A machine of simple type, with vertically rotating disk, furnished on its face with knives set slightly in advance, serves to remove the bark. The log section is then peeled into a thin veneer of about $\frac{1}{10}$ in. depth. For this process the log is fixed between two clutches which hold the ends while the veneer is being peeled into one long shaving. This ribbon of wood is then sliced into proper widths and cut into splints at a rate of 2,000,000 per hour. The splints are then treated in a bath of ammonium phosphate, or boric acid, impregnating them against afterglow. The splints are then cleaned and dried for feeding into the hopper of a continuous match machine. These machines can paraffin, dip and dry matches at a rate of 750,000 an hour or more, depending on the type of machine. One model is 53 ft. long, 10 ft. high and 9 ft. wide. Its principal part is an endless chain of perforated metal plates into which the splints are inserted as they emerge from the hopper. Held perpendicular to the plates, the matches are dipped in hot paraffin, dried and redipped, this time in a liquid composition which becomes the striking head when dry. These operations take an hour after which the completed matches are punched out of the endless chain into waiting boxes.

Round Wooden Matches.—Roughly round, grooved matches wearing a head of two colours are the product of an American double dip, continuous machine based on the inventions of Ebene-

zer Beecher of Connecticut. In the United States the wood for the matches, usually pine. is sawed into planks 2 in. thick, cured from 12 to 18 months. and then resawed into blocks which are 2 in. wide and from $1\frac{3}{4}$ in. to $2\frac{3}{8}$ in. deep with the grain. depending on the type of match. These match blocks are fed into a match machine equipped with a row of from 42 to 57 dies which slice the wood into splints at 300–350 strokes a minute, inserting the splints in perforated metal plates. These machines are from 60 to 90 ft. long, 20 to 30 ft. high and about 10 ft. wide with a capacity of as high as 1.125,000 matches per hour. On this type of machine the impregnation is accomplished with a spray of ammonium phosphate on the machine, followed by paraffin, bulb and "eye" dips with suitable drying periods between each step. The large bulb of the match is comprised largely of inert substances while the "eye" contains the readily ignitible ingredients. The bulb having the larger diameter prevents the sensitive "eyes" from rubbing together after packing and provides an additional safety factor. As in the veneer process. the matches upon completion are forced from the plates into boxes.

Paper Book **Matches.**—Two separate machines are used in the manufacture of paper book matches (1) cut. set and dip; and (2) booking machine. A roll of pre-impregnated cardboard is fed into the first machine which cuts it into "combs" of 60 match splints joined at the base. These "combs" are carried by plates through paraffin and head composition baths, each followed by a drying period. The combs of completed matches are then fed into the booking machine which cuts them into shorter combs of 10 match width and staples them between the folds of previously printed covers. The same machine paints on the striking surface, discharging completed books of 20 matches each at a rate of 350 books a minute. Modern book match factories are equipped with printing establishments capable of preparing multicoloured covers for the matches.

Chemicals.— Elaborate laboratories for the preparation of vast quantities of paraffin, match composition and impregnating fluids are a part of every match factory. Under expert supervision the basic ingredients such as sesquisulphide of phosphorus, chlorate of potash. pulverized earth, quartz; ground glass, gums, dyes and zinc oxide are carefully blended with the utmost precision. As an added precaution most large match factories maintain testing laboratories which carefully check newly made matches for safety, ready ignitibility. strength and splint and anti-afterglow. Any batches which fail to meet rigid standards are destroyed.

Boxes and Printing.— The modern match factory is equipped with a complete box factory within itself synchronized so that each of the match machines receives an adequate flow of boxes and covers to receive completed matches. (S. LI.)

MATCHLOCK: *see* SMALL ARMS. THE DEVELOPMENT OF.

MATE or PARAGUAY TEA. the dried leaves of *Ilex paraguariensis* (and some other species), an evergreen shrub or small tree belonging to the same genus as the common holly. The leaves are from 6 to 8 in. long, shortly stalked with a somewhat acute tip and finely toothed at the margin. The small white flowers grow in forked clusters in the axils of the leaves; the sepals. petals and stamens are four in number, or occasionally five; and the berry is 4-seeded. The plant grows abundantly in Paraguay. and the south of Brazil, forming woods called *yerbales.*

Although mate appears to have been used from time immemorial by the Indians, the Jesuits were the first to attempt its cultivation. This was begun at their branch missions in Paraguay and the province of Rio Grande de San Pedro, where some plantations still exist, and yield the best tea that is made. From this circumstance the names Jesuits' tea. tea of the Missions. St. Bartholomew's tea, etc.. are sometimes applied to mate. Under cultivation the quality of the tea improves. but the plant remains a small shrub with numerous stems. instead of forming, as in the wild state. a tree with a rounded head. From cultivated plants the leaves are gathered every two or three years. that interval being necessary for restoration to vigorous growth.

The collection of mate is chiefly effected by Indians employed for that purpose by merchants, who pay money to the government for the privilege. An open space, called a *tatacua,* about 6 ft. square is prepared in which the surface of the soil is beaten hard and smooth with mallets. The leafy branches of the mate are then cut down and placed on the *tatacua,* where they undergo a preliminary roasting from a fire kindled around it. An arch of poles, or of hurdles. is then erected above it, on which the mate is placed, a fire being lighted underneath. After drying. the leaves are reduced to coarse powder in mortars formed of pits in the earth well rammed. Mate so prepared is called *caa gazu* or *yerva do polos,* and is chiefly used in Brazil. In Paraguay and the vicinity of Parana in the Argentine Republic, the leaves are deprived of the midrib before roasting; this is called *caa-miri.* A very superior quality, or *caa-cuys,* is also prepared in Paraguay from the scarcely expanded buds. Another method of drying mate has been adopted, the leaves being heated in large cast-iron pans set in brickwork, in the same way that tea is dried in China.

The tea is prepared in a small silver-mounted calabash, the tapering end of which serves for a handle. In the top, there is a hole and the tea is sucked by means of a bombilla. This instrument consists of a small tube 6 or 7 in. long, formed either of metal or a reed. which has at one end a bulb made either of extremely fine basketwork or of metal perforated with minute holes. so as to prevent the particles of the tea-leaves from being drawn up into the mouth. Some sugar and a little hot water are first placed in the gourd, the yerba is then added. and finally the vessel is filled to the brim with boiling water, or milk previously heated by a spirit lamp. A little burnt sugar or lemon juice is sometimes added instead of milk.

Mate, like tea and coffee, contains caffeine. but in less quantity. It is also less astringent. Mate retains its flavour against exposure to the air and damp.

See R. H. Porter, "Mate—South American or Paraguay Tea," Econ. *Bot.* 4:37–51 (1950).

MATERA, a city of Lucania. Italy. capital of the province of Matera. 1; mi. S. of Altamura (which is 30 mi. W. of Bari) by rail; the line goes on to Miglionico, 18 mi. S.W.. 1,312 ft. above sea level. Pop. (1951) 30,009. Part of it is built on a level plateau and part in deep valleys adjoining. The western façade of the cathedral is plain and the south front facing the piazza richly dccoratcd. The campanile is 17j ft. high. Nearby are caves with 13th-century frescoes.

The district was well populated in the paleolithic and neolithic periods, and important discoveries were made by Domenico Ridola.

MATERIAL **CULTURE.** Even under civilized conditions a great part of man's material culture is directly associated with his primary need, that of procuring food, and his progress in many other directions depends upon the measure of his success in this. The old classification of peoples or communities as hunters, herders or tillers of the soil, is therefore not without value, though it lays undue stress upon this aspect ,of human life, and more than one question is begged when it is assumed that the higher cultures must have passed through the lower stages to reach their present level. It is quite probable that the first men to begin the cultivation of plants were neither hunters nor herders in a specialized sense, but food-gatherers who, from depending upon such plant and animal produce as they could collect, were led to discover that roots and shoots and seeds could be made productive under control. Apart from those existing backward peoples who live by collecting, hunting and fishing alone, hunting may be a more or less essential activity in higher grades of culture, its importance decreasing with the extension of plant and animal cultivation, until in the higher civilizations it degenerates into a sport. The domestication of animals is, as is well known, often associated with agriculture, though in its intensive form it may have had its first big developments amongst nomadic peoples. The three categories may be regarded as specializations which arose out of the food-gathering that was in the beginning the compulsory occupation of the human stock, as it is of the existing apes. Specialization in, and dependence upon, hunting or the rearing of animal stock, involved a mode of life less likely to lead to and foster plant-growing than would a more settled exis-

tence in an area where vegetable food was plentiful, and where the phenomena of growth could be observed under similar conditions year after year. As is generally recognized, a settled life would also provide favourable conditions and incentives for the initiation of other peaceful arts, such as basket- and pottery-making, spinning and weaving; but it was only when plant cultivation established itself as cereal culture — the growing of grain such as barley and wheat, which could be stored for winter consumption — that the first civilizations became possible.

If food is the primary need of man, clothing and shelter, however they first arose, assumed the form of needs partly under stress of climate. Means of travel and transportation, especially over water, were accessory to the more immediate material aims, since they played an important part in opening up new food-areas, and provided new natural products and new environmental stimuli.

Arts and Crafts. — A close study of the means of procuring food leads to the consideration of the innumerable weapons and devices for hunting and fishing; of methods and appliances used in plant cultivation and the tending of domesticated animals; and of the great variety of methods, implements and utensils for carrying, storing and preparing food. With clothing are associated skin-dressing, bark-cloth making, spinning and weaving, whilst in shelter and in travel and transport are involved the building of wind-screens and dwellings, and the construction of carrying devices and water-craft. To the implements and appliances needed for the carrying out of operations connected with all these activities there must be added — with considerable overlap the tools and mechanisms used in the treatment of materials, and in the construction of artefacts of all kinds.

Many artefacts have their main significance outside the limits of material culture, as, for example, in the case of personal ornaments, instruments for measuring time and weight, musical instruments, religious buildings and images of gods; but as artefacts or inventions these claim consideration from the same point of view as others serving more material ends. Their nature is, indeed, determined by the state of culture with which they are associated, and in their development they may react conspicuously upon the technique or constructional principles upon which they depend. It is clear that man, even savage man, has aspirations besides those of preserving his life and making himself comfortable, and these carry him far beyond the limits to which he is pushed by necessity.

The ethnologist, in his studies of the culture of an alien people, finds the investigation of the material side of their life less difficult, and more reliable in its results, than is that of the social and religious aspects. There is less risk of error in describing a canoe or a method of making pottery, than in giving an account of a social or religious custom or belief. In the material object or the method the greater part of the truth is on the surface, and is easily grasped. The custom or belief may present features which are utterly foreign to the mode of thought of the investigator, and its real significance exists in the minds of men who may be incapable of explaining it clearly, or who may not desire to do so. Material culture is in fact a study of greater certainty because the evidences are stable and material, and can often be collected for detailed and leisured study. The fact that many artefacts are capable of preservation for hundreds or thousands of years adds to the scope of a study which thus ranges not only wide in space but deep in time.

Cpon our accumulated knowledge of the material activities of peoples of all grades of culture a science of comparative technology has been built up which deals in detailed fashion with the technique of arts and crafts. Basket-work (see BASKET), pottery (*q.v.*), dwellings, weapons, weaving (*q.v.*) and other subjects are treated from this point of view elsewhere in this section, and only a few general considerations need be touched upon here.

Implements. — Even with some knowledge of natural materials, processes and forces. man can do little with his hands alone; but very much more can be achieved with the aid of a smooth pebble. a pointed stick and a sharp flint (see FLINTS). It was in the working of hard materials such as stone, wood and bone, that the hands had to admit their primary incapacity, though there were other things they could not do unaided. In some cases, however, an elaboration of tools and appliances can only increase speed and precision, though even a simple appliance like the primitive plough may produce results which are out of all proportion to its own structural complexity. In the development of most arts and crafts there has necessarily been constant interaction between materials, methods and appliances, but there is no common formula to express the degree of interdependence. Seeds may be sown, and clay may be shaped with little or no assistance from artefacts, but for breaking and crushing hard materials, for cutting, piercing, abrading and similar operations, tools are essential. Simple devices involving the application of leverage, the elasticity of wood and especially rotary motion — as in the drill, the wheel and the rotary quern — pointed the way to the development of machinery as we know it; progress in this direction was, however, dependent not only upon increased knowledge of natural forces and mechanical principles, but upon the production of iron in large quantities, and upon the evolution of methods of working and shaping the metal.

That there are conspicuous differences in the parts played by methods and appliances, respectively, in various arts and crafts, needs little demonstration, and in some cases there has been a great development in appliances without an equivalent improvement in the products. Basket-work, which reaches its highest level amongst uncivilized peoples, requires the simplest of tools, or even none at all, and the forms and fabrics are such as to preclude the use of mechanisms or machines; development has resulted from change and improvement in technique, and not from the invention of artificial aids for the craftsman. Similarly, though not equally, pottery-making was for long an art in which the hand was the only important tool employed in shaping the clay, and the early potter's wheel did not bring about a fundamental change in this respect — discoveries of new kinds of clay, and of better methods of preparing them, and of firing the pots, have been the most important factors in the evolution of pottery. Appliances have, however, played a greater part in the advances that have been made, than in the case of basket-making. In plant cultivation, again, much could be done with the hoe, or even with the simple digging-stick, but the evolution of the plough and of other accessory appliances, was essential to the growth of agriculture to its full usefulness. In modern spinning and weaving complex machinery does rapidly and surely what for some thousands of years was done slowly but adequately — as it is still done in some parts of the world — by means of spindles and simple looms made of a few sticks and wooden slats.

Theories of Development. — Since evolution became a dominant motive in scientific studies, the descriptive and comparative methods of treatment have been extended for reconstructive purposes. In anthropology this tendency has been encouraged by the stimulus afforded by the discoveries of the archaeologist, which give us clues not only as to the general course of evolution of material culture, and of individual appliances, but as to the relationships between ancient peoples. That there have been since early days in the history of man, innumerable instances of contact, migration and conquest, and that such relationships have led to transmissions of culture, or of cultural elements, from place to place and from people to people, is generally agreed. The attempts to ascertain how far an existing culture in any part of the world can be resolved into its historical elements — how far stratification can be detected, and transmissions be traced to their sources — have necessarily been based on analyses which take into account not material culture alone, but linguistic, religious, social and physical characters. Reconstructive work of this kind, though sometimes one sided, is the only approach to a scientific history of mankind, as distinct from literary histories of nations and peoples.

The attempted reconstructions are based on views which in their most definite form are regarded as characterizing the historical or diffusionist school of anthropologists. In controversial opposition are those to whom the term "evolutionists" has unaccountably become attached. Whilst the extreme diffusionist regards the independent origin and development of similar or

identical methods, artefacts, beliefs and customs, as having been so infrequent as to be of negligible significance, the extreme evolutionist is supposed to postulate independent evolution as an ever-ready explanation of such similarities. It is not probable, however, that there is any evolutionist who denies the occurrence of diffusion, and there is certainly no diffusionist who denies the occurrence of evolution. There is, too, the belief that the whole controversy is futile.

The test question is that of the cultures of the Indians of America. There are some anthropologists who are prepared to regard diffusion as an acceptable and far-reaching explanation within the limits of the Old World and the New. respectively, but who look upon the culture of the American Indians as to all intents and purposes indigenous. This view involves the acceptance of a great number of difficult cases of independent origin and parallel or converging development.

Directional Invention. — In this enquiry much depends on whether we regard man's inventive powers as originative in character, based upon a far-seeing anticipation of ways and means as well as ends, or as an opportunism which ranges from the casual to the persistent according to circumstances. Under modern civilized conditions there is a constant striving on the part of a small number of individuals, after discovery and invention. Even when the unexpected happens and is seized upon, there is some end in view, though it may be different from that eventually achieved. The world-wide literature of science, modern knowledge of the properties of materials, and of chemical and physical forces, combined with the possession of a great variety of tools and machines, are apt to lead us to conceive of the inventor as a creator rather than an adapter and improviser. Giant strides are apparently made, but they are in reality due to the summation of a number of much smaller steps; judgment is often confused, also, by the fact that a simple discovery may have important results, the discovery being judged by its consequences, and not by its own intrinsic simplicity. The fact that, as is the case with most modern advances, it could not have been made without elaborate apparatus or refined technique, may be of historical interest, but this does not take it out of the category of the discoveries that man has been making since his career began. In short, the existing social and material conditions enable the civilized inventor to place himself in the way of receiving suggestions that can only reach him by way of methods and appliances that are themselves the end-results of a prolonged process of gradual evolution. Civilized man has, moreover, become convinced that nearly all things are possible, and that the unknown is not only a territory to be explored without fear, but with hope of great reward. He is an opportunist, pursuing discovery and invention by way of experiment to the furthering of directional aims, and his advantages over his early predecessors are due to his social and material heritage, and not to intellectual superiority. We can scarcely doubt that under conditions that favoured the accumulation of knowledge, and that provided opportunities and incentives to the discoverer and inventor, there have been in all the higher human cultures, individuals, relatively few in number, who have adopted such directional methods as their knowledge and material equipment allowed. But the ancient civilizations were themselves based upon the prior evolution of a grade of culture that rendered their foundation possible, and only when these had become well established were the conditions for the emergence of directional invention fulfilled. Even then the limitations of knowledge and the inhibitions of habit, prejudice and superstition, made progress incomparably slower than it is in our own times. Amongst uncivilized peoples, perceptible advance has probably been made only when racial contacts and impacts, great changes in environment, or discoveries which opened up new possibilities — such as those which led to agriculture and metal-working respectively — raised men out of the stagnation due to unchanging environment and a static condition of knowledge. There was new material to work upon, and attempts to apply the old methods were met by unexpected reactions on the part of the material or appliances used.

Chance Discoveries. — If we regard directional invention as characteristic of peoples living under civilized conditions, it is necessary to enquire how progress was made before civiiization was established. If it could be said in 1927 that "most discoveries in physics arise from some experimental fact discovered rnore or less accidentally" (Presidential address [by Sir James B. Henderson] to the engineering section of the British Association for the Advancement of Science, 1927), it is not unreasonable to ascribe to chance the discoveries of early man. It can hardly be supposed that he experimented with stones in order to produce fire, before he had observed the production of sparks by a chance percussion; or that he took to testing the germinating power of seeds, because he felt the need of a more reliable food-supply; nor did he invent the blow-tube because he wanted something with which to shoot pellets or darts. He discovered accidentally that certain results followed certain actions, and in many cases the means came to hand and the end was achieved before the need was realized. There must have been innumerable instances of failure to recognize that a useful discovery was within reach, and the means and the end and the need alike remained unknown. Clay may have hardened in the fire, and copper melted, many times in vain.

It may be said that a manner of progress such as this, may account for the primary discoveries of man, and for their application in simple methods and appliances, but that he must have soon got beyond this dependence upon environmental suggestion; and indeed there was a gradually increasing change in the conditions determining the nature of his discoveries and inventions But the change was one of scope rather than of character, and was due to the extension of his environment by the addition to it of. his own accumulating knowledge and equipment. Thus, the ore of a metal was at first merely one kind of rock or stone amongst many others, but with increasing discoveries of its potentialities, man's environment was enlarged no less than it would have been if the ore had fallen from the skies, with instructions for use. Similarly, when he discovered that he could make a new kind of weapon or tool by thrusting a blade of stone into a bend or a cleft or a hole in a stick, he opened up a new field of invention, which had previously been outside his environment. Certain discoveries and inventions contained great possibilities, others had their chief value in their immediate utility, and were destined to advance but little. The pestle and mortar are much as they have always been, except in diversity of material, but the pick or the hoe led to the modern plough, and the canoe now figures as a battle-ship. In all the developments, each step has depended upon its predecessors, except in cases in which an appliance or method has reached its highest level only to be superseded by a rival which had evolved along different lines, and which contained greater potentialities. Thus, the spear-thrower gave place to the bow, and this to the gun, the push-quern to the rotary quern, stone-working to metal-working, though where the newer knowledge never penetrated, or met with opposition, the older ways survived.

Method of Variation. — If we take a closer view of the manner in which inventions develop, we find that two chief factors can be distinguished. In the one case, there is the method of variation, in which the individual changes are small in amount and unimportant in their effects, or, if not so small, they are such as could have been produced by the summation of a number of such changes. It is obvious that form and size may easily change as the result of the selection of variations, whether the selection is made with a clear consciousness of possibilities or not. By variation the bronze dagger was lengthened to become a sword, the flanged celt became a palstave, and such artefacts as wooden clubs, stone celts and arrow-heads, pots and a multitude of others developed into a variety of forms without the intervention of what is often called the inventive faculty, though not necessarily without imitation corning into play.

Mutations. — In addition to these variational changes, there are others which can only occur each as a single step of a decisive character. There can be no true intermediate stages, no summation of series, for example, between the worked stone held in the hand, and one fixed in a wooden haft; between the spear with a

fixed point. and a harpoon with a detaching point; between a plain bow and a crossbow; between a simple wooden drill and a bow-drill. In all these cases the second appliance arose by an abrupt change, of an inventive character, and we may borrow a biological term and speak of such steps as mutations.

Two kinds of mutations may be distinguished. On the one hand there are improvements made as a-result of discoveries arising during the manufacture or utilization of the artefact itself. These we may call free-mutations, and they are strictly comparable with the applied discoveries of the potentialities of natural objects. If we assume that the harpoon arose from a spear which had a bone point or blade tied to the shaft, we may regard the occasional breaking away of the point as the determining accident in the evolution of the new appliance. The tying cord might easily retain its connection with the shaft and become entangled with the point, in such a way that the essential feature of the harpoon presented itself ready-made. The observation that there were certain advantages in this looser mode of attachment might lead to its permanent adoption for spearing fish or aquatic mammals, and the free-mutation established itself. It is not possible to do more than speculate as to the mode of origin of most ancient inventions. In this case, as no doubt in many others, accident may well have played the predominant part.

It is in the second kind of mutations, which may be called cross-mutations, that the inventive faculty has its main opportunity. Here not only is the end pre-conceived, but a possible means is foreseen. Most modern inventions (the single steps, not complexes such as aeroplanes and loud-speakers) are cross-mutations, and they involve the adaptational transfer of a device or feature from one appliance to another, or the application of a device or feature that has become well-known through its utilization in other artefacts. The more highly developed the state of material culture, the more numerous are the opportunities for cross-mutation, though progress is still made step by step. Early man. and even early civilized man, had relatively few such opportunities, but occasionally he hit upon a new method or device that contained extensive possibilities of transfer and adaptation. The idea of hafting, and the several methods of hafting (by means of lashings, tangs, sockets, etc.) were in origin based on free-mutation and variation; but they could be transferred as cross-mutations. Similarly, devices for utilizing and controlling rotary motion were capable of transfer. We must suppose that such transfer only took place to an artefact which had reached a stage of development at which the application of the mutation was a more or less obvious step to take; nevertheless it is clear that in cross-mutation there was a greater foresight and awareness than in the case of free-mutation, which only involved an appreciation of the immediate possibilities of a chance discovery. A free-mutation is a new discovery directly applied to the construction or improvement of an artefact, whilst a cross-mutation is the result of the extension of the utility of a known device. Any true inventive step is a mutation, and the term may be restricted in its use to the evolution of artefacts.

This "opportunist" view of the manner in which man's methods and artefacts have been evolved, emphasizes the extreme gradualness of the process. The simplest tool and method that are based on the most superficial phenomena, may have been arrived at over and over again. Such knowledge was probably part of the equipment of *Homo sapiens* at the time of his first dispersal. It is evident that the greater the number of determining variations and mutations involved, the less probable is it that the same result will have been reached independently in different parts of the world. The fact that in modern times two investigators occasionally make the same discovery or invent a similar device, has no bearing upon the question, since they work in reality in collaboration, starting from the same point, using similar apparatus, and drawing upon the records of the same predecessors. A consideration of modern inventive progress, in spite of its directional aims, strongly supports the opportunist view of the development of material culture.

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MATERIAL HANDLING. Since the beginnings of civilization. man has sought ways of moving objects which were too heavy or too bulky to be easily moved by himself. The use of mechanical devices to eliminate or simplify elements of human work has been termed mechanization, and material handling is that part of mechanization which is concerned with the transporting, positioning and storage of materials in industry.

The science of industrial material handling dates back to the late 18th and early 19th centuries. The use of an integrated system of belt conveyers for handling materials in a flour-processing mill was discussed by Oliver Evans in *The Young Mill-Wright and Miller's* Guide (1795). Bucket conveyers were employed in grain elevators as early as 1843, and overhead cranes were in limited use by 1850. By 1900, two-wheel and four-wheel industrial trucks were employed in industry for handling bags, drums and pans, and in 1913 the Ford Motor company established the first progressive assembly line for automobiles.

During World Wars I and II and in the intermediate period, the development of material-handling equipment progressed at a rapid pace. More and more. industrial plants adopted line-manufacturing methods in which whole processes were designed around the material-handling system. Although U.S. firms adopted mechanized production systems more rapidly than those in other countries, considerable progress was made in all industrial areas of the world in replacing manual handling with mechanical-handling devices. In some cases, integrated systems of automatic processing equipment and material-handling equipment have produced completely automated processes which have eliminated the need for direct manual labour. Of course, skilled technicians are required to set up and maintain such complex manufacturing systems.

Since the handling of material does not usually contribute to its value, the moving, positioning and storing of product is always expensive, and one of the prime objectives of material handling is to lower handling costs. Various studies have shown that from 22% to 60% of total manufacturing cost may be attributed to handling materials. In addition, there are many indirect costs which may be affected by the procedures used for material handling, such as scrap material losses and machine delay losses. Other important objectives of good material handling are to (1) reduce production time; (2) aid in the control of the flow of materials; (3) reduce inventory quantities; (4) conserve on plant floor space; (5) limit worker fatigue and prevent injuries; and (6) integrate handling and processing operations.

Selection of the proper handling equipment for a particular installation involves considerations of cost, reliability and suitability. For handling that involves area coverage. long hauls or changing flow patterns, industrial trucks or overhead cranes may provide the best solution; for fixed-path coverage, medium hauls or relatively stable flow patterns, conveyers may prove more satisfactory. The selection of a specific type of equipment requires detailed study of the product, the nature of the handling operation and the design of the manufacturing process in general. In selecting positioning or storage devices, product orientation or alignment may be another important consideration. Material-handling equipment may be classified as (1) conveyers, (2) hoists and cranes, (3) industrial trucks, and (4) unit-load accessories. Each type has certain defined areas of usage, although in many situations an integrated system of several different types of material-handling equipment is needed.

Conveyers.—The conveyer provides continuous, mechanized handling of material at any desired rate of movement. Conveyers may be operated intermittently or continuously, as desired, depending upon the type of drive mechanism provided. conveyers mill move anything from the lightest to the heaviest material, in almost any size. shape or condition and with a speed, accuracy and ease seldom achieved manually. The conveyer may serve solely as a movement device between points in the plant, or it may be an

integral part of the manufacturing operation. It usually permits a reduction in work-in-process inventory, provides an excellent mechanism for controlling production and may serve as a ready-access, moving storage system. In addition to industrial applications, conveyers find many uses on farms and in other types of enterprise. Conveyers range in length from a few inches to an integrated system of conveyers several miles long. The major types of conveyers are gravity roller, gravity wheel, live roller, belt, floor, slat, flight, apron, vibrating, trolley, en masse, bucket, screw, pneumatic, tow, portable and transfer—each of which is briefly described below.

Gravity-Roller Conveyer.—Roller conveyers employ a series of parallel rollers of various diameters and materials which are supported at specified spacings in a metal frame and are used to convey objects and packages by gravity or manually (fig. 1). The conveyer frame sections may be placed directly on the floor, supported on fixed or adjustable-height legs, or supported on hangers from overhead structures. The frame sections may be straight or curved, and spirals, switches and crossovers are also available. Usually, several conveyer sections are joined together to form a system, and the system is inclined slightly if gravity flow of material is desired.

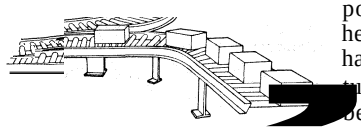

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FIG. 1.—ROLLER CONVEYER

Gravity-Wheel Conveyer.—Wheel conveyers consist of a series of "skate" wheels mounted on parallel axles and supported at selected spacings between frame sections. They are used to convey packages and other flat-bottomed objects by gravity or applied manual force. They are similar to gravity-roller conveyers except that wheel conveyers are generally used for lighter loads and are comparatively less expensive. The use of wheels also limits the usefulness of the conveyer to specific handling jobs. The conveyer sections are available in both straight sections and curves and are supported like the gravity roller conveyer.

Live-Roller Conveyer.—This type of conveyer is similar to the gravity-roller conveyer except that the rolls are power driven by means of a belt snubbed against the underpart of the rolls or by a chain driving sprockets attached to the rolls. Power may be applied to all or only a part of the rolls, and the driving medium may be of constant or variable speed. Live-roller conveyers are used to move materials in containers without the need for manual pushing or pulling and where the use of gravity is impractical.

Belt Conveyer.—Where it is desired to move packaged or bulk material, or even individual objects, on a continuously moving conveying medium, the belt conveyer is often selected. The belt may be of fabric, rubber, plastic, leather or metal, and is driven by a power-operated roll mounted underneath or at one end of the conveyer. The belt forms a continuous loop and is supported either on a metal slider pan or on rollers. In addition, suitable take-ups provide enough tension to keep the belt taut. The slider-pan support is used with flat belts when the load is sufficiently light to prevent a heavy frictional drag on the belt. For heavier loads, roller supports are always used. In some cases, the supporting rolls are mounted to form an angular trough in the belt, so that bulk materials can be carried in the cavity (fig. 2). Belt conveyers are generally laid out horizontally, but they can be operated at an incline if the material being carried is of such form that it will not slide back on the belt. For steeper angles of inclination, cleats may be mounted across the belt to prevent slippage of the material during rise or descent. Belt conveyers can be operated close to the floor on low supports, at table height with fixed or adjustable legs or at higher elevations when supported from the overhead structure. Power is generally provided by electric motors operating through a constant or variable-speed reduction gear.

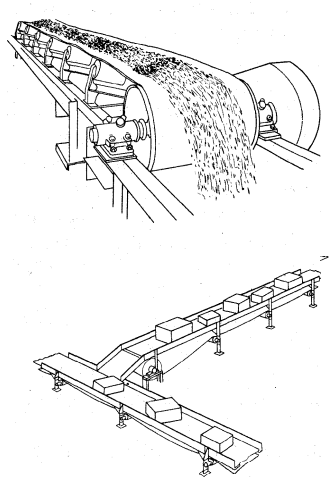

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FIG. 2.—TWO TYPES OF BELT CONVEYERS

Floor Conveyer.—This may be any of several types of conveyers using chain, cable or other linkage mounted in or close to the floor. Such conveyers are often designed to drag a series of four-wheel carts around in a horizontal loop, to carry large products or to permit assembly of products while on the conveying system. Power is supplied to the chain or cable, which operates within an endless track by means of guiding rollers. The material carriers are then attached with permanent or removable clamps to the conveying chain or cable.

Slat Conveyer.—Slat conveyers consist of one or more power-driven endless chains or other linkage, to which are attached spaced slats of various materials, to carry objects which would damage a belt because of weight or sharp edges and for which a live-roller conveyer would not be suitable. The parallel slats do not overlap and are not interlocking; they are attached to provide a continuous moving bed or platform. The chains or other linkage are driven by electric motors operating through suitable reduction gears and sprockets.

Flight Conveyer.—In this type of conveyer, scrapers or flights of various materials are mounted at spaced intervals perpendicular to the direction of travel on one or more endless, power-driven chains operating within a trough. The flights are attached to the power-driven chain and serve to push bulk materials along the trough. These conveyers are designed in many different styles for handling sawdust, sand, gravel, stone, coal, chemicals and many other bulk materials.

Apron Conveyer.—When a continuous moving bed for bulk materials, packages or objects is desired, the apron conveyer may be the best solution. Overlapping and interlocking plates of various materials are joined to one or more endless chains to provide a continuous carrying surface which can be run either horizontally or up and down, as determined by the chain guides or supporting rollers. One of the main advantages of the apron conveyer is the "leakproof" bed which makes it suitable for bulk materials without containers (fig. 3).

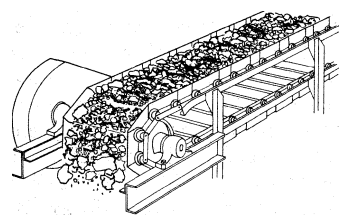

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FIG. 3.—APRON CONVEYER

Vibrating Conveyer.—The vibrating conveyer consists of a trough or tube which is flexibly supported and vibrated by mechanical or electrical means to convey objects or bulk materials. Vibration is in an inclined, elliptical pattern to cause directional as well as upward movement of the material. Since the conveyer has no moving parts other than the drive mechanism, it is particularly suitable for abrasive bulk material.

Trolley Conveyer.—Designed to carry objects and materials in containers from overhead supports, the trolley conveyer utilizes an overhead rail carrying a series of load-bearing carriers or trolleys which are coupled together on an endless propelling medium such as chain, cable or other linkage (fig. 4). Trolley conveyers provide an extremely flexible handling system, in that the rail may be installed to provide both straight and curved horizontal travel as well as inclines and twists. This type of

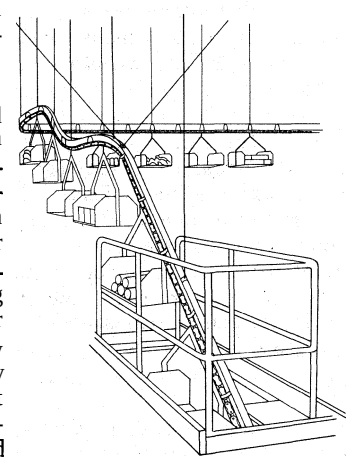

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FIG. 4.—TROLLEY CONVEYER

conveyer is used with hooks, magnets or various carriers designed for the particular load to be handled. The trolley conveyer is particularly suitable for long moves between fixed locations, for in-process storage of material between operations, for special processes such as painting, baking and degreasing and for assembly work during movement. The rails are usually supported by the overhead structure of the plant building.

En Masse Conveyer.—This type of conveyer employs a series of skeletal or solid flights mounted at spaced intervals on a chain or cable which is power driven within a closely fitting casing. It is primarily designed for bulk materials which must be enclosed during transfer to prevent leakage or explosion. The conveyer can operate in horizontal, vertical or inclined positions, and it moves the bulk material in a continuous stream within the casing.

Bucket Conveyer.—The bucket conveyer consists of one or more strands of endless chain, belt or other linkage to which are attached buckets of various shapes and sizes, spaced at regular intervals, to convey bulk material in horizontal, inclined and vertical paths (fig. 5). The buckets remain in the carrying position until they are tipped to discharge the material. The bucket conveyer can be used with or without a casing and can be designed with several different types of discharging mechanisms.

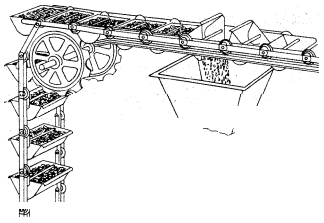

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FIG. 5—PIVOTED BUCKET CONVEYER

Screw Conveyer.—Screw conveyers are essentially a revolving shaft with continuous or broken spiral flighting which operates within a casing to convey materials along a prescribed path. The screw is usually designed to operate in only one direction and is powered by an electric motor and suitable gearing. Screw conveyers are particularly suited to fine bulk material such as meal, seeds and coal.

Pneumatic Conveyer.—Pneumatic conveyers move bulk material in tubes or ducts by means of air pressure or vacuum. Objects can also be handled by enclosing them in a cylindrical sleeve which closely fits the internal diameter of the pipe and is conveyed by the air pressure. Vacuum systems are used for drawing light bulk material from railway cars or bins, and the system works very much like a household vacuum cleaner.

Tow Conveyer.—Either the overhead trolley conveyer or the floor conveyer can be adapted for use as a tow conveyer. The cars or four-wheel carts are locked in to the towing chain or cable to move them from any one point in the system to any other point. Tow conveyers are used for handling many different types of dollies. trucks and cars. When the cars are disconnected from the towing conveyer, they may be used as storage devices or moved manually to any location in the plant. The towing system is usually provided with a variable-speed drive to permit flexibility in its use.

Portable Conveyer.—Any type of conveyer which is mounted on mobile supports, usually wheels, may be considered portable. Gravity roller and wheel conveyers and short belt conveyers are particularly adaptable to portable use.

Transfer Conveyer.—This term has been applied to the intermittent transfer equipment which is utilized in the automatic transfer machine. It may consist of either a rotary indexing table or a straight-line indexing device which moves work-holding fixtures from one work station to another within one basic machine. The transfer device is a form of conveyer which is incorporated within the machine itself, and the machining heads are mounted onto or around the conveyer. (See also ELEVATOR.)

Hoists and Cranes.—These devices are used for lifting and lowering material and for limited area movement. The hoist is primarily a lifting device, the common types being chain, air and electric.

The chain hoist is manually operated. The air or pneumatic hoist employs compressed air to operate a cylinder or air motor and provide the lifting force. The electric hoist, which utilizes an electric motor for power, is the most economical unit for rapid lifting and lowering. In addition, the range of lifting capacities is greater for electric hoists than for air hoists and electrical outlets may be more readily available. However, air hoists are generally considered to require less maintenance. Fig. 6 illustrates a typical electric hoist.

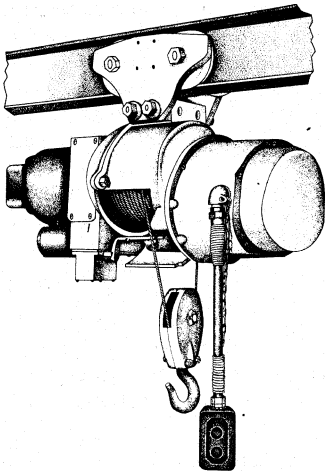

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FIG. 6.—ELECTRIC HOIST

A special type of hoist is known as the skip hoist. It is a motorized hoist having bucket cars which operate on steeply inclined rails. The skip bucket moves up and down the rails by means of a wire rope or chain, driven by a sprocket or drum at the head end. Skip hoists are used for elevating bulk material or parts for delivery into bins, mixers, grinders, etc., and may be either fixed or portable.

Cranes permit both vertical and horizontal movement of material within the limitations of their travel area. The more common industrial types are the portable, jib, gantry and bridge cranes. Portable cranes consist of a curved or straight boom, over which the lifting cable rides on special pulleys, mounted on a portable base which is either moved manually or has a power-drive unit. Truck, tractor and locomotive cranes are examples of portable cranes. The jib crane consists of a hoisting mechanism mounted on a trolley to move back and forth along a horizontal bar or beam, which is supported on a vertical pillar or mast or attached to a wall, and permits rotary motion of the beam such that the crane can be used to service a circular or semicircular area. The gantry crane consists of a hoisting mechanism mounted on a trolley to move back and forth on a horizontal beam or bridge which is supported at each end on vertical frames, often A shaped. These frames may be either fixed or mounted on wheels, the latter riding on rails to permit traverse of the bridge. If both of the supports are the same length, the crane is known as a full-portal gantry. However, if one end is supported on an elevated stand or runway, the crane is called a semiportal gantry. The bridge crane consists of an overhead beam or bridge which traverses an area of the plant on elevated rails or runways, supported on the building structure.

The crane is moved along the runways by either manual or electric power, depending primarily upon the size of the crane. The lifting mechanism is trolley mounted to permit movement of the hoisting mechanism back and forth across the bridge. In large bridge cranes, a cage is mounted under and attached to the bridge for an operator, who rides with the bridge. All movement is electrically powered and controlled from the cage.

Cranes are discussed in more detail in a separate article (see CRANES).

Industrial Trucks.—The industrial truck provides intermittent movement of unit loads of material from any point in the plant area to any other point. A unit load is that amount of material which is grouped together for handling as one load. Industrial trucks provide maximum flexibility in making moves within the plant area, and they permit rapid, mechanized handling of all material which can be handled as a "load." Most of the many types of industrial trucks also permit mechanized pickup and deposit of these loads, thus eliminating manual work in lifting as well as in carrying.

Industrial trucks may be classified as hand trucks or power trucks depending upon the means of locomotion.

Hand trucks may, in turn, be classified by the number of wheels and by usage and general design. In general, two-wheel hand trucks permit most of the load to be carried on the wheels, but a portion of the load must be supported in the hands of the operator in order to balance the truck during movement. Some of the more common two-wheel hand trucks are the barrel, box, drum, hopper,

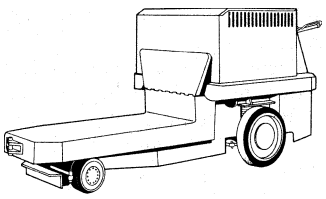
refrigerator, paper-roll and tote-box trucks. Four-wheel hand trucks are found in many more varieties, including dollies, high- and low-bed flat trucks, carts, rack carries, wagons and a number of different types of hand-lift trucks. The latter have mechanical or hydraulic lifting mechanisms for raising and lowering a load preceding and following transport.

Power trucks, as the name implies, have a power drive for locomotion. The use of such trucks in industry dates back to 1906, when electric drives were applied to ordinary baggage trucks at a Philadelphia railroad station. Power is supplied by (1) a gasoline engine and mechanical drive; (2) a gasoline engine, generator and electric-motor drive; or (3) batteries and an electric-motor drive.

Propane and diesel engines are also used in place of gasoline engines on some types of trucks. The common types of powered industrial trucks are the nonlift platform, low-lift platform, high-lift platform, fork, motorized pallet, side-clamp lift, ram, crane, tractor, straddle and side-loading trucks.

Nonlift Platform Truck.—One group of industrial power trucks is designed purely for hauling. A platform is provided on the truck for the load, which may consist of pans, packages or other objects. The nonlift platform truck is used to haul heavy loads over longer distances than would be desirable for a hand truck. In most cases, the operator rides on the truck with the load.

Low-Lift Platform *Truck*.—This type of power-operated truck is self-loading and provides a low platform for use with skids and certain types of metal boxes. These boxes provide a space for entrance of the platform and the front wheels of the truck. Since the front wheels ride under the load, the truck does not require counterbalancing and therefore heavier loads can be handled for a given size truck than with a fork truck. Capacities of these trucks vary from 2,000 to 10,000 lb. and up (fig. 7).



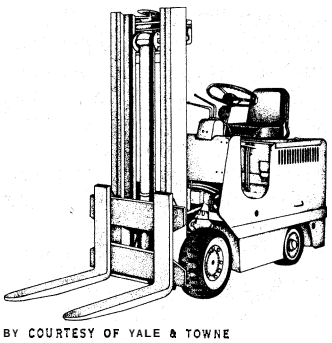
BY COURTESY OF FLOW

FIG. 7.—SELF-LOADING LOW-LIFT PLATFORM TRUCK

High-Lift Platform Truck.—Similar to low-lift platform trucks, the high-lift trucks are able to stack material. Both low-lift and high-lift platform trucks are available in "walkie" units, in which the operator walks and guides the truck, and in "rider" units, in which the operator rides on the truck. Walkie trucks have capacities up to 4,000 lb.; rider trucks range up to capacities of 60,000 lb. The maximum stacking height for high-lift platform trucks is approximately 130 in. High-lift platform trucks are also self-loading and are used with skids and boxes which permit the platform and front wheels to run under the load. This type of truck is sometimes employed to handle heavy press dies and large tooling. Some types of walkie platform trucks provide outrigger arms which contain the front wheels and go around the load rather than under it. In most cases, a hydraulic cylinder is used as the lifting mechanism.

Fork Truck.—The fork truck, which first appeared around 1927, is either a low-lift or high-lift, self-loading truck equipped with forks to handle loads on pallets, the elevating mechanism permitting multiple-tiering in the case of the high-lift models. The pallet is a load carrier of wood, metal or both, specifically designed to be picked up by and carried on the forks. The load is supported on a cantilever principle, with the rear of the truck being heavily weighted to balance the overhanging load. The fork carriage is supported on two upright masts which may be either rigid or permit tilting backward and forward for easy handling of the load. The masts on some models telescope to permit stacking up to 16 ft. Capacities of these trucks range from 1,000 to 60,000 lb. (fig. 8).

Motorized Pallet Truck.—This is another walkie truck, but with forks rather than a platform. It is particularly designed for use in narrow aisles, for moving and stacking loads which are too heavy for a hand truck., Motorized pallet trucks may be counterbalanced, like a fork truck, or they may have outrigger arms with front wheels like the platform truck. Capacities of these trucks range up to 4,000 lb. and may provide telescopic stacking to 130 in.



BY COURTESY OF YALE & TOWNE

FIG. 8.—FORK TRUCK

Side-Clamp Lift Truck.—Side-clamp lift trucks are similar to fork trucks except that the forks are replaced with hydraulically actuated side clamps, thus eliminating the need for a skid or pallet for many types of loads. Side clamps are available in several different designs for handling paper rolls, drums, stacked crates and boxes, bails, etc. In some cases a revolving head is provided so that the load may be turned over while supported in the clamps. One type of side-clamp truck employs hydraulically expanded rubber cushions to lift tile or brick stacked in unit loads.

Ram Truck.—Similar to the fork truck, the ram truck has a single protruding ram or fork for handling coils of sheet, wire or other coiled material. These trucks are constructed for heavy loads and may have several front wheels back of the ram to support weights of up to 100,000 lb. For lighter loads, a standard fork truck can be used by removing one of the two forks. Both ram and fork trucks are often driven backward, particularly when empty, to avoid serious injuries to workers in the area.

Crane Truck.—This truck consists of a portable boom crane mounted on an industrial truck, and it is used with hooks, grabs and slings for handling bundled or coiled material.

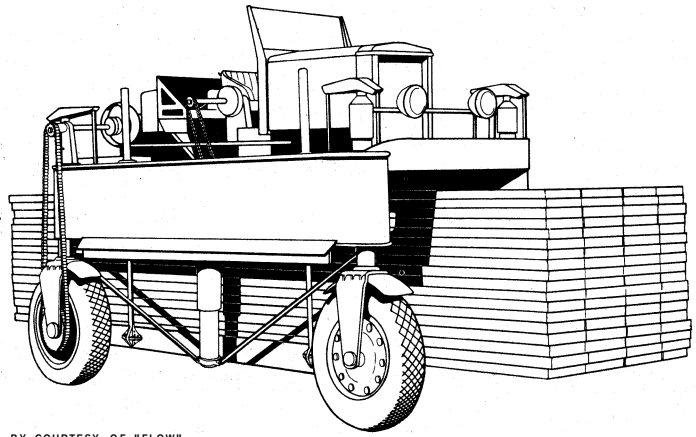
Tractor.—The tractor is essentially a mobile towing vehicle, used with four-wheel carts to make up a trackless train. It is usually co-ordinated with other facilities for loading and unloading.

Straddle Truck.—The straddle carrier closely resembles a gantry crane mounted on four pneumatic-tired wheels. The operator rides above the inverted U frame, within which the load is carried on elevating shoes. These trucks are used to handle lumber, bar steel and pipe. The size of the load can be as large as 108 in. high by 100 in. wide and as heavy as 30,000 lb. (fig. 9).

Side-Loading Truck.—This is a special design which combines features of the platform and fork-lift trucks. The platform portion of the truck has a centrally located well or bay in which is mounted the fork-lifting mechanism. These trucks are useful for picking up and carrying long, bulky loads.

Unit-Load Accessories.—Unit loads may be composed of individual items, grouped together and handled without breaking bulk, or of items which are held together by strapping, gluing or other physical means. The two most important unit-load accessories are skids and pallets.

There are three types of skids used in industry: live skids, which are dollylike carriers with wheels or casters; semilive skids, which have two wheels and two rigid supports; and dead skids, with runners or four rigid supports. Skids are handled by either



BY COURTESY OF "FLOW"

FIG. 9.— STRADDLE TRUCK

two-wheel jack trucks or manual- or power-lift trucks.

Pallets usually have three stringers which, with single-platform pallets, act as supports and with double-platform pallets, as separators between the two platforms. Compared with skids, pallets are lower—usually about six inches over-all, with four-inch vertical openings to admit the forks. Double-faced pallets can be obtained for two-way, four-way or even eight-way fork entrance. Pallets are handled by fork trucks, pallet hand trucks or lift trucks adapted with forks. See also MASS PRODUCTION.

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MATERIALISM, in philosophy, the view that all facts (including facts about men's minds and wills and the course of human history) are causally dependent upon physical processes, or even reducible to them. The many materialistic philosophies that have arisen from time to time may be said to maintain one or more of the following theses: (1) that what are called mental events are really certain complicated physical events; (2) that mental processes are entirely determined by physical processes (*e.g.,* that "making up one's mind," while it is a real process that can be introspected, is caused by bodily processes, its apparent consequences also really following from the bodily causes); (3) that mental and physical processes are two aspects of what goes on in a substance at once mental and bodily (this thesis, whether called "materialistic" or not, is commonly opposed by those who oppose materialism); and (4) that men's thoughts and wishes influence their individual lives, but that the course of history is determined by the interaction of masses of men and masses of material things, in such a way as to be predictable without reference to the "higher" processes of thought and will.

Materialism is thus opposed to philosophical dualism or idealism and, in general, to belief in God, in disembodied spirits, in free will or in certain kinds of introspective psychology. Materialistic views insist upon settling questions by reference to public observation and not to private intuitions. Since this is a maxim which scientists must profess within the limits of their special inquiries, it is natural that philosophies which attach the highest importance to science should lean toward materialism. But none of the great empiricists have been satisfied (at least for long) with systematic materialism.

Materialistic Schools.—The Greek atomists of the 5th century B.C. (Leucippus and Democritus) offered simple mechanical explanations of perception and thought—a view which was condemned by the Socrates of the Phaedo; in the 17th century Thomas Hobbes and Pierre Gassendi, inspired by the Greek atomists, used materialistic arguments in defense of science against Aristotle and the orthodox tradition; and in the next century the materialists of the Enlightenment (Julien de Lamettrie, Paul d'Holbach, etc.) attempted to provide a detailed account of psychology.

In the 19th century the battle moved to new grounds. In the first place, some thinkers were encouraged by the theory of evolution to hope that, just as human life had grown out of animal and plant life, so these in turn might be explained as products of the simplest forms of matter; others, however, for instance C. Lloyd Morgan, later came to hold that new properties "emerged" in evolution—properties not fully explicable in terms of their antecedents (see EMERGENCE).

The question of materialism was thus merged into problems of method and interpretation in science (Henri Bergson, Samuel Alexander, A. N. Whitehead). Secondly, Georg Hegel, Auguste Comte, Karl Marx and others raised the question of the explanation of human history. Here Marx offered a new kind of materialism, dialectic and not mechanistic, and embracing all sciences—a materialism which alone retains its full vitality and coherence (see MARXISM).

In the 20th century other systems had to face novel developments in the sciences and in philosophy. In physics, relativity and quantum theory modified, though they did not abandon, the notions of cause and of universal determinism. In psychology, J. B. Watson's behaviourism, an extreme form of materialism, did not find general acceptance; and researches both in psychology and in psychoanalysis made it impossible to hold any simple direct view of the mind's dependence on the brain and the nervous system. At the same time experiments in psychical research showed (it was claimed) that mental events might have almost any kind of independence of bodily events. In philosophy, further reflection on the concepts of science and of common sense (especially those of cause and of explanation) suggested to many that it is futile to try to erect a system of belief whether materialistic or otherwise, on such a basis. See BODY AND MIND; IDEALISM; see also Index references under "Materialism" in vol. 24.

BIBLIOGRAPHY.—F. A. Lange, *History of Materialism,* 3 vol. Eng. trans., 3rd ed. (1925); B. Russell, *The Analysis of Mind* (1911); *C.* D. Broad, *Mind and Its Place in Nature* (1925); *H.* Levy, *A Philosophy for a Modern Man* (1938); *E.* A. Burtt, *The Metaphysical Foundations of Modern Physical Science,* rev. ed. (1952); E. Schrödinger, *Mind and Matter* (1958). (K. W. B.)

MATERIALS, STRENGTH OF, is that part of engineering science which deals with the behaviour of solids under the influence of forces which are in equilibrium. The forces may be of mechanical origin such as gravity, inertia or fluid pressure or they may be electrical or magnetic. In statics and dynamics it is assumed that solids are rigid and do not suffer any changes under the influence of forces other than those of equilibrium or position. Strength of materials is concerned with the deformation and disruption of solids when forces are acting upon them without consideration of changes in equilibrium or position.

Most engineering products are subjected to forces under whose influence they must neither break down nor deform beyond certain relatively small permissible limits. Strength of materials enables the engineer to estimate the forces which can be safely imposed on a given structure or engineering component, or to choose the appropriate material for and determine the necessary dimensions of structures and components which have to withstand given loads without suffering effects deleterious to their proper functioning.

Strength of materials is involved also in engineering problems of a different kind. The design of machinery such as rock crushers and coal cutters for the breaking up of materials involves consideration of the mechanical strength of these materials. Machining processes such as turning, drilling and planing pose other problems falling within the province of strength of materials. Cold- or hot-forming processes for the production of metal parts such as pressing, extruding or forging involve the problem of determining the forces necessary to produce certain permanent changes in form, and this is yet another group of problems in strength of materials.

This article is divided into the following sections:

I. Elasticity
II. Experimental Stress Analysis
III. Testing of Materials
IV. The Problem of Failure
V. Metal Physics
VI. Survey and Outlook

I. ELASTICITY

The fundamental concepts used in strength of materials are those of the theory of elasticity. This is a branch of applied mathematics, and for a full account reference should be made to the special article ELASTICITY. For the purpose of this article only certain fundamental concepts of this theory will be considered.

Concept of Stress.—Consider a solid of any arbitrary shape upon which several forces, P_1, P_2, P_3, are acting as shown in fig. 1, where these forces are in equilibrium so that the solid is at rest. If a cut such as A–A is now made destroying the cohesion of the solid the two parts would move away from one another because the forces acting on each of the two parts are now no longer in equilibrium. Since, prior to the making of the cut, the two parts did not move apart it must of necessity be assumed that forces are acting within the solid on the cut face which prevent this movement. The forces must, therefore, be of such a character that

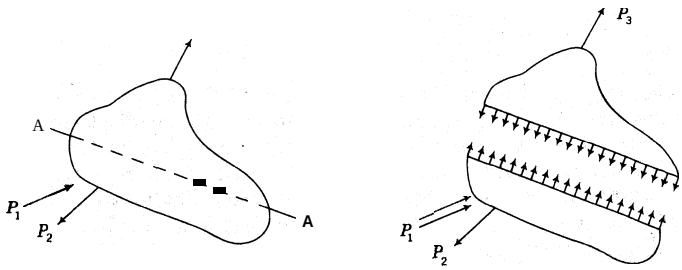

FIG. 1.—STRESSES DUE TO LOADS P_1, P_2 AND P_3 ACTING ALONG LINE A–A OF SOLID BODY

their resultant balances the forces applied to each of the two parts. These internal forces called into play by external forces acting on a solid will be distributed in some manner over the entire surface of the imaginary cut, and each unit of area of the internal surface will carry an appropriate proportion of the force. This proportion of internal force carried by unit area is termed the stress.

If the force which has to be balanced is P and the area over which the stress can be assumed to be distributed is A then the average magnitude of the stress at every point of the surface A–A will be equal to P/A. In general, the distribution of stress over the area of an imaginary cut will not be uniform, and it is one of the general problems of the theory of elasticity to determine the exact distribution of stress in the interior of a solid subject to external forces.

If a solid instead of being divided by one cut into two parts is divided by a large number of cuts into many small cubes of unit volume, each of these cubes by the same reasoning will transmit a force on each of its six cube faces. These forces will not be acting at right angles to the cube faces but each of them can be resolved into three components of which one, the normal stress, is acting at right angles to the cube face, and two components. called shear stresses, are acting in the cube face. Since there are six cube faces there will be 18 such components. Those, designated X_x, X_y, X_z, Y_x, Y_y, Y_z, Z_x, Z_y, Z_z, are shown in fig. 2.

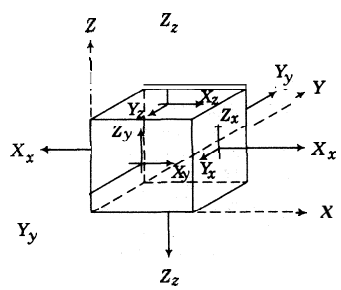

FIG. 2.—CUBICAL ELEMENT OF SOLID WITH STRESS COMPONENTS OF A GENERAL TRIAXIAL STATE OF STRESS ACTING IN THE CUBE FACES

Equilibrium Conditions.—Considerations of equilibrium lead to certain relations between these 18 stress components which reduce their number to 6, of which 3 are normal stresses and 3 are shear stresses. Moreover, certain first-order partial differential equations containing the derivatives of the stress components with regard to a system of rectangular co-ordinates can be deduced from considerations of equilibrium and continuity, and these equilibrium conditions form one set of fundamental equations which must be satisfied by the solutions obtained for any stress problem.

These three equilibrium conditions in the absence of body forces —that is forces proportional to mass and acting on each cubical element—are obtained in the following form where X_x, Y_y, Z_z, are the three normal components, and $X_y = Y_x$, $X_z = Z_x$, $Y_z = Z_y$ are the three shear stress components:

$$\frac{\partial X_x}{\partial x} + \frac{\partial X_y}{\partial y} + \frac{\partial X_z}{\partial z} = 0$$

$$\frac{\partial Y_x}{\partial x} + \frac{\partial Y_y}{\partial y} + \frac{\partial Y_z}{\partial z} = 0 \qquad (1)$$

$$\frac{\partial Z_x}{\partial x} + \frac{\partial Z_y}{\partial y} + \frac{\partial Z_z}{\partial z} = 0$$

Tensile and Compressive Stress; Triaxial and Plane Stress.—Consider a solid in the form of a fine wire AB (fig. 3) at the ends of which two forces P of equal magnitude but opposite direction are acting, trying to tear the wire apart. Such forces produce stresses over any cross section of the wire directed away from the area of the cross section, and such stresses are called tensile stresses.

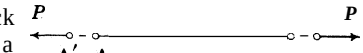

FIG. 3.—WIRE AB EXTENDS TO A′B′ UNDER THE INFLUENCE OF FORCES P, PRODUCING TENSILE STRESSES

Consider a short pillar or block (fig. 4) carrying at the top a load P; an equal and opposite reaction will be produced in the base of the pillar resting on the foundations. The pillar is under the influence of two forces trying to shorten it, and in every cross section of the pillar at right angles to the forces stresses will be produced directed toward the surface of the cross section. Such stresses are termed compressive stresses. The wire under tension and the pillar under compression illustrate two of the simplest types of stress distributions in solids. The stress at every point of the solid will be the same, and will be in the same direction. If a small cubical element is considered with its edges parallel to the applied forces only one of the six stress components is acting, all the others will be zero. Such a state of stress is called a uniaxial state of stress. The more general case when stresses are acting on all six cube faces is a general triaxial state of stress.

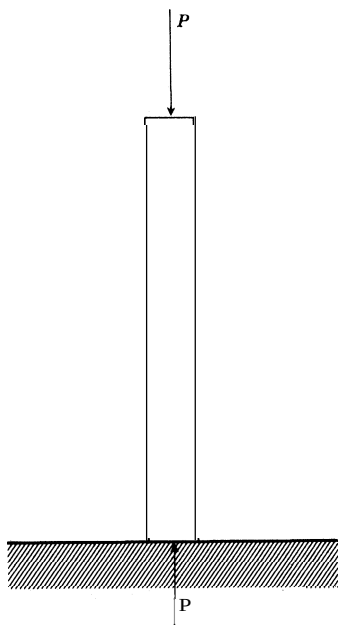

FIG. 4.— COLUMN UNDER COMPRESSION STRESSES PRODUCED BY FORCES P

If stresses are acting only on four of the six cube faces as in fig. 5, the number of stress components will be reduced from six to three and the problem is one of biaxial stress or plane stress.

In the wire under tension or the pillar under compression the state of stress is the same at every point. Such states of stress, and they need not necessarily be uniaxial, are termed homogeneous states of stress. In general, the state of stress in a solid will be nonhomogeneous; this means it will be different at every point, or mathematically speaking: the state of stress is a function of the co-ordinates.

Concept of Strain; Poisson's Ratio.—Under the influence of the forces P acting on the wire in fig. 3, the ends will be displaced to points A′ and B′ respectively. If the original length of the wire AB was I and the stretched length AB' is l′ the extension of the wire by the force P is $\Delta l = l' - l$. If the material of the wire is perfectly homogeneous each unit length of wire will make an equal contribution to the total extension and the extension per unit length is $\Delta l/l$. This is called the longitudinal strain.

Exact measurements of the diameter of the wire before and after application of the load would reveal that as the wire lengthens the diameter diminishes. The longitudinal dilatation of the wire under the influence of the tensile forces P is accompanied by a lateral contraction. This lateral contraction per unit length of diameter will be only a fraction of the longitudinal strain, so that the volume of the wire will slightly increase. The ratio of lateral contraction to longitudinal extension is a constant for a given material and is termed Poisson's ratio, μ. Its value varies be-

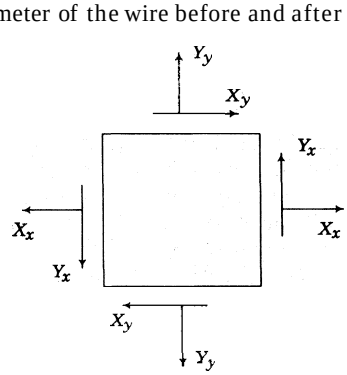

FIG. 5.—CUBICAL ELEMENT WITH STRESS COMPONENTS OF A PLANE STATE OF STRESS

tween 0.2 and 0.5 for different materials. If the value of Poisson's ratio approaches 0.5, as it does for cork, there will be no change in volume in consequence of stress.

Shear Strain; General Deformation; Compatibility.— The deformation produced by a general state of stress cannot be described in terms of dilatations and contractions alone. A square ABCD under the influence of shear stresses will deform into the rhombus ABC'D' (fig. 6) much in the manner of cards sliding over each other in a pack. The deformation is described by the angle DBD', and this is called a shear strain. If, as before, a solid of arbitrary shape is divided into a large number of small cubes each of the cubes can in the most general case suffer dilatations or contractions in the directions of the three cube edges, and in addition each of the squares bounding the cube can suffer a shear strain so that the cube is deformed into a parallelepiped. The three dilatations in the directions of the co-ordinate axes and the three shear strains in the co-ordinate planes describe the deformation of the elementary cube completely, and if these six strain components are known as functions of the co-ordinates they are known at every point of the solid and the deformation of the solid is then fully described.

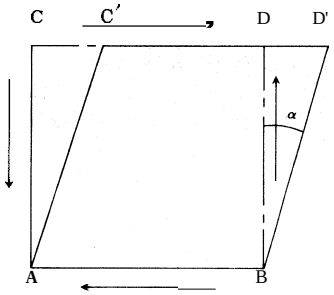

FIG. 6.—CUBICAL ELEMENT ABCD SUBJECTED TO PURE SHEAR STRESS

There is one important condition which must be satisfied by the strain components. If they were entirely independent from each other, each elementary cube might be deformed in such a manner that after deformation the cubes would no longer fit together without gaps and the continuity of the solid would be destroyed. In order to ensure the continuity of the solid after deformation the functions representing the strain components must satisfy a set of six second-order partial differential equations which are known as the compatibility conditions.

These six compatibility conditions are obtained in the following form where e_{xx}, e_{yy}, e_{zz} are the three normal strains and $e_{xy} = e_{yx}$, $e_{xz} = e_{zx}$, $e_{yz} = e_{zy}$ are the three shear strains:

$$\frac{\partial^2 e_{xx}}{\partial y^2} + \frac{\partial^2 e_{yy}}{\partial x^2} - \frac{\partial^2 e_{xy}}{\partial x \partial y} = 0$$

$$\frac{\partial^2 e_{yy}}{\partial z^2} + \frac{\partial^2 e_{zz}}{\partial y^2} - \frac{\partial^2 e_{yz}}{\partial y \partial z} = 0$$

$$\frac{\partial^2 e_{zz}}{\partial x^2} + \frac{\partial^2 e_{xx}}{\partial z^2} - \frac{\partial^2 e_{xz}}{\partial x \partial z} = 0 \qquad (2)$$

$$\frac{\partial}{\partial x}\left(\frac{\partial e_{xy}}{\partial z} + \frac{\partial e_{xz}}{\partial y} - \frac{\partial e_{yz}}{\partial x}\right) - 2\frac{\partial^2 e_{xx}}{\partial y \partial z} = 0$$

$$\frac{\partial}{\partial y}\left(\frac{\partial e_{yz}}{\partial x} + \frac{\partial e_{xy}}{\partial z} - \frac{\partial e_{xz}}{\partial y}\right) - 2\frac{\partial^2 e_{yy}}{\partial x \partial z} = 0$$

$$\frac{\partial}{\partial z}\left(\frac{\partial e_{xz}}{\partial y} + \frac{\partial e_{yz}}{\partial x} - \frac{\partial e_{xy}}{\partial z}\right) - 2\frac{\partial^2 e_{zz}}{\partial x \partial y} = 0$$

The compatibility conditions can be derived from the fact that the components of strain are derivatives of the components of the displacement vector. The displacement vector is a measure of the displacement of each cubical element in space with regard to a fixed system of co-ordinate axes. If the components of the displacement vector in the three directions x, y, z of the co-ordinate system are designated by u, v, w respectively, the components of strain are derived as follows:

$$e_{xx} = \frac{\partial u}{\partial x} \qquad e_{xy} = \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}$$

$$e_{yy} = \frac{\partial v}{\partial y} \qquad e_{yz} = \frac{\partial v}{\partial z} + \frac{\partial w}{\partial y} \qquad (3)$$

$$e_{zz} = \frac{\partial w}{\partial z} \qquad e_{xz} = \frac{\partial u}{\partial z} + \frac{\partial w}{\partial x}$$

The compatibility conditions can be derived from these six equations by eliminating the three components of the displacement vector. These six equations are therefore equivalent to the compatibility equations and are frequently used in their place.

Relation Between Stress and Strain; Proportionality; Elasticity.— It is a fact of experience that a wire subjected to equal and opposite forces P at its ends (fig. 3) extends. The extension is considered a consequence of the stresses produced in the wire by the forces. There exists, therefore, a relation of cause and effect between stress and strain, or strain can be considered a function of stress. This functional relationship must be expressible by some mathematical law, and two distinct possibilities for postulating such a law present themselves.

The one possibility would be to determine the relationship experimentally and then find a mathematical expression representing this relationship. This meets with formidable difficulties because such measurements are possible only for relatively simple states of stress and deformation and cannot be carried out for general states of deformation resulting from triaxial states of stress. Measurements on metal wires and metal pillars, however, show that for certain simple types of stress, when the stresses do not exceed certain limits, the strain is proportional to stress so that a linear relationship holds.

For other metals and materials such as concrete, stone or timber, the relation even for simple states of stress is not linear. Such empirical stress-strain relations could of course only be applied with confidence within the region for which they have been experimentally confirmed.

The second possibility, and this is the one adopted in the theory of elasticity, is to postdate a relationship which will result in a mathematical theory aesthetically satisfying and at the same time simple. Only the assumption of a linear law permits this.

Robert Hooke published an anagram in 1678 embodying a discovery of his made in 1676. The solution of the anagram, "cciiinosssttuu," when published two years later *(De potentia restitutiva)*, expressed proportionality between stress and strain *ut tensio sic uis* (vis), "the power of any spring is in the same proportion with the tension thereof" where, as Hooke explains, spring means any "springy body" and tension is used for what is now called strain.

This law of proportionality has to be generalized for triaxial states of stress, and six equations can be written expressing the six strain components as linear functions of stress. This would involve 36 constants of proportionality.

The proportionality between stress and strain does not involve elasticity, this being the property of the solid to recover its original shape completely after the forces producing the deformation are removed. Elasticity on the other hand does not necessarily require proportionality between stress and strain. Modern spring steels, the most perfectly elastic materials known, recover their shape completely after deformation but stress and strain do not obey even approximately a linear law. Despite these fundamental conceptual differences between stress-strain proportionality and elasticity, the two concepts are used indiscriminately in such a way that elasticity implies proportionality and vice versa. The theory of elasticity paradoxically is in fact not primarily concerned with elasticity, that is, with the behaviour of solids after removal of the load, but is essentially concerned as a linear theory with proportionality when the load is applied.

The assumption of elasticity, however, permits the application of certain thermodynamic principles which enable the reduction of the 36 independent elastic constants to 21. This number can be further reduced to 15 and if it is assumed that the material is isotropic with regard to its elastic properties, the number of elastic constants can be reduced to 2. These are the modulus of elasticity, generally denoted by the symbol E, and Poisson's ratio, μ, which has already been mentioned. The modulus of elasticity E is also called Young's modulus after Thomas Young who first defined it. It is for a given material the ratio between stress

and strain for a simple uniaxial state of stress. Isotropy with regard to elastic properties means that the properties of the material are independent of direction. This is far from being true for most engineering materials. It is obviously not so for wood, which will exhibit different properties along the grain and across the grain. Metals produced by casting, rolling, forging or extrusion. however, will also exhibit some directionality with regard to elastic properties.

The six equations of proportionality or Hooke's law for a general triaxial state of stress are obtained in the following form:

Strains expressed in terms of stresses

$$e_{xx} = \frac{1}{E}[(X_x - \mu(Y_y + Z_z)] \qquad e_{xy} = \frac{1}{G}X_y$$

$$e_{yy} = \frac{1}{E}[(Y_y - \mu(X_x + Z_z)] \qquad e_{xz} = \frac{1}{G}X_z \qquad (4a)$$

$$e_{zz} = \frac{1}{E}[(Z_z - \mu(X_x + Y_y)] \qquad e_{yz} = \frac{1}{G}Y_z$$

In these equations G is introduced as a further elastic constant, the modulus of rigidity. This, however, is not a third independent constant but is a function of Young's modulus and Poisson's ratio; *i.e.*,

$$G = \frac{E}{2(1+\mu)}$$

Stresses in terms of strain

$$X_x = 2G\left(e_{xx} + \mu\frac{e}{1-2\mu}\right) \qquad X, = Ge_{xy}$$

$$Y_y = 2G\left(e_{yy} + \mu\frac{e}{1-2\mu}\right) \qquad X_z = Ge_{xz} \qquad (4b)$$

$$Z_z = 2G\left(e_{zz} + \mu\frac{e}{1-2\mu}\right) \qquad Y_z = Ge_{yz}$$

In these equations

$$e = e_{xx} + e_{yy} + e_{zz} \qquad (5)$$

is the change in volume of the unit cube of the material under the given state of stress, the cubical dilatation.

For a hydrostatic state of stress for which the three normal stress components $X_x =$ Y, $= X_z$ are equal to a uniform pressure p and the three shear stress components X, $= X_z = Y_z = 0$ the cubical dilatation from summation of equations (4a) is obtained as

$$e = \frac{1-2\mu}{E}p = kp \qquad \text{where } k = \frac{1-2\mu}{E}$$

and k is called the modulus of compression or bulk modulus of the material. It follows from this relation that the value for p cannot exceed 0.5 since for values of p greater than 0.5 the bulk modulus becomes negative, which would require the solid to increase its volume under hydrostatic pressure.

Principal Stresses and Strains; Invariants and Strain Energy. — The six stress components describing the state of stress and the six strain components describing the state of strain at every point are of course functions of the co-ordinate axes and will change if a different co-ordinate system of co-ordinate axes is used. They form what are called tensors in mathematics, and from this fact one can make two important deductions with regard to the effect of transformations of co-ordinate axes.

The first is that there are always three orthogonal directions for which, when they are chosen as the co-ordinate axes, the expressions for the shear stresses and shear strains become zero and for which the values of the normal stresses are extreme values. These directions are the directions of principal stress or strain and the largest of the three principal stresses or strains will be the absolute maximum value of the stress or strain at the given point and the smallest of the three will be the absolute minimum value.

If the state of stress or strain is written in the form of a matrix; *i.e.*,

$$\begin{pmatrix} X_x & X_y & X_z \\ Y_x & Y_y & Y_z \\ Z_x & Z_y & Z_z \end{pmatrix} \qquad \begin{pmatrix} e_{xx} & e_{xy} & e_{xz} \\ e_{yx} & e_{yy} & e_{yz} \\ e_{zx} & e_{zy} & e_{zz} \end{pmatrix}$$

then for the three principal directions $x \rightarrow 1$ $y \rightarrow 2$ $z \rightarrow 3$ the state of stress will be fully characterized by three principal stress components.

$$\begin{pmatrix} X_1 & 0 & 0 \\ 0 & Y_2 & 0 \\ 0 & 0 & Z_3 \end{pmatrix}$$

and the state of strain by three strain components

$$\begin{pmatrix} e_{11} & 0 & 0 \\ 0 & e_{22} & 0 \\ 0 & 0 & e_{33} \end{pmatrix}$$

In the case of simple tension or compression already discussed the direction of the tensile or compressive stress will be a direction of principal stress because the shear stresses in planes at right angles and parallel to this direction must be zero.

The equations of equilibrium (1), the compatibility conditions (2) and the equations of proportionality (4a, 4b) can be written in terms of principal stresses without losing generality.

In tensor analysis, which is that branch of mathematics dealing with tensors, it is shown that certain expressions can be formed from the components of tensors of the type used for the description of states of stress or strain which are invariants with regard to transformations of co-ordinate axes. These invariants must clearly be representative of some intrinsic properties of the stressed solid since only such properties can be entirely independent of the system of co-ordinate axes and this is the second important deduction to be considered. The first of these invariants for stress and strain are

$$I_1^x = X_x + Y, + Z_z$$
$$I_1^e = e_{xx} + e_{yy} + e_{zz} \qquad (5a)$$

The first of these expressions indicates that the sum of the three principal stresses is a constant. The second of these two expressions is the cubical dilatation and this, as expressing the change in volume, must clearly be independent of the co-ordinate axes.

The following two expressions are further invariants for the two tensors:

$$I_2^x = X_xY_y + X_xZ_z + Y_yZ_z - X_x^2 - Y_z^2 - X_z^2$$
$$I_2^e = e_{xx}e_{yy} + e_{xx}e_{zz} + e_{yy}e_{zz} - e_{xy}^2 - e_{xz}^2 - e_{yz}^2 \qquad (5b)$$

They have no physical meaning in themselves but an expression obtained by combining the two invariants (5a) and (5b) either for stress or strain has a physical meaning and must, of course, itself be again invariant. Thus the expression

$$U = \frac{E(1-\mu)}{2(1+\mu)(1-2\mu)}(I_1^e)^2 - \frac{E}{1+\mu}I_2^e \qquad (6)$$

is invariant and must represent a physical property U, the strain energy per unit volume of the strained solid. Work is required to be done against the resistance of the body by the external forces in deforming it. This is stored in the form of the elastic energy mhich is released when the loads producing the deformation are removed. The unwinding of a clock spring is perhaps the best example illustrating stored strain energy.

A similar expression for U can, of course, be derived in terms of stress components by combining I_1^x and I_2^x. This is in fact the form in which strain energy is mostly used. Evaluated in a convenient form the expression (6) becomes

$$U = U_1 + U_2 \qquad (7a)$$

$$U_1 = \frac{1-2\mu}{6E}(X_x + Y_y + Z_z)^2 \qquad (7b)$$

$$U_2 = \frac{1+\mu}{6E}[(X_x - Y_y)^2 + (Y_y - Z_z)^2 + (Z_z - X_x)^2] + \frac{1}{2G}(X_y^2 + X_z^2 + Y_z^2) \qquad (7c)$$

The first part U_1 of this expression is that part of the strain energy which is absorbed by changing the volume of the solid. The second part U_2 is called the shear strain energy or energy of distortion. It is that part of the total strain energy which is absorbed by a pure change in form without any change in volume. Considerations of strain energy play an important part in the solution of many problems in the theory.

Application of Elastic Theory.— The equilibrium conditions, the compatibility conditions and Hooke's law form the fundamental system of equations which must be solved for given boundary conditions in order to determine stresses and strains at every point of a solid subject to given external forces. This undertaking is, even in relatively simple cases, a formidable mathematical one and is possible only by the use of fairly extensive mathematical apparatus and manipulation. Even then solutions are generally obtainable only if certain a priori assumptions are made with regard to the stress distribution or the deformation to be expected which simplify the problem.

Since two dimensions are more easily handled than three, most problems of a practical nature are reduced to problems of either plane strain or plane stress. In the first case it is assumed that the deformation is entirely confined to two directions so that no change in dimensions of the solid takes place in a direction at right angles to the plane of the co-ordinate axes, or at any rate that this change in dimension is a constant. In the case of plane stress problems it is assumed that the object is flat and that stresses can only act on it within its own plane and not at right angles to it. It is certainly no exaggeration to say that hardly ever is a general solution found of a strength of materials problem by producing general solutions without a priori assumptions. In this fact alone lies a severe limitation of the scope of the theory of elasticity. Most solutions involve certain a priori assumptions and are therefore at best approximations. Most of the approximate solutions that have to be used by the engineer are crude in the extreme, though little benefit can be derived by more accurate solutions obtainable only by prodigious labour, because the scope of the theory of elasticity is far too restricted to give in any case more than approximate solutions because the actual behaviour of materials deviates widely from that assumed in the theory of elasticity. For the exact numerical solution of two-dimensional problems step-by-step methods have been developed, primarily by R. V. Southwell; these are known as relaxation methods.

In order to illustrate the character of approximation made where exact methods are too complex a simple case will be considered, that of the bending of a beam, which is in itself important.

Bending of Beams.—If a load P (fig. 7[A]) is acting on a beam resting on two supports A and B, reaction forces R_A and R_B will be produced at these two supports which can be determined from the conditions of equilibrium of the beam considered as a rigid body. Equilibrium in the direction of the load P requires that

$$R_A + R_B = P \tag{8}$$

and if the beam under the influence of the three forces P, R_A and R_B is not to rotate, the moments of the forces about any point must be zero. Take for instance moments about point B.

$$R_A \times l + P \times b + R_B \times 0 = 0 \tag{9}$$

from this $R_A = -\frac{Pb}{l}$ and R_B from equation (8) gives $R_B = -\frac{Pa}{l}$.

If an imaginary cut is now made at say ED and the equilibrium of the length of beam DB is considered (fig. 7[B]), a force S equal and opposite to R_B ($S = -R_B$) must act in the cross section in order to prevent translatory

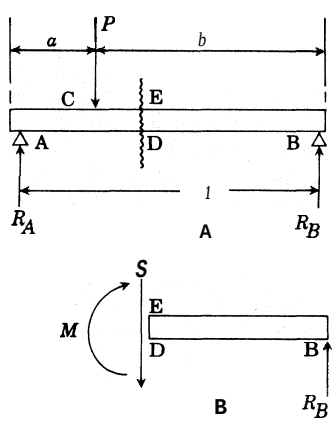

FIG. 7.—(A) BENDING OF A BEAM DUE TO APPLIED FORCE P; (B) SHEAR FORCE S AND BENDING MOMENT M ACTING IN CROSS SECTION ED

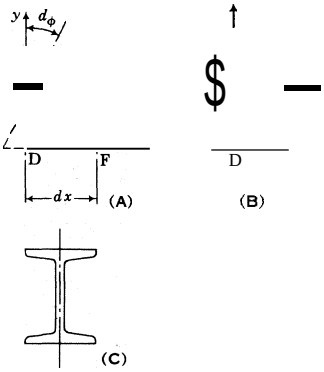

FIG. 8.— BENDING OF BEAM. (A) ROTATION OF CROSS SECTION DE BY ANGLE $d\phi$ RELATIVE TO CROSS SECTION FG: (B) LINEAR DISTRIBUTION OF BENDING STRESSES OVER CROSS SECTION DE; (C) ROLLED STEEL JOIST IN CROSS SECTION

movement. This, however, would cause the beam DB to rotate, and in order to prevent the rotation a couple or moment $M = R_B \times \overline{DB}$ must be assumed to be acting in the cross section as well. This moment is called the bending moment acting in the cross section, and the force S is called the shear force.

Bending moment M and shear force S must be produced by internal stresses in the cross section and the problem is to find the distribution of these stresses. This problem can be solved laboriously by solving the general equations (1), (2), (4) considered previously for the particular boundary conditions of the problem. If, however, one makes the a priori assumption that each of the cross sections of the beam including DE deforms in such a way under the influence of the stresses resulting in the bending moment M that it remains a plane cross section, the problem is greatly simplified.

The cross section DE will turn through a small angle $d\phi$ relative to another cross section FG a small distance dx away from it (fig. 8[A]). This requires that the material near point D becomes longer and the material near point E shortens. These changes in length, equal to the strain in the x-direction e_{xx}—if we assume the direction of the x-co-ordinate axis coinciding with the axis of the beam—multiplied by the original length dx of each element are proportional to the distance y of the element from the axis of the beam and since the stresses are proportional to strain, these too will be distributed linearly over the cross section as shown in fig. 8(B),

The resultant of this stress distribution which is antisymmetrical with respect to the x-axis is a moment, the bending moment M. A simple calculation gives the stress

$$X_x = \frac{Mxy}{I_z} \tag{10}$$

where I, is the second moment of area or moment of inertia of the cross section with regard to the axis z at right angles to x and y. The moment of inertia is a simple geometric property of the cross section. It is easily calculated as the integral $I_z = \int y^2 dydz$ and its value will depend on the size and shape of the cross section. The bending stress X, is a maximum at the extreme fibres and zero at the centre. This region of zero stress coinciding in the present example with the axis of the beam is called the neutral axis.

The maximum value for the bending stress is obtained by substituting the boundary value $\frac{d}{2}$ for y in equation (10) where d is the total depth of cross section. Hence

$$Max\ X_x = \frac{M\frac{d}{2}}{I} = \frac{M}{Z} \tag{11}$$

where

$$Z = \frac{2I}{d} \tag{12}$$

The value Z is called the modulus of the section and this, like the moment of inertia, is a geometrical property of the section.

It is obvious from equation (11) that the maximum stress X_x decreases as the value of Z increases. For a given weight, sections of the form shown in fig. 8 (C) where the material is concentrated as far away as possible from the neutral axis nave larger Z values than other possible shapes, and it is for this reason that rolled I sections are generally used as metal beams. They are fabricated in standard sizes and their values of I and Z are tabulated.

The distribution of the shear force S has to be considered

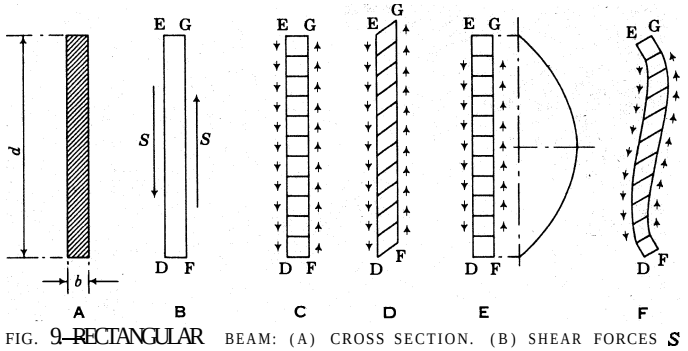

FIG. 9.—RECTANGULAR BEAM: (A) CROSS SECTION. (B) SHEAR FORCES S ACTING IN ADJACENT CROSS SECTIONS DE AND FG; (C) LINEAR DISTRIBUTION OF SHEAR STRESSES: (D) DEFORMATION DUE TO LINEAR DISTRIBUTION OF SHEAR STRESSES; (E) PARABOLIC DISTRIBUTION OF SHEAR STRESSES; (F) DEFORMATION DUE TO PARABOLIC DISTRIBUTION OF SHEAR STRESSES. CROSS SECTIONS DE AND FG WARPED

next. If a narrow slice of the beam at the section DE is produced by making a second cut FG at a small distance away from DE (fig. 9), the shear forces S will be acting on the two sections in opposite directions (fig. 9[B]). If the cross section of the beam is assumed rectangular of depth d and width b (fig. 9[A]), one can consider the slice DE divided into a number of small cubes as shown in fig. 9(C) and if as a first step one considers the shear force uniformly distributed over the cross section, each cube would carry a fraction of the shear force equal to $\frac{S}{db}$ and the shear deformation of each cube would be the same as shown in fig. 9(D). It mill be noted that this deformation still leaves the plane cross sections DE and FG plane. This uniform distribution of shear stress, however, is impossible because it would require shear stresses, which can only occur in pairs for reasons of equilibrium, to act in the surface elements EG and DF. These elements, however, since no force is acting in the surface, must be free from stress. The uniform shear distribution is, therefore, impossible and the next simple assumption that can be made is a distribution obeying not a linear law but a square law (see fig. 9[E]). The shear stresses are distributed in accordance with a parabolic law, so that the shear stress at the neutral axis is a maximum and that at EG and DF is zero.

If the deformation resulting from this shear distribution is now considered (fig. 9[F]), it-will be seen that the elementary cubes at EG and DF remain entirely undeformed, whereas the elementary cube situated at the neutral axis is deformed most. The cross sections ED and FG, however, are now no longer plane but warped, and this is directly in contradiction with the assumption used in calculating the bending stresses, that plane cross sections remain plane.

This solution for the distribution of bending stresses and shear stresses obtained on the basis of simple a priori assumptions with regard to the deformation leads, therefore, to a contradiction of the original assumption of plane sections and can only be considered as an approximation to the true distribution of stresses over the cross section. It is, nevertheless, found to give reasonably good agreement with experience and observation and the linear distribution for bending stresses and the parabolic distribution for shear stresses are universally used in the design of beams subjected to bending loads.

Calculation of Deformations.— The same assumptions enable the deformations. in particular the curved form of the initially straight beam when it is deflected, to be determined simply. In this instance also the results of calculations are in good agreement with the results of measurements.

The calculation of elastic deformations is in fact one of the most important applications of the theory of elasticity. Whereas the usefulness of the theory is gradually diminishing in other fields, yet to be discussed, it is still of great importance to the engineer when the criterion for the proper functioning of the part is not primarily strength, but deformation.

Limits of deformation have to be imposed, for instance, on the deflections of beams in buildings, since if deflections were not limited, ceilings might sag, walls and glass might crack. To prevent this, it has been found from experience that beams should not be allowed to deflect by more than about $\frac{1}{300}$ part of the distance between supports.

II. EXPERIMENTAL STRESS ANALYSIS

There are many stress problems for which it is impossible to find mathematical solutions. Solutions for the simpler problems such as the one just discussed were worked out 100 years ago. More complex problems require formidable mathematical skill and labour and in many cases mathematical solutions cannot be found at all. Very often the form of the solid is such that the boundary conditions cannot be expressed in mathematical form; often simplifying assumptions that would permit solution are unjustifiable.

Numerous experimental methods have been developed, particularly after the first quarter of the 20th century, which permit the determination of stresses and deformations by measurement. Of these the most important are: photoelasticity, analogy methods, strain measurements and brittle coatings.

Photoelasticity.— Transparent materials when under stress exhibit coloured patterns. This photoelastic effect, discovered by Sir David Brewster in 1816, can be used for the experimental determination of the stresses in transparent objects. Methods for this purpose were developed by E. G. Coker and L. N. G. Filon, which have reached a high state of perfection and refinement.

A scale model of the object to be studied is made from a transparent synthetic resin such as Bakelite, Catalin, Lucite or Columbia resin—glass, Celluloid and gelatin which were used by the pioneers of this method are rarely used. This model is mounted in the loading frame of the photoelastic bench and strained in such a way that the conditions of loading correspond to those expected in practice. Certain optical effects occur which are related to the direction and magnitude of the principal stresses in the model, and which become evident by the appearance of coloured bands or alternatively bright and dark bands in the model when this is viewed through an analyzer which is generally a disk of Polaroid, a plastic material having the property of polarizing light. These coloured bands or light and dark fringes, shown in fig. 10 for a plate with a circular hole, can be readily interpreted to give the directions of the principal stresses and their magnitude at every point of the model.

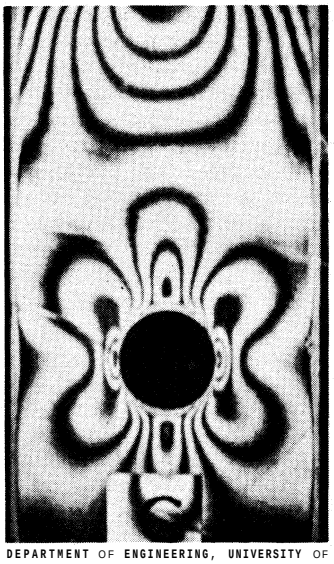

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FIG. 10.—PHOTOELASTICITY. TRANSPARENT MATERIAL UNDER STRESS VIEWED IN POLARIZED LIGHT TO SHOW "INTERFERENCE FRINGES" FROM WHICH MAGNITUDE OF STRESS AT EACH POINT CAN BE DEDUCED. BLACK CIRCULAR AREA IS HOLE

The great value of the method lies in giving a visual image of the regions where the stresses are particularly high, that is where so-called stress concentrations occur. Such stress concentrations are generally associated with abrupt changes in section and contour. Photoelasticity is a magnificent tool for evaluating such stress concentrations quickly and for obtaining exact information on the influence of alterations in form and contour on the magnitude of such stress concentrations. This evaluation is often quite impossible by mathematical analysis and even if it is possible, the amount of mathematical labour involved is prodigious.

Photoelasticity is primarily useful for plane stress problems, but recent developments permit the method to be used in the form of the "frozen stress technique" also for three-dimensional problems.

Analogy Methods.— These

are generally based on the fact that some problems in stress analysis lead to differential equations identical to those pertaining to some other physical problem which can be readily solved experimentally.

For instance, the stresses produced by twisting a bar are obtainable mathematically only if the cross section of the bar is circular or of some other simple geometric shape. There is, however, an analogy between this problem and certain geometric properties of a soap film stretched over the contour of the cross section of the bar and maintained under slight air pressure. The geometric properties of the soap film, such as the volume enclosed, the form of the contour lines and the gradients, can be determined relatively easily by measurement, and from such measurement the stresses in, and rigidity of, a noncircular component of a similar cross section subjected to twisting can be readily determined.

Strain Measurements. — A large number of special instruments have been developed which permit the strains experienced by a loaded solid to be measured directly on the surface. Since in most cases the maximum values for the stresses and hence the strains occur in the surface of the loaded solid, this method permits the direct determination of the maximum value of stress from the measured strains by multiplication with the appropriate elastic constant.

Strains are, of course, extremely small quantities of the order of microinches per inch (10^{-6} in. per inch). The change in length of 1 in. of a steel bar subjected to the maximum value of stress that might normally be permitted to occur in an engineering component would be $\frac{1}{1,000}$ of an inch.

In regions of stress concentration, which are always the most important, the strains alter abruptly within short distances so that the gauge length of the instrument over which the total change in length is measured must be small. Instruments with gauge lengths of $\frac{1}{20}$ in. and less have been constructed. With a gauge length of $\frac{1}{20}$ in. a large strain of 10^{-3} would only be a change in length of $\frac{1}{2}$ of $\frac{1}{10,000}$ in. The measurement of such minute quantities requires that some principle of magnification is made use of in the construction of the instrument. Mechanical, optical, pneumatic, electrical and magnetic principles have been used for magnification in the design of such instruments.

The most ingenious and perhaps most widely used is the electric resistance strain gauge. This is essentially a small piece of thin paper to which a short length of fine wire is cemented. This piece of paper with the wire is glued to the object prior to the application of the load at the point where it is desired to know the stress. When the load is applied and the object deforms, the paper and the wire will suffer a strain equal to that of the object at the particular point. Now, if a fine wire is stretched, its electrical resistance will change because of its change in length and its change in cross section. This resistance change is proportional to the strain experienced by the object and can be accurately measured. An installation of electric resistance strain gauges in the interior of a pressure vessel to determine the stresses in the vicinity of a nozzle can be seen in fig 11. Strain gauges also can be seen attached to the buckled cylindrical shell shown in fig. 22.

Methods of strain measurement, particularly by electric resistance strain gauges, have been found of particular value in the solution of dynamic stress problems. Where the conditions of loading change rapidly with time as would be the case in all parts of moving machinery or in the members of a bridge when a train passes over it, or in the wings of an airplane passing through a gust, the state of stress will change equally rapidly. In all such cases strain gauges have proved a most valuable research tool and have permitted the solution of problems which, had they been left to mathematical analysis on the basis of the theory of elasticity, would have remained unsolved.

Brittle Coatings. — If an object is coated with a lacquer or other substance which cannot suffer strains equal in magnitude to those suffered by the object, the lacquer will crack along lines at right angles to the direction of principal stresses, and a pattern of cracks in the lacquer will be obtained which can give a valuable indication of the direction of principal stresses, and from the density of the cracks conclusions with regard to the magnitude of the stresses can be drawn.

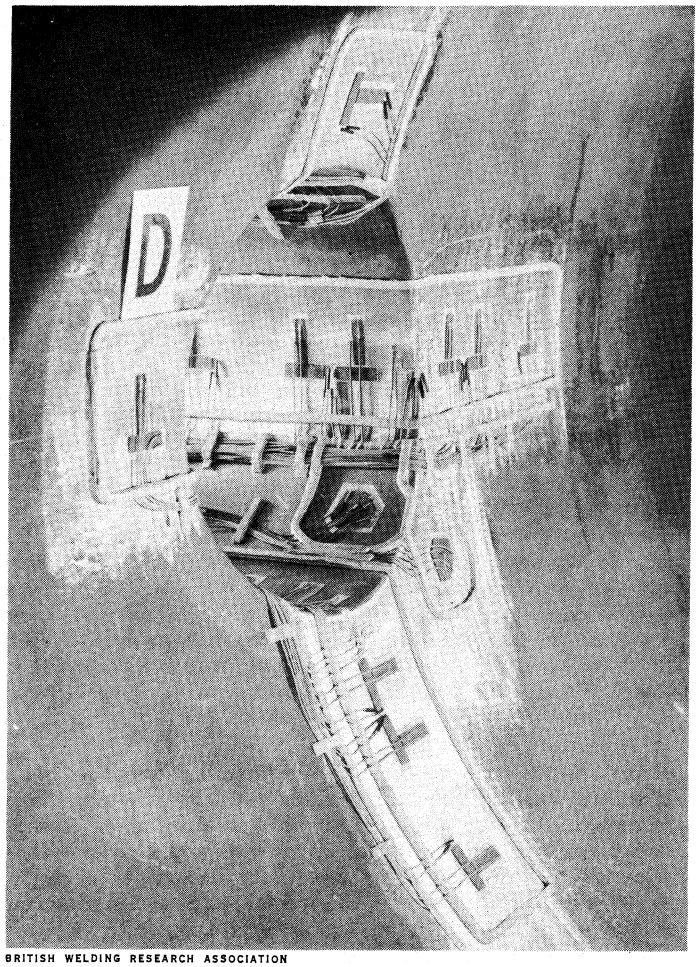

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FIG. 11. — INSTALLATION OF ELECTRIC RESISTANCE WIRE STRAIN GAUGES INSIDE A PRESSURE VESSEL TO DETERMINE STRESS DISTRIBUTION IN THE VICINITY OF A NOZZLE

III. TESTING OF MATERIALS

The theory of elasticity permits the determination of the deformation of an object under load as long as these loads do not exceed certain limits. The deformation problem, however, is only one aspect of the engineer's strength problem. Far more difficult and far more important is the problem of failure. It might appear at first sight that the theory of elasticity aided by the powerful methods of experimental stress analysis would be equally effective in solving the failure problem.

Until comparatively recently the problem appeared simple enough. Since the stresses are calculated on the basis of the theory of elasticity, it was argued, the stresses must be limited to the maximum value of stress for which proportionality between stress and strain is maintained and for which the material behaves, in accordance with the theory, as an elastic body. In order to determine these limits it became necessary to test materials and to determine their mechanical properties such as the elastic constants, Young's modulus and Poisson's ratio, the limit of proportionality, that is the maximum stress up to which proportionality between stress and strain is maintained, and the elastic limit, which is the maximum stress up to which elasticity is maintained. It was also interesting to determine to what extent the stress could be increased beyond the elastic limit before rupture occurred under different forms of loading. From such modest beginnings grew a whole separate branch of the science of strength of materials concerned with materials testing.

Originally, materials testing or mechanical testing was confined to the determination of mechanical properties under simple tensile or compressive loading. By the late 1950s the number of different

mechanical tests was large. Whereas in the beginning mechanical testing was concerned with the determination of the limits within which elastic theory could be safely applied to engineering materials, it changed its character completely and largely became a method of quality control. In fact, many mechanical tests were no longer concerned with mechanical strength properties in the sense in which this concept logically arises in strength of materials, but with properties required in the fabrication of materials such as the property of a steel sheet to be deformed by deep drawing and pressing, or of a steel plate to be joined by welding.

Tensile Test.—The tensile test occupies a unique position among mechanical tests. This is an extremely curious phenomenon because the true significance of the so-called tensile properties is not easily interpreted. Nevertheless, engineers often judge a material primarily by its properties exhibited in the tensile test. It is simple and economical, it takes little time, it does not require much material or elaborate apparatus other than a tensile testing machine of which one can now be found in almost every metal-producing or metal-using factory. No elaborate or precision measuring equipment is required and the test can be carried out by semiskilled or unskilled labour because the results can be autographically recorded. Tensile testing, like almost all material testing, is governed far more by simplicity, convenience, cheapness and expediency than by scientific requirements.

The tensile test is carried out with a prismatic or cylindrical piece of material of standardized dimensions. Its ends are clamped in the testing machine which applies a tensile load whose magnitude is increased from zero to its maximum value either slowly or sometimes, particularly in routine tests, fairly rapidly. By plotting the load against the extension of the test piece measured over a gauge length of several inches marked out along the test piece prior to the test, the load extension diagram of the material may be obtained.

The salient features of the diagram as shown in fig. 12 are these: from zero load to point A the diagram may closely approximate to a straight line. In this case the material has a proportional limit, the stress corresponding to point A. If the test were interrupted at or below this point and the load released, the specimen would be likely to resume its original length; that is, it would appear to behave with perfect elasticity, and the elastic limit would be found to coincide reasonably well with the limit of proportionality. In actual fact if sensitive methods of measurement were used it would be found on unloading that the specimen did not resume its original length but was left with a "permanent set," because no material exists which on first straining exhibits perfect elasticity. If, however, the test were continued to a point such as C it would be found that the rate of deformation now increased more rapidly than the rate of loading, and if the specimen were unloaded from a point such as C the unloading curve would not follow the original loading curve but would run parallel to the straight (elastic) part of the loading curve to D. The specimen would be found to have suffered a permanent elongation 0D. This form of permanent deformation is called plastic deformation.

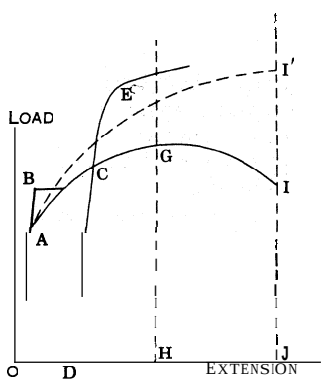

FIG. 12.—SCHEMATIC LOAD EXTENSION DIAGRAM OF A METAL

If the specimen were immediately reloaded the loading curve would follow the almost perfectly straight line from D to C and would then follow the curve CG as if no previous unloading had taken place. Unloading from point C, however, has raised the limit of proportionality of the material which had previously been at point A to a level corresponding to point C. The previous deformation increases, as it were, the resistance of the material to plastic deformation. This increase in resistance against plastic deformation by previous plastic deformation is known as work hardening.

If the test piece instead of being reloaded immediately were allowed to rest for perhaps several months and was then loaded again it would be observed that it had hardened even more. The resistance to plastic deformation might have been increased to a value corresponding to point E. This phenomenon is known as strain age hardening or strain aging. At the same time as the resistance to plastic deformation is raised the capacity of the material for plastic deformation is greatly reduced. Many of the modern aluminum alloys owe their high strength properties to this process of work hardening, which takes place during one stage of the manufacture when the material is shaped by processes, such as cold-rolling or extruding, which impose a large degree of plastic deformation.

If no unloading at any point takes place and the tensile test is completed without interruption the load will reach a maximum value at the point G (fig. 12). Up to this point the specimen will have extended fairly uniformly and the diameter will uniformly diminish because during plastic deformation virtually no change in volume takes place.

After reaching the maximum load, however, the cross section of the specimen at one point diminishes rapidly and a kind of local narrowing down or necking takes place. Further plastic deformation is now confined to a relatively narrow zone in the neck and then fracture occurs suddenly.

The stress obtained by dividing the maximum load by the original cross section of the material is called the ultimate tensile strength of the material. If, however, the actual load at fracture (corresponding to point I, fig. 12) is determined, which is not easy because necking down and fracture may occur in fairly rapid succession, and if this load at fracture is divided by the greatly diminished cross section in the neck, a stress value is obtained appreciably larger than the ultimate tensile strength. This stress value is called the true fracture strength of the material. The method of plotting load against extension hides this fact. If, instead of load, true stress, obtained by dividing the load at any point during the test by the actual cross section corresponding to the load, is plotted against extension the true stress extension diagram is obtained and this is represented by the dotted line going to I' (fig. 12). The point I' represents the true fracture strength and it can be seen that this is larger than the stress corresponding to point H, the ultimate tensile strength. Nevertheless, it is not true fracture strength but the ultimate tensile strength of the material which has been considered by engineers as the most important mechanical strength property characterizing a material.

The total extension of the specimen consists of two distinct parts, 0 to H, the uniform extension and the part from H to I the necking extension. It is expressed as a percentage of the original standard gauge length and is known as the percentage elongation. For ductile materials such as some steels and some of the lower strength aluminum alloys, the percentage elongation may be 20% and more. For relatively brittle materials such as white cast iron or severely work-hardened materials the percentage elongation may be only 1%. Percentage elongation is considered as the most important property characterizing the ability of a material to be severely deformed although there are strong indications that the percentage reduction of area, $\frac{A, - A}{A_o} \times 100\%$ (A, original area, A minimum area at fracture in the neck), is more valuable for this purpose.

Yield Point.—This brief outline of the tensile test could apply to every metal used in engineering except the most commonly used, mild steel or steel of medium carbon content. The load extension diagram of this material exhibits a curious but important anomaly. Soon after the limit of proportionality is exceeded and slight plastic deformation has set in, the material "yields," that is, it deforms rapidly at constant load; sometimes there is even a small drop in load before the rapid deformation. This drop is indicated by the horizontal step shown as a thicker line in the load extension diagram at point B in fig. 12. The load B at which yielding takes place is called the yield point of the steel. After yielding is completed, which is accompanied by an extension of between 0.5% and

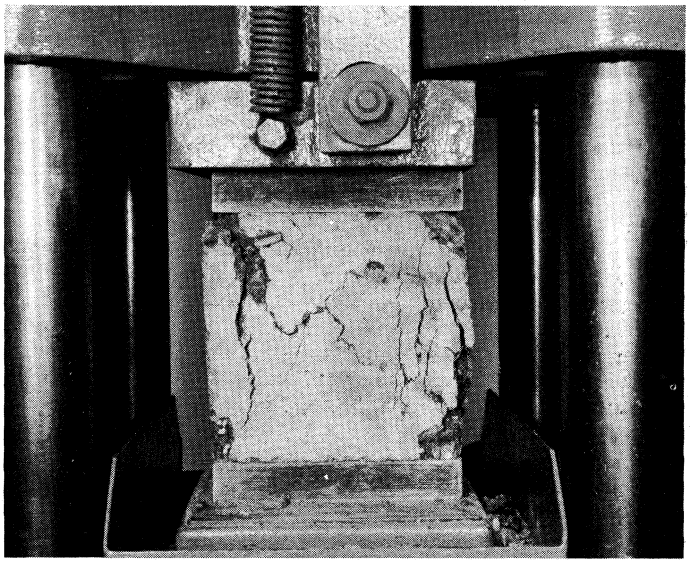

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FIG. 13.— FRACTURE OF CONCRETE IN A COMPRESSION TEST

1%, the material begins to harden and the remainder of the tensile test proceeds as described earlier.

The yield point is an important property of the material because it clearly defines a stress level at which the amount of plastic deformation begins to grow large. So useful has this been found that an artificial yield point has been defined for materials such as certain alloyed steels and light alloys which do not exhibit, as it were, a natural yield point. This artificial yield point is termed the proof stress and is defined as the stress for which there is a definite amount of permanent plastic strain after removal of the load. This is generally 0.1% or 0.2% and one then speaks of the 0.1% or 0.2% proof stress.

The yield point of steel is of great importance because it has long been considered that the permissible or working stresses in structures and components, that is to say the stresses developed when the working loads are applied, should be kept well below the yield point.

The yield phenomenon is the basis of an extensive and relatively new subject of strength of materials: the theory of plasticity. This subject is concerned with the study of the behaviour of metals and to some extent other substances such as concrete. For metals the theory of plasticity is of particular value. On the one hand a much more realistic approach than is possible by the theory of elasticity can be made to the problem of failure. On the other many problems arising in the plastic working of metals, such as forging, rolling and extruding, can be solved only by the new theory.

Compression Test.—This is one of many other mechanical tests. A test piece, generally in the form of a cube, a prism or cylinder, is compressed between the platens of a compression testing machine. Ductile metals such as mild steel will deform elastically up to a certain limit, then plastic deformations will occur, and the test piece, if the metal is ductile, can be completely flattened under increasing loads.

Brittle materials such as rock, brick, cast iron and concrete will fracture as shown in fig. 13 though they may exhibit great compressive strengths. Thus, the crushing strength of concrete determined by breaking a cube, and often called the cube strength, may reach values of three tons per square inch and more. Granite may reach 10 tons per square inch and cast iron from 25 to 60 tons per square inch.

Notch Impact Test.—There are various forms of this test. In one of them, the so-called Charpy V-notch impact test—and all notch impact tests are similar in character—a specimen in the form of a simply supported beam approximately 50 mm. long and 10 mm. by 10 mm. cross section with a sharp notch of 2 mm. depth in the form of a 45° "V" machined in the middle of the underside is broken by a sharp blow from a weight falling on the specimen. The energy absorbed by the specimen in fracturing is measured.

There is no way of relating results obtained in this test to any strength of materials concept based on the theory of elasticity. Nevertheless the test. is most valuable and gives an indication of the toughness of the material under conditions of impact or shock loading. Under such impact conditions and in the presence of a notch producing stress concentrations, ductile and deformable materials may break in a brittle manner without absorbing much energy. A lowering of testing temperature has the same effect and the notch impact test is considered a valuable test for steels used in welded structures and exposed to low temperatures in service *(see* the section *Brittle Fracture,* below).

Hardness Test.—This is carried out by pressing with a given load a hard steel ball (Brinell hardness test), of standardized dimension, or a diamond ground in the form of a square pyramid with an angle of 136° between faces (Vickers' pyramid hardness), into the surface of the material, and by measuring the dimensions of the impression. The harder the material the smaller will be the impression. There are several other forms of hardness test all based on the same principle.

Fatigue Tests.—It is found that a metal and in fact most other materials can be broken by applying a smaller stress than that corresponding to its static tensile strength if this is applied not once, but many times. This phenomenon is called fatigue. The smaller the applied stress the larger is the number of cycles required to produce fracture, and if the stress is small enough fracture may not occur until the stress has been applied perhaps hundreds of millions of times.

The character and appearance of the fracture is different from that produced in a static test, at least for ductile metals. In the static test appreciable plastic deformation takes place before fracture supervenes; fracture as it were is preceded by a visible warning. No such warning precedes fatigue fracture. A microscopic, sharp crack is formed at some stage during the test which continues to grow until fracture occurs suddenly. There is no sign of deformation visible to the naked eye, the fracture surfaces exhibit a smooth appearance and are often characterized by prominent sea shell-like markings as can be seen in fig. 14 showing a fracture in a crankshaft due to fatigue. The two parts into which the fracture divides the object can be fitted togther and match perfectly whereas the plastic deformation during a static test of the same object would so deform the fracture surfaces that the fractured parts would not fit together. This absence of visible deformation makes it appear as if the material was made brittle by the fatigue test. This is not the case. Brittle fracture, although somewhat similar to a fatigue fracture, is due to an entirely different mechanism.

Attempts have been made to deduce the strength of metals under the repeated application of loading, which is called the fatigue strength, from static strength properties and even in the late 1950s some engineers still believed that the fatigue strength of a metal could be assumed to be a definite fraction of the static strength. This, unfortunately, is not the case and the fatigue strength must

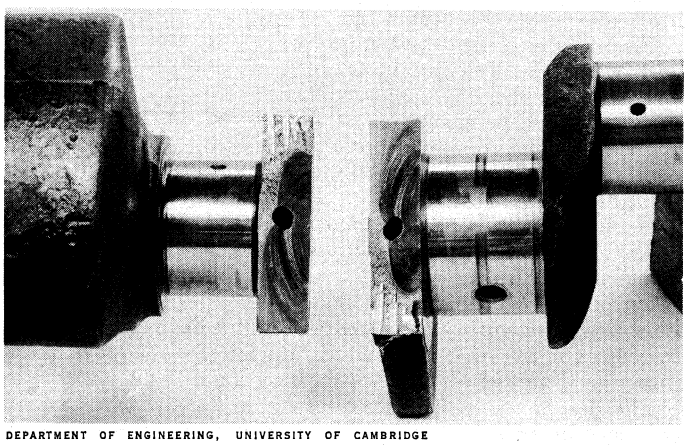

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FIG. 14.— CRANKSHAFT FRACTURED BY FATIGUE

be determined by separate tests.

Special testing machines are necessary for the carrying out of fatigue tests. The machines must be capable of applying many loading and unloading cycles rapidly if fatigue tests are to be completed within a reasonable time, because unlike the static strength which can be determined with one test piece. the determination of the fatigue strength of a given metal requires several. There are many different types of fatigue testing machines, some of which can apply up to 10,000 stress cycles per minute.

The fatigue strength of a material is generally determined in the following way. The first specimen is subjected to cyclic variation of stress of constant amplitude until it breaks. Generally a fairly high value of stress will be selected for the first specimen so that fracture is obtained fairly rapidly. The number of cycles endured to fracture is plotted, say point 1 in fig. 15, against the value of the applied stress. Further specimens are tested in the same way but at smaller and smaller stresses and the results are plotted. In this way a diagram of stress versus number of cycles is obtained which is called the S–N diagram (fig. 15). This diagram tends for certain materials — particularly steels — to run more and more parallel to the N-axis as the stress is reduced. It is concluded from this that there will be a maximum value of stress which could be applied infinitely often without producing failure, and this is termed the endurance limit or sometimes the fatigue limit of the material.

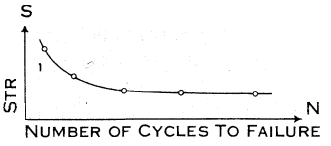

FIG. 15.—S–N (STRESS *v.* NUMBER OF CYCLES TO FRACTURE) DIAGRAM USED FOR PLOTTING RESULTS OF FATIGUE TESTS

If such an endurance limit exists it will not be much smaller than. say the stress which gives failure at 2,000,000 or 10,000,000 cycles, and in general fatigue tests are not carried to greater lengths and the stress for which failure occurs at 2,000,000 cycles or 10,000,000 cycles is determined and used as the mechanical property characteristic of the fatigue strength of the material.

For some other metals, particularly aluminum alloys, the S–N diagram does not become parallel to the N-axis so that one must assume the fracture in consequence of fatigue will supervene eventually however small the stress is. Fatigue tests ending in fracture have in fact been carried out up to 1,000,000,000 cycles.

Fatigue testing by the late 1950s had largely moved out of the field of material testing and was being established as a separate branch of strength of materials. The idea that fatigue strength is a mechanical property of the material, which can be determined basically in the same way as the yield point or ultimate tensile strength, has been abandoned because fatigue strength is influenced by far too many variables. Different values for fatigue strength of the same material will be obtained when it is tested in tension varying between zero and a maximum and when it is tested under some other form of cyclic loading such as equal limits of tension and compression or a cycle varying between two constant tensile limits.

The fatigue strength is also found to be strongly influenced by a whole host of other variables such as the form and surface condition of the specimen, the testing frequency, the type of stressing, either tensile or bending. Moreover, it is found that engineering components may quite readily fail from fatigue even if the maximum value of the stress is well below the endurance limit of the material as determined by tests on specimens of the metal. There is a size effect and numerous other circumstances have compelled engineers to look upon fatigue resistance as something more complex than a simple mechanical property which can be determined unequivocally by testing a few small specimens of the material.

IV. THE PROBLEM OF FAILURE

This brief survey of the testing of materials shows that the region in which materials behave in accordance with the pattern assumed in the theory of elasticity is narrow. The "solid" assumed in the theory of elasticity is in fact a structureless, homogeneous, stiff, but nevertheless jellylike substance, unlike any real solid, conforming to a certain behaviour pattern chosen for mathematical convenience and not for its correspondence to reality. The theory of elasticity in fact does not deal with solids but with regions of space of certain simple properties within closed boundaries. It is only natural that fracture or failure is quite outside its province. There is nothing in the theory of elasticity which would permit the introduction of the concept of fracture.

A solid could, of course, be conceived of perfectly proportional and elastic behaviour up to a maximum value of the stress when it would suddenly break; this maximum value of stress would then be the breaking strength of the material, but no such ideal material exists and the behaviour pattern of most materials used by the engineer is markedly different from this ideal pattern. Moreover, even if such materials existed an important problem would still arise.

In the elastic analysis of the state of stress produced for instance in a thin tube by twisting, it is found that on each element of the tube two stresses are acting: one a tensile stress and at right angles to this a compression stress of equal magnitude. If it is now assumed that the "fracture strength" of the ideal elastic solid had been determined for a simple state of uniaxial tensile stress, the problem arises how large the stresses in the tube may become before fracture occurs. Will fracture occur when the tensile stress reaches the same value as in uniaxial tension, the tensile fracture strength, or will the compression stress at right angles influence the magnitude of the fracture strength? The theory of elasticity by its very nature cannot answer a problem such as this because it is not concerned with fracture.

If the theory of elasticity does not permit the prediction of the stresses at which solids fail, in what way is it then possible to determine the loads which can be safely imposed on engineering structures and components? The answer to this important question is that, except in a few cases, these loads cannot be predicted on the basis of any theory; they can only be determined experimentally. It is obviously impracticable to design all engineering structures on the basis of tests to destruction though this method has been used for such large and important products as motorcars and airplanes.

The difficulty has been overcome in the past by a most plausible and ingenious piece of sophistry and self-deception, the "permissible stress." Since most engineering materials have a range in which they are almost elastic and in which strain is proportional to stress, the theory of elasticity could be assumed to represent actual conditions of stress accurately if the stresses were limited to permissible values not exceeding the proportional limit. If this is possible, fracture and failure need obviously not be considered. In fact, to the late 1950s, permissible stress methods of design were used by the majority of engineering designers, not because the inherent flaws in the method remained unrecognized, but because with one or two exceptions to which reference is made under "plastic theory" there was nothing more satisfactory to take their place.

There are four flaws in the permissible stress concept of which two are fundamental, the third is practical and the fourth economic.

The first flaw is similar in character to the difficulty of predicting the fracture strength of a solid under conditions of triaxial stress. The proportional limit stress of the material which the permissible stress is supposed not to exceed can be determined by experiment only for relatively few and very simple types of stress such as tension (tensile test), compression (compression test) and pure shear (twisting of thin tubes). A crankshaft, for instance, would be subjected in service to bending stresses, to shear stresses from the bending loads and to additional shear stress from the torque transmitted by the shaft. Each small element of the crankshaft would be subjected to a combination of stresses, what in fact has been previously referred to as a general triaxial state of stress. The problem is to define the proportional limit for triaxial states of stress from the experimentally determined proportional limits of uniaxial stress. This problem has been quite successfully solved by certain hypotheses which are discussed below, but a second problem remained and this had not been solved by the late 1950s.

The state of stress in the crankshaft is not uniform. The three

stress components describing the state of stress vary from point to point, the question—impossible to decide—is which of these innumerable combinations of stress actually occurring at different points is the most dangerous. Will the proportional limit be exceeded first at the point where the bending stress is a maximum irrespective of the magnitude of shear stress, or where the shear stress reaches a maximum value, or where both bending and shear stress reach modest values? This aspect of the problem can still be overcome in some sort of fashion by introducing a "reference stress" which is calculated for any point by taking account of both shear and bending though there are formidable practical difficulties in doing this.

There is, however, a third difficulty and this cannot be overcome because it is fundamental. The proportional limit is determined experimentally for states of stress which do not vary from point to point. In applying such data to states of stress which vary from point to point, the assumption is implicitly made that what happens at one point is determined only by the state of stress at that point irrespective of the state of stress at neighbouring points, which means that provided the state of stress at the point considered is not varied its proportional limit will also not be varied however drastically the state of stress is varied in neighbouring material. This assumption is known to be false—the behaviour of the metal at one point is dependent not only on the state of stress at that point but is strongly influenced by the state of stress in the neighbouring material because certain deformation processes will only take place if an appreciable volume of the material is, as it were, ready to take part in this deformation. It follows that under most practical conditions the stress which can be permitted without exceeding the proportional limit is unknown.

The second flaw in the permissible stress concept is also fundamental. It is in fact virtually impossible to limit the stresses in an engineering component or structure to the proportional limit even if the value of this for complex stress conditions were accurately known. A simple example will make this clear.

Steel structures have for many years been assembled by riveting, which entails the drilling of holes in the members of the structure through which the rivets pass. It was known by the late 1950s that the stresses in the immediate vicinity of a hole in a member under load may, by virtue of the sudden geometric discontinuity, reach three times the value which would have been found in the absence of the hole. Similarly the oil holes necessary in the crankshaft referred to earlier and the junctions between crank webs and pins represent geometric discontinuities which give rise to great, though purely local, increases in stress or stress concentrations. Fetv structures or engineering components have ever gone into service so devoid of geometric stress raisers that the stresses under working conditions were below the proportional limit. From this one can conclude that it is not really sound to base design on the limitation of the permissible stress to the proportional limit.

On the whole, with such exceptions as the all-welded ships which failed at low stresses during World War II, structures so designed have nevertheless given satisfactory service and it was realized by the late 1950s that this is due to the ductility of most engineering materials. Once, however, it is conceded that limiting the permissible stress to the proportional limit does not necessarily result in safety, it follows that failure and fracture cannot be neglected, and this hard fact of experience is the third flaw in the permissible stress argument.

The fourth, economic, flaw in the argument immediately follows from the third. If in most cases the plasticity of the material is sufficient to protect a structure against failure despite the fact that stresses occur in excess of the proportional limit, the design based on such low stress values cannot be in fact as economical as it might be. If higher stresses than the proportional limit can obviously be sustained without harm under certain circumstances at points of stress concentrations, it might be possible to permit stresses in excess of the proportional limit far more generally by invoking deliberately the mechanism of plasticity for the whole of the structure or component. Such deliberate recourse to plasticity should afford much greater economy in design.

Consideration of failure could no longer be side-stepped in the late 1950s by the artful dodge of limiting permissible stresses to the proportional limit. Adherence to these concepts not only leads to extravagance, it has other far more pernicious effects. On the one hand it stultified the development of structural design, and on the other it has forced the development of metal manufacture into directions which have not altogether proved fruitful and beneficial. In the manufacture of aluminum alloys in particular these outmoded and rigid concepts have led to the development of alloys of ever higher tensile strength which have proved disappointing under actual service conditions.

Modern endeavours are devoted to the development of methods which permit design to be based on actual conditions of failure. There are six primary conditions of structural or material failure which must be considered entirely separate. Which of these six has to be envisaged in design depends of course on the service conditions of the structure.

Structures and engineering components fail by (1) plastic failure; (2) instability; (3) fatigue; (4) creep; (5) corrosion; and (6) brittle fracture.

There may be other circumstances such as excessive wear but these six are responsible for almost all failures in industry and transport, and it is believed that fatigue alone accounts for 90% of service failures.

Plastic Failure.—Stress concentration.—This type of failure is extremely rare because plasticity is by its nature a protective mechanism. This can best be appreciated from a single example. Consider a bar of uniform rectangular cross section (fig. 16[A]) with two tensile loads P acting at the ends as in the tensile test. The stress distribution over any cross section such as A–A will be uniform, the stress being everywhere of magnitude S. If now a circular hole is made in the bar (fig. 16[B]) at the section A–A the stress distribution will be greatly changed. At the ends of the diameter B–B the stress will be increased to a value $S_k = Sk_t$ where k_t is a factor of 3 and is called the stress concentration factor for the circular hole. Other forms of geometric discontinuities will have a similar effect except that the numerical value of the stress concentration factor can be much larger or much smaller than that for a circular hole.

As the load is increased from P to P_1 the stress at points B will reach the proportional limit of the material, and soon after the yield point, if the material is mild steel. The stress distribution will then be that shown in fig. 16(C). Further increase in the load to P_2 (fig. 16[D]) cannot produce any further increase in stress at points B because the material there yields at constant stress and the increase in load must be absorbed by increased stresses on both sides of points B.

In this way increases in load will produce two zones of yielding starting from points B and moving outward toward the parallel edges of the bar. Eventually (fig. 16[E]) load P_3 will be reached for which the zones of yielding have reached the edges and every point of the cross section A–A carries a stress equal to the yield point of the material. The total load carried is, therefore, $A \times fy$ where fy is the yield point stress: this is the same load as would be carried by a bar with the same cross section A but without a hole.

The mechanism of plastic deformation has protected the bar from the effect of stress concentration, so that in fact the load carried by the bar when it is loaded up to the yield point is only influenced by the presence of the hole insofar as the cross section is reduced. If it is assumed that a bar without a hole is perfectly safe as long as the stress does not exceed the limit of proportionality one would obtain the cross section of the bar required to carry a load P as $A = \frac{P}{f_p}$ where f_p is the limit of proportionality. If it is further assumed that the proportional limit is 90% of the yield so that $f_p = 0.9\ fy$ $A = \frac{P}{0.9_{fy}}$. If it is in order for the bar without the hole of fig. 16(A) to carry this load it must necessarily be so for the bar of fig. 16(E) with the hole also because at yielding there is no difference in the stress distribution of the bar of fig. 16(A) and that of fig. 16(E), so that for the perforated bar the

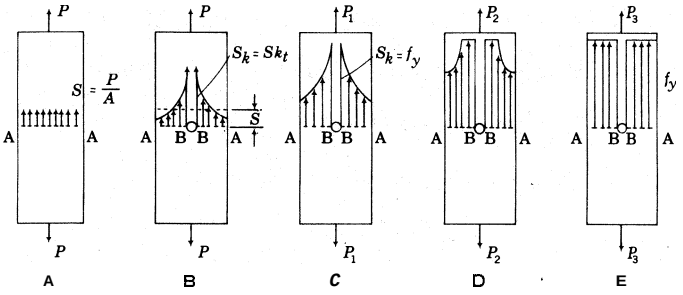

FIG. 16.— EFFECTIVE ELIMINATION OF STRESS CONCENTRATIONS BY PLASTICITY: (A) UNIFORM STRESS DISTRIBUTION IN A BAR OF UNIFORM CROSS SECTION UNDER THE INFLUENCE OF TENSILE LOADS: (B) STRESS CONCENTRATIONS AT THE EDGE OF A CIRCULAR HOLE: (C) MAXIMUM STRESS AT EDGE OF HOLE REACHES YIELD POINT OF MATERIAL WHEN LOAD REACHES VALUE P_2; (D) FOR LOADS LARGER THAN P_2 STRESSES AT EDGE OF HOLE CANNOT INCREASE BEYOND YIELD POINT. ZONES OF YIELDING SPREAD OUTWARD; (E) THE ENTIRE CROSS SECTION AT YIELD POINT STRESS FOR LOAD P_3

required cross section is also $A = \frac{P}{0.0 f_y}$. On the basis of elastic theory and permissible stress the required cross section would be three times as great. This is because the maximum stress in the perforated bar, occurring at the surface of the hole and of magnitude three times that of the average stress P/A, would have to be restricted to the value of the limit of proportionality; *i.e.*,

$$\frac{3P}{A} = f_p \quad \text{or} \quad A = \frac{3P}{0.9 f_y}$$

This illustrates the point made earlier that the same mechanism of plasticity which, more by accident than by design, protects structures against the effects of stress concentrations ignored in calculations, can be deliberately used in design to effect appreciable economies. The perforated bar in fig. 16(E) would be considered to have reached its maximum carrying capacity when the collapse load $A \times fy$ was reached because large deformations would then be produced. It is important to realize that such a collapse load can be defined only for conditions of static loading, that is. loading which is applied relatively slowly and then remains constant. Applications of the theory of plasticity are, therefore, necessarily limited to cases of statically loaded structures. Unfortunately the theory had not been developed far enough, by the late 1950s, to be used in the design of all such statically loaded structures, but there was one group of structures for which the plastic method of design had reached a high degree of efficiency and perfection: the steel frame for buildings, which is essentially composed of mild steel beams and columns.

Plastic Theory of Beams and Frame Structures.— It was pointed out in considering the bending of a beam that every cross section is subjected to bending stresses which are linearly distributed over the cross section. Consider now what happens in that cross section of a simply supported beam (fig. 17[A]) where the bending stresses are largest, when the load and hence the bending moment is increased.

The bending stresses at the extreme fibre will reach the limit of proportionality and soon after that the yield point of the material *fy* (fig. 18[A]). Further increase in load and bending moment can no longer produce any increase in the maximum bending stresses in the extreme fibres. These will yield at constant stress so that the increase in bending moment has to be absorbed by material closer to the neutral axis which in turn will reach the yield point stress of the material as is shown in fig. 18(B). Two zones of yielding will develop which will spread toward the neutral axis and along the beam as the load is increased. Eventually the state of fig. 18(C) will be attained when the material has reached yield point stress throughout the cross section. No further increase in stress in this cross section is possible until the material begins to work harden. Before this work hardening can set in, the deformations would, however, have grown so large that the beam would have become useless, so that the state of fig. 18(C) must be assumed to characterize the maximum load carrying capacity of the beam.

The distribution of bending stress of fig. 18(C) in fact represents a limiting condition and the bending moment represented by this stress distribution is called the full plastic moment of the cross section. When this full plastic moment is reached the two parts of the beam on either side of this fully plastic cross section will continue to rotate at constant load. This condition means, however, that the beam is no longer a structure but a mechanism as shown in fig. 17(B). The cross section which has become fully plastic has the same effect as the insertion of a friction hinge in the beam. The full plastic moment for a rectangular cross section of depth d and width b is given by $M_p = \frac{bd^2}{4} fy$, where fy is the yield point stress of the material.

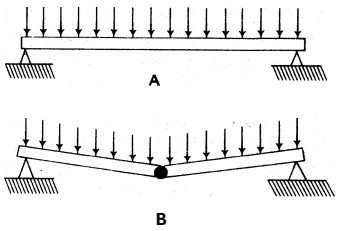

FIG. 17.—(A) SIMPLY SUPPORTED BEAM WITH UNIFORMLY DISTRIBUTED LOAD: (B) DEVELOPMENT OF ONE HINGE AT CENTRE CROSS SECTION. BEAM BECOMES MECHANISM

If, instead of a freely supported beam as in fig. 17(A) a beam is considered whose ends are encastered (fig. 19[A]), that is, prevented from rotation, plastic hinges will form not only at a section within the span but at the encastered ends. It is only when three hinges form that the beam becomes a mechanism (fig. 19[B]), and its full carrying capacity is attained.

Such a structure in which more than one hinge must be formed before it is converted into a mechanism, is called a redundant structure. The portal frame in fig. 20 under vertical and horizontal

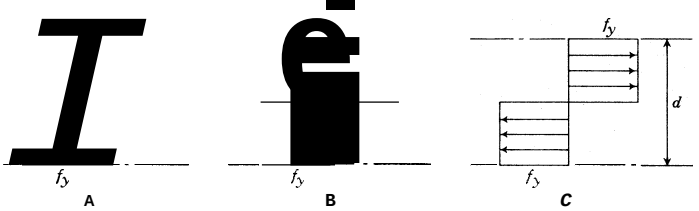

FIG. 16.— BENDING STRESS DISTRIBUTION IN CROSS SECTION OF BEAM SHOWN IN FIG. 17. (A) EXTREME FIBRE STRESS AT YIELD POINT; (B) YIELD POINT STRESS REACHED IN MOST OF CROSS SECTION; (C) YIELDING HAS TAKEN PLACE THROUGHOUT. THE BENDING MOMENT HAS REACHED THE FULL PLASTIC MOMENT

load will not, in general, become a mechanism until four such plastic hinges are formed.

The carrying capacity of the encastered beam of fig. 19 is twice as large as that of the simply supported beam of fig. 17(A) although the two beams are otherwise identical. This condition is due to the two extra hinges which can be formed in the encastered beam before collapse takes place. On the basis of elastic theory and permissible stresses the encastered beam would only be considered 1.5 times as strong. This example shows that plastic theory permits the more effective exploitation of the reserves of carrying capacity which ductile redundant structures are shown to possess in comparison with statically determinate structures.

The preceding considerations have left out of account the fact that a beam subjected to bending is generally subjected to shear stresses at the same time. These do not, however, exercise a pronounced influence on carrying capacity in the case considered and can usually be neglected. The presence of other stresses in addition to one normal stress cannot, however, always be neglected and a general problem arises to which reference has already been made in a different context. This is the problem: Supposing that yielding occurs in uniaxial tension at a stress fy, what is the individual value of the stresses $X_1 Y_2 Z_3$, the three principal stresses characterizing a general triaxial state of stress, when yielding is due not

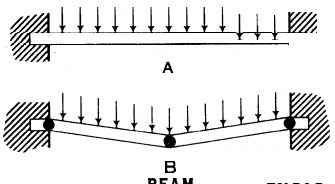

FIG. 19.—(A) BEAM WITH ENCASTERED ENDS WITH UNIFORMLY DISTRIBUTED LOAD; (B) FORMATION OF THREE PLASTIC HINGES CONVERTS BEAM INTO A MECHANISM

to simple tension but to this triaxial state of stress?

Hypotheses of Yielding or Elastic Breakdown.— *Principal Stress Hypothesis.*—The simplest hypothesis would be to postulate that if X, is the largest of the three principal stresses so that X, $> Y_2 > Z_3$ the stresses Y_2 and Z_3 have no influence on yielding. This hypothesis is not borne out by experiment. While it is impossible in the laboratory to realize and measure uniform triaxial states of stress, biaxial states of stress can be realized either by the twisting of thin tubes in which the two principal stresses are equal but of opposite sign, X_1 tension, $Y_2 = -X_1$ compression and $Z_3 = 0$, or by subjecting thin tubes to internal pressure in which case X_1, the largest stress, is the circumferential or hoop stress. and Y_2, the longitudinal stress, occurs in the direction of the axis' and is equal to half the circumferential stress $Y_2 = \frac{1}{2}X_1$.

It was found experimentally by W. Lode that thin tybes subjected to twisting yield when $X_1 = -Y_2 = 0.6$ fy. Thus yielding takes place under these conditions when the stresses are equal to only 60% of the yield point stress in simple tension, from which it must be concluded that the principal stress hypothesis is untenable.

Principal Strain Hypothesis.—This hypothesis postulates that the maximum principal strain is constant at the onset of yield irrespective of the state of stress. If we postulate a somewhat simplified stress-strain diagram for the material which is generally used in plasticity and in which the region of proportionality (straight line relation) OA (fig. 21) is assumed to be valid up to the yield point of the material, followed by an unlimited yield range AB without any work hardening, we obtain for the maximum strain at yield $e_y = $ fy. For the tube subjected to twisting we obtain

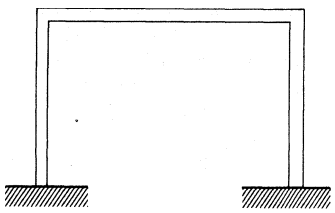

FIG. 20.— RIGIDPORTAL FRAME

$$e_1 = \frac{1}{E}[X_1 - \mu(Y_2 + Z_3)] = \frac{1}{E}[X_1 - \mu(-X_1 + 0)]$$

$$e_1 = \frac{X_1}{E}(1 + \mu)$$

and since μ for steel is approximately 0.28 we obtain

$$e_1 = e_y = \frac{X_1}{E} \times 1.28 = \frac{fy}{E}$$

and hence $$X_1 = \frac{fy}{1.28} = 0.78\,fy$$

Experiment, however, demands $X_1 = 0.6$ fy so that this hypothesis cannot be maintained.

Maximum Shear Stress Hypothesis.—According to this hypothesis yielding depends on half the difference between the largest and the smallest of the two principal stresses which equals the largest value of shear stress. Yielding is, therefore, assumed to take place when the largest shear stress assumes the value of the shear in uniaxial tension at yield. In uniaxial tension the largest shear stress is one-half the applied tensile stress, hence at yield when X, = fy the largest shear stress is 0.5 fy. For the tube subjected to twisting, the largest shear stress $= \frac{X_1 - Y_2}{2} = \frac{X_1 + X_1}{2}$

and this must be equal to 0.5 fy hence $X_1 = 0.5$ fy. Experiment demands $X_1 = 0.6$ fy and this is therefore a good approximation.

Shear Strain Energy *Hypothesis.*—This, also known as the Mises, Huber, Hencky hypothesis, postulates that the capacity of the material to absorb shear strain energy without yielding is limited to a constant value and that this value is independent of the state of stress.

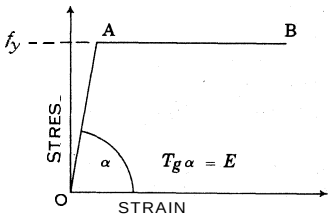

FIG. 21.—SCHEMATIC STRESS-STRAIN DIAGRAM. AB YIELD RANGE

Earlier we found the shear strain energy U_2 to be

$$U_2 = \frac{1+\mu}{6E}[X_x - Y_y)^2 + (Y_y - Z_z)^2 + (Z_z - X_x)^2] + \frac{1}{2G}(X_y^2 + X_z^2 + Y_z^2)$$

and written in principal stresses this expression becomes

$$U_2 = \frac{1+\mu}{6E}[(X_1 - Y_2)^2 + (Y_2 - Z_3)^2 + (Z_3 - X_1)^2]$$

For uniaxial tension at yield $X_1 = fy$ $Y_2 = Z_3 = 0$ and

$$U_2 = \frac{1+\mu}{6E}(X_1^2 + X_1) - \frac{2(1+\mu)}{6E}fy^2$$

For the tube under torsion $X_1 = -Y_2$, $Z_3 = 0$ and

$$U_2 = \frac{1+\mu}{6E}[(X_1 + X_1)^2 + X_1^2 + X_1^2)] = \frac{6(1+\mu)}{6E}X_1^2$$

hence $X_1^2 = \frac{1}{3}fy^2$ and $X_1 = \frac{1}{\sqrt{3}}fy = 0.58fy$

Experiment demands $X_1 = 0.6$ fy and it is seen that this hypothesis represents experimental results more accurately than any of the other hypotheses. It is now generally accepted as the hypothesis for elastic breakdown or yielding.

Since for hydrostatic states of stress for which $X_1 = Y_2 = Z_3$ the value of U_2 vanishes, yielding cannot occur, however large the magnitude of the principal stresses. This is borne out by experience since metals will tolerate enormous hydrostatic pressures without yielding.

Triaxial isotropic tension with all three principal stresses equal would also make yielding and plastic deformation impossible however large the principal stresses are. It would then have to be assumed that fracture supervenes even in ductile materials without being preceded by plastic deformation. Some authorities in the past have attributed the occurrence of brittle fracture in normally ductile materials to the existence of such states of isotropic triaxial tension. There are, however, objections to this interpretation.

Instability and Buckling.—If a ball is considered resting within a hemispherical shell it is in stable equilibrium because after any small displacement from its position it will return to its original equilibrium position. The potential energy of the ball is a minimum and this is characteristic for stable equilibrium. The potential energy of a ball resting on the outside of a hemispherical shell is a maximum and hence after a small displacement it cannot return to its equilibrium position which is unstable. The ball will roll off altogether after a small displacement from this equilibrium position and may assume another stable equilibrium position by the side of the hemispherical shell.

A somewhat similar situation arises in many cases of stressed solids. The internal stresses with the associated deformation must be in equilibrium with the external forces in the same way as the weight of the ball, when at rest, is in equilibrium with the pressure exerted on it by the supporting shell. But in the same way as the equilibrium of the ball can be either stable or unstable, that of the stressed solid can be stable or unstable. If the equilibrium is unstable a small deformation may cause the pattern of equilibrium to change radically to a stable form, but this change may be associated with such large deformations that it must be considered as failure. Because these deformations frequently appear as buckles this phenomenon of instability is known to the engineer as "buckling." A thin cylindrical shell after buckling under compression is shown in fig. 22.

The commonest form of buckling is that of a column or pillar supporting a load. For loads not exceeding a certain value the axis of the column remains straight, but as the load increases the stored strain energy increases and may become a maximum. This means that when the load reaches a certain limiting value, the buckling load, another equilibrium position of smaller potential energy becomes possible but no longer with the column axis straight, but curved. At the moment of buckling, each point along the axis will move laterally—as if to shed and evade the load—and the column will no longer be straight but curved and may collapse altogether if another equilibrium position cannot be found for only small displacements.

Every structure or part of a structure in which there are com-

pressive stresses is potentially liable to buckle, although the danger is real only for relatively slender or thin-walled structural members. Buckling is not necessarily always destructive as every airplane passenger is able to observe by looking out at the somewhat crinkly skin of the wing when the plane is air-borne, whereas this skin before buckling while the airplane was on the ground, was perfectly smooth.

Buckling as an equilibrium problem is not associated with the compressive strength of the material as discussed in the section on compression tests although certain mechanical properties such as Young's modulus and the yield point of the material may enter into the problem. Largely, however, buckling is a function of form —a long straight column will collapse under a much smaller load than a short column of the same material and cross section. though the stresses in the two members would be the same under the same load. Buckling may take place entirely within the elastic region of the material and for such cases solutions may be found by applying the theory of elasticity. It will always be advisable, though, to check such solutions by experiment. Whereas the theory of elasticity gives results in the case of columns in good agreement with experiment, at least for columns of such slender proportions that they will buckle within the elastic region of the material, in other cases this is not so. In the case of the axially compressed thin-walled metal cylinder with a large ratio of diameter to wall thickness, such as that illustrated in fig. 22. the theory of elasticity gives solutions for the buckling load which may be three to four times as large as those found by experiment.

The mathematical solution of all but the simplest buckling problems poses formidable difficulties even if it is fully within the elastic region. These difficulties are enormously increased for buckling problems involving partly plastic deformation, and progress in this field is as yet extremely limited.

Thus, theoretically complete solutions, confirmed by experiment, are not available for many cases of engineering application. Even relatively ancient and common problems. such as the buckling of webs in plate girders and the necessary stiffening, are still the subject of controversy and research, so that the engineer frequently has to rely on the results of past experience and on ad *hoc* tests to prevent failure of his structures from instability.

Fatigue. — Reference to failure by fatigue has already been made under Fatigue *Tests*. The problem must now be considered in its broader aspects. Only a few engineering structures or components are loaded in such a way that the load once applied remains constant for the whole of the life of the structure. In most cases there will be variation of stress, and since fatigue failure is a phenomenon resulting from such variation, almost every engineering component is exposed to the risk of failure from fatigue. Variation of stress may result even if there is no variation in load. The axle of a railway car, even if the axle load remains constant all the time, is nevertheless subject to fatigue. It acts as a beam so that there are always tension stresses on the underside of the axle and compression stresses on top. Since the axle is not stationary but revolves, the material in tension at one moment will be subjected to compression the next moment when the axle has completed half a revolution, and after a further half revolution will be subjected to tension again.

In this case the alternations of stress are sinusoidal and of constant amplitude. This is by no means the case generally. The wings of an aircraft during flight are subjected to many, though quite irregular, alterations of loading depending on the velocity of gusts so that the stress cycles in the wing will be distributed at random between a maximum and a minimum stress. Such random loading complicates the fatigue problem enormously since fatigue data, insofar as they are available, have been obtained for cyclic loading of constant amplitude.

The number of loading cycles endured during the lifetime of a structure may also vary enormously from one type of structure to another. One hundred million loading and unloading cycles may have to be endured in the lifetime of a bridge outside the main line station of a capital city, whereas a similar bridge in some remote part of the country may only be loaded a few times every day. It is estimated that a railway bridge may have to endure between 1,000,000 and 100,000,000 cycles of loading, the axle of a railway car 400,000,000 cycles, and the shaft of a steam turbine 15,000,000,000 cycles of loading. Each blade of a modern aircraft gas turbine may have to endure 60,000,000,000 stress cycles in 500 flying hours. Even if testing machines were available for applying 200,000 cycles of loading per minute, a test on such a turbine blade would still take about a month. At the other extreme, even a few thousand cycles may be sufficient to produce fatigue as the investigations into the failure of the pressure cabin of a famous airliner have shown.

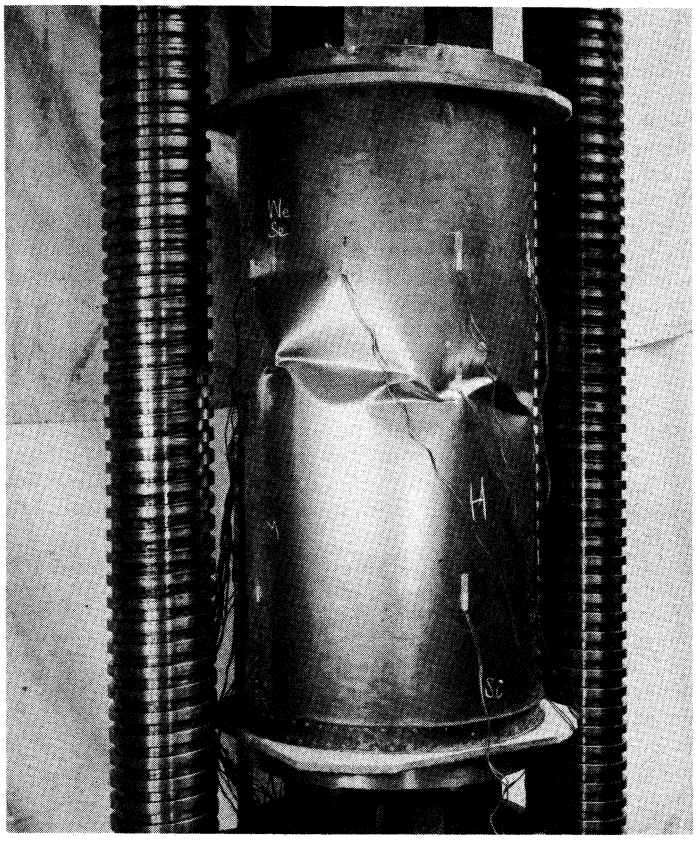

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FIG. 22.— THIN CYLINDRICAL SHELL BUCKLED BY AXIAL COMPRESSION

The frequent occurrence of service failure from fatigue is entirely due to the completely inadequate design procedures in use in the 1950s. In them the stresses in the structure were calculated by some approximate method based on the theory of elasticity and were then limited to some value near the proportional limit of the material or, which comes much to the same thing, to some fraction of the material's fatigue strength determined in tests with small metal specimens. Such procedures leave out of account many effects of which only a few important ones can be considered here.

Notch Sensitivity and Size Effect. — Under conditions of fatigue, as has been explained, the material does not deform plastically in bulk as under static loading. Plastic deformation is definitely associated with fatigue but it occurs on a microscopic scale so that it may be highly localized, concentrated as it were at certain points. where a fatigue crack will then start. A microsection through a piece of mild steel containing a fatigue crack is shown in fig. 23. These points where the microscopic plastic deformation is concentrated will naturally be those where the stresses are highest. that is, at points of stress concentration. Fatigue failures almost without exception will start from points of stress concentration produced by discontinuities in form, either necessarily introduced in design or manufacture such as riveted, bolted or welded joints, shoulders in shafts. oil holes and keyways. or accidentally introduced in manufacture such as tool marks, grinding scratches, accidental indentations, electric arcing marks, small defects such as blowholes in castings and similar minor damage.

Since the fatigue crack starts at a point, it will be the magnitude

of stress at this single point which decides whether in fact the part survives in service or fails.

This might appear, at first sight, to simplify the problem, since all the designer has to do is to ensure that the stress at this critical point does not exceed the endurance limit of the material. One of the difficulties is to find the "point," although experience frequently helps greatly in pinpointing the discontinuity most likely to produce the critical stress concentration.

The second difficulty arises in determining the exact value of the stress before the part is made. Mathematical analysis will give solutions in some cases but fails in others. There was, for instance, by the late 1950s, no method of evaluating accurately the stress cycle experienced by the material at the root of gear teeth when the gears are running, particularly if the gears are of more complex form than straight spur gears. In many other common engineering components the situation was similar, though in some cases the value of the peak stress could be determined by one or other of the methods of experimental stress analysis.

Finally, even if the stress value is accurately known, it is not sufficient for this value to be simply limited to the fatigue strength of the material. For one thing, as has already been pointed out, fatigue strength is not a mechanical property depending only on the material. Fatigue tests carried out with identical specimens of rectangular cross section, for instance, will give different values for the "fatigue strength of the material" depending on whether the specimens are tested by applying axial tension, bending about the minor axis of inertia (specimen bent on the flat) or about the major axis (specimen bent on edge). A different result will be obtained for specimens with sharp edges. The surface finish of the specimen whether as rolled, machined, ground or polished will also profoundly influence the result, so that it is really impossible to define the fatigue strength of the material.

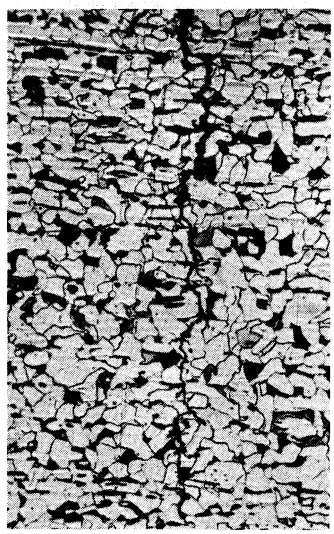

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FIG. 23.—MICROSECTION THROUGH STEEL CONTAINING FATIGUE CRACK

Secondly, the reduction in fatigue strength is not necessarily proportional to the value of the stress concentration factor as defined earlier. If, for instance, the fatigue strength of two components is determined experimentally, the two being identical with the exception of some minor detail which produces the stress concentration — such as a variation in the radius of the transition between pin and web of otherwise identical crankshafts — it is found that the reduction in fatigue strength is not proportional to the values of these stress concentrations. Moreover, if the fatigue strength of two crankshafts entirely similar in form but of different size is compared, the fatigue strength of the larger shaft will be smaller than that of the smaller shaft despite the fact that the stress concentrations for both shafts are the same.

This phenomenon of increasing effectiveness of stress concentration with size is known as the size effect in fatigue.

More "highly cultivated" materials, where high values of tensile strength are produced by careful alloying and heat treatment, suffer relatively greater losses in fatigue strength through the presence of a stress concentration than some more ordinary materials such as gray cast iron. This difference between different materials to suffer relatively greater or smaller reductions in fatigue strength in consequence of stress concentrations produced by notches or other geometric discontinuities is spoken of as the differing "notch sensitivity" of different materials.

There is, however, one important overriding consideration which to some extent at least simplifies matters. Provided the magnitude of the worst stress concentration can be accurately evaluated, the reduction in fatigue strength will never be greater than that which could be expected by dividing the fatigue strength of the material, obtained of course in an appropriate test with a test piece of similar characteristics and subjected to types of stressing similar to that of the component, by the full value of the elastic stress concentration factor. That the value of fatigue strength used must be chosen with great care is perhaps evident when it is considered that a rail steel of 50 tons per square inch tensile strength when tested in the form of machined specimens in bending will give a fatigue strength of perhaps 30 tons per square inch, whereas the actual rail even without stress concentrations will give scarcely more than 24 tons per square inch in bending, whereas with the stress concentrations introduced by the circular holes of the fish-plated joint, no more than 8 tons per square inch can be expected.

Cumulative Damage. — Many engineering structures and components are not subjected to stress variations of constant amplitude. The stresses experienced in a ship during a voyage will largely depend on the weather experienced, and similar considerations will apply to aircraft. Experimental means were at the disposal of the engineer in the late 1950s to obtain extensive records of the stress variations for such cases. In the 1950s testing machines were developed capable of applying "program loading"; that is, loading of an amplitude which can be varied in a regular manner during the fatigue test to approximate more closely to conditions in service where a few cycles of high stress amplitude may be followed by thousands or millions of cycles of low amplitude, in contrast to the constant amplitude of stress applied in the conventional fatigue test. The problem of predicting the life of a part subjected in service to stress cycles of variable amplitude. from experimental data obtained with the aid of constant amplitude machines is known as the cumulative damage problem.

Various methods for assessing cumulative damage have been proposed, based on statistical reasoning, but the problem is still unsolved and will only be solved when the fundamental mechanism of fatigue is better understood. By the late 1950s the many theories proposed explained fatigue with the aid of some conceptual model behaving in accordance with the known laws governing the deformation of metal crystals, but none of them had found general acceptance.

Statistical Aspects. — Until the late 1950s it was assumed that ferrous metals have a limiting stress — the endurance limit below which iatigue failure cannot occur — and that this stress can only differ by an insignificant amount from that which still produces failure at 10,000,000 cycles. This would mean that if a part does not fail in 10,000,000 cycles it will not fail at all. Service failures after much longer endurances, thousands of millions of cycles, are, however, not unknown and perhaps it would be more correct to say that if a part does not fail after 10,000,000 cycles it is unlikely to fail at all. This expression "unlikely" introduces a probability aspect into the fatigue phenomenon for which there is increasing experimental support.

For one thing, the S–N diagram discussed earlier is never obtained as a smooth curve passing exactly through the experimental points. In fact, if instead of testing only one specimen at a given stress level, several are tested, each of them will give a different endurance, that is, a different value for N, so that the test results will exhibit more or less scatter. The different values will be distributed in accordance with some frequency distribution. It would appear to follow from this that the life of a specimen subjected to a certain amplitude of cyclic stress cannot be predicted accurately. All that can be said — and even this only if there are sufficient experimental data — is that any given specimen may have a certain definite chance to survive a given number of cycles at a certain stress value. Instead of plotting S–N diagrams one would plot S–N–P diagrams consisting of several lines similar to the conventional S–N diagram, but each of them associated with a certain probability of survival "*P*." If the S–N diagram were drawn in such a way that, if for a given value S, *n* specimens have been tested, and the S–N diagram would be made to pass through a point corresponding to N cycles, so that $n/2$ results lie to the right of it and $n/2$ to the left, it could be concluded that the chance of a specimen surviving to the endurance of N cycles at the given stress

is 3. The S–N diagram drawn through these points for different values of S would be the S–N diagram for 50% probability, and other S–N diagrams for different probabilities of survival could be obtained in a similar manner.

The lives or endurances of fatigue specimens could be considered to be distributed in accordance with some mathematical frequency distribution in much the same way as the ages of man at death.

The determination of this frequency distribution was in the late 1950s one of the cardinal problems for research workers in this field. That fatigue is in fact a statistical phenomenon was becoming widely realized, but engineers were reluctant to accept the inescapable consequence, that however "safe" an engineering part is designed it may nevertheless fail from fatigue. Where millions of identical parts are used in mass-produced machinery such as motorcars, a few of this large number will inevitably fail.

If the frequency distribution for fatigue failure were known, the engineer might on this basis deliberately select a priori the number of failures he is willing to tolerate as a percentage of total production, instead of hoping that it will be tolerably small.

Full-Scale Tests.—It will be clear that no fatigue problem can be solved satisfactorily without fairly extensive experimental data. In the complete absence of fundamental principles upon which to build a reliable theory, engineers are driven increasingly to the full-scale prototype fatigue test of which perhaps the most notable development has been the testing to destruction of complete pressure cabins of large airliners under repeated internal pressurization. Full-scale tests of this and similar types, of course, can no longer be carried out in testing machines. They require an extensive, complex and costly plant, but at the state of knowledge in the late 1950s they cannot, unfortunately, be dispensed with.

Creep.—This subject until the early 1950s was of almost purely academic interest. With the rapid increase in the working temperatures of steam-power stations, however, and in particular with the development of the gas turbine and the modern jet engine, the subject has assumed tremendous importance.

If a tensile test, as discussed earlier, is interrupted at a point C (fig. 12), say, on the load extension diagram and the load is maintained at the value represented by C, the specimen will continue to deform at constant load for a long time. This type of plastic deformation which may eventually end in fracture is called creep. On the application of the load the time rate of deformation will at first decrease (primary creep), then remain fairly constant (secondary creep) and then increase just prior to fracture (tertiary creep). The whole process may take place within a few hours or within hundreds of thousands of hours depending on the applied stress, the material and the temperature.

The fabrication of metals by forging, rolling or extrusion is generally carried out at higher temperatures because the resistance of the material against deformation decreases with increasing temperature, but this also means that for a given applied stress the total creep in a given time will increase with increasing temperature and at a given temperature with increasing stress.

Quite apart from the need to avoid failures in steam plant and gas turbines, the deformations which can be permitted to take place aithin the required service life are necessarily limited to small amounts. If the blades of a gas turbine were permitted to elongate appreciably by creep under the influence of the centrifugal forces, they would soon begin to rub on the casing. The temperatures at which ordinary engineering steels can be used without excessive creep are modest and special steels alloyed with molybdenum. nickel, chromium and vanadium must be used for the high temperatures of a modern steam plant. For the temperatures produced in gas turbines even these steels are not satisfactory, and alloys primarily consisting of nickel and chromium, the "Nimonic" alloys, were developed for jet engines.

Further increases in jet engine efficiency could be obtained if higher engine compression could be used at present operating temperatures or higher operating temperatures for present engine compressions. In both cases higher creep resistance than that offered by present materials is required. One of the materials used in the late 1950s was "Nimonic 80." It would suffer an extension of 0.5% in 10,000 hours at a temperature of 750° C. under an applied stress of four tons per square inch. This type of information essential to the designer is obtained in creep tests. Specimens are tested in tension in specially designed machines which permit the application of loads of varying magnitude within a furnace kept at constant temperature. Apparatus for measuring the creep under load with time must also be provided.

One difficulty in creep testing arises from the fact that the cross-sectional area of the specimen diminishes as creep proceeds and if the load is kept constant the stress applied to the specimen will gradually increase during the test. Most creep tests are nevertheless carried out at constant load and the error is not large if the diminution of cross section remains small. Some ingenious devices, however, have been developed for keeping the stress constant rather than the load. Creep tests are carried out in several different ways and according to the method adopted different types of information will be obtained.

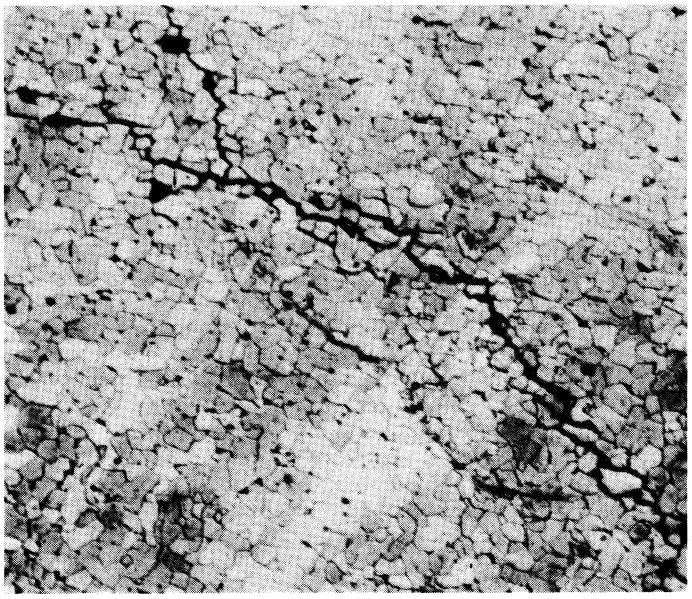
In the "creep rupture test," also known as "time to rupture test," the specimen is loaded at constant load and the time to rupture at constant temperature is observed. By testing a number of specimens at the same temperature but at different stresses and plotting stress against time to rupture, curves are obtained which in appearance are not unlike the S–N diagrams obtained in fatigue tests but with time taking the place of numbers of cycles. While such tests will give no information on the amount of deformation, they will give a good indication of the stress values which might be used at different temperatures without causing rupture within a given period of time. In another type of test, the Rohn test, the temperature is determined at which creep will cease under given stress.

Since the amount of deformation suffered by the material at a given stress and temperature within a given time is of great importance in many practical cases, it has been found necessary to perform creep tests of 10,000 hours' duration at different stresses and temperatures. To obtain complete information of this type within a reasonable time requires batteries of creep-testing machines. Even then it is necessary for the engineer to extrapolate from say 10,000 hours to 100,000 hours which might represent the required service life of a steam pipe. In this light it is perhaps understandable that such problems as the effect of triaxial states of stress, or the effect of nonuniform stress distribution, or the effect of stress concentrations on creep behaviour, has not as yet been investigated to any appreciable extent. It is clear, however, that failure by creep need be considered only for those engineering components which must operate at high temperatures and where, as in steam plants, cooling is impossible. In gas turbines internally cooled blades have been adopted. These enable greater operating temperatures to be used than would otherwise be possible with existing materials. Creep and fatigue frequently arise together and present a problem which is not yet resolved.

Corrosion.—Corrosion is certainly one of the agents responsible for many failures though its connection with strength of materials may seem remote. There is the obvious weakening in consequence of the profound change in the strength properties of metals when they are converted into chemical compounds by corrosion, but there are at least two other phenomena in which corrosion plays a more immediate part in the destruction of the strength of a metal.

Corrosion fatigue is one of them. The fatigue strength of all but passivated metals, that is to say, those not liable to corrode in certain mediums, will be greatly reduced by the presence of a corrosive medium. Even that of passivated metals may be reduced if the passivity depends on a surface film which cracks under the influence of fatigue loading conditions and cannot be repaired rapidly enough.

Thus stainless steel, which does not corrode in water, has its endurance limit reduced from 23 tons per square inch to 16 tons per square inch when tested in water. It is clear from this that the most elaborate design procedures may be useless if the designer leaves out of account the possible presence of a corrosive medium, and there mas in the late 1950s no evidence that paints, which may prevent general corrosion, would effectively prevent this reduction in fatigue strength.



BRITISH WELDING RESEARCH ASSOCIATION

FIG. 24.—MICROSECTION THROUGH STEEL CONTAINING INTERGRANULAR STRESS CORROSION CRACK

Stress corrosion is another way in which a corrosive agent can rapidly destroy the resistance of a material to stress. Whereas, in the absence of stress, a corrosive medium may produce only slow general surface corrosion, in the presence of stress the attack may become highly localized and accelerated. In this case deep cracks will develop rapidly, such as that shown in fig. 24, generally along the grain boundaries of the metal, where, in the absence of the corrosive medium stress by itself would not produce such cracking. Stress corrosion cracking may occur in riveted boilers in consequence of alkali concentrations building up in riveted seams from alkali dissolved in boiler-water treatment. This phenomenon is also known as caustic cracking. An atmosphere containing traces of ammonia may produce cracking in brass articles especially when these have been produced by cold-working processes. This is known as season cracking. Stainless steel and aluminum alloys also are liable to suffer such destruction in the presence of certain chemicals.

Brittle Fracture. — This term in its original meaning denoted fracture of a brittle material such as glass which occurs suddenly at a certain stress without being preceded by any plastic deformation. In the 1950s the term was used increasingly to denote, not the fracture of a brittle material, but that of a ductile material, in particular carbon steel, in an unusual and to all appearances perfectly brittle manner. There is in fact a small amount of plastic deformation present, though this is only revealed by accurate measurement.

Such brittle fractures have occurred in large structures such as bridges, ships and oil storage tanks. All these failures have certain common features: (1) they have occurred mainly in welded structures though a few riveted structures have been affected; (2) in only a few cases was the steel found to be below accepted high standards of quality; (3) the fracture generally occurred suddenly without warning and progressed along its path with great speed; (4) in most cases the ambient temperature was relatively low; (5) the fracture generally originated from one or several geometric discontinuities which produced stress concentration; (6) all the fractures were produced at ordinary working stresses below the proportional limit of the material; (7) the static tensile strength and ductility of the material when tested at the casualty temperature were satisfactory; in particular the material exhibited large ductility.

Although isotropic triaxial states of tensile stress might permit a ductile material to fail in a brittle manner in accordance with the shear strain energy hypothesis for plastic deformation discussed earlier. this simple explanation is not satisfactory for several reasons. For one thing, it is difficult to see why such triaxial states of stress, even if there were grounds to suspect that they might exist in such extensive areas of structures, should be tolerated by the structure at one temperature and not at a somewhat lower temperature.

Although the problem of brittle fracture of ductile steel was far from being solved in the late 1950s, it began to be better understood when it was shown by C. F. Tipper that a tensile test piece with a notch could break either in a perfectly ductile or in a brittle manner depending entirely on the testing temperature. The fractures experienced were then seen to be due primarily to a change in a property of steel termed notch toughness in consequence of decreasing temperature.

Why exactly this change in property takes place was not clear in the late 1950s but it was known that the relation between the notch toughness of a steel and the temperature is strcngly influenced by the steelmaking process, the chemical composition of the steel. the temperature at which the steel is rolled and the thickness in ahich it is produced. In general, the notch toughness decreases with increasing thickness of material, and plates one inch thick of material produced to current specifications would generally show signs of becoming notch brittle at ordinary room temperature. This change in notch toughness would not become evident from test results obtained with the standard tensile test commonly used for the acceptance and quality control of ordinary structural steel such as is used for ships, bridges, buildings, storage and pressure vessels.

Since the standard tensile test gives no indication that the material may be notch brittle at the temperature at which it is to be used, it is important that a test be devised which would permit the selection of materials suitable for service at different ranges of low temperature. For economic reasons the test should be not too severe, but for reasons of safety it must be sufficiently discriminating to exclude material which might become dangerous, since if fracture occurs it does so at quite modest stress levels, not due to overload. Such a test must fix for each steel a narrow temperature range above which a structure made from the steel could not fail by brittle fracture, and below which it would be likely to fail. A large number of different tests have been proposed but none has so far been generally accepted as giving the perfect correlation with expected service behaviour. Some tests, such as the notch tensile test proposed by Tipper, are certainly safe but are claimed to be too severe. Other tests such as the Charpy V-notch impact test are considered not to be severe enough.

There are certain indications that it is in fact inherent in the nature of the problem that such an ideal test cannot be devised. For one thing, there is a fundamental difference in the failure of the structure and that of a test piece. Structures have definitely been known to fail at stresses well below the yield point stress of the material, whereas none of the many test pieces proposed can be broken at stresses below the yield.

It appears as if in the structure not only the notch ductility of the material is reduced by the decrease in temperature, but its brittle strength as well, and this is never found in the test piece.

This apparent drop in strength, however, is better understood since A. A. Wells succeeded in reproducing at low stresses in the laboratory such fast brittle through fractures in large welded test pieces.

Two stages in the fracture have to be distinguished: initiation and propagation. Initiation requires the stress at the bottom of the notch to be raised to yield point magnitude. The plastic deformation produced in welding by the severely localized heating will, however, do this, so that an external load producing yield point stress is not required. The second stage of fracture, propagation, is an instability effect.

A. A. Griffith proposed a criterion for the propagation of a fast fracture starting from an internal notch in a brittle solid such as glass. As the internal notch or crack extends. new surfaces are created for which surface energy is required. This cannot be supplied by the external loads since the fracture propagates so rapidly that the external loads cannot move and cannot, therefore, do any uork. The energy can, however, be derived from the interior of the solid, since, as the fracture propagates, increasingly large

portions of the material become stress free and strain energy is released. If the strain energy release rate exceeds the rate at which energy is absorbed in the form of surface energy in the newly created surfaces, the process is clearly unstable and must proceed at an accelerated rate.

G. Irwin, by interpreting "surface energy" in such a way as to include the energy absorbed in the plastic deformation of two narrow zones at each side of the crack in a steel plate, showed that the same instability effect could explain the rapid propagation of fractures in large structures. The level of the energy to be liberated in crack propagation depends, of course, on the material and the general stress level. High stresses are necessary to propagate small cracks, but the general stress level necessary for propagation rapidly decreases as the length of the fracture increases. High stresses are always present in the form of residual stresses in the immediate vicinity of welds in welded structures, and Wells's experiments have shown that the strain energy from the relief of these residual stresses is sufficient to supply the high strain energy release rate required in the early stages of the extension of a small crack from a weld at low average applied stresses.

V. METAL PHYSICS

The vast number of questions arising in the problem of the failure of metals by plastic deformation, creep, fatigue and brittle fracture which cannot be satisfactorily explained with the aid of the fundamental concepts of the theory of elasticity have given rise to innumerable and diverse investigations, both theoretical and experimental, which have only one feature in common: that they endeavour to take account of the structure of metals instead of operating with the abstract structureless elastic space of the theory of elasticity. By the 1950s investigations of this type were generally considered to fall within the province of metal physics, though metal physics is concerned with many problems other than strength.

Structure of Metals.—Metals are composed of aggregates of small crystals as can be seen from the microsections in fig. 23 and 24. Whereas crystals grown in a solution have regular plane boundaries, the crystals in metals are of quite irregular shape because on solidification of a metal from the liquid state, many crystals grow simultaneously and then meet along irregular grain boundaries. This original cast structure generally is profoundly modified by later working and heat-treatment processes.

A solid is a crystal when the atoms are arranged in a regular pattern which is repeated throughout the solid. The atoms of iron, for instance, arrange themselves in such a manner that eight of them occupy positions at the corners of a cube and the ninth places itself in the centre of the cube. This arrangement of the crystal is called a body-centred cubic lattice. The existence of such structures can be verified experimentally by the methods of X-ray crystallography which are based on the diffraction phenomenon. These methods also permit the determination of the distance between the atoms. the so-called lattice constant, which for the body-centred cubic lattice of iron is 2.8 Å or 2.8×10^{-8} cm.

Elastic Deformation.—This can be shown to produce changes in the distance between atoms, and this fact has been used for purposes of experimental stress analysis. The change in the lattice constant as measured by X-ray diffraction can be related to the applied stress so that X-ray diffraction can be used for stress analysis though the method has severe limitations.

Plastic Deformation; Slip.—This has been studied extensiveiy nith the aid of single metal crystals which can be produced by straining and heat treatment up to several inches in length. Such single metal crystals do not. of course. exhibit the regular arrangement of plane boundaries one generally associates nith a single crystal, but unlike polycrystalline materials the orientation of the atomic lattice planes is the same throughout the crystal which is the essential criterion for the crystal being "single."

It is found that plastic deformation proceeds by individual layers of atoms in lattice planes of definite orientation with regard to the faces of the cube sliding over each other like a pack of cards This can be seen under the microscope in the form of so-called slip lines which are edges of blocks of lattice planes breaking the surface after slip.

Resistance to Slip.—From the forces of attraction between the atoms the resistance against this deformation can be calculated, and is found to be about 1,000 times as large as that actually measured in experiments. Actually, single crystals generally are relatively soft, their resistance against plastic deformation is much less than that of the same material composed of many tiny crystals. This lessened resistance is understandable since the irregularly arranged atoms in the grain boundaries may, to some extent, delay the movement of the glide planes.

Dislocations.—The insertion of a few foreign atoms into the lattice, such as carbon in iron, will increase the resistance against deformation. Steels are made creep resistant by the addition of quite small quantities of foreign atoms. On the other hand, the postulation of irregularities in the lattice which can be produced by the insertion of additional atoms into one plane, or by assuming vacant lattice sites, can be used to explain the small deformation resistance of actual metal crystals. These irregularities have been termed dislocations and a whole theory of strength, the dislocation theory, has developed which endeavours to explain many of the phenomena revealed by observation and experiment and which in fact is successful in explaining the small strength of simple crystals in relation to the theoretical strength and many diverse effects observed in plastic deformation.

Cleavage.—Crystals can, however, not only be plastically deformed, but they can be split by cleavage along certain crystallographic planes, the so-called cleavage planes well known from the observation of the exfoliation of mica. Crystals cleave frequently during plastic deformation. **A** fracture which consists primarily of cleavages of undeformed crystals would be a brittle fracture, and whether brittle or ductile fracture occurs in a piece of metal may depend on the stress components acting in the glide planes and in the cleavage planes, and the relative resistance against slip and cleavage. The resistance against slip is certainly known to increase with decreasing temperature, and if the cleavage strength remained constant it would be natural to expect an increasing number of crystals in a polycrystalline material to fail from cleavage as the temperature decreases so that with decreasing temperature fracture would tend to become increasingly brittle.

Metal Physics and Engineering.—Despite the great contribution these physical considerations have made to our understanding of deformation and fracture phenomena, we are as yet far from having established a unique set of simple fundamental principles which would permit satisfactory explanation for the observed phenomena. The situation in the late 1950s was this, that principles which permit one group of phenomena to be explained satisfactorily are in direct contradiction with other phenomena. The whole subject was still so much in a state of flux that it would be unwise in this article to do more than indicate some elementary facts which are firmly established.

While metal physical theories of strength have made notable contributions to our understanding of many of our strength problems, they have not developed in a direction in which the engineer can make use of them directly in his problem of design for strength. This situation is, to some extent, a consequence of the fact that physical theories are postulated for pure metals whereas engineers use metals which are anything but pure. Steel contains, as well as iron, carbon in solid solution and iron carbides in the form of a second phase. Brass consists of a mixture of copper and zinc crystals, stainless steel contains impurities to the extent of 18% chromium and 8% nickel, and all engineering metals contain gases such as hydrogen, oxygen and nitrogen together with other metallic and nonmetallic impurities. These trace elements in metals are nevertheless known to have such a profound influence on mechanical behaviour that their presence or absence is often the only criterion whether a metal can be safely used for a given purpose or not. In view of these and other facts one is reluctant to advise engineers to look to metal physics for the ultimate solution of their engineering failure problems.

VI. SURVEY AND OUTLOOK

Strength of materials, while firmly rooted in mathematics and

physics, did not, at the stage of its development in the late 1950s, offer such aesthetically satisfying an appearance as either of these two sciences. It was composed of many heterogeneous elements. There was no unique set of fundamental principles and assumptions from which satisfactory solutions to all problems can be derived. The link between the fundamental theoretical concepts derived from the theory of elasticity and the observations made in the testing of materials, and particularly in service, was missing.

As is perhaps to be expected in a science of such utilitarian character, it abounds in contradictions. In some respects it is highly theoretical, in many others purely empirical, and the link between theory and empiricism has become increasingly tenuous. The development of the science in the 20th century had become extremely centrifugal and there was little doubt that for some time, at any rate, its many diverse branches such as the theory of plasticity, fatigue, brittle fracture, metal physics and so forth would have to develop along more or less independent lines. It can only be hoped that at the end of such developments some new concepts may emerge which can serve as fundamental principles on which to build a unified science of deformation and fracture in which theory and experiment would no longer be in conflict.

In the late 1950s the old concepts rooted in the theory of elasticity were being increasingly abandoned, and even such basic ideas as stress and strain were becoming inadequate for the description of observed phenomena.

Since the cardinal questions of fracture and deformation are so closely dependent on the methods of manufacture of materials, it is inconceivable that progress can be made on a purely physical basis. Already strength of materials is closely linked with the science of metallurgy and the technologies of extracting, refining and fabrication of metals. This association must become closer. A science of the strength of materials, unable to account for the profound influence on strength properties of what may be termed manufacturing variables such as chemical composition, heat treatment and fabrication, will not serve the engineer. Metallurgy in turn must take note of the fact that the old mechanical properties which are still used for purposes of development, testing and acceptance of metallic materials have lost much of their previous importance, and that the significance of some of these properties in relation to the service conditions imposed on the material has become questionable.

Strength of materials is undergoing a profound though slow revolution. As in every revolution the first result is confusion. Since past theories no longer serve their purpose and new ones are only slowly emerging, the engineer, for a time at least, will be driven to solve his "strength of materials" problems on the basis of results obtained from *ad hoc* tests. In this way we have turned full circle because it was from such *ad hoc* tests, carried out by the early engineers, that the whole body of our knowledge has developed. *See* ARCHITECTURAL ENGINEERING; *see* also Index references under "Materials, Strength of" in vol. 24.

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(J. F. BR.; R. WK.)

MATER MATUTA, goddess of Italian cult, probably most accurately described as a deity of the ripening of grain (Varro, in Augustine, *City of* God, iv, *8),* although Lucretius (v, 656) makes her a goddess of dawn. Indeed the root *ma-* is found in both *mane* ("dawn") and *matutus* ("ripe"), but the agricultural explanation is perhaps more in keeping with a deity of Italian cult.

Her worship in Italy was both widespread and of ancient origin. Her temple at Rome, located in the Forum Boarium, was dedicated in 395 B.C. with antecedents going back traditionally to the time of Servius Tullius. The temple, long associated with Fortuna Virilis, an Ionic tetrastyle prostyle temple from the middle of the 1st century B.C., may represent a rebuilding. It is one of the best-preserved temples in Rome thanks to its conversion into the church of Sta. Maria Egiziaca in A.D. 872. That this temple is properly assigned to Mater Matuta, however, has been seriously questioned.

The festival of the Mater Matuta was held on June 11 and was marked by several unusual customs, among them that only free women of a first marriage might take part and that the women allegedly prayed not for their own children but for those of their sisters (but *cf.* H. J. Rose in *Classical Quarterly,* vol. xxviii, pp. 156 ff., 1934).

The goddess was later identified with the Greek Leucothea (Ovid, *Fasti,* vi, 473 ff.), who in turn was identifikd with Ino, wife of Athamas (*q.v.*). Thus she derives an association with the sea which did not originally belong to her.

See G. Wissowa, *Religion und Kultus,* 2nd ed., pp. 110–112 (1912); *Roman Questions of Plutarch,* trans. by H. J. Rose, pp. 175 ff. (1924).

(R. B. LD.)

MATERNAL AND CHILD HEALTH. Maternal and child health work denotes the action for safeguarding the life and health of mothers and children.

Begun on a modest scale by private organizations, maternal and child health work was gradually taken over by the governments, which brought to it greater financial resources on a nation-wide scope. At first, the work in individual countries was divided among several government departments, but in the course of time it was combined under the direction of one national agency for each country. For example, this agency in England was the ministry of health; in the U.S.S.R., the commissariat of public health, which in 1946 became the ministry of public health; in Italy, the national bureau for maternal and child welfare, established under a law of 1925; in Uruguay, the council of the child, 1934; in Argentina, the bureau of motherhood and childhood, 1936; Brazil, the national children's bureau, 1940; and Mexico, the bureau of child health and welfare, which was reorganized in 1943–44.

Welfare Work for Mothers.— The first step in safeguarding the mother is prenatal care. Such care is given at prenatal clinics which exist in varying numbers practically throughout the civilized world. These clinics, staffed with physicians and nurses, are open to all women. Situated mostly in cities, the clinics offer to expectant mothers periodic medical examinations with laboratory tests, advice in the care of health and in many localities treatment for syphilis and endemic diseases. In many places mothers attending clinics are visited in their homes by nurses who advise them on care of health, home management and related matters. Prenatal clinics are usually maintained by the government—national, municipal, or jointly by both—which also sets the standards and controls the work; in some countries also by private organizations.

Next to prenatal care the provision of childbirth attendance has been a matter of concern to the governments. Increasing grants have been made by some governments for the construction of free maternity homes or maternity wards in general hospitals. For the women who cannot go to a hospital, free or partly free attendance in the home by trained midwives is available in some countries. The training of the midwives is regulated by law. In England this was done by the law of 1936, which supplemented those of 1902–26. Also free maternity attendance was introduced under the National Health Service act, 1946, which aimed to provide medical care for every citizen regardless of income or insurance status. In the U.S.S.R. attendance at childbirth is free to every woman, whether in the hospital or in the home, in cities or rural areas. Measures for improving medical care were included in the fourth five-year plan for the economic reconstruction of the country, uhich became law in 1946.

An important part of the health services for mothers is the maternity benefit. These benefits consist of medical care and cash payments in the latter part of pregnancy and at the time of childbirth; they are intended for employed women who are subject to compulsory sickness insurance and are consequently pro-

hibited by law from engaging in paid work during that period. The purpose of these benefits is to help the woman meet the expenses incidental to the birth of a child and compensate her, at least in part, for the loss of wages. These benefits were first introduced in Germany under the sickness insurance law of 1883; Austria, 1889; and later in practically every country of Europe, in Japan, New Zealand and a number of countries on the American continent. The cash benefits are paid from the sickness insurance funds over a period of several weeks in amounts ahich vary according to country. Medical care and in some countries cash benefits are also given to the wives of insured men. even if they themselves are not subject to sickness insurance. Unlike the maternity benefits, maternity allowances are paid in some countries from the government treasury regardless of sickness insurance. In England maternity allowances are paid, in addition to maternity benefits, under the National Insurance act of 1946, which became effective in 1948.

Child Health Clinics. — After the birth of the child, action to safeguard his health is taken in many countries through the child health clinic. The first such clinics were established in France in 1892 for the expressed purpose of checking the high infant mortality rate; from there they spread throughout the world. The clinics, usually intended for children less than one year of age, are aimed at the prevention of disease rather than its treatment, although in some of them venereal and other diseases are treated. Recently confined mothers are visited at their homes by nurses or health visitors and are urged to bring their newborn children to the clinic. There the children are weighed, measured and examined by a physician. The mother is informed of her child's condition, given advice on his care and told to return at a specified time. Follow-up visits to the homes are made by nurses employed by the clinics. In some countries milk, cod-liver oil and orange juice are distributed at the clinics.

The attendance at the clinics is usually optional, but in some countries (for example, in Sweden in 1937 and France in 1945) it was prescribed as a condition for receiving maternity benefits. Also in France regular attendance is rewarded by premiums in cash or in kind. In the U.S.S.R. attendance is required regardless of maternity benefits.

The child health clinics were at first limited to cities but gradually they were extended to rural districts in France, Sweden, U.S.S.R., Argentina, Peru, Venezuela and elsewhere. Itinerant clinics serve the sparsely populated territories of some countries. Child health clinics are maintained by the national or municipal governments, or jointly by both, or by private organizations. No charge is made for the services. A rapid increase in child health clinics followed the end of World War I in 1918 as one of the efforts to counteract the deterioration of child health. In England government grants for such clinics became available under the Maternity and Child Welfare act, 1918, and in Italy under the law on the national bureau of maternal and child welfare, 1925. In Germany the Federal Child Welfare law of 1922 helped to stimulate the growth of the clinics. The example of Europe was soon followed by countries on the other continents.

Health Services for School Children. — The health of children in the next age group, preschool children, received less attention than that of babies. A beginning was made, however, in some countries by giving physical examinations to children in kindergartens. The needs of primary school children came to the foreground with the introduction of compulsory school attendance, which placed on society the duty to protect the health of the children gathered in schoolrooms in large numbers for many hours of a day. The purpose of this protection is to check communicable diseases, detect and treat illness and defects in the health of school children and improve their physical condition and mental development.

The first step in this school health service is the compulsory medical inspection of all school entrants and, at intervals, of children in other grades. Special inspections are also made in many countries at other times at the request of the teacher, parents, school physician or school nurse. In some localities attention is centred on the detection of tuberculosis and other communicable diseases. Conditions requiring medical care are reported to the parents, who are advised to arrange for treatment. In some countries the parents are expected to bear the expense, except in cases of poverty, when free treatment is given at public clinics and hospitals. Mental health care of school-age children has also been given increasing attention.

School children's teeth are examined in a number of countries. The examinations are optional in some places, required in others. Many countries have special dental clinics for school children where treatment is free to pupils from low-income families and given at a nominal charge to others.

Medical and dental care, as described above, were introduced at first in cities because of the large numbers of children but were later extended to rural areas. Itinerant medical and dental clinics. operate in sparsely populated areas of some countries. The physicians, dentists and nurses are employed full or part time by the national or local government, or jointly by both. All these school health services exist, in varying extent and degree of effectiveness, almost everywhere in Europe, in the British dominions, in the American republics and elsewhere in the world. One of the oldest systems is that of England. Established on a nation-wide basis in 1907, it provided under the Education act of 1944 medical inspections and free medical treatment to school children. In Sweden scattered efforts made by various cities gave way to a national system under the law of 1944, which prescribed the organization of medical inspections in elementary, secondary and normal schools throughout the country with attention centred on prevention of disease. In the U.S.S.R., where school health services were regulated at various times in the past, new regulations were issued in 1946. In Venezuela such services were introduced under an executive order of 1939 and in Peru under the Education law of 1941.

Closely connected with school health is the serving of a daily lunch to the children who come to school with little or no breakfast and to those who cannot get a nourishing lunch at home because of poverty, or the mother's employment outside the home, or the long distance between home and school or for other reasons. The absence of such a meal was found to affect not only the child's health but also his ability to benefit by the instruction in school. To meet this need national and municipal governments and private organizations began early in the 20th century to provide funds for serving school lunches, free or at cost, to needy children. In the Netherlands this was done under a law of 1900; Switzerland, 1903; England, 1906; and Scotland, 1908. Many other countries soon' followed. New regulations were authorized in England under the Education act, 1944, part of which went into effect in April 1947, and in Sweden under a decree of 1946, which aimed to provide free lunches to all school children.

Family Allowances. — Family allowances, often called children's allowances and payable to family breadwinners in addition to their wages, were introduced by law after 1945 in England, France, Hungary, Norway, Sweden, and in the province of Santa Fé, Arg. These allowances are paid regularly, out of government funds, for each child after the first, beginning with his birth and until the end of the compulsory school attendance period; in some cases even later. In some countries, for example, Italy, which had such allowances before World War II, the amounts were increased.

Child Labour Laws. — Several countries amended their child labour laws after World War II. In England and Wales the minimum age for industrial employment was raised in 1948 from 14 to 15 years; in Sweden, from 13 to 14 for boys; for girls it has always been 14 years; in India from 12 to 14 years. Measures for a better protection of the young workers' health were introduced in these countries and also in Austria and France.

United Nations' International Children's Emergency Fund. — The United Nations' International Children's Emergency fund, commonly called UNICEF, was created by the United Nations in 1947 for the purpose of helping to feed. clothe and provide medical care for children in war-devastated Europe and other critical areas. The funds available to UNICEF consist of voluntary governmental and private contributions, together with money left available after the dissolution in 1946 of the United

Nations' Relief and Rehabilitation administration (UNRRA). The fund is directed by an executive board consisting of representatives of 26 countries.

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THE UNITED STATES

Development.— Late in the 19th century private agencies in several large cities opened stations to distribute pasteurized milk for infant feeding. This effort to combat excessive infant mortality can be said to have started the infant welfare movement in the United States. As improved milk supplies became more generally available, the purpose of these stations changed. Gradually a new program developed, aimed to prevent disease in infancy, to provide opportunities for mothers regularly to consult physicians at the stations regarding the growth, physical condition, feeding and general care of their children, and to receive from the nurses employed at the station home demonstrations in the care of the baby.

As the early child health programs grew, recognition of the great value of prenatal care became more widespread. Measures to improve maternal health as a phase of public health in general, however, did not begin until organized prenatal nursing services and prenatal medical clinics were developed during the first decade of the 20th century. In 1908 the New York city department of health established a division of child hygiene. By this action, the first great municipality in the United States admitted that child hygiene was a matter worthy of and requiring special attention from a health department. Thus began a new era in the child health program.

The U.S. government in 1912 recognized the special needs of children and the necessity of establishing a bureau to study and protect them and created the U.S. children's bureau. The act of congress establishing this first agency of its kind in any national government directed the children's bureau to ". . . investigate and report . . . upon all matters pertaining to the welfare of children and child life among all classes of people, and shall especially investigate the question of infant mortality, the birth rate. . . . and diseases of children. . . ." Julia C. Lathrop was the first chief of the bureau. She served until 1921, when Grace Abbott became chief. Katharine F. Lenroot became the third chief of the children's bureau in 1934. At first the bureau was in the department of commerce and labour, but in 1913, when the department of labour was established, it was transferred to that department. In 1946 it was placed under the Social Security administration, Federal Security agency.

An epoch in child welfare legislation in the United States was marked in 1921 with the passage of the Sheppard-Towner bill for the protection of maternity and infancy. This act, administered by the children's bureau, laid the groundwork in the states for the child health and welfare programs in the Social Security act and caused the creation of maternal and child health bureaus in many of the states. It lapsed in 1929.

On Aug. 14, 1935, Pres. Franklin D. Roosevelt approved the Social Security act following its passage by congress. Because of its special provisions for maternal and child health and child welfare as part of a general program of security, this act was called the most important permanent federal child welfare legislation enacted up to that time in the United States. Title V of the Social Security act authorized grants to state agencies through the children's bureau for two types of health services: maternal and child health services and services for crippled children.

The provisions of the act relating to maternal and child health services and services for crippled children were to enable the states to extend and improve these services, especially in "rural areas and in areas suffering from severe economic distress." Allotments were made on the basis of plans submitted by the states and approved by the children's bureau. Maternal and child health services were administered through state health agencies, and services for crippled children through a state agency the state designated, usually one of the state health agencies.

Scope.—One of the basic services of the maternal and child health program was the health supervision of expectant mothers by physicians in maternity clinics, with instruction by public health nurses and nutritionists as to hygiene and diet during pregnancy and the nursing period. Another basic service was child health conferences to protect the health of children, prevent disease and promote optimal growth and development. Because of limited funds, state agencies did not attempt to provide care at childbirth for all mothers. needing care, but a few demonstrated complete maternity care on a public health basis and developed home and hospital delivery services with medical and nursing supervision throughout pregnancy and the postpartum period.

During 1949, medical supervision was provided to 168,000 expectant mothers and to 683,000 infants and preschool children at medical clinics and conferences. School children examined by physicians numbered approximately 2,246,000. More than 1,562,000 persons were immunized against smallpox and 1,547,000 against diphtheria. Public health nurses gave service to 242,000 mothers during pregnancy and to 1,129,000 infants and preschool children. Over 75,000 preschool children and 2,314,000 school children were inspected by dentists or dental hygienists.

By the end of 1948, there were 523,000 crippled children on state registers of the 53 official agencies operating under the services for crippled children's program. During 1948, 131,000 children received clinic services. Approximately 32,000 children were cared for in hospitals that year, and 5,000 in convalescent homes. More than 12,000 children were seen by physicians at their offices or in homes. Related to this care were services by public health nurses, physical therapists, dentists, medical social workers. nutritionists, and other professional workers.

In total, 175,000 children received services under the crippled children's program in 1948.

Originally the primary emphasis of the crippled children's program was on orthopedic crippling. By the middle of 1950, with funds from the crippled children's program, programs for the care of children with rheumatic heart disease were in operation in 23 states, with 2 additional states operating similar programs with maternal and child health funds. An increasing number of states were planning programs for children with cerebral palsy.

In 1946 it was estimated that in the United States there were about 200,000 children with epilepsy; 500,000 with rheumatic fever and rheumatic heart disease; 175,000 with active tuberculosis; 500,000 with orthopedic and plastic defects; 1,000,000 with hearing defects; 4,000,000 with visual defects; and 20,000,000 with dental defects.

A special World War II program to provide maternity and infant care for the wives and infants of enlisted men in the lowest pay grades in the armed forces was authorized by congress in March 1943 following procedures for grants to states for maternal and child health services. Grants were made by the children's bureau to state health departments, which in turn made payments directly to physicians, hospitals, nurses, and others rendering service. The emergency maternity and infant care program continued for more than six years, during which time more than $125,000,000 of federal funds was spent by the state agencies for mothers and children under the program.

One month after March 1943, the first state plans were approved, and by March 1944 all the 48 states, the District of Columbia, Alaska and Puerto Rico were providing obstetric and pediatric

care to mothers and infants eligible under the program. The peak of the program was reached in 1944, when more than 488,000 cases were authorized.

Liquidation of the program was begun at the direction of congress on July 1, 1947. A total of more than 1,223,000 maternity cases and almost 231,000 infant cases were authorized in the course of the program, representing the largest single public maternity care measure undertaken thus far in the U.S.

One way of determining the adequacy of maternal and child health services is by infant and maternal mortality and stillbirth rates. Not until the first birth registration area was established by the bureau of the census in 1915 was the United States able accurately to obtain this information. For 1915 out of every 1,000 live births, 100 infants died during their first year, and out of every 1,000 live births, 6 mothers died from causes directly attributable to pregnancy and childbirth. After 1915 the trend was downward. For 1948, the infant mortality rate was 32 out of every 1,000 live births; the maternal mortality rate, 12 out of every 10.000 live births.

These reductions were the result of many causes, including the cumulative work of research workers, educators, health and medical authorities and state health departments. Undoubtedly they reflect in part the greater availability of health and medical services made possible by the Social Security act. Also, other important factors that preceded the passage of the Social Security act had already begun to have an effect before the act began its operation. The education of the population in general by the state health departments was given great stimulus in the 1920s by the Maternity and Infancy act. During the 1930s improvement in obstetric care became quite general as a result of the action of professional study groups, improved hospital standards and a growing increase in hospitalization of women for delivery. As a result of knowledge gained, hygiene of the pregnant woman was improved and such abnormalities as toxemias, syphilis and medical complications were detected early and treatment given.

The development of prenatal clinics brought with it the application of advances in general medicine, metabolism and public health to obstetrics and led to a decrease in mortality and morbidity from toxemias of pregnancy, cardiac, renal metabolic, venereal and associated medical complications. The consideration of adequate vitamin, mineral and caloric content in connection with the diet of pregnant and puerperal women not only decreased the morbidity but enhanced the health of all mothers and children who received competent obstetric care. Improvement in pediatric and obstetric care resulted in part from the organization of postgraduate education in these subjects through the use of social security funds. Also, by the use of these funds the number of public health nurses was increased, as were maternity and child health clinics under the charge of physicians who were paid for their service.

Even with the great strides made in providing maternal and infant services in the United States as a whole, the distribution of these services was not equal. The public health services which were the basic administrative structure for the maternal and child health program were lacking in many rural areas. Many areas, both urban and rural, had no facilities in which to carry on the health service for children.

Of the 3,535,068 live births reported in 1948, 1,441,050 or 41% occurred in rural areas. Of these 1,441,050 births, 10% occurred with no medically trained person in attendance; 17% were born at home with physicians in attendance and 73% were born in hospitals or similar institutions.

Of the 2,094,018 births in urban areas, only 2% were without medical attendance, while 4% were home deliveries by physicians and 94% occurred in hospitals.

The 1948 death rate for white mothers for the whole country was 9 per 10,000 live births. For nonwhite mothers, the death rate was 30—more than three times as high. The mortality rate for white infants in 1948 for the United States as a whole was 30 for every 1,000 live births; for nonwhite infants, it was 47.

Although the death rate from causes directly attributable to pregnancy and childbirth in 1948 was the lowest ever obtained in the United States, much could still be done to reduce further such deaths, for it has been estimated that a majority of maternal deaths are preventable.

In 1948, of the 113,169 infants who died during their first year, 33% or 37,652 died during the first day of life. Approximately 36% or 40,774 infants died after the first day but before the end of the first month. Thus deaths under one month of age totalled 78,426, or 69% of the 113,169 deaths in the first year of life. In terms of rates per 1,000 live births, the rate for deaths under one day was 10.7; for deaths between one day and one month of age, the rate was 11.5; and for all deaths under one month (neonatal mortality) the rate was 22.2. In contrast, the rate for deaths occurring between one month and one year of age was only 9.9.

The latter rate declined much more rapidly than the neonatal rate after 1915, and the rate for deaths under one day of age scarcely decreased at all until 1940. At mid-century, more infants were dying in the very first day of life than in the whole age range from one month to one year. In 1948, the ratio of fetal deaths (stillbirths of five or more months gestation) per 1,000 live births was 20.6, or nearly as high as the neonatal mortality rate.

In Nov. 1944 the American Academy of Pediatrics took the first step in a nation-wide study of child health services. The academy —with the co-operation of the children's bureau and the U.S. public health service—sought to find out what extension of personnel and facilities would be necessary to make available to all mothers and children in the United States essential preventive, diagnostic and curative medical services of high quality.

The study was completed in 1948 and the report published in 1949 by the Commonwealth fund under the title, *Child Health Services and Pediatric Education.* A companion volume called *Supplement to Child Health Services and Pediatric Education,* contains a description of methods used in the study, together with a series of tables showing the basic data from which the condensed material in the report is drawn. The study is the first nation-wide survey ever made covering health services for a total segment of the population.

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MATHEMATICAL INDUCTION, one of various methods of proof of mathematical statements. It is based upon the following property of the set N of all natural numbers: if S is a subset of N which contains 1 and also contains $k+1$ whenever it contains k, then S is equal to the set N. The use of the principle is best understood from an illustration. Suppose it is desired to prove that the sum of the first n odd integers is n^2; that is, that

$$(1) \qquad 1+3+5+\ldots+(2n-1)=n^2$$

for every integer n. Let S be the set of integers for which equation (1) is true. The set S contains 1 since $1=1^2$. If k is in S then

$$(2) \qquad 1+3+5+\ldots+(2k-1)=k^2.$$

When the next odd integer, which is $(2k-1)+2$ or zkf 1, is added to both members of the equality (2), the result is

$$1+3+5+\ldots+(2k+1)=k^2+2k+1=(k+1)^2.$$

This equality shows that (1) is true for $k+1$, and hence it has been shown that, when k is in S, so also is $k+1$. It follows from the principle stated above that S equals N and consequently equation (1) is true for all integers.

The method is widely used to establish a great variety of properties of the integers. For example, it is easy to show by induc-

tion that the sum of the first n integers is $\frac{1}{2}n(n+1)$; that the sum of the squares of the first n integers is $\frac{1}{6}n(n+1)(2n+1)$; and that the sum of the cubes of the first n integers is $\frac{1}{4}n^2(n+1)^2$.

The method of induction is applicable to systems other than the natural numbers. Let A be any class whose elements are so ordered that every nonempty subset of A has a first element, *i.e.*, contains an element which is preceded by no element of the subset. For such sets A there is also an induction principle: if S is a subset of A which contains the element b of A whenever no element precedes b or all elements of A preceding b are in S, then S is equal to A. The principle is used to prove that every element of A has a property P by letting S be the subset of A containing all elements which have the property P. It is then argued that S satisfies the condition stated in the principle from which the conclusion is drawn that $S=A$. Proofs by this principle are often referred to as transfinite induction.

A particular case of this general principle is that of double induction in which it is desired to show that every pair of integers (m, n) has a property P. The class A consists of the pairs (m, n) and the desired order may be obtained by making (m, n) precede the pair (p, q) if m is less than p or if $m=p$ and n is less than q. In order that S satisfy the condition in the principle, it is sufficient to show: (1) that (1, 1) has the property; (2) that $(p, 1)$ has the property when all pairs (m, n) with m less than p have the property; and (3) that (p, q) has the property when all pairs (m, n) with m less than p and all pairs (p, r) with r less than q have the property. The order may also be given by making (m, n) precede (p, q) whenever m and n do not exceed p and q respectively and at least one is smaller. There is then a corresponding change in the argument needed to show that S satisfies the condition in the principle. (R. W. Bd.)

MATHEMATICAL INSTRUMENTS. The increasing use of mathematics, both as a language for expressing the problems of science and industry, and as a tool for dealing with those problems, has spurred the development of rapid and economical means for obtaining answers to the mathematical problems posed. In a broad sense, any device capable of supplying such answers is a mathematical instrument. which may be defined as a device in which measurable physical quantities such as distances between marks on a rule, electric currents in wires, etc.. are used to represent mathematical quantities, and the physical laws governing the device correspond to a set of mathematical relations for which a solution is sought.

Classification of Instruments.—Mathematical instruments have been constructed of a great variety of elements, but despite the diversity of the mechanisms employed most of the instruments in common use fall into the three main categories discussed below, which are defined by the characteristic mathematical operations they perform. One group solves finite equations, either algebraic or transcendental and in typical instances makes use of cams, linkages, gears or variable electrical elements to establish the required connections among the given variables. A second group evaluates integrals and derivatives by means such as wheels rolling on surfaces of various shapes, or charges and currents in electrical circuits or the quantity of light transmitted thru specially prepared optical media. The third group solves partial differential equations and may employ elastic membranes, electric currents in conducting sheets or polarized light.

Further information will be found under Computing Machines, Electronic; Cybernetics; Information Theory; Servomechanism; and Office Machines and Appliances.

INSTRUMENTS FOR THE SOLUTION OF FINITE EQUATIONS

Tide Predictor. — The behaviour of the tides at any given port is characteristic of the behaviour of many physical variables. It is found that the height of the tides is a function of time which can be formed by adding together a number of sinusoidal or simple harmonic functions of time, the periods of the latter agreeing with those of the apparent rotation of the sun and moon. Thus the height of the tide is representable by a trigonometic sum: the value of which can be calculated once the amplitudes of the various sinusoidal components have been determined for the port in question. To avoid the labour of computation, Lord Kelvin, in 1872, built his tide predictor, which is preserved in the Science museum in Kensington. In Kelvin's first model, eight trigonometric components are generated by eight pulleys carried on axes at the ends of eight cranks of adjustable lengths. Four pulleys are carried on the upper and four on the lower side of a rectangular wooden frame. A cord, fixed at one end, passes alternately under the lower and over the upper pulleys, and at the other end carries a weight and marker. The centre of each pulley can describe a circular motion of adjustable amplitude, which circular motion is equivalent to the sum of two simple harmonic or sinusoidal motions, one vertical and the other horizontal. The horizontal component of the circular motion moves the cord out of its vertical position, but if the radius of the circle described by the centre of each pulley is a small fraction of the distance between the lower and upper pulleys, the effect of the horizontal component is small, and the principal effect on the cord is that of the sinusoidal vertical component. The hanging weight will therefore perform a motion which is the sum of the constituent vertical motions of the pulleys.

In the first complete working machine made on the lines of Kelvin's original model, ten components are added, and the curve representing a year's tide for any port can be drawn in about four hours. In later machines of larger capacity, the horizontal motion of the pulleys was eliminated by the use of scotch crossheads, the portion of the wire between upper and lower pulleys remaining always vertical. In a machine made in 1924 and located at Liverpool, there are 26 components; in an American machine completed in 1910 there are 37 components, and the tidal curves for seven years can be run off in 12 hours.

Harmonic Synthesizer.—While height of the tide is representable by a trigonometric sum having periods that agree with those of the sun and moon, certain other physical functions such as the voltage produced by an alternating-current generator, are representable by sums of components with periods which are all submultiples of a single fundamental period. Several harmonic synthesizers have been built along the lines of the Kelvin tide predictor described in the preceding paragraph but modified so that the rotational speeds of the cranks carrying the pulleys are in the ratios 1:2:3 etc. and hence the periods of the component motions are submultiples of a fundamental period.

A harmonic synthesizer was designed by Albert A. Michelson and Samuel W. Stratton in *1898*. It differs in principle from the Kelvin machine, in that components are added by the summation of forces due to a set of springs, instead of the summation of the displacements of pulleys. In 1897 a machine with *20* components was made, and in the following year one with 80 components. Each component is generated by an element containing an eccentric (near the base of the machine) which communicates a sinusoidal motion to the end of a horizontal lever. The foot of a long rod may be clamped in any position along the lever, the amplitude of the motion which the lever communicates to the rod being therefore proportional to the distance from the fulcrum of the lever to the foot of the rod. The upper end of the rod actuates a lever which in turn extends a small spring. The springs of all the elements are attached to one edge of a wide balance lever and the sum of their forces is balanced by the action of a *single very stiff counterspring*.

The motion of the balance lever is accordingly nearly proportional to the sum of the motions of the rods, and this resultant motion is conveyed to a pen which draws a graph on a paper carried by a traveling plate.

Polynomial Solvers. — In the design of communication circuits, and in the determination of the stability of dynamical systems, it is important to know the values of the roots of polynomials such as

$$P(z)=A_0+A_1z=A_2z^2+\cdots+A_nz^n$$

that is, it is required to find the values of z which make $P(z)=0$. The theory of functions of a complex variable shows that if one draws the curve whose rectangular co-ordinates are derived from

the coefficients of the polynominal by the relations

$$x = pA_1 \sin\theta + p^2 A_2 \sin 2\theta + \cdots + p^n A_n \sin n\theta$$
$$y = A_0 + pA_1 \cos\theta + p^2 A_2 \cos 2\theta + \cdots + p^n A_n \cos n\theta$$

and if this curve wraps itself k times around the point $x=0$, $y=0$, then there are k roots with absolute values less than p.

The graph defined by x and y is drawn by an instrument devised in 1937 by Thornton C. Fry and R. L. Dietzold and named by them the "Isograph." Mechanically, this machine is a ten-component harmonic synthesizer of the Kelvin type, in which the sine components are added and applied to move a pencil, while the cosine components are added separately from the sine components and caused to move the table on which the pencil traces the curve (x, y), these two motions taking place at right angles to each other.

In operation, a value of p is chosen; the coefficients are multiplied by the appropriate powers of p, and the products are set on the synthesizer. A curve (x, y) is drawn by the machine, and the number of roots with absolute values less than p is determined by inspection of the curve. A new value of p is taken, and the process repeated. If the number of roots counted has changed, then at least one root lies between the two values of p. By successive trials, the region containing a root is thus narrowed down as far as may be desired, within the limits of error of the machine. While the isograph is applicable only to polynomials with real coefficients, S. Leroy Brown has employed his harmonic synthesizer-analyzer in a similar way to the search for roots of polynomials with complex coefficients.

A polynomial solver in which the synthesis is performed electrically was designed by H. C. Hart and Irven Travis in 1937. In this machine, the components are represented by electrical voltages generated by a set of adjustable transformers. The transformers are built in a form similar to that of a motor, and are so designed that the amplitude of the voltage supplied by them is proportional to the sine of θ, the angular position of the rotor shaft. and to the voltage applied to the primary windings. The shafts of the set of transformers are so geared that their rotations are proportional to the integers. 1:2:3, etc. The primary voltages are made proportional to the coefficients $p^n A_n$, and the secondary voltages are added together by connecting the transformer secondaries in series. A set of potential dividers, properly interconnected, supplies voltages proportional to the appropriate powers of p multiplied into the coefficients A. In operation, both p and θ are adjusted by hand until the values of the voltages representing the sine sum and the cosine sum are simultaneously zero. The values of p and θ at which this null point is found define a root which is, in complex exponential form,

$$z = pe^{i\theta}$$

Still another form of polynomial solver was proposed and built by Felix Lucas, in 1887. The operation of this device depended upon certain theorems in the theory of functions of a complex variable and in the theory of the flow of electric currents in sheets of conducting material. In Lucas' device. electric currents whose values are calculated from the values of the coefficients of the polynomial, are applied to certain points in a large (theoretically unbounded) sheet of material. The complex plane for z is plotted on the sheet and the required roots of the polynomial are read off this plot at the points where the current vanishes. Lucas found that the errors introduced by neglecting the finite size of his sheets are appreciable but this difficulty can be avoided by throwing one-half the infinite z-plane into a finite region before mapping.

Linear Algebraic Equation Solvers.—A great variety of engineering problems, such, for example, as those of computing stresses in structures, electric currents in distribution networks, and correlations among statistical data, reduce to the solution of a system of linear algebraic equations, in the form

$$C_{00} + C_{01}x_1 + C_{02}x_2 + \cdots + C_{0n}x_n = 0$$
$$C_{10} + C_{11}x_1 + C_{12}x_2 + \cdots + C_{1n}x_n = 0$$
$$\cdots$$
$$C_{n0} + C_{n1}x_1 + \cdots + C_{nn}x_n = 0$$

where the C's are given numerical values, and it is required to find the values of the x's which satisfy the' equations.

Much ingenuity and effort has gone into the problem of designing mechanisms to solve this problem, and many theoretically correct designs have been produced. In general, however, it may be said that the low accuracy obtainable together with the time required to set up the data of problems have prevented these mechanisms from finding extensive application. Many of them depended upon balances among the forces due to springs or weights, or upon the level sought by a fluid in interconnecting vessels.

A lineal equation solver which depends upon the addition of mechanical displacements was reported by John B. Wilbur in 1936. With this solver ten unknowns can be found, usually to within 1% of the value of the largest unknown.

In 1933, R. R. M. Mallock described an electrical machine for solving linear systems. An improved version of Mallock's instrument made by the Cambridge Instrument Co., will solve for ten unknowns to 0.1% of the largest, and will also give a least-squares solution of a set of inconsistent equations. The Mallock machine consists of sets of electrical transformers, one for each unknown, and a set of closed electrical circuits, one for each equation. The coefficients are introduced by adjusting the number of turns each circuit makes about each transformer core.

INSTRUMENTS WHICH INTEGRATE AND DIFFERENTIATE

Planimeter.---One of the simplest applications of integration, and one of the earliest historically, is the determination of the area under a curve. If x and y are the rectangular co-ordinates of a curve defined by $y=f(x)$, then the area bounded by the curve, the two abscissa, x_1 and x_2, and the axis $y=0$, is the integral of $f(x)$ taken from x_1 to x_2:

$$A = \int_{x_1}^{x_2} y\, dx$$

Frequently, the area under a curve represents some quantity of engineering interest and it becomes worth while to make use of an instrument for the rapid determination of that area. To quote only one instance out of many, the area of the curve drawn by a steam-engine indicator is used as the basis for determining the efficiency of the engine.

The invention in 1814 of the first instrument for the direct measurement of the area bounded by an irregular curve is attributed to the Bavarian engineer, J. H. Hermann, and was followed by the invention of similar instruments by numerous men, notably by Tito Gonella of Florence (1824), the Swiss engineer Johannes Oppikofer (1826), and Wetli of Zurich (1849). An example engraved, "Patent von Wetli a Starke, no. 103," which was constructed in 1860, consists of a rotatable horizontal circular disk on which the registering roller rests. The disk is mounted on a frame supported by three grooved wheels, which can roll on three parallel rails. Beneath the disk and mounted on the frame is a horizontal rod held between two pairs of guide rollers, so that it can move in a direction at right angles to the rails. By means of a thin wire wound round the axle of the disk and attached to the ends of the rod the disk is given an angular movement proportional to the longitudinal displacement of the rod. As the tracing point attached to one end of the rod is guided along the curve whose area is to be measured, the distance between the centre of the disk and the plane of the registering wheel is always proportional to the ordinate of the curve. The number of revolutions of the registering wheel is therefore a measure of the area.

J. Clerk Maxwell in 1855 designed a planimeter in which pure rolling was substituted for the undesirable partial sliding of the register wheel, but the instrument was never constructed. James Thomson in 1876 investigated the same problem, and in attempting to simplify Maxwell's mechanism evolved his disk, sphere and cylinder combination which has since been widely used in other mechanisms.

Jacob Amsler, about 1854, invented his polar planimeter which because of its simple construction and low price very soon came

into extensive use. In using the instrument made by Stanley about 1875, the weighted point F is fixed and the tracing pointer T is guided around the figure whose area is to be measured. The difference of the readings on the graduated roller R before and after this operation gives the area of the figure in units depending on the radius TP of the tracing arm.

Integrators. — A generalized form of planimeter called an "integrator" was invented by Amsler in 1856. In addition to the area of a figure, this device also measures the moment, $\frac{1}{2} y^2 dx$ and the moment of inertia $\frac{1}{3} y^3 dx$ of the figure about the axis, $y=0$. The instrument is carried by a pair of wheels moving in a straight groove in a long steel bar, and a counterweight is provided. If the tracing point T be guided so as to describe the outline of a plane figure, the graduated roller A attached to the swinging arm will register the area of the figure, as in the Amsler planimeter. The outer roller M will register the moment of the areas about the axis of rotation of the instrument. The moment of inertia about the same axis is deduced from the readings on the first roller and the inner one.

In 1887, Captain Andreas Prytz invented the simple knife-edge or "hatchet" planimeter. In its original form it consisted of a metal bar, bent at right angles at both ends, one end of which (the tracer) was pointed, and the other was in the form of a curved knife-edge. In using the instrument, a point is chosen near the centre of the area to be measured, and a radial line is drawn from that point to the boundary. The tracer of the instrument is placed at the chosen point, and the hatchet pressed into the paper to form a dent. The tracer of the instrument is then made to follow the radial line and the boundary curve, ultimately returning to the centre point of the area along the same radial line. The hatchet is again pressed into the paper to form a dent. If AB, AB' be the initial and final positions of the arm, the area described is equal to the length of the arm multiplied by the length of the arc BB'.

Integraphs.—In mathematical language, the planimeter measures the value of a definite integral; for certain applications it is necessary to know the indefinite integral of a function defined by a graph; that is, an instrument is required which will draw the integral curve corresponding to any given curve. One integraph was invented by Charles V. Boys in 1881.

For any value of x the steepness $\frac{dz}{dx}$ of the curve drawn by the instrument is proportional to the ordinate (y) of the given curve for the same value of x. Thus the integraph solves the relation

$$\frac{dz}{dx}=y, \text{ or } z=\int y\,dx$$

The framework of Boys' instrument is a kind of T-square (which can slide along a horizontal straight edge) carrying a centre B which moves along the axis of x of the given curve. A rod passing always through B carries a pointer A which is constrained to move in the vertical line *ee* of the T-square; A can then be made to follow any curve. The distance from B to *ee* is constant (k); therefore the inclination of the rod AB is such that its tangent is equal to the ordinate of the given curve divided by k. Thus AB has always the inclination of the required curve.

The integral curve is generated by a three-wheeled cart, whose front wheel C is steerable. By means of epicyclic gearing this wheel is kept parallel to AB and can move only in the direction of its own plane. As C is always in the line ee produced, the wheel draws the required curve when allowed to pass over carbon paper.

The first integraph made commercially was invented independently by Abdank-Abakanowicz about the same time as that of Boys. This instrument has been made in considerable numbers, with modifications and improvements in design and construction, by Coradi of Zurich.

Harmonic Analyzers. — Jean B. J. Fourier, in his study of the transmission and diffusion of heat, first made use of the simplification which often occurs when a complicated function or curve is represented as the sum of a number of simple harmonic or sinusoidal components. The importance of such a representation has increased with the years, and the measurement of the harmonic components in empirically given data is of importance to the study of communication lines, of electrical power machinery, of mechanical vibrations and noise, of musical instruments, and even in the theory of prediction of statistical data.

While much of the analysis in these fields is carried out by numerical processes, some is done by harmonic analyzers. It is shown in the theory of harmonic analysis (*q.v.*) that under suitable restrictions on the function analyzed a periodic function f(x) can be represented by the series

$$f(x)=\sum(A_n \sin nx+B_n \cos nx$$

where the amplitudes A_nB_n are determined by

$$A_n=\frac{1}{\pi}\int_0^{2\pi} f(x)\sin nx\,dx$$

$$B_n=\frac{1}{\pi}\int_0^{2\pi} f(x)\cos nx dx$$

It is the object of the harmonic analyzer to determine the coefficients A_nB_n by a rapid and easy process. There are in use harmonic analyzers of at least three basically different types. The earliest is an extension of the planimeter and integrator; more recent analyzers have been constructed in which the function is represented on photographic film, and the analysis performed photoelectrically; still other analyzers have converted the given data into electric currents and applied the extensive mechanisms in existence for the analysis of such currents.

Lord Kelvin in 1876 was the first to invent an instrument for performing harmonic analysis mechanically, by an adaptation of the disk-sphere-cylinder mechanism invented by his brother, James Thomson, in 1876. The first completed instrument designed by Kelvin and used for the harmonic analysis of tidal observations, embodies 11 sets of the disk-sphere-cylinder combination, one for each harmonic to be measured. The curve to be analyzed is wound on a central cylinder, and the simple harmonic motions of the proper periods are communicated to the disks by suitable gearing. The bar to which the tracer is attached has a series of forks which embrace the spheres. In actual use, the tracer is made to follow the curve, and the readings on the different integrating cylinders give the required coefficients. An improved form of the analyzer was invented by O. Henrici and Abraham Sharp in 1894.

A different type of harmonic analyzer in which the principle of action is based on William K. Clifford's graphic method of harmonic analysis, was invented by O. Mader in 1909. Essentially Mader's instrument consists of a gear and linkage which, as a pointer traces a given curve, cause a point on the gear to describe a transformed curve; the area enclosed by the transformed curve is measured by an ordinary polar planimeter, and is proportional to the required harmonic coefficient. In using the Mader instrument, a guide ruler which forms part of the machine is placed parallel to the base line of the curve to be analyzed, and the tracer of the planimeter is placed in one of two holes in the gear. For each harmonic to be found there is an appropriate gear with two indentations in its face. To find the sine coefficient, the tracer of the planimeter is placed in one of the indentations while the analyzer traces the given curve, while to find the cosine coefficient, the tracer of the planimeter is placed in the other. The Mader instrument measures only one harmonic at a time, as contrasted with the Henrici which measures several simultaneously.

Several analyzers have been devised to use optical and photoelectric means. One such device was designed by H. C. Montgomery in 1939. To use Montgomery's analyzer, the curve to be analyzed is drawn or photographed on a transparent film, and the area of the film on one side of the curve is blacked out to make it opaque. A set of standard films is available in which the "density" varies along the length of the film. Thus when light falls on any part of the film, the fraction of the light transmitted is proportional to the function C + D sin nx, where

C and D are constants and x is the distance from a reference mark to that part of the film where the light falls. If the film carrying the curve to be analyzed is superposed on the standard film, then the quantity of light transmitted through any transverse strip of the two superposed films is proportional to the width of the clear part of the one film multiplied by the transmission ratio of that strip of the standard film. Except for the appearance of the additive constants in the factors, this product is the integrand in the definition of the required harmonic coefficient, and the total light transmitted by the entire length of the films is the integral of the product. The total light is measured by photocells, and from this quantity the harmonic component can be deduced. The operation of the instrument is largely automatic, and 30 harmonics can be measured in about a minute and a half.

Differential Analyzer. — The most frequently encountered mathematical problems of engineering and physics are expressed in terms of differential equations, either ordinary or partial. The methods and theory of the solution of ordinary differential equations have received treatment at the hands of many of the masters of mathematics, but there are comparatively few of the differential equations arising in practice that have solutions expressible in terms of a finite number of the elementary functions: sines, cosines, Bessel functions and so forth. Often in the applications of differential equations to engineering, formal solutions may not be necessary or even desirable if a numerical or graphic solution is obtainable. To calculate the latter kind of solution a number of differential analyzers have been constructed in the United States, Great Britain and other countries. Besides solving numerous problems in the design of electrical machinery, in the study of the scattering of electrons by atoms and the determination of the paths of electrons in the field of magnetic dipoles, in the treatment of the performance of automatic industrial control systems and of transients in electric lines, in the determination of the energy exchanges between gases and solids, and in, the study of the boundary layer motion of viscous fluids, to mention a few items, the analyzers found extensive use in World War II in the computation of thousands of ballistic trajectories.

The development of the differential analyzer is largely due to Vannevar Bush and his associates at the Massachusetts Institute of Technology in Cambridge. In 1927 Bush and others completed and described a product integraph or continuous integraph which was a forerunner to the analyzer. This device solved differential equations of the form

$$\frac{d^2y}{dx^2}=f_a\,(f_1+f_2)$$

where the f's are functions of x ordinarily given in the form of graphs.

In 1928 Bush published a description of the first differential analyzer capable of solving a broad class of differential equations. Many minor modifications have been made in the detailed mechanisms of this machine, and more or less exact copies have been produced for use at educational institutions and industrial laboratories throughout the United States, Great Britain and Europe.

The Rockefeller Differential Analyzer, dedicated in Nov. 1945, represents a considerable advance over the original model partly in refinement of elements but principally in the speed and convenience of means for setting up and controlling the operation of the analyzer.

The basic elementary device in the differential analyzer is the disk and wheel integrator, which appeared first in the early planimeters. Its function is to perform the integration,

$$z=\int y\,dx$$

where, in the integrator, x is the angular displacement of the disk, y is the distance of the integrating wheel from the centre of the disk, and z is the resulting angular displacement of the integrating wheel. The addition of two quantities, x and y, each represented by the angular displacement of a shaft, is performed by a mechanical "differential" or adder, so arranged that a third shaft is rotated through an angle equal to the sum, z, of the first-mentioned displacements:

$$z=x+y$$

Multiplication by a constant is accomplished in the analyzer by appropriate gearing; thus, if k is the gear–ratio between a shaft representing a variable x and another shaft representing a variable y, then

$$y=kx$$

Arbitrary or empirical functions are introduced by means of "input tables," on which are plotted the necessary functions in graphic form.

The solutions which result from the operation of the differential analyzer appear in the form of graphs drawn by the analyzer on output tables, or in the form of numerical values printed by the machine at predetermined intervals.

The original differential analyzer is entirely mechanical in construction, all connections between the computing elements being made by means of shafts and gears which are mounted on a bedplate approximately 4 ft. wide by 18 ft. long. In using the differential analyzer, the equations to be solved are first written as a set of equations each of which may contain an integration, an addition, a multiplication by a constant, or a functional relation like $y=f(x)$. From the equations, a working diagram is made in which symbolic representations of shafts, integrators, adders and gears appear. The variables of the equations are equated to the rotations of corresponding shafts with suitable proportionality factors, and the performance of each mathematical operation in the equations is assigned to a particular one of the elementary mechanisms. The shafts, gears, integrators and other elements of the analyzer are set up in accordance with their symbolic representation on the working diagram.

In the Rockefeller analyzer, shaft rotations are converted by means of rotating electrical condensers into electrical signals which control motors in such a way that the shafts driven by the motors follow very closely the positions of the controlling shafts. Electrically operated switches steer the control signals as required from place to place, thus dispensing with the necessity of connecting shafts by mechanical means. All the information needed to set up the analyzer for a given problem is coded and punched in paper tapes which automatically arrange the electrically operated switches as required, in a few minutes.

Weiss Integrator. — When rapid approximate solution of a system of linear differential equations with constant coefficients is required, a device invented in 1944 by H. K. Weiss is applicable. By well-known analytic means, such systems of differential equations can be solved with the aid of any device which will solve the simple differential equations

$$a\frac{dy}{dx}-by=f(x)$$

$$a\frac{d^2y}{dx^2}-b\frac{dy}{dx}-cy=f(x)$$

where a, b and c are real numbers.

Weiss' integrator for the former of these equations consists of an arm at one end of which is a roller fitted with an inking pad so that it traces out the graph of y, when an adjustable pointer on the arm is made to follow a graph of $f(x)$. The integrator for the second differential equation consists of a pair of arms with a parallel linkage between them; each arm is equipped with a roller, one of which is inked and traces the graph of y. The lengths of the arms and the scale of $f(x)$ must be chosen so that the angles of the arms with the axis of x remain small throughout the solution.

INSTRUMENTS FOR THE SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS

All mathematical instruments are in a sense analogues of the physical situation for which they are intended to furnish a solution, but in the case of certain devices which are

used to obtain the solution of partial differential equations the analogy is very close. A typical device of this kind is that used to solve the differential equations of the potential in electronic tubes, and to predict the paths followed by electrons moving under the influence of that potential. It is shown in the potential theory, that the electric potential and the displacements of a stretched elastic membrane satisfy the same partial differential equation. Several industrial and educational laboratories concerned with the study and design of electron tubes have developed instruments consisting of rigid frames with circumferential clamps which maintain a practically uniform tension in a sheet of rubber stretched across the frame. The sheet being horizontal, its vertical displacements satisfy the potential equations, and when suitable boundary values are introduced by means of supporting blocks or clamps, the sheet supplies the solution to the potential problem with specified boundary conditions. A light marble rolled on the rubber sheet follows the path which an electron would in an electric potential field.

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(G. R. S.)

MATHEMATICAL **MODELS.** The child's box of bricks is probably mankind's earliest acquaintance or contact with mathematical conceptions. The concrete forms of the cube which go to make up the puzzle pictures of the nursery, or the more complete selection of geometrical solids comprising cubes, prisms and cylinders which make up the "Building Sets" of the same period, must, however, in some measure, appeal to the latent mathematical faculty of the child mind, just as the abacus or "counting bead frame" may have stirred some little impulse in the arithmetical complex.

At an early stage in the child's career it is instructed that the cube, prism, etc., have many special properties which may, when used in right proportions, render them amongst the most pleasing forms of architecture. The simple doubled cube, for example, provides an exquisite form of pedestal; in fact, the inherent beauties of the rectangular prism furnish a valuable architectural theme; also, by means of models it is possible to illustrate to the practical man a conception which may be perfectly clear to a gifted or trained mathematical mind.

A knowledge of plane geometry acquired without any reference to models may be said to flatten out the mind and to engender habits of thought which make it difficult at a later stage of mathematical educatiori to explore space of three dimensions.

Plane Geometry.— Some early editions of Euclid had diagrams intended to be cut and folded, and a work by Cowley of 1752, *New and Methodical Explanations of the Elements of Geometry,* included pieces of cardboard for the building up of various models. So talented a thinker and philosopher as Herbert Spencer appreciated the advantage of a model, for, writing to his father in Jan. 1839, and speaking of his self-set task of regular, daily and systematic study of mathematics, he says "I have found out the grand principle of the projection of shadows and I feel almost certain of its correctness. To make myself still more satisfied I have made a model in pasteboard and I find that the real shadow is as exactly as possible what I had made it by projection."

Intuitive Geometry.— A valuable aid to the training of the young mathematical mind is to cut out, in cardboard, a number of equilateral triangles of the same size; the single triangle representing the plane figure, several piled one on top of another with corresponding edges coplanar and corresponding corners collinear illustrate the solid figure of the triangular prism, while four of them placed together with pairs of edges coinciding, one of them being used as a base, give the first of the regular solids: the tetrahedron. The student may thus, by an inductive process, quickly arrive at the historical selection of the five regular solids.

Simple models of this nature may be used to demonstrate common practical problems involving important principles relating to regularity and maximum and minimum values; as for example: (1) a triangle of given perimeter encloses the greatest area when it is equilateral; (2) a tetrahedron of given surface area encloses the greatest volume when it is regular.

The latter statement could be varied by saying that for a given volume enclosed by four planes the surface is a minimum when the planes form a regular tetrahedron.

Polyhedrons.— An important application of this style of model can be made by drawing a cluster of seven equal hexagons, one surrounded by six others. Cut with a sharp knife along the 18 boundary lines of the cluster, along the 6 sides of the central hexagon (which can then be discarded) and along just 1 of the remaining (radial) lines of the ring of 6 hexagons. Then cut halfway through and fold back or crease the rest of the radial lines. The paper may now be folded and provides a medium for the illustration of some interesting figures. First slide one hexagon over another, so that the hole becomes pentagonal. Sliding two over two, we get a square hole; three over three, triangular. If a number of such rings are cut out and made up permanently by gumming the folds, three of the Archimedean solids may be worked up in an effective manner. Twelve of the rings with pentagonal holes may be stuck together (with overlapping hexagons) to make a sturdy model of the truncated icosahedron, sufficiently suggestive although the pentagonal faces are lacking. Similarly, a truncated octahedron (Pl. I, fig. 1) may be constructed from six of the rings with square holes; in fact, two such rings will suffice if they are connected by extra flaps of adhesive paper instead of overlapping hexagons. Again, the truncated tetrahedron may be constructed from two of the rings with triangular holes, or from one such ring attached by flaps to one extra hexagon.

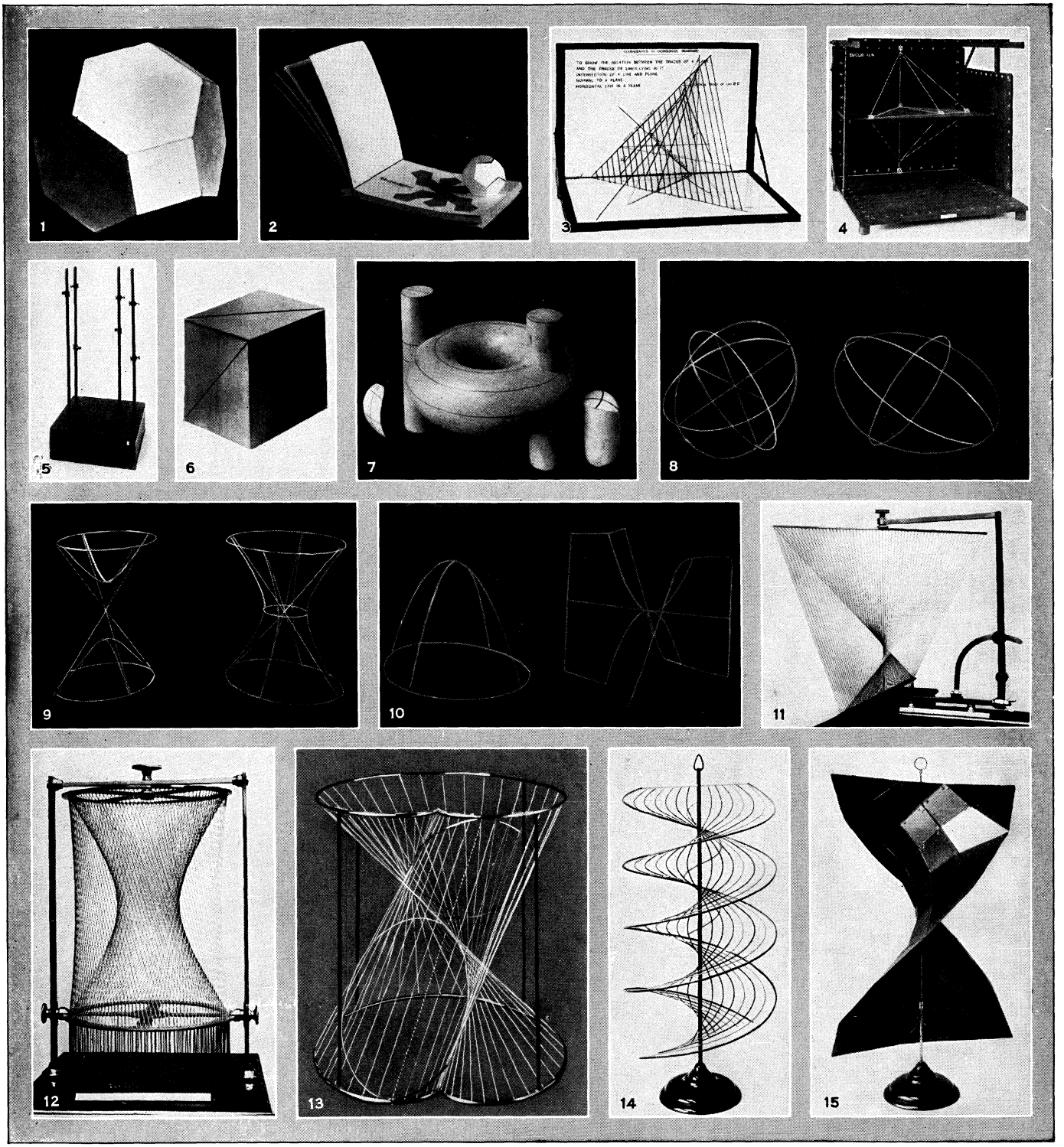
A large number of such models of the truncated octahedron or of the truncated tetrahedron may be fitted together like bricks to fill any volume of space. The hexagons are then the faces of a regular sponge or skew polyhedron, each vertex being surrounded by four hexagons in the former case, six in the latter.[1]

There are altogether three such regular skew polyhedrons. The third has square faces, six at each vertex, and may be built up from repetitions of a simple ring of four squares, like a cube with two opposite faces omitted. This last model has the peculiar property of being collapsible. It may be rendered rigid by inserting diagonal struts into two or more of the rings. These "sponges" have equal regular faces and equal angles, just like the five Platonic solids.

Another kind of generalized regular polyhedron is obtained by "stellating" those three of the Platonic solids whose dihedral angles are obtuse; *i.e.,* extending or producing the faces until they meet again in new vertexes, always preserving the rotational symmetry of the original solid. In this manner the octahedron leads to the *stella octangula* of Johann Kepler (1619), which may be regarded as a compound of two interpenetrating tetrahedrons whose edges are the diagonals of the faces of a cube. A dodecahedron (Pl. I, fig. 2) leads to three of the four Kepler-Poinsot polyhedrons, as follows. The 12 faces of the *small stellated dodecahedron* are pentagrams or star pentagons (of angle 36") obtained by producing the sides of the ordinary pentagon until they meet again. The 12 faces of the *great dodecahedron* are larger pentagons having the same vertexes as these pentagrams. The 12 faces of the *great stellated dodecahedron* are pentagrams obtained by producing the sides of the large pentagons. In other words, the

[1] *See the Proceedings of the London Mathematical Society* (2), vol. 43, pp. 33–62 (1937), or *Scripta Mathematica,* vol. 6, pp. 240–244 (1939).

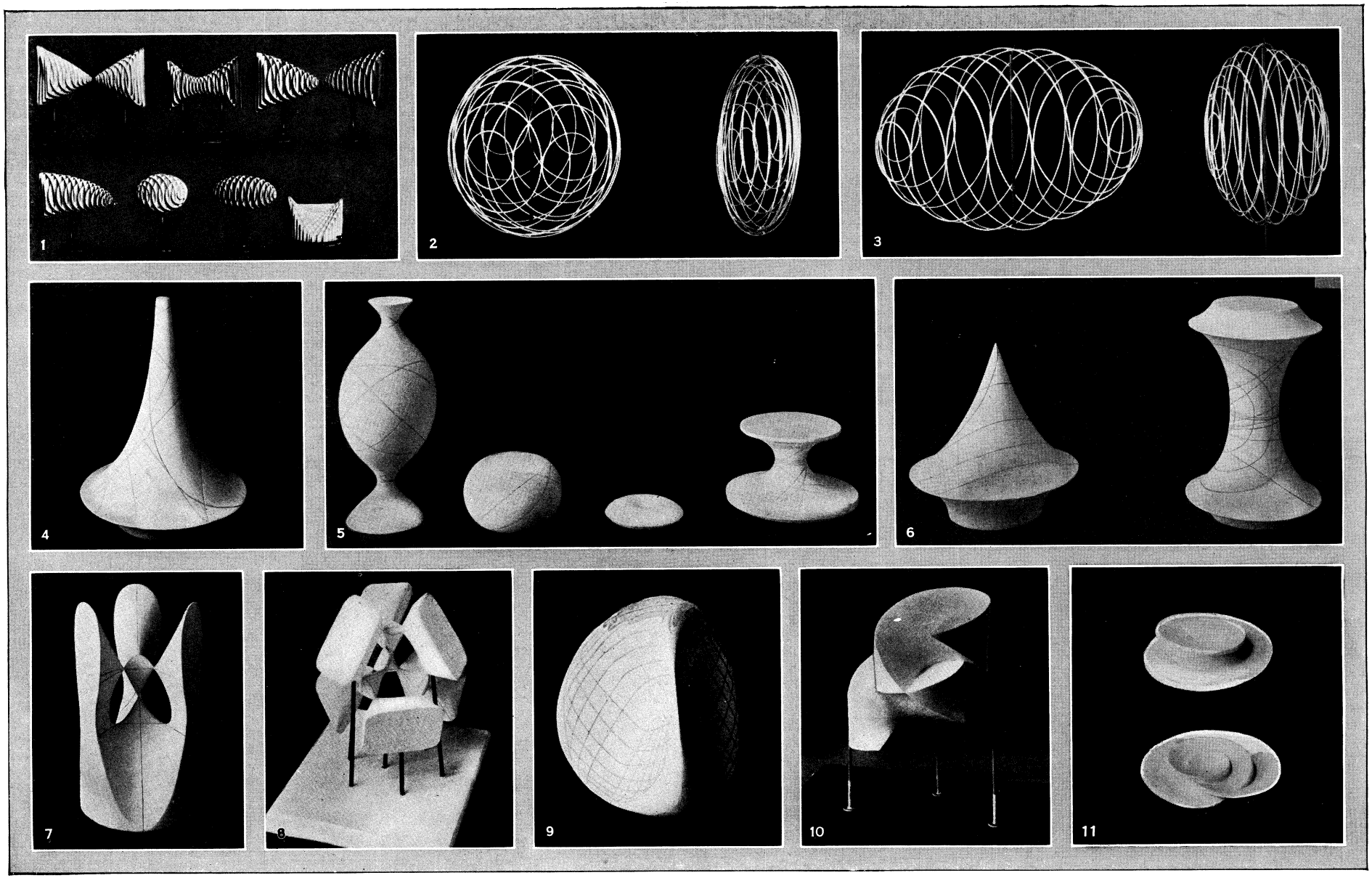
MATHEMATICAL MODELS



MODELS ILLUSTRATING PLANES, SOLIDS AND OTHER MATHEMATICAL FIGURES

1. Paper model of polyhedron having 14 faces (6 square, 8 hexagonal)
2. Dodecahedron; with page showing shape in one plane of all surfaces of the model
3. Folding planes for use in the study of descriptive geometry
4. Model for geometrical study. Planes and solids may be built up in the classroom by changing adjustment of shelf and threads
5. A model for figures of three dimensions, useful in trigonometrical studies
6. Wood model: a cube dissected into six equal tetrahedrons
7. The torus (anchor ring) and cylinder, showing interpenetration
8. Wire models for the demonstration of ellipsoid figures
9. Wire models showing two-sheet and one-sheet hyperboloid
10. Wire figures of the elliptic and hyperbolic paraboloids
11. Bar and thread model; to illustrate changes from the plane through ail forms of paraboloid to double plane, the threads acting as generators
12. Disk and thread model for demonstrating (a) cylinder, (b) hyperboloid of revolution. (c) limiting position of a pair of cones
13. Space curve model illustrating the envelope of the planes which touch two conic sections possessing a common tangent. Curves and supports are of wire; threads serve to indicate generators of the developable surface
14. Shaped wires on an upright support demonstrating helical surfaces; generators and principal tangent curves are of different colours
15. Helical surfaces: model made of small hinged sections with a vertical support; polyhedrons applied to theory of the bending of surfaces

MATHEMATICAL MODELS



CARDBOARD, WIRE, PLASTER AND WOOD MODELS OF ADVANCED MATHEMATICAL CONCEPTS

1. Models illustrating the whole series of surfaces of the second order
2. and 3. Wire circles loosely jointed by special hinge (Wiener's joint) allowing an extraordinary degree of either freedom or restraint
4. Plaster model: surface of rotation of tractrix about asymptote
5. Plaster models: (left to right) onduloid; nodoid; ring of nodoid arising by rotation of the loop; catenoid, a minimal surface
6. Surface of constant negative curvature: (1) cone type, (2) hyperboloid type
7. Third-order surface; four real conical nodes and tangent curves
8. Kummer surface: singularity surface of a complex of second degree
9. Roman surface (Steiner); three intersecting double lines
10. Model illustrating minimal surface; contains system of parabolas
11. Riemann surfaces

small stellated dodecahedron may be constructed by placing a pentagonal pyramid (with face angles of 36° at the apex) on each face of the ordinary dodecahedron; and the great stellated dodecahedron, by placing a triangular pyramid (again with angles of 36° at the apex) on each face of the icosahedron. The great dodecahedron may be derived from a solid icosahedron (of wood or wax, for example) by digging a shallow pyramidal pit in each face, and retaining the original edges. Finally, by stellating the icosahedron we obtain the great icosahedron, as well as several compounds and many irregular but beautiful figures.[1]

Material for Models.—It is not the purpose of mathematical models to prove propositions, but to aid our understanding and to suggest further lines of investigation. They need not attain the standard of accuracy required for graphs or nomograms. (See NOMOGRAPHY.) But they should be constructed with reasonable care, and of suitable materials.

The nearest approach to a mathematically plane surface that occurs in nature is a face of a good crystal. In practice, thin sheet metal or cardboard suffices for many purposes although in certain cases transparent celluloid or glass is to be preferred, while in others. strings, elastic, silk or cotton cords—which may be of different' colours—arranged closely together and parallel may be employed as where, for instance, it may be desired to demonstrate the warping or deformation of a surface, or to illustrate the continuously intersecting planes of descriptive geometry or the discriminant surfaces involved in algebraic equations of the fourth or higher degree.

Descriptive Geometry.— For the study of descriptive geometry (*q.v.*), perspective (*q.v.*), etc., a useful device is found in a pair of planes hinged together and possibly provided with a third plane of reference. Such folding planes if perforated allow of the setting up of problems in situ and the elucidation of the problems of orthogonal projection. The models introduced by Osborne Reynolds and G. Cussons of Manchester (1876) (Pl. I, fig. 3) and the later developments by Andrew H. Miller of Glasgow university (Pl. I, fig. 4) are interesting examples of this class. In the former type the problems are permanently drawn out, in the latter they may be built up before the eyes of the student (precaution being taken in the design to avoid distracting the student's attention from the mathematics to the mechanism), thus enabling the solution of the problems to be demonstrated in proper sequence step by step. In this class may be included the design (Pl. I, fig. 5) of H. G. Green of Nottingham University college and described in the Mathematical Gazette (London), no. 174, as "A Model for Figures in Three Dimensions," which is particularly useful for three-dimensional and trigonornetrical studies. Posts may readily be fixed in the holes of the double base of the apparatus; and cords as "lines of vision," etc., serve to illustrate questions of the man-and-flagstaff type, subtended angles, etc.

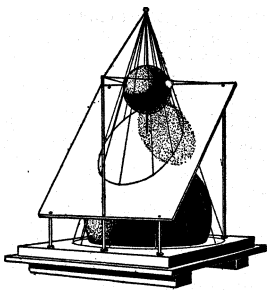


FIG. 1.—CONE WITH INSCRIBED SPHERES AND SECTION PLANE

Models of Wood.—Solid models of wood may be cut in sections to elucidate many problems. An impressive example is shown in Pl. I, fig. 6, where a cube is dissected into six equal tetrahedrons without making any new corners. Three of the tetrahedrons are directly congruent; so are the other three, but they are the reflected images of the first three. All four faces of each tetrahedron are right-angled triangles.

A further example is the well-known model of the binomial cube; *i.e.*, a cube built up of small cubes and prisms whose lengths of edge are represented by arbitrary values of a and b, and an entirely new and of course larger cube $(a + b)^3$ being formable by a combination of blocks equalling $a3 + 3a^2b + 3ab^2 + b^3$.

The study of conic sections, so frequently treated analytically, is much simplified by the use of a model, such as the right circular cone, in which plane sections are made: (1) parallel to the base; (2) parallel to a generating line of the cone; (3) inclined to the axis at an angle greater than the semivertical angle of the cone; (4) inclined to the axis at an angle less than the semivertical angle of the cone, giving respectively the circle, parabola, ellipse and hyperbola (one branch), while a combination of solid, wire and plane model allows demonstration (as in fig. 1) of the famous theorem that the inscribed spheres touch the plane of section at the two focuses of the ellipse.

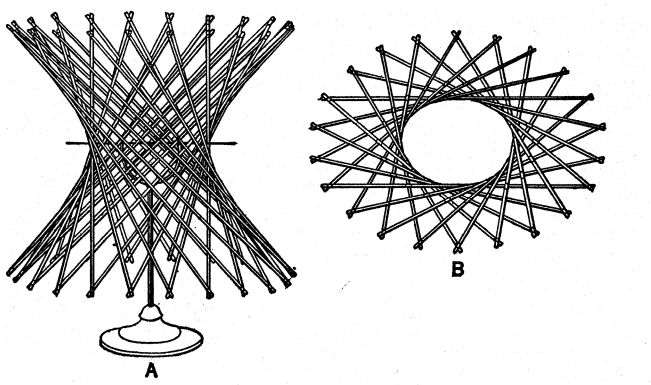


FIG. 2A.—MOVABLE ROD MODEL OF HYPERBOLOID OF ONE SHEET
FIG. 2B.— THE SAME KIND OF MODEL VIEWED FROM ABOVE

Problems concerned with the torus (anchor ring) and cylinder and interpenetration generally can be most satisfactorily illustrated by wooden models since the intersection is produced in the course of manufacture and its shape may be separately examined (Pl. I, fig. 7).

Technical Construction.— Symmetrical solids and surfaces of revolution can be turned in a lathe, a templet representing a plane section containing the axis being applied to the work from time to time until the whole solid of revolution is worked up. Surfaces which are not symmetrical round the axis may also be formed in a suitable lathe having a chuck capable of eccentric motion. Such models may attain a high order of accuracy since micrometer measurements may be applied to the work in the machine. It is of course easy to represent many of the surfaces by means of fixed wires shaped and assembled to represent their principal axes (Pl. I, figs. 8, g, 10), but a more intriguing series of flexible models can be made up of rods or strips, pin jointed or hinged at their extremities, since such provide a mechanism whereby ruled hyperboloids may be continuously converted into their confocal surfaces. (See fig. 2A and 2B.)

Thread Models.—Ruled surfaces (*i.e.*, surfaces generated by the motion of a straight line) fall naturally into a class for easy modelling, since the generators can be represented by successive stretched threads. (See SURFACE.) Thread models can, therefore, illustrate a wide variety of combinations as in Pl. I, fig. 12, which consists of two circular disks drilled with equidistant holes close together, supported as shown and threaded with weighted cords so that the cords may slide through the lower holes.

This model is a demonstration of: (1) a cylinder—when the disks and cords hang freely; (2) a hyperboloid of revolution—when one or the other disk is rotated slightly relative to the other; and (3) the limiting position of a double cone.

Threads stretched as generators across the bars of a jointed quadrilateral of which the sides are movable in pairs may be used to illustrate the changes from a plane through all forms of hyperbolic paraboloid to double plane. Pl. I, fig. 11, shows an example. It comprises two bars pierced with equidistant holes, one bar being fixed, the other capable of swinging around an axis which can also be inclined at different angles to the fixed bar. It should be observed that the hyperbolic paraboloid cannot be made by simply twisting a plane sheet of metal. Surfaces that can be so developed from a plane (*e.g.*, cylinders and cones) are said to be developable.

Space Curves.—Twisted curves may be modelled either by

[1] *See* H. S. M. Coxeter, P. Du Val, H. T. Flather and J. F. Petrie, ***The Fifty-nine*** Icosakedra (Toronto, 1938).

wires suitably bent, as in fig. 4 and 5, or by threads representing their tangents, as in fig. 3. The tangents generate a developable surface which is also the envelope of the osculating planes.

A twisted cubic (*i.e.,* curve of the third order) is called a *cubic ellipse* if it is all in one piece. Any twisted cubic may be constructed as the residual intersection of two quadric cones that have a common generator. Pl. I, fig. 13, shows the dual figure: the envelope of planes touching two conics that have *a* common tangent line.

Fig. *j* shows a physical application of twisted curves, illustrating the equipotential lines and lines of force corresponding to the two electric conductors bearing equal charges.

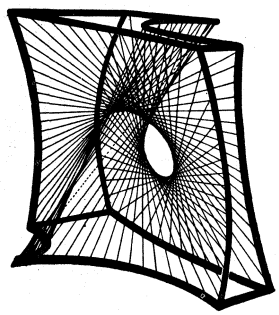


FIG. 3.—THE OSCULATING DEVELOPABLE OF A CUBIC ELLIPSE

Helical Surfaces.—Helical surfaces may best be demonstrated by either shaped wires or small surfaces of tin plate hinged together, the former providing the cheaper but a less flexible medium. Typical examples are the helical surfaces of Pl. I, fig. 14, where generators and lines of curvature are picked out in different colours to render them distinguishable, and in Pl. I, fig. 1*j*, a model composed of small hinged sections, we have an illustration of the same problem solved by the application of the idea of polyhedrons to the theory of the bending of surfaces.

Cardboard Models.—Pl. II, fig. 1, shows several models made up of thin sheets; *e.g.,* cardboard circles of regularly varying diameters set evenly apart in parallel vertical planes, whereby it is possible to evolve the whole series of surfaces of the second order (ellipsoid, hyperboloid, paraboloid, etc.).

A further advantage of this type of model is that the sections may be interlocked across an axis and thereby deformed at will, a feature which may be reached in another way as in the deformable circles of fig. 2 and 3 of Pl. II. In this type a number of different sized wire circles are loosely jointed together across a diameter by a special form of hinge—Wiener's limited joint—which allows at once an extraordinary freedom and restraint.

The figure shows the limiting positions of circle and sphere and the formation of prolate and oblate spheroids. Similar models may he readily made to illustrate the elliptic paraboloid, and the hyperboloids of one sheet or of two sheets, and of double cones, etc., the method of construction with its property of semitransparency enabling a clear idea to be obtained of the constant relationship of the asymptotic cone and of the fact that the lengths of all segments of generating lines remain unaltered.

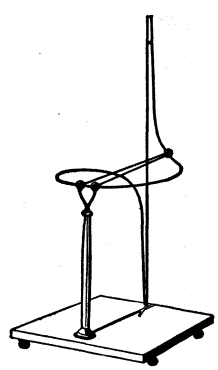


FIG. 4.—THE HOROPTER, A SYMMETRICAL CUBIC ELLIPSE LYING ON A CIRCULAR

Surface Models.—The method of representing the surfaces of the second order by thin sheet circles arranged in parallel planes suggests the means of producing what is probably the most generally useful of all types; viz., surface models of wood, clay or plaster. A model of a cubic surface, for example, may be considered as built up of a number of parallel horizontal sections, each of which is a plane cubic curve.

In order to produce such models, it is in the first place essential to prepare templets which embody the particular function to be illustrated. If, then, a series of such be erected in the appropriate coordinate planes, a surface will ultimately emerge which may be definitely outlined by narrow strips of thin muslin or fabric fixed into position by a plastic medium such as clay wash, wax or plasticine, from which subsequently a plaster cast may be taken. On the permanent surface may be marked appropriate axial and geodesic lines and to it tangent planes of, say, transparent celluloid, etc., may readily be applied. Surface models may alternatively be made up of thin layers of wood suitably shaped, the smooth contour being filled in by wax, or they may be evolved by applying templets after the manner employed in shaping a model ship's hull. Such a model may of course represent a function of pure mathematics, $f(x, y, z) = 0$, or some physical function say of the pressure, volume and temperature of a gas, as in the case of James Thomson's model of 1871, made to illustrate the data obtained by Thomas Andrews in his classic experiments on the relation between temperature, pressure and volume of a constant mass of carbon dioxide when the values were plotted, with temperature as the x, pressure as the y and volume as the z co-ordinates respectively.

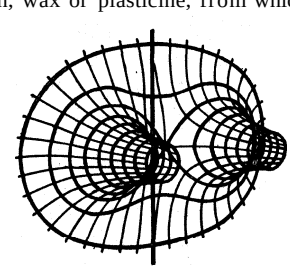


FIG. 5.—EQUIPOTENTIAL LINES

A somewhat later application of the method was made by James Clerk Maxwell who, as the outcome of a suggestion by Willard Gibbs, used the quantities *volume, energy* and *entropy* in making his famous *thermodynamic surface model* in which the properties of a substance in its solid, liquid and gaseous states are indicated by the geometrical properties of the surface.

Maxwell showed how isothermal and isopiestic lines could be drawn upon it and that there is one position of the tangent plane in which it touches the surface in three points which represent the solid, liquid and gaseous states of the substance when the temperature and pressure are such that the three states can exist together.

Plaster Models.—Plaster casts can obviously be produced at less cost than the original mould, so that wherever feasible fhe method affords a convenient means of reproducing surface models either of continuous functions as in surfaces of revolution or of polyhedrons, etc.

The former is typically represented by Pl. II, fig. 4, the surface of rotation of the tractrix about its asymptote, upon which may easily be scribed after moulding some samples of asymptotic lines, geodesics, etc., or such surfaces of constant mean curvature shown in Pl. II, fig. 5, *(1) onduloid,* (2) *nodoid, (3) ring of the nodoid* arising by rotation of the loop, and (4) the *catenoid,* a minimal surface whose constant mean curvature is null.

Surfaces of rotation having a constant negative Gaussian curvature are shown in Pl. II, fig. *6*, that on the left being of the cone type and bearing geodesic and asymptotic lines, that on the right illustrating the hyperboloid type and being marked with parallel geodesic lines and geodesic circles.

Plate II, fig. 7, illustrates a surface of the third order having four real conical nodes.

A form of Kummer surface (singularity surface of a complex of the second degree) is shown in Pl. II, fig. *8*. It is of the fourth order, of the fourth class, and has *16* real nodes and the same number of double tangent planes.

A further example of a surface of the fourth order is Steiner's *Roman surface,* shown in Pl. II, fig. g. It has the equation $y^2z^2+z^2x^2+x^2y^2+xyz=0$, crosses itself along each of the co-ordinate axes and is one-sided. Its asymptotic lines are indicated on the model.

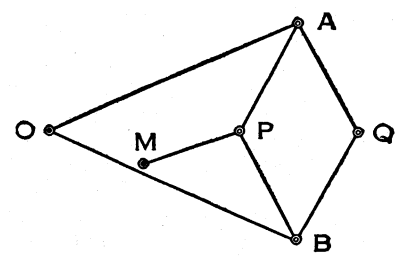


FIG. 6.—PEAUCELLIER'S PLANE LINKAGE

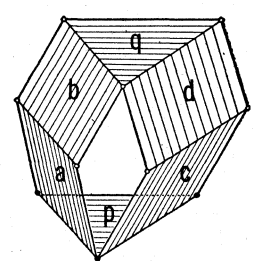


FIG. 7.—SARRUS'S SPACE LINKAGE

An interesting example of a model illustrating a minimal surface is shown in PI. II, fig. 10. It contains a system of real parabolas, the planes of which make a constant angle with a fixed plane of the space.

In Pl. II, fig. 11, we see a representation of winding points of the first and second order on Riemann surfaces. They arise, for instance, when we consider the complex functions $z^{\frac{1}{2}}$ and $z^{\frac{1}{3}}$ in the neighbourhood of the origin.

Linkages and Kinematical Models.—Linkages may be described as systems of bars connected by pin joints or hinges to allow deformation without sliding motion. The most famous plane linkage is Charles N. Peaucellier's inversor, whose six bars consist of a rhombus APBQ and two equal links joining the opposite vertexes A and B to a fixed point O. When P is constrained to trace a given curve, Q will trace the inverse curve. In particular, if P is joined by a seventh link to a fixed point M, whose distance from O is equal to the length of this new link (so that P traces a circle through O), then Q will trace *a* straight line. *(See* fig. *6.)*

Space linkages may be made whose "links" consist of rigid flat plates, hinged together. In the special case when the hinges are all parallel, such a space linkage is clearly equivalent to a plane linkage. Peaucellier's inversor was preceded by the remarkable space linkage of P. F. Sarrus (1853), which is shown-in fig. 7. This consists of six plates, p, a, b, q, d, c, having three parallel hinges at the edges pa, ab and bq and three parallel hinges at the edges pc, cd and dq. The plates p and q will remain parallel; if the former is fixed. every point of the latter will describe a straight line.[1]

Stereoscopic and Optical Methods.—A solid effect can be produced from plane figures, suitably drawn, either by means of the true stereoscope or by viewing red and blue diagrams through absorption screens, one colour for each eye. Instruments of the latter type are

[1] *See* Michael Goldberg, "Polyhedral Linkages," *National Mathematics Magazine,* vol. 16, pp. 1–10 (1942); H. M. Cundy and A. P. Rollett, *Mathematical Models,* pp. 216–217 (New York and London, 1952).

called anaglyphs; they were invented by Louis Ducos du Hauron.

A series of lantern slides illustrating certain algebraic curves was developed by Arnold Emch at the University of Illinois, Urbana, who also produced a cinematograph film of the Poncelet polygon; *i.e.*, showing the continuous movement of a variable polygon which remains inscribed and circumscribed to two fixed circles respectively.

A novel method of treatment is that devised by Papperitz of Freiberg; viz., kinodiaphragmatic projection. The device consists essentially of a variable speed gear box capable of imparting rotatory motion to a transparent diaphragm placed parallel to and immediately in front of the condenser of an optical lantern. Upon the diaphragm may be fixed any combination of thin polished wires which will reflect narrow beams of light into the focusing lens. Beyond and in front of the lens is placed a second rotating axis which may be vertical or inclined, and carry a surface model—say, a sphere, cylinder, etc.—built up of wires, spaced apart. Shadowgraphs are thus projected onto a distant screen, the forms being continuously changed or dissolved into one another according to their relative axial speeds. (G. W. Cu.; H. S. M. C.)

MATHEMATICAL NOTATIONS. The development of mathematical notations has a confused history. The use of symbols as an aid to thought and to the concise expression of mathematical relationships is far-reaching. Chinese, Hindu and Arabic manuscripts show varied abbreviations and symbols, but mathematical notations as known at the present time are the product of the period since the invention of printing. It is a stimulating experience to look through outstanding mathematical works from Luca di Pacioli's *Suma* (1494) to John Wallis's *Algebra* (1693) noting the gradual change from a notation which consisted in large measure of initial letters and abbreviations to one close to our own.

The study of the history of mathematical notations shows that except for Gottfried W. Leibniz and Leonhard Euler, no single mathematician is responsible for as many as four of the symbols that have won a place in mathematical literature. In fact, Florian Cajori said that our symbols are a "mosaic of individual signs of rejected systems."

The qualities that seem to govern the survival of a symbol are adaptability to developing mathematical theory and ease in printing. Contributing factors are the prestige of an individual, the popularity of a book, or the influence of a man's friends. It must also be admitted that a symbol that becomes rooted in a particular body of subject matter is discarded with reluctance if at all even though a more useful symbol may have been developed. As an illustration of this, consider the radical sign which is so entrenched in elementary physics and statistics, to name but two instances, that it survives in spite of the greater flexibility of the fractional exponent. The explanation, of course, is that the radical sign had attained a wide use before the exponent had had its scope extended to include exponents that were negative or fractional.

The history of this subject may be illustrated by examples taken from the symbolism of elementary algebra. Robert Recorde (1557) introduced his equality sign with the following explanation:

> And to auoide the tediouse repetition of these woordes: is equalle to: I will sette as I doe often in woorke vse, a paire of parralleles, or Gemowe (*i.e.,* twin) lines of one lengthe, thus: ═══ bicause noe .2. thynges, can be moare equalle.

Simple as the sign was, it did not again appear in print until 1618. But the horizontal parallel lines were used by François Vieta in 1591 to indicate a numerical difference, and by René Descartes (1638) with the meaning plus or minus. Meantime other symbols used for equality were [, ||, and ∞, the last being sponsored by Descartes. Yet ultimately Recorde's symbol gained universal use.

The plus and minus signs first appeared in print in Johann Widman's arithmetic of 1489 where the weights of barrels of figs were given as 4 ct.+5 lb., 4 ct.−17 lb., and so on. Elsewhere Widman used these signs to indicate excess or deficiency in applying the Rule of False to the solution of problems. Investigations by J. W. L. Glaisher indicate that the signs were not warehouse practice in marking weights, and lead to the conclusion that Widman used them in his arithmetic to have his readers accustomed to them when he needed them in his work in algebra. The plus sign later assumed various forms, probably according to the type the printer had at his disposal. Among these forms are a Maltese cross, a sign with the horizontal line much longer than the vertical one, and the hybrid −/−.

The multiplication sign (×) was used by the Englishman William Oughtred (1631). The symbol became popular in England but not on the continent where the raised dot, due to Leibniz (1698), won acceptance. In England, the dot was also used with the meaning of multiplication, but in this case, the symbol was a period (.). This led to the odd condition that 2.5 means two times 5 in England, while two and five-tenths is written on the continent as 2,5, and in England as 2.5.

The division sign (÷) used in Great Britain and in the United States comes from an algebra written by Johann H. Rahn. The book was published in Switzerland in 1659 and in an English translation in 1668. The translation proved more popular than the original edition and this led to the adopting of the symbol by the English while the colon (:) became popular on the continent.

These instances could be supplemented by many others, but they will serve to indicate how slow a process is the evolution of workable symbolism, and to point out that the process is far from complete.

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MATHEMATICAL TABLES. By a mathematical table is meant any set of tabulated values the primary purpose of which is to render less laborious the work of professional computers in mathematics, engineering, astronomy, physics, chemistry, statistics and other fields of applied science. The term mathematical tables as commonly employed includes specifically the values of mathematical functions such as $\log x$, $\sin x$, etc., and lists of special quantities such as prime numbers, mathematical constants, etc. In a broad sense it is sometimes used to include certain numerical values obtained empirically in scientific laboratories. In this category, for example, are actuarial tables, lists of physical constants, astronomical tables, etc.

Classification. — The need for some system of classification of tables was early recognized, and such a system was made by Arthur Cayley (1821–95) to accompany the extensive report by James W. L. Glaisher on *Mathematical Tables* published by the British Association for the Advancement of Science in 1873. But the modern development of the field revealed the inadequacy of this classification, and a new system was devised in 1940 by the Committee on Mathematical Tables and Other Aids to Computation of the National Research Committee of the United States under the chairmanship of Raymond C. Archibald. The classification adopted by the committee was as follows:

A. Arithmetical tables; mathematical constants
B. Powers
C. Logarithms
D. Circular functions
E. Hyperbolic and exponential functions
F. Theory of numbers
G. Higher algebra
H Numerical solution of equations
I. Finite differences
J. Summation of series
K. Statistics
L. Higher mathematical functions
M. Integrals
N. Interest and investment
O. Actuarial science
P. Engineering
Q. Astronomy
R. Geodesy
S. Physics
T. Chemistry
U. Navigation
V. Calculating machines and mechanical computation

Basic Concepts. — Most mathematical tables are designed to give the numerical values of some particular function, $f(x)$, corresponding to a set of values of the independent variable x. Thus tables of square roots provide values of the function $\sqrt{x}$ over a range of values of x, let us say from 1 to 10,000. The numbers recorded in the table are called tabular entries, and the values by which the table is entered, namely the values of x, are called the

arguments. Such an array of values is called a single-entry table. Although such tables are the most common type. functions of two variables, $f(x,y)$, are frequently tabulated. Thus, multiplication tables record the values of the product xy in terms of the two arguments x and y. Such arrays of values are called double-entry tables.

The length and the size of tables depend upon the character of the functions tabulated, the order of the approximation desired and the uses for which the tables are designed. For example, in tabulating sin x, where x is given in degrees, minutes, and seconds, it is sufficient to take x by appropriate intervals from 0° to 90°, since the numerical values repeat from quadrant to quadrant. But if x is given in radian measure, then, because of the incommensurability of π, a complete table would require that x be taken from 0 to infinity. Tables have actually been constructed to 100 radians. The interval over which the values of the argument are taken is called the range of the table, and the interval between the argument entries is called the tabular interval. The number of decimal places to which the function is computed is called the place value of the table. Thus we speak of a table of logarithms computed to five decimal places as a five-place table, or a table computed to n decimal places as an n-place table. Sometimes, however, it is more important to refer to the number of significant figures rather than to the decimal places. For example. exp 10 = 22022.466 is an approximation to three decimal places although it contains eight significant figures. Tables which emphasize significant figures are often referred to as n-figure tables. The size of a table clearly depends upon three factors; namely, the range, the tabular interval and the place value. For much practical work, tables computed to four or five decimal places are usually sufficient and many important collections are computed to this approximation However, other needs have required more place values for certain functions. Tables seldom exceed ten places, although there are some remarkable exceptions which will be mentioned later.

A table is said to be linear if the tabular interval is chosen small enough so that linear interpolation is sufficient to obtain, to the place-value approximation of the table, the values of the function at unrecorded value of the argument. For example, a five-place table of the function log sin x is linear, except near 0°, if the tabular interval is one minute, but a seven-place table is computed at intervals of ten seconds. Aside from its convenience, a linear table has the advantage of serving also as a table of the function inverse to the one tabulated. Thus a linear table of logarithms is also a table of antilogarithms, for if one enters the tabular values with a number he may obtain, by inverse interpolation, the corresponding argument. This value is the antilogarithm of the number. Similarly a linear table of sin x will also provide the values of arc sin x, and a linear table of squares may be used to compute square roots.

When values of a function are needed over a long range, it is often impossible to choose the tabular interval sufficiently small to attain linear interpolation without making the table too large. (See INTERPOLATION.) In this case differences of second and higher order may be provided for interpolation. Various types of differences have been given, the most usual, particularly in older tables, being the ordinary differences, $\triangle$, $\triangle^2$, etc., which enter into the Newton-Gregory interpolation formula:

$$f(x + ph) = f(x) + p\Delta f + \tfrac{1}{2}p(p - 1)\Delta^2 f + \ldots$$

where h is the tabular interval, x any argument, and p a fraction.

Many recent tables have provided central differences, δ^2, δ^4, etc., instead of ordinary differences, since the Everett formula for interpolation is specially adapted to their use. A fe tables have printed derivatives instead of differences, in which case the interpolation formula has the convenient form:

$$f(x + ph) = f(x) + phf'(x) + \tfrac{1}{2}p^2h^2f''(x) + \ldots$$

where, as above, h is the tabular interval, x any argument, and p a fraction.

Inverse interpolation in tables which require differences of second or higher order for direct interpolation is usually difficult. Hence such tables are not useful as tables of the functions inverse to those tabulated. For this reason. if the tabular interval is not chosen sufficiently small to permit linear interpolation, two tables are required to evaluate any function whose inverse is also desired. Thus one finds tables of sines and tables of inverse sines, tables of logarithms and tables of antilogarithms, tables of elliptic functions and tables of elliptic integrals, etc,

As to the value of a table we may quote J. W. L. Glaisher (1848–1928), one of the greatest computers of modern times: The intrinsic value of a table may be estimated by the actual amount of time saved by consulting it; for example, a table of square roots to ten decimals is more valuable than a table of squares, as the extraction of the root would occupy more time than the multiplication of the number by itself. The value of a table does not depend upon the difficulty of calculating it; for, once made, it is made forever and as far as the user is concerned the amount of labour devoted to its original construction is immaterial. In some tables the labour required in the construction is the same as if all the tabular results had been calculated separately; but in the majority of instances a table can be formed by expeditious methods which are inapplicable to the calculation of an individual result. This is the case with tables of a continuous quantity, which may frequently be constructed by differences. The most striking instance perhaps is afforded by a factor table or a table of primes; for, if it is required to determine whether a given number is prime or not, the only universally available method (in the absence of tables) is to divide it by every prime less than its square root or until one is found that divides it without remainder. But to form a table of prime numbers the process is theoretically simple and rapid, for we have only to range all numbers in a line and strike out every second number beginning from 2, every third beginning from 3, and so on, those that remain being primes. Even when the tabular results are constructed separately, the method of differences or other methods connecting together different tabular results may afford valuable verifications. By having recourse to tables not only does the computer save time and labour, but he also obtains the certainty of accuracy.

Notation. — In describing the range, the tabular interval and the place value of tables, a notation has recently come into general use. It may be best described by an example. Thus, let us suppose that we are describing H. Andoyer's table of sin x which has been computed to 15 decimal places over a range from 0° to 90° at intervals of 10". All these facts are contained in the simple statement that the values of sin x are given for x = [0° (10") 90"; 15D]. More complicated ranges may be similarly expressed. Thus, a recent table of e^x gave 15 decimal values from $x = 1$ to $x = 2.5$ at intervals of .0001 and from 2.5 to 5 at intervals of .001. We might then write that the function was tabulated for x = [1 (.0001) 2.5 (.001) 5; 15D]. If the approximation was to significant figures rather than to decimal places, then S is substituted for D. Thus. the table just described also gave the values of the function from $x = -100$ to $x = +100$, at intervals of 1, to 19 significant figures. These facts are included in the statement that the function was evaluated for x = [−100 (1) + 100; 19S].

The Computation of Tables. — The computation of tables is an art to which great mathematical ingenuity has been devoted in the 20 or more centuries during which tables have been made. A broad knowledge of the theory of functions and the calculus of finite differences is a primary requirement for anyone beginning an extensive computing program, since many hours of computing labour can be saved by the use of special properties of functions or by the appropriate adaptation of some of the formulas in the difference calculus.

The first task of the computer is to determine (1) the range over which the function is to be evaluated. (2) the approximation to be attained and (3) the tabular interval. The determination of the first two depends primarily upon the purposes for which the table is to be used; the last upon the order of interpolation contemplated. If the table is to be linear, that is to say, if linear interpolation is to be used. then the tabular interval depends upon the degree of the approximation. As an example, let us consider the function log sin x, where x is in degrees. Standard seven-place tables usually give this function for x = 0° (1") 6° (10") 84" (1") 90°. Linear interpolation to seven places is attained throughout this table, except very close to 0°; but this would not be the case for, let us say, a tabular interval of 1', which is the one used in five-place tables of the same function. In most

cases the tabular interval may be estimated from the equation $|\triangle^2 f(x)| = h^2 D^2 f(x)$, where h is the tabular interval, $|\triangle^2 f(x)|$ is the absolute value of the second difference of the function at argument x, and $|D^2 f(x)|$ is the absolute value of the second derivative. In order to attain seven-place accuracy by linear interpolation, it is clear that $|\triangle^2 f(x)|$ cannot be greater than 10^{-8}. Hence the upper limit of h^2 (in radian measure) is approximately equal to $10^{-8}/|D^2 f(x)|$. Computing the second derivative of log sin x, we obtain $|D^2 f(x)| = \csc^2 x/M$, where $M = ,43429$. Hence we have $h^2 = 10^{-8} M \sin^2 x$, or $h = \sqrt{M}\ 10^{-4} \sin x = 6.590 \times 10^{-5} \sin x$. For $x = 6°$ we find that $\sin x = .1045$, and thus we obtain the tabular interval $h = 6.887 \times 10^{-6}$ radians = 14". From this it may be concluded that, from $x = 6°$ to the end of the table, linear interpolation is assured to seven-place accuracy if the interval is at least as small as 14". The choice of 10" is thus below the required value and was made for convenience of those using the table.

After the determination of the tabular interval, the computer faces the task of evaluating the function over the range of values which he has selected. In modern times the powerful tools of mathematical analysis have been at his disposal; many types of expansions exist for his use. This was not the case in earlier times. For example, Claudius Ptolemy (c. A.D. 150) in computing his table of chords, which is described in more detail below, required the most ingenious theorems of the ancients to attain a six-place approximation. Thus Ptolemy found it necessary, in evaluating his critical quantity: chord $1° = 2 \sin \frac{1}{2}°$, to establish with much effort the inequality: $\frac{2}{3}$ chord $1\frac{1}{2}° <$ chord $1° < \frac{4}{3}$ chord $0°$. Computing by a succession of square roots the upper and lower limits of the inequality, Ptolemy obtained a value for chord 1° which was correct to six places. The computer today, however, has available the power series

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \cdots$$

by which approximations to ten or more places are readily achieved.

In addition to power series, the modern table maker has available to his use asymptotic series, continued fractions, iterative processes. expansions in orthogonal functions, inverse factorial series and other types of series. He has certain devices by means of which the rapidity of the convergence of his series may be increased. Moreover, he has at his disposal the various formulas of the calculus of finite differences, which are adapted to interpolation, numerical integration. differentiation, etc.

In constructing a table of values of a function the usual method of procedure is to compute first a set of key values over some convenient set of coarsely spaced values within the range. These key quantities are computed to more places than are to be retained in the final table. The function is then computed at the intervening values of the argument by what is called subtabulation. This may be accomplished by means of ordinary interpolation, but when many values are desired, as in the case of extensive tables, the differences of the functions at the tabular interval may be computed from the differences of the key values and these in turn used to construct the tabular values.

In the computation of tables which have an extensive range it is often useful to employ certain fundamental properties of the functions tabulated. For example, from a table of values of the gamma function, $\Gamma(x)$, computed between $x = 1$ and $x = 2$, an extension of the table is readily computed between $x = 2$ and $x = 3$ by making use of the well-known difference relationship: $\Gamma(x+1) = x\,\Gamma(x)$. Thus $\Gamma(2.5)$ is obtained from $\Gamma(1.5)$ merely by multiplying the latter value by 1.5. It is clear that the table can be extended to any value by successive applications of this process. Similarly tables of e^x are extended by observing that $e^x . e^y = e^{x+y}$. In the absence of convenient properties of the kind given above, a function may be evaluated over an extensive range by a proper application of the series

$$f(x+h) = f(x) + hf'(x) + \tfrac{1}{2}h^2 f''(x) + \cdots$$

Thus, let us suppose that a function has been tabulated to some value of the argument x, and that by means of differences or otherwise the values of the derivatives $f'(x)$, $f''(x)$, etc., have also been computed at x. It is clear that the table can then be extended to $x + 1$ by letting h range over the values from 0 to 1. Once the function and its derivatives have been evaluated at $x + 1$. the formula is shifted to this new argument and the computation of the table continued. This device has been used effectively in the formation of tables of the Bessel functions $J_0(x)$ and $J_1(x)$ over a long range.

As an example of an iterative process we may cite what has been called Hero's formula for the extraction of square roots. If N is the number whose square root is desired, and if x_1 is some approximation to the root, then a better approximation will be given by the formula: $x_2 = \frac{1}{2}(N/x_1 + x_1)$. Higher approximations are obtained by successive repetitions of the formula. This device is very effective in extending existing tables of square roots to additional place values, since one iteration is usually sufficient to double the order of the approximation.

Prodigies of computation have been achieved by means of some of these modern devices. For example, William Shanks (1812–1882) in 1873 published a value of π to 707 places (of which only 527 are believed to be correct), using Machin's formula:

$$\tfrac{1}{4}\pi = 4 \arctan \tfrac{1}{5} - \arctan \tfrac{1}{239}$$

The values of the inverse tangents were found from the ordinary power-series expansion of the function. An approximation for e, the base of natural logarithms, to 707 decimal places was published in 1926 by D. H. Lehmer who used continued fractions. Such extreme values have no intrinsic merit in themselves for one may show that if the radius of space is assumed to be of the order of 2.7×10^{10} parsecs (1 parsec = 3.258 light years) and if the diameter of an electron is assumed to be of the order of 2×10^{-13} centimetres, then a value of π to 41 decimal places is sufficient to express the circumference of space in electron-diameters.

However, such computations do serve to show the great power of the methods which have been developed for computing. Among those who have contributed to such high approximations of fundamental constants are the following: J. C. Adams, J. M. Boorman, C. A. Bretschneider, Z. Dase. J. W. L. Glaisher, D. H. Lehmer, A. Martin, H. M Parkhurst. W. Rutherford. W. Shanks, H. S. Uhler, C. E. Van Orstrand, G. Vega and J. Wolfram.

The next task of the computer, and perhaps his most important one, is to assure the accuracy of his table. The difficulty of attaining complete accuracy may be indicated by the fact that one error was detected in the 82nd edition of a well-known standard table, which had been issued continuously for more than a century. The accuracy of a table is sometimes checked by an independent recomputation of the values, preferably by a method different from that used in the original work; but more commonly the computer differences his tabular values. A common error in some tables is the inaccuracy of the last decimal place of the approximation, since this figure is obtained by rounding off the last place in the computed values.

The difficulty in the situation is illustrated by the fact that a five-place table of logarithms cannot be formed completely from a seven-place table of logarithms. For example, in a seven-place table of log x one finds for $x = 3012$ the tabular entry 4788550. In forming a five-place table should this be reduced to 47885 or increased to 47886? The answer is obviously contained in the question whether the last two figures in the seven-place table were rounded off from a number less than 50 or greater than 50. Consulting a ten-place table we find that the corresponding logarithm is 4788549675 and thus the logarithm in a five-place table should appear as 47885. It is often a matter of considerable difficulty to answer a question of this kind. Much attention has been given recently to the formation of lists of errata for important tables, notable contributions to this work having been made by L. J. Comrie. D. H. Lehmer, the Mathematical Tables project, New York (directed by A. N. Lowan), J. Peters and others.

The final task of the computer is to see that his table is well and accurately printed. Tables vary widely in this respect, clear printing on good paper sometimes being offset by poor arrangement of

the values and their differences. Printing errors also often destroy the accuracy of well-computed tables, a fact which emphasizes the rule that proofreading, in the case of tables set from type, is as much a part of the computation of the table as the original determination of the values.

The **History** of Tables.— Mathematical tables appear in the earliest records of history. Thus, certain elementary numerical values connected with the combination of the unit-numerator fractions of the Egyptians are found in the Rhind mathematical papyrus, the copy of a scribe named Ahmes, written some time before **1700** B.C. More extensive than these are the records of the Babylonians, dated perhaps as early as 2000 B.C., which contain multiplication tables and tables of reciprocal values, useful in performing elementary arithmetical operations.

The first mathematical table in the modern sense of the word is the table of chords found in the *Syntaxis Mathematica,* or as it is more commonly called, the *Almagest* of Claudius Ptolemy. This remarkable table, dating from the middle of the 2nd century A.D, gives the values of the chords of a circle at intervals of one-half degree to six-place approximation. In the computation of this table, Greek mathematical ingenuity reaches one of its highest points It is probable that the table is derived from an earlier work by Hipparchus *(c.* **150** B.C.), which is mentioned by Theon of Alexandria.

Three lines of this table as it appears in a Greek edition of the *Almagest* published in Basel in **1538,** together with a translation into modern symbols, is given below:

KXNOKION			Translation of the CANON		
κγ	κγ νε κζ	ο α α λγ	23	23 55 27	0 1 1 33
κγs″	κδ κs ιγ	ο α α λ	23½	24 26 13	0 1 1 30
κδ	κδ νs νη	ο α α κs	24	24 56 58	0 1 1 26

For the translation into Hindu-Arabic numerals the following table of equivalent symbols is necessary:

α	β	γ	δ	ϵ	s	ζ	η	θ	ι	κ	λ	μ	ν	ξ	ο	π	ϙ	ρ
1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100

Fractions were customarily written with one accent on the numerator and two on the denominator, which was written twice. Thus we have: $\iota\gamma'\ \kappa\theta''\ \kappa\theta'' =$ **13/29.** For fractions of unit numerator the denominator only was written. Thus we interpret $\mu\delta'' =$ **1/44,** $\gamma'' = \frac{1}{3}$, etc. Although the usual way of writing ½ was β'' the symbol s" was also in common use for ½ as we observe in the table of Ptolemy.

The modern character of this table is seen from the fact that it contains first the values of the argument, then the tabular entries and finally a table of differences. To interpret the table we need to know only that Ptolemy used the sexagesimal system of numbers. He divided the radius into **60** parts, each of these units into **60** parts, and so on. Hence, in terms of the radius, we have

$$\text{chord } 24° = \frac{24}{60} + \frac{56}{60^2} + \frac{58}{60^3} = .415824$$

This value is equivalent to $\sin 12° = \frac{1}{2}$ chord $24° = .207912$, which is correct to the last place.

Although mathematical tables were prepared and used both by Hindu and Arab mathematicians, it was not until the 15th century that modern development of this art began. Great tables of the natural trigonometric functions were started under the direction of George Peurbach (1423–61), who divided the radius into **600.000** parts; and his pupil Johann Müller, more generally called Regiomontanus (1436–76), who computed a table of sines to every minute of arc with a radius of **1,000,000.** In the first book of his *De revolutionibus orbium coelestium* (1 543), Nicolaus Copernicus (1473–1543) gave a five-place table of sines. The first table of tangents appeared in the *Canon foecundus* (1 553) of Erasmus Reinhold and the first table of secants in the contemporary *Tabula benefica* of Franciscus Maurolycus (1494–1**575).**

Among the greatest labours ever undertaken in table making were those of Rheticus, Otho and Pitiscus. George Joachim, generally known as Rheticus (1514–76), a student of Copernicus, began the task of computing a table of the trigonometric functions to **15** decimal places for every 10 seconds of arc and for every second in the first and last degrees of the quadrant. He completed the tables of sines and began the construction of tables of tangents and secants, but died before they were completed. It is said that he kept several calculators in his employ for 12 years.

The great task was finished by his pupil Valentine Otho (c. 1550–1605), who produced the celebrated ten-place canon *Opus palatinum* in **1596.** The 15-place table of sines was published in **1613** under the title of *Thesaurus mathematicus* by Bartholomaus Pitiscus (1561–1613). These works are the basis of modern tables.

With the independent publication of a table of logarithms by John Napier (1550–1617) in Scotland in **1614** and a brief table of antilogarithms by Joost Biirgi (1552–1632) in Prague in **1620,** numerical computation took a fresh start. Napier's table of logarithms extended to eight places, but his base was essentially $1/e$, $e =$ **2.7183.**. . . Although it is common to refer to tables of logarithms to the base e, namely of log, x, as tables of Naperian logarithms, the more proper name is natural or hyperbolic logarithms. The first table of logarithms to the base **10** was computed by Henry Briggs (1561–1631) and published under the title *Arithmetica logarithmica* in **1624.** The computations were made to **14** decimal places, but included only the logarithms of numbers from 1 to **20.000** and **90,000** to **101,000.** Although Briggs had intended to complete his monumental computations he was anticipated in this by E. de Decker in his *Tweede Deel der Nieuwe Telkonst* **(1627)** and A. Vlacq *(c.* 1600–67) in his so-called *Editio secunda* of Briggs's *Arithrnetica* **(1628).** These men, who were essentially partners in the undertaking, gave ten-place logarithms together with differences over the integers 1 to **100,000.**

The work of De Decker and Vlacq was reprinted by G. Vega in 1794 under the title *Thesaurus logarithmorum completus.* Vega also included Vlacq's table of log sines and log tangents described below and a table of natural logarithms to **48** places computed by J. Wolfram, a lieutenant of artillery in the Netherlands. Wolfram's tables, which extended over all the numbers up to **2,200** and all the primes, together with a few numbers whose least factor is a large prime, to **10,000,** was printed for the first time in the *Sammlung* by J. *C.* Schulze **(1778).**

Tables of the logarithmic trigonometric functions followed shortly the publication of the logarithmic tables of integers. The fundamental contributions were made (1) by Vlacq in his *Trigonometria artificialis* (1633), which gave ten-place values of log sines and log tangents to every 10 seconds of the quadrant with differences, and (2) by Briggs in his *Trigonometria Britannica* (1633), which gave the natural sines to **15** places, tangents and secants to **10** places, log sines to **14** places and log tangents to **10** places at intervals of 0.°01 from 0° to 45°. It is interesting to observe that mathematicians have followed Vlacq's division of the degree rather than that of Briggs. A new turn to this question was given at the time of the French Revolution, when weights and measures were being reduced to the metric system.

Gaspard Riche, baron de Prony (1755–1839) was placed in charge of a project to produce the values of the trigonometric functions in terms of centesimal units, namely divisions of the quadrant into **100** parts called grades, each grade into **100** minutes, and each minute into **100** seconds. This vast undertaking, called the *Tables du Cadastre* from the fact that Prony was the director of the Bureau du Cadastre, was carried out on a scale which involved the calculation of the natural sine to **22** decimal places and log sine and log tangent to **14** decimal places. Although the original work was never published, tables based upon it have appeared.

With the now rapidly growing demands both of science on the one hand and commerce on the other, as shown by extensive manuals of navigation, the number of tables increased rapidly. The 18th century produced more tables than the 17th; and the 19th, by greatly expanding the number of functions tabulated, increased both the volume of tables and their variety. It is around the beginning of that century, for example. that we find the origin of tables of the elliptic integrals. the elliptic functions, the hyperbolic functions, the gamma function, the probability functions, the Bessel functions, etc. With the widespread use of rapid calculat-

ing devices the 20th century has already increased by several fold the total number of tables produced in preceding centuries Hence the history of tables is becoming rather a history of the tables of special functions.

The Bibliography of **Tables.**—With the rapid increase in mathematical tables it became clear more than a century ago that if the needs of science, engineering and commerce were to be served properly, some systematic account of the origin, size and accuracy of tables must be made. A number of excellent historical and bibliographical surveys were produced during the 19th century by J. W. L. Glaisher for the Mathematical Tables committee of the British Association for the Advancement of Science, and by Augustus De Morgan, J. B. J. Delambre and Charles Hutton.

Such surveys were supplemented by a number of others, but by 1943 the need for current information became so great that the National Research council of the United States, under the auspices of its Committee on Mathematical Tables and Other Aids to Computation, established a special quarterly journal, *Mathematical* Tables and Other Aids to *Computation*, with R. C. Archibald as managing editor. This journal is designed to provide current reviens of recent tables, a record of manuscript tables, lists of errata in standard tables, miscellaneous notes on tabular material, publication of bibliographies of tables in special fields of research and of particular functions, as well as descriptions of calculating machines.

In addition to the report of Glaisher referred to above, others of value concerning tables of historical interest include the following: (1) A. De Morgan's article on "Table" in the Penny Cyclopaedia (1842) and *Supplement* (1846), which also appeared later with numerous additions in the English Cyclopaedia, Arts and Science section (1861); (2) Glaisher's articles on "Logarithms" and "Table, Mathematical" in the 11th ed. (1910–11) of the Encyclopedia *Britannica;* Charles Hutton in the first six editions, but not in later ones, of his *Mathematical* Tables (1st ed., 1785; 6th ed., 1820) included an extensive historical survey.

A few reports have been made on the tables of special functions. These include the following: (1) J. Henderson's Bibliotheca *Tabularum Mathematicarum,* part i; "Logarithms of Numbers" (1926, 208 pages) gives a detailed description of historically important tables and of essentially all tables of logarithms which had appeared to 1926; (2) D. H. Lehmer, in a *Guide* to Tables in the *Theory* of Numbers, National Research council (1940), gives a complete account of tables which have appeared in this active field; (3) Harry Bateman and R. C. Archibald have surveyed the extensive literature of Bessel functions in their report, "A Guide to Tables of Bessel Functions!" published as no. 7 (1944) of Mathematical *Tables and Other* Aids to *Computation.* This work superseded the earlier bibliographies of G. N. Watson in his Theory of Bessel *Functions* (1922) and of R. von Mises' *Verzeichnis* berechneter *Funktionentafeln* (1928).

Except in the case of the *Guide* of Lehmer and the quarterly. referred to above, all material for the ordinary inquirer concerning tabular material published and unpublished to the end of 1944 was provided by a remarkable work of A. Fletcher, J. C. P. Miller and L. Rosenhead, *An* Index of *Mathematical* Tables (Scientific Computing service, 1946, viii, 450 pages). Here in excellent form, with all information concerning material for interpolation with each table is a comprehensive guide to tables in the following fields:

(1) Primes, factors, products and quotients. (2) Powers, positive, negative, and fractional. (3) Factorials, binomial coefficients, partitions, etc. (4) Bernoulli and Euler numbers and polynomials; sums of powers and of inverse powers; differences and derivatives of zero, etc. (5) Mathematical constants, π, e, M, γ, etc.; multiples and powers; roots of algebraic and transcendental equations; miscellaneous constants; conversion tables. (6) Common logarithms, antilogarithms, addition and subtraction logarithms. (7) Natural trigonometrical functions; miscellaneous functions connected with the circle and the sphere. (8) Logarithms of trigonometrical functions. (9) Inverse circular functions; trigonometrical functions of two or three arguments (including products. solutions of plane and spherical triangles, etc.); sexagesimal interpolation tables. (10) Natural and logarithmic values of exponential and hyperbolic functions. (11) Natural logarithms of numbers and of trigonometrical functions; inverse hyperbolic functions. (12) The gudermannian; combinations of circular and hyperbolic functions; circular and hyperbolic functions of a complex variable. (13) Exponential and logarithmic integrals; sine and cosine integrals, etc. (14) Factorial or gamma function. psi function, polygamma functions, beta function, incomplete gamma and beta functions. (15) The error integral, higher integrals, derivatives, Hermite polynomials and functions; moments. (16) Legendre functions. (17) Bessel functions of real argument. (18) Bessel functions of pure imaginary argument, or modified Bessel functions. (19) Bessel functions of complex argument; Kelvin functions. (20) Miscellaneous Bessel and related functions. (21) Elliptic integrals, elliptic functions, theta functions. (22) Miscellaneous higher mathematical functions. (23) Interpolation, numerical differentiationand integration, curve fitting. (24) Tables and schedules for harmonic analysis, etc.

See also MATHEMATICAL INSTRUMENTS and the references given therein for electronic and mechanical computing methods.

BIBLIOGRAPHY.—In addition to the bibliographies mentioned above, the reader is referred to the following works especially for the details which they contain relating to the techniques used by the computer: E. T. Whittaker and G. Robinson, The Calculus of *Observations* (1924 and 1937); J. B. Scarborough, *Numerical Mathematical* Analysis (1930); R. Mehmke, "Numerisches Rechen," *Encyk.* der *Math.* Wiss., vol. i, part ii, pp. 941–1079 (1900–04); E. M. Horsburgh, Modern Instruments of Calculation (1914); L. J. Comrie, Interpolation and Allied Tables (1936); Karl Pearson, On the Construction of Tables and on Interpolation, Univariate Tables, Tracts for Computers, no. 2 (1920); Bivariate Tables, no. 3 (1920); J. K. Steffenson, Interpolation (1927); H. T. Davis, Tables of the Higher *Mathematical* Functions, vol. 1 (1933), vol. 2 (1935); Publications of the Mathematical Tables Project (A. N. Lowan, technical director)—this project has produced more than 20 excellent volumes, which contain, in addition to the tabular material, many details of computation and extensive bibliographies; E. Jahnke and F. Emde, *Funktionentafeln,* 1st ed. (1909), 4th ed. (1943), which contains a varied collection of tables together with graphical representation of the functions and bibliographical references.

(H. T. D.)

MATHEMATICS (ARTICLES ON). For the foundations of mathematics—the basic concepts of the science and the assumptions underlying those concepts and the nature of mathematical theories and methods—see MATHEMATICS, FOUNDATIONS OF; LOGIC; and LOGIC, HISTORY OF.

The recorded history of mathematics from the pre-Hellenic age through the periods of classical antiquity and the middle ages to modem times is covered under MATHEMATICS. HISTORY OF.

In addition to these general articles, there are many separate articles on the various branches of mathematics. For the more elementary aspects. including the arts of measurement and computation, see articles such as ARITHMETIC; FRACTION; NUMERALS; NUMERAL SYSTEMS; and MATHEMATICAL NOTATIONS. The theory of numbers is treated in detail under the key article NUMBERS, THEORY OF, and in the articles on special subjects. for example, NUMBER SEQUENCES; GROUPS; COMBINATORIAL AXALYSIS; and FERMAT'S LAST THEOREM.

For the use of graphs and charts, see GRAPHIC METHODS IN MATHEMATICS.

For an introduction to algebra and the history of that branch of mathematics. see ALGEBRA. Algebraic. forms are discussed under that title, and other articles include ALGEBRAIC GEOMETRY; POLYNOMIAL; DETERMINANT; GROUPS; BINOMIAL THEOREM; COMPLEX NUMBERS; CONTINUED FRACTIONS; LOGARITHMS; and INTERPOLATION; EQUATIONS, THEORY OF; ALGEBRAS (LINEAR); and VECTOR ANALYSIS

For the relations and properties of certain functions of angles, see TRIGONOMETRY.

GEOMETRY is the key article on the branch of mathematics concerned with the properties of space. See also ANALYTIC GEOMETRY; CURVES; SURFACE; and CURVES, SPECIAL. Articles on special geometries include LINE GEOMETRY; DESCRIPTIVE GEOMETRY; DIFFERENTIAL GEOMETRY: ANALYSIS, COMPLEX; TOPOLOGY, ALGEBRAIC; and TOPOLOGY, GENERAL.

Calculus, which differs essentially from elementary algebra and geometry in that it emphasizes the operation of taking a limit, is covered under CALCULUS, DIFFERENTIAL AND INTEGRAL; INTEGRAL EQUATIONS; DIFFERENTIAL EQUATIONS, ORDINARY; DIFFERENTIAL EQUATIONS, PARTIAL; SERIES; and FUNCTION.

Articles on related branches of higher mathematics are CALCULUS OF DIFFERENCES; CALCULUS OF VARIATIONS; and SPHERICAL HARMONICS.

For the study of mathematical probabilities as relating to statistical and economic theories and to games of chance, *see* PROBABILITY; PROBABILITY AND STATISTICAL THEORY; and GAMES, THEORY OF. Other articles on special subjects include MATHEMATICAL INSTRUMENTS; MATHEMATICAL MODELS; MATHEMATICAL TABLES and MATHEMATICS, SOCIETIES OF.

See also biographies of famous mathematicians, for example, PYTHAGORAS AND PYTHAGOREANISM; ECLER, LEONHARD, who made important contributions in pure mathematics; DESCARTES, RENÉ, who has been described as the first modern mathematician; FOURIER, JEAN BAPTISTE JOSEPH. whose Fourier series (*q.v.*) marked an epoch in the history of mathematical physics; TAYLOR, BROOK, whose celebrated formula known as Taylor's theorem was important in the history of differential calculus; LAPLACE, PIERRE SIMON. whose name is associated with a famous equation in spherical harmonics; POINCARÉ, (JULES) HENRI, who simplified theories in pure analytical mathematics; and BOOLE, GEORGE, renowned for his contribution in logic and mathematics.

MATHEMATICS, FOUNDATIONS OF. The study of the foundations of mathematics has dealt with the concepts, and the assumptions about those concepts, with mhich mathematics starts. Especially since 1900, foundational investigations have come to include also an inquiry into the nature of mathematical theories and the scope of mathematical methods.

THE AXIOMATIC METHOD

Geometry According to **Euclid.**—Euclid's *Elements* (*c.* 300 B.C.) is a treatise on the foundations of mathematics as well as on geometry. which is said to have had a greater circulation than any book in history except the Bible. Euclid employs the deductive method. which had come down from Pythagoras two centuries earlier.

First. Euclid introduces fundamental concepts such as point, line, plane, and angle. He relates these to physical space by such "definitions" as "A line is length without breadth"; but since their definitions play no further role in his system, they constitute *primitive* or *undefined terms*.

Second. Euclid asserts certain *primitive propositions* or *postulates* (*q.v.*) about these primitive terms. These are propositions which the reader is asked to accept as true immediately on the basis of the "definitions" of the primitive terms relative to the physical world.

Third. Euclid deduces further propositions, called *theorenzs,* such as the theorem of Pythagoras. "The sum of the squares constructed on the arms of a right triangle is equal to the square constructed on the hypotenuse." That is, he shows that their truth follows logically from the truth of the primitive propositions. While doing so, he also introduces defined terms, such as triangle, right triangle, and hypotenuse, which are single words that can take the place of phrases using besides ordinary language only the undefined terms.

The net result is that the reader, starting with postulates of which he is supposed to be immediately convinced, is led, by a long series of simple steps each intended to be convincing. to accept the truth of other propositions of which he would be far from convinced had they been asserted at the outset. (*See* LOGIC; LOGIC, HISTORY OF.)

Non-Euclidean Geometry.—Euclid's parallel postulate, on which depends the theorem "Through a point P not on a line L there can be drawn exactly one line parallel to L," had seemed less evident than his other postulates. Attempts to prove it as a theorem from the other postulates culminated in the discovery published by Nikolai Lobachevski in 1829 and Johann Bolyai in 1832 that a different parallel postulate can be substituted to give a non-Euclidean geometry in which instead "Through a point P not on a line L there can be drawn infinitely many different lines parallel to L."

Insofar as Euclidean geometry fits physical space, it is impossible to say that the geometry of Lobachevski and Bolyai does not also fit. It is only necessary that the discrepancies between the two be too small to show up in any measurements we can make. So while Euclid thought of his geometry as a true description of physical space, we are obliged to regard it as one of a number of different possible mathematical models of that space.

That a theorem of Euclidean geometry be exactly true can only be a property of the geometry as a logical structure. Now a person who accepts Euclidean geometry as a valid logical structure is equally obliged to accept the geometry of Lobachevski and Bolyai. For example, as Felix Klein observed in 1871 (and Eugenio Beltrami in somewhat different terms in 1868), the postulates of Lobachevski and Bolyai's plane geometry are true in Euclidean plane geometry, when in those postulates the plane is interpreted to be the interior of a circle, the lines to be the chords of that circle. and congruence, distance, and angle are defined by a method given by Arthur Cayley in 1859. (*See* GEOMETRY.)

Formal Axiomatic Method. — Here we have varied the meaning of the undefined terms of a postulational theory while holding the deductive structure fixed, a procedure mhich is characteristically modern. One can deduce a theory from its postulates without saying at all what the undefined terms are to mean. Then the theory applies to any system of objects which, when taken as the meanings of the undefined terms, make the postulates true.

Indeed. in a postulational theory, one should be able to perform the deductions treating the undefined terms as meaningless. For if their meanings had to be used, whatever had to be taken from their meanings should instead be provided by additional postulates. In Euclid's *Elements* some properties of the undefined-terms did in fact enter from their meanings *via* the figures. These hidden assumptions were brought to light and stated as postulates by Moritz Pasch (1882) and by David Hilbert (1862–1943) in his *Grundlagen der Geometrie* (1899). Thus Hilbert states as a postulate, "If a line L cuts the side *AB* of a triangle *ABC* and does not pass through *A*, *B* or *C*, then it must also cut *AC* or *BC*."

The postulational method when the undefined terms are treated as meaningless is called the *formal postulational method,* or *formal axiomatic method* as in this connection *axionz* (*q.v.*) and *postulate* are often used synonymously, in contrast with the *material axiomatic method* of Euclid. Formal axiomatics is represented par *excellence* by Hilbert in the work cited.

It might be thought that meaninglessness of the undefined terms would rob a theory of its interest. but the opposite can be the case. Thus for some theories many different interpretations of their undefined terms each make the postulates true (*e.g.,* Euclidean geometry without the parallel postulate, or in algebra abstract groups). The deduction of such a theory independently of any interpretation makes it a mathematical tool prepared in advance for diverse applications. If in essential respects only one such interpretation exists, the postulates are *categorical* (*q.v.*). Of course, if there is no such interpretation, the theory is without value, and one of the problems for foundations is to exclude such theories.

THE GENETIC METHOD

Arithmetic, Analysis. — Systems of numbers are more often introduced by the *genetic method,* so called by Hilbert (1900). In this the objects are generated or constructed in a certain orderly manner, and the theorems express properties of the system of the objects assured by this mode of generation. Of course deductive reasoning is used, just as in the axiomatic method, to obtain unobvious properties from obvious or immediate ones, and the immediate properties can be listed as postulates. Thus the *natural numbers* 0, 1, 2, . . . , used in counting discrete objects, are describable genetically as the objects which are generated by starting with a first object 0 and by proceeding from any object n already generated to a next object $n+1$, objects differently generated being distinct. A suitable selection of immediate properties con-

stitutes the five postulates of Giuseppe Peano (1889), which are categorical for the arithmetic of the natural numbers. By starting from these postulates, rather than from the generation, that arithmetic can then be considered as a formal axiomatic theory. But we shall continue here with the genetic method in describing some other mathematical systems of objects.

Arithmetic (*q.v.*) has several senses; but one of them is the theory of the natural numbers, and of similar systems of numbers, such as the *(rational) integers* . . . , $-2, -1, 0, 1, 2, \ldots$, or the *rational numbers* which are the numbers expressible as fractions p/q where p and q are integers and $q \neq 0$.

Analysis (*q.v.*) deals with such systems of objects as the *real numbers*, used in the measurement of continuously variable magnitudes. A theory of real numbers not resting on vague geometrical imagery was only achieved in the latter part of the 19th century, by Karl Weierstrass. (Julius Wilhelm) Richard Dedekind, Charles Méray and Georg Cantor. The version using infinite decimals will suffice here For example, $9/4 = 2.25 = 2.24999\ldots$, $-9/4 = -2.25 = -3 + .75 = -3 + .74999\ldots$, $1 = 0.99999\ldots$, $\sqrt{2} = 1.41421\ldots$, $\pi = 3.14159\ldots$. In each example, a real number x is expressed as a sum $X + .x_0x_1x_2x_3x_4\ldots$ of an integer X and a non-terminating decimal fraction $.x_0x_1x_2x_3x_4\ldots$ (*i.e.*, one without all digits *o* after some place). The real numbers are given genetically, each number uniquely, as all possible such sums.

Cardinal Number, the Theory of Sets.—Imagine a tribe of aborigines, unable to count above 20, ahose chief is by custom their member with the most numerous herd. If there were two contenders for the chieftaincy, the tribe could decide the winner (or that the two contenders are tied) by passing their herds through a gate, a pair of animals one from each herd at a time.

Cantor was the first who applied this idea systematically to the comparison of infinite collections. A *one-to-one correspondence* between two collections or *sets* of objects is a pairing in which each set contributes one member to each pair. Two sets have the *same cardinal number* if there is a one-to-one correspondence between them.

The natural numbers 0, 1, 2, . . . , the positive integers 1, 2, 3, . . . , the squares of the positive integers 1, 4, 9, . . . (an example used by Galileo Galilei in 1638), and the integers 0, 1, -1, 2, -2, . . . have the same cardinal number. Infinite sets with this cardinal are *countable* (or *countably infinite,* to distinguish them from finite sets which are also countable), since they can be counted off or *listed* by using the natural numbers. A fifth example of a countably infinite set is the rational numbers; for each rational can be written as $(-1)^n p/q$ with the least possible natural numbers $n, p,$ q, and then the rationals can be enumerated in the order of magnitude of the positive integers $2^n 3^p 5^q$.

A part or *subset* of a set S is a set each member of which is a member of S. As Galileo had noted. a part not the whole of an infinite set can be in one-to-one correspondence with the whole. (Dedekind in *1888* used this property to distinguish infinite sets from finite sets.) A set T is of *greater cardinal number* than another set S, if there is a one-to-one correspondence between S and a subset of T but not *vice versa*.

Cantor showed in *1874* by his "diagonal method" that there are sets of greater cardinal number than the natural numbers. A *(single-valued) number-theoretic function f of one variable x* is a correspondence by which, to each natural number x, there corresponds a unique natural number $f(x)$, called *the value of f for x as argument*. The set of these functions is uncountable. For consider any infinite list $f, f_1, f_2, \ldots$ of such functions. Then the function f defined by $f(x) = f_x(x) + 1$ (so the values of f come by altering every value in the diagonal, if the values of $f, f_1, f_2, \ldots$ have been written in successive rows) is not in the list; for if f uere f_q, the contradictory equation $f_q(q) = f_q(q) + 1$ would be obtained upon taking the value for q as argument. The set of these functions is of greater cardinal number than the natural numbers; for on the other hand, the natural numbers n are in one-to-one correspondence with the constant functions $f(x) = n$.

In our generation of the real numbers, the non-terminating decimals can be construed as number-theoretic functions taking values $\leqq 9$; so the reals are uncountable, by reasoning the same as above except taking $f(x) = 8$ when $f_x(x) = 9$.

A given set of natural numbers is represented by a function which takes *o* or 1 as value according as the argument is in the set or not; so the sets of natural numbers are uncountable, by reasoning the same as above except taking $f(x) = o$ when $f_x(x) = 1$.

It is not hard to show that these three uncountable sets have the same cardinal. The third illustrates Cantor's theorem. "The cardinal number of the set of the subsets of a set S is greater than the cardinal number of S."

Thus infinity is not simple, but indeed there are a whole host of *infinite* or *transfinite* cardinal numbers. This is only one of the results of Cantor's theory of sets, which greatly extended the mathematical horizon, besides seeming to provide the ideas for a general foundation of mathematics.

THE CRISIS IN FOUNDATIONS FOLLOWING 1900

The Paradoxes.—Already in the last decade of his scientific life Cantor became aware that his theory of sets pushed too far leads to contradictions. We describe two. *(See* ANTINOMY; LOGIC. HISTORY OF.)

Let S be the set of all sets, and T the set of the subsets of S. Since T corresponds one-to-one to itself as a subset of S, it cannot have a greater cardinal than S. Yet by Cantor's theorem it must. This is Cantor's paradox (1899).

The phrases in the English language are countable. After listing all the phrases, strike out those which do not define number-theoretic functions. Application of Cantor's diagonal method to the list remaining enables one to define in the English language a function which differs from every function definable in the English language. This paradox was found by Jules Richard (1905).

These modern paradoxes have a counterpart in the ancient paradox of the Liar, which in one form appears in a paradoxical statement attributed to Epimenides (6th century B.C.); and in another is due to Eubulides (4th century B.C.) who has a person say, "What I am now saying is a lie." The quoted sentence if true must by what it says be false, and if false be true.

No one has succeeded in disposing of the paradoxes by simply pointing out a fallacy upon which all can agree.

Cantor's paradox is evidently connected with the use of too large sets But where shall a line be drawn? And what definition of set shall replace Cantor's as "any collection of definite well-distinguished objects of our perception or our thought into a whole?"

In fact it is possible to reformulate set theory to exclude too large sets. In doing so, axioms are listed to govern just what sets shall be allowed; and set theory becomes a formal axiomatic theory instead of a genetic one. The first system of *axiomatic set theory* was given by Frnst Zermelo in 1908, and improved by Adolf Fraenkel and Thoralf Skolem in 1922–23 *(see* LOGIC). Axiomatic set theory provides probably the simplest system in which most existing mathematics, but not the paradoxes as far as is known, can be deduced. Kurt Goedel in *1938* showed that Cantor's continuum hypothesis, "The cardinal number of the real numbers is the least cardinal number greater than that of the natural numbers," which no one has succeeded in proving, can be added as a new axiom to set theory without introducing contradiction.

That the paradoxes arose shows there is some defect in the methods, which hitherto had been trusted.. of constructing and reasoning about mathematical objects. Transforming the theory of sets from a genetic into a formal axiomatic theory leaves over the problem whether there is an interpretation of the undefined terms which makes the axioms in some sense true. To ignore these issues is to adopt a mathematical nihilism. Formally axiomatized mathematics cannot be all of mathematics. To draw upon another formal axiomatic theory for such an interpretation is a regress. At some level there must be a meaningful mathematics. At the very least we must believe that the theorems of a formal axiomatic theory really do follow from the axioms. As a further example, when mathematicians say that by a certain method it can be determined in a finite number of steps whether an equation $ax + by + c = o$ with given integral coefficients a, b, c has a solution for $x,$ y in integers, they certainly do not mean merely that this

proposition can be deduced from certain axioms.

(Jules) Henri Poincare and Bertrand Russell around 1905 concluded that the explanation of the paradoxes lies in a certain circularity of definition. When a set M and an object m are so defined that m is a member of M but is defined only by reference to M, the definition of M or of m is called *impredicative*. An impredicative definition can be found in each of the paradoxes. Thus the sickness of mathematics could be cured by banning impredicative definitions, if it did not inconveniently turn out that the cure would kill the patient. For. as was especially emphasized in Hermann Weyl's *Dus Kontinuum* (1918), there are impredicative definitions also in analysis.

Three main schools of thought have arisen which have provided both a philosophy of mathematics and a development of mathematics based upon it.

Logicism. — The logicistic thesis is that mathematics is a branch of logic. Gottfried Wilhelm von' Leibniz in *1666* had conceived of logic as a universal science embracing the principles underlying all others. Dedekind (1888) and especially Gottlob Frege *(1884,* 1893) derived arithmetic from logic. The thesis that all of mathematics is reducible to logic alone is due to Russell. *(See* LOGIC, HISTORY OF.)

Russell, after rediscovering results of Frege, had to make provision against the paradoxes. This provision took the form of a *ramified theory of types*. Roughly described. the primary objects not being subjected to logical analysis he took to be of one type, say *type* o, properties of objects of type o to be of *type* 1, properties of properties of type 1 to be of *type* 2, etc.; and he excluded from use any properties not belonging to one of these types. Then to exclude impredicative definitions within a type, he separated the types above type o into orders, the properties defined using the totality of properties of a given order being placed in the next higher order. Finally to overcome the obstacle which exclusion of impredicative definitions opposes to analysis, he postulated his *axiom of reducibility,* which asserts that to any property belonging to an order above the lowest there is a property of order *o* possessed by exactly the same objects.

On this basis, mathematics was deduced from logic, in a symbolic language. in the monumental *Principia Mathematica* by Alfred North Whitehead and Russell (3 vol.. 1910–13).

The use of the axiom of reducibility weakens the case for the logicistic thesis. For if the axiom be true, should not the reductions to order o be constructed instead of being merely postulated as existing? Weyl hence remarked *(1946)* that in *Principia Mathematica* .'mathematics is no longer founded on logic, but on a sort of logician's paradise."

Leon Chwistek (1921) and Frank P. Ramsey *(1926)* introduced 3 *simple theory of types* in which the separation into orders is suppressed. This still allows the deduction of mathematics from logic, with the paradoxes apparently excluded, but it does not improve the philosophical position.

A fundamental objection to the logicistic thesis is posed by the intuitionists *(see* below), who find an essential mathematical kernel in the idea of iteration, which already has to be used in establishing the hierarchy of types and even in listing the propositions in a proof.

Willard Van Orman Quine (1937) weakened the type restriction to one of '.stratification." The resulting system is a form of axiomatic set theory rather than of type theory *(see* LOGIC). Indeed, though the logicistic thesis did not so develop historically, it could be based as well on a set theory as on a type theory.

Intuitionism. — In the 1880s Leopold Kronecker had objected to the methods of Weierstrass, Dedekind, and Cantor that their fundamental definitions are only words since they do not enable one in every case to decide whether a given object satisfies the definition.

In 1908, in a paper on the untrustworthiness of the principles of logic, L. E. J. Brouwer challenged the belief that the laws of the classical logic as they have come down to us essentially from Aristotle (4th century B.C.) have an absolute validity, independent of the subject matter to which they are applied.

In particular, Brouwer refuses to accept the law of the excluded middle, "Either A or not-A," as valid for all A's. Suppose A is "There exists a member of the set S having the property P." Then not-A is equivalent to "Every member of S lacks the property P." Thus the law of the excluded middle would give "Either there is a member of S with the property P, or every member of S lacks the property P," call this M. Suppose it is possible in principle to decide, for any given member of S, whether it has property P. Then if S is finite, it is possible in principle, by examining each member of S in turn, either to find a member of S with property P or to verify that every member of S lacks property P, though it might be impracticable to complete the examination for large S or even for small S if the determination for some members whether they have property P is lengthy. On the basis of this possibility, Brouwer accepts the truth of M for such P and finite S. But when S is infinite, the described examination cannot in principle be completed; if in pursuing it one has come upon a member of S with property P, the first alternative is substantiated, but if at any stage of the examination a member with property P has not yet been found, one does not know whether it is because there is none or because he has not persisted long enough. In some examples the second alternative might be substantiated by deducing a contradiction from the supposition that an arbitrary member of S has property P. This is the case when S is the set of pairs (p, q) of positive integers and P the property that $p^2 = 2q^2$, as was discovered by Pythagoras in the 6th century B.C. (i.e., $\sqrt{2}$ is irrational). But take the case that S is the quadruples (x, y, z, n) of positive integers with $n > 2$, and P the property that $x^n + y^n = z^n$. About *1637* Pierre de Fermat wrote that he had a proof of the proposition that every member of this S lacks this property P, which is known as Fermat's "last theorem." He did not record his "proof," and no one has since been able to find a proof or a counterexample, though immense effort has been expended. We know of no method which must resolve the question if pursued long enough. Brouwer says that M can only mean that one can in principle find out that one or the other alternative is true; and in the face of examples for infinite S in which we have no assurance that we can, he declines to accept M, and hence also the law of the excluded middle, as a universally valid principle of logic.

Similarly, for Brouwer a statement that an object exists having a given property means that, and is only proved when, a method is known which in principle would enable such an object to be found or constructed. Thus he does not accept indirect existence proofs, which consist in deducing a contradiction from the assumption of nonexistence.

In classical mathematics, i.e., mathematics as based on the classical logic, infinite sets are treated as though they could be given completely, whereas Brouwer admits only a potential infinite. The concept of the natural number sequence $0, 1, 2, \ldots$ has its origin, as he sees it (1907), in our capacity to distinguish one sensation as it recedes into the past and is retained by memory from another which replaces it, and to imagine an unlimited repetition of this process. The sequence 0, 1, 2. . . . is thus only "a manifold of possibilities open towards infinity" (Weyl, *1946).*

For Brouwer, neither language nor logic is a presupposition for mathematics, which has its source in an intuition that makes its concepts and inferences immediately clear to us.

Most theorems of classical arithmetic can be established intuitionistically. But Brouwer's critique affects the whole methodology of classical analysis. Thus to say that any two real numbers x and y are either unequal or equal is to say that either there exists, among the integer of x and successive digits of x, one which is different from the corresponding one of y, or that all are the same. This is an application of the law of the excluded middle of the kind which Brouwer eschews.

Brouwer developed an intuitionistic mathematics, including an analysis and set theory (1918–24). This is interesting in itself, but too different and too complicated to serve as a substitute for classical mathematics satisfactory to most mathematicians or to be practically usable in the natural sciences. But his insights have played an important role in foundational investigations.

Formalism.—Hilbert accepted that the parts of classical mathematics which employ the completed infinite go beyond intuitive

evidence. But instead of rejecting those parts, he proposed, roughly, to formulate classical mathematics up to a suitable point as a formal axiomatic theory, and to prove this theory consistent, *i.e.*, free from contradiction.

Previous to this proposal of Hilbert's (1905, and more specifically from 1918 on), proofs of consistency had been given for axiomatic theories by interpreting their undefined terms in another theory so that the axioms become true, or briefly by giving a *model*. Thus the plane Lobachevskiian geometry was interpreted in Euclidean geometry by Beltrami. The consistency of geometries generally is reduced to that of analysis by René Descartes' analytic geometry (1637), which employs real numbers as coordinates of points, so that geometrical propositions become propositions in the algebra of real numbers. For proving the consistency of analysis itself, the method of models offers no hope, since no theory is available in which analysis could be interpreted which appears safer than analysis.

Hilbert's proposal called for proving consistency by a new method based directly on the meaning of consistency as freedom from contradiction. Not only should all the mathematical assumptions of a theory be listed, but also all of the principles of logic, both the primitive propositions and the rules for drawing inferences, to be used in deducing theorems from the mathematical postulates. This done, one could undertake to show that no two proofs in the theory terminate in theorems one of which is the negation of the other. Hilbert would thus make the proofs of the formal theory the object of an intuitive theory, called *proof theory* or *metamathematics*. The latter should use only intuitively convincing methods, called by him *finitary methods*. These methods in practice are intuitionistic methods on the level of number theory. The formal theory provides a sort of stereotyped model of the previously existing informal theory. which is called the *interpretation* of the formal theory. This interpretation should play no role in the metamathematics, though it motivates the choice of the particular formal theory which is the object of the metamathematics.

To guarantee that all the principles of logic used in deducing theorems have been listed as axioms and rules of inference, the meanings of all the words should be left out of account in deducing theorems, just as in a formal axiomatic theory it should be possible to leave out of account the meanings of the undefined mathematical terms. Because of the irregularities and ambiguities of the existing word languages, it is only feasible to do this by reconstructing the informal theory as a symbolic language, which can be done by combining symbolic logic with the symbolization common in modern mathematics. The resulting formal theory is called a *formal system* or *logistic system*, a statement in it a *formula* (or by some writers a *well-formed formula*, to emphasize that it must be formed from the symbols by listed formation rules), and the method the *logistic method*. The description of a formal system must be given from outside in an informal theory. The method was already available *(see* LOGIC; LOGIC, HISTORY OF), but Hilbert added the proposal to make the formal system the object of mathematical investigations in this informal theory or metamathematics.

There ensued a controversy in which Brouwer questioned how a metamathematical proof of consistency of classical mathematics would meet the objection that the propositions of classical mathematics beyond a certain elementary level lack a clear intuitive meaning. The upshot was that the intuitionists would accept Hilbert's program as unobjectionable, provided the formalists refrain from construing a consistency proof as in some manner vindicating classical mathematics intuitively. Hilbert drew an analogy with the stratagem in mathematics of adjoining "ideal" elements to a previously constituted system to achieve some theoretical end (*e.g.*, the irrational numbers were added to the rationals so that all convergent sequences should have limits, the imaginary numbers to the reals so that all algebraic equations should have solutions; *see* NUMBER). He called the statements of classical mathematics with an intuitive meaning *real*, the others *ideal*. The statements involving the completed infinite are ideal. So he said, in classical mathematics the ideal statements are adjoined to the real to give the theory as a whole a simpler logical structure, and it is no more reasonable to require that each separate statement should be interpretable taken by itself, than that in theoretical physics each separate statement should be capable of being checked by experiment. The possibility appeared that classical mathematics'reinforced by a proof of consistency might even serve as a tool for the intuitionistic proof of real statements via short cuts through the ideal statements.

Hilbert's program was undertaken by him, Paul Bernays, Wilhelm Ackermann, John von Neumann, and others after 1920. The start was made by investigating a formal system of classical arithmetic (with several variants), obtained by adding Peano's postulates and definitions of sum and product to the first-order functional calculus *(see* LOGIC), as described in Hilbert and Bernays' *Grundlagen der Mathematik* (2 vol., 1934 and 1939). A proof by Ackermann in 1924–25 of consistency of a subsystem did not lead at once to a proof of consistency of the whole system. Then in 1931 results of Goedel appeared which clarified the situation, and which we present below from a standpoint reached after 1935. The metamathematical method proved valuable for a variety of purposes in studying formal systems generally. as well as the ones Hilbert considered. Thus a formal system of intuitionistic logic and mathematics was described by Arend Heyting in 1930.

COMPUTABILITY AND DECIDABILITY

Decision Problems, Church's Thesis.—For certain classes of questions in mathematics, a method is known which can be applied to answer by "yes" or "no" any given question of the class. For example, for any positive integers a and b, the question "Is a a multiple of b?" can be answered by dividing a by b and seeing uhether the remainder is o or not. As a less obvious example, there is a method for deciding, for any given integers a, b, c, whether $ax + by + c = 0$ has solutions for x, y in integers. Such a method is called an *algorithm* or *decision procedure;* and the problem of finding such a method for a class of questions is called the *decision problem* for that class. Similarly, for a class of questions nhich require for their answers, not "yes" or "no," but the exhibiting of some object, we speak of an *algorithm* or *computation procedure*, and a *computation problem*.

In the logistic method, the description of a formal system must enable one to decide whether any given formula is an axiom, and whether any given formula comes by a permitted inference from one or two others; so there is a decision procedure for whether a given finite list of formulas is a proof in the system. But a decision procedure is not thereby provided for whether a given formula is provable, *i.e.*, for whether there is a proof of it. The problem of finding a decision procedure for the latter is often called *the decision problem* for the formal system, and was recognized as a problem of logic by Ernst Schroeder (1895), Leopold Loewenheim (1915) and Hilbert (1918). Emil L. Post (1921) gave a decision procedure for the classical propositional calculus *(see* LOGIC; LOGIC. HISTORY OF).

A decision procedure for a formal system embracing a given portion of mathematics would make automatic the solution of any problem in that portion stateable as a "yes" or "no" question. It is therefore implausible that there should be a decision procedure for a formal system embracing the usual arithmetic, in view of the experience of mathematicians in trying to solve the one particular problem whether Fermat's "last theorem" is true; and many other similarly refractory problems are known. For there to be a decision procedure would mean, so to speak, that the infinitely many arithmetical problems involve only a finite number of difficulties such that once those are overcome no further ingenuity will be required. But it might have seemed equally farfetched in 1918 to hope that mathematics could get a hold on the problem of finding a decision procedure for arithmetic, which would enable this problem to be solved by showing that there cannot be one. Exactly this latter was done in 1936 by Alonzo Church.

We begin by considering the computation problems for number-theoretic functions. What functions can be computed or effectively calculated, in the sense that, for a given argument, the value can be found by use only of preassigned rules, applicable without

ingenuity on the part of the computer? Instead of a human computer, we can propose to have a machine to do the computation, according to rules built into its structure.

As this description is somewhat vague, what is needed is an exact mathematical formulation which comes to the same. Such a formulation was given briefly by Post in 1936 and independently in detail by Alan M. Turing (1936–37). What Turing did was to describe a kind of theoretical computing machine, not limited in use by a fixed maximum amount of storage of information nor liable to malfunctioning, as are actual computing machines. A *Turing machine* operates in the following manner. At discrete moments the machine assumes one of a finite list of *states* (fixed for a given machine), the first of which we call the *passive state,* the other k ($\geqq 1$) *active.* A linear *tape,* potentially infinite to the right, is ruled in *squares,* each of which is either *blank* or has printed upon it one of a finite number j ($\geqq 1$) of *symbols* (fixed for a given machine), including say the tally |; but only a finite number of squares are printed. The tape passes through the machine so that one of its squares is *scanned.* If at the given moment the machine is in an active state, then it can alter the condition of the scanned square (by erasing, printing, or both), and/or move the tape so that the scanned square becomes the one next right or left, and/or change to another state, between the given moment and the next; this *act* is determined (for a given Turing machine) by the state of the machine and the condition of the scanned square at the given moment.

Turing used his machines primarily to compute in succession the digits of decimal expansions of real numbers, but they can be adapted to compute number-theoretic functions. Let an argument x be *supplied* to the machine by placing a blank followed by $x+1$ tallies on successive squares of the tape starting with the leftmost square, leaving the tape otherwise blank, and placing the tape in the machine with the rightmost tally scanned and the machine in its first active state. The machine is said to *compute a value y fur x as argument,* if then it eventually reaches the passive state with the $x+1$ tallies followed immediately to the right by a blank and $y+1$ tallies, the rightmost being scanned and the tape being otherwise blank. If, for each natural number x, the machine computes the correct value $y = f(x)$ of a function f, when supplied the argument x, it *computes* the function f, which is then said to be *Turing computable.*

Turing advocated the thesis that any function which can be effectively calculated is Turing computable. His arguments include showing that various operations that a human computer can perform can be analyzed into successions of the simple operations his machines perform. Church had already in 1936 proposed the thesis that every effectively calculable function is "λ-definable" in a sense due to Church and Stephen C. Kleene, or equivalently "general recursive" in a sense due to Goedel, who built on a suggestion of Jacques Herbrand; and this thesis was subsequently proved equivalent to Turing's, so the A-definable functions, the general recursive functions, and the Turing computable functions are the same.

Church's Theorem.— The pattern of behaviour of a Turing machine is completely described by a $k \times (j+1)$ table showing the act to be performed for each of the k active states with each of the $j+1$ conditions of the scanned square. A system for encoding such tables can be established which, to each table, gives a natural number t as code *number* so that a person who knows the system can from t find the table and thence the behaviour of a machine M_t with this table. If t is the code number of a machine M_t which computes a value for x as argument, let $f_t(x)$ be this value; and let $f_t(x)$ be undefined otherwise.

Consider the iunction f defined by letting $f(x) = f_x(x) + 1$ if $f_x(x)$ is defined, and $f(x) = 0$ otherwise. This function f is not computable. For if machine M_q with code number q computes a value for q as argument, that value-is $f_q(q)$, not $f_q(q)+1$ as it would have to be if M_q computes f. It follows that the property "$f_x(x)$ is defined" is undecidable. For otherwise we could compute $f(x)$, given x, thus: first decide whether $f_x(x)$ is defined; then if it is imitate the behaviour of M_x to compute it and add 1, if it is not write 0.

Thus from Turing's thesis we have proved that there is a class of quite elementary arithmetical questions for which there is no decision procedure. This essentially is Church's theorem (1936), which he proved from his thesis using a corresponding class of questions in terms of A-definability. For each x, the proposition "$f_x(x)$ is defined" is expressible in any formal system S which includes the usual vocabulary of arithmetic, by a iormula A_x effectively determinable given x. If the quoted proposition is true, it is demonstrable intuitively by exhibiting the sequence of the acts of machine M_x in computing $f_x(x)$. Suppose S includes ordinary arithmetical reasoning; then that demonstration can be translated into a proof in S of A„ *i.e.,* A, is provable in S whenever (the proposition expressed by it is) true. Finally suppose about S that A, is provable in S only when true. Then there can be no decision procedure for provability in S; for if there were, by answering the question whether **A,** is provable in S, we would have a decision procedure for "$f_x(x)$ is defined."

Moreover there is no decision procedure for the important logical system F of first-order functional (or predicate) calculus (see LOGIC), as Church (1936) and Turing (1936–37) showed. For a proof of $\mathbf{A}_x$ in S can be arranged as a deduction by F of A, from a suitable finite set of arithmetical axioms independent oi x, the conjunction of which can be written as one iormula C. If the symbolism has been suitably chosen, then $\mathbf{A}_x$ is provable in S, if and only ii the implication $\mathrm{C} \supset \mathrm{A}$, is provable in F. From these beginnings, a considerable theory has grown about "unsolvable decision problems," with further major contributions by Post, Andrei A. Markov (the younger), Turing, Alfred Tarski, and Andrzej Mostowski.

Goedel's Theorem.— A formal system like S is *consistent,* if for no iormula B are both B and its negation $\sim$B provable in S; complete, if for each formula B without free variables (otherwise $\sim$B may not express the opposite of B) either B or $\sim$B is provable in S.

Now suppose further that $\sim\mathbf{A}_x$ is provable in S only when true. Then it is absurd that S be complete (and that $\sim\mathrm{A}_x$ be provable in S whenever true). For **A,** is provable in S (when and) only when true. So if, for each x, either A, or $\sim\mathbf{A}_x$ were provable, we could decide whether $f_x(x)$ is defined or not, by searching through all the proofs in S till we find one of A, or of $\sim\mathbf{A}_x$. This is Goedel's theorem (1931) in a negative form.

To obtain the positive form, consider the process, for a given x, of searching through all the proofs in S for one of $\sim\mathrm{A}_x$, and writing o if one is found. A Turing machine, say machine M, with code number q, carries out this process, when supplied with x. Now by the choice of the formulas A_x, $\sim\mathrm{A}_q$ is true if and only if $f_q(q)$ is undefined, which by the choice of M_q is the case if and only if $\sim\mathrm{A}_q$ is unprovable in S. In brief, $\sim\mathrm{A}_q$ expresses its own unprovability (*cf.* the paradox of the Liar). So were $\sim\mathrm{A}_q$ provable, it would be false, contradicting our supposition that $\sim\mathbf{A}_x$ is provable only when true. So $\sim\mathrm{A}_q$ is unprovable but true, and A, is also unprovable (since false).

Hilbert's program called for embodying classical mathematics, including arithmetic, analysis, and set theory short of the paradoxes, in a formal system, and proving that system consistent by finitary methods. The part of Goedel's theorem that $\sim\mathrm{A}_q$ is unprovable but true shows that not even the first step can be carried out fully. Despite the great value of the logistic method as a way of defining exactly the presuppositions of a given portion of mathematics, this very process of definition restricts that portion to include less of arithmetic than free use of intuitive reasoning would give, at least if what is already incorporated in the formal system is intuitively correct.

The part of the theorem that neither $\sim\mathrm{A}_q$ nor A_q is provable in S shows the inadequacy of S to decide by proof or disproof, irrespective of the interpretation, all the statements expressible in it. Thus A_q is said to be *formally* undecidable in S.

In showing $\sim\mathrm{A}_q$ unprovable (and true), we used (for $x = q$) the assumption that $\sim\mathbf{A}_x$ is provable in S only when true. This can be replaced by the metamathematical assumption (not ostensibly using the interpretation) that S is consistent. For if $\sim\mathrm{A}_q$ were provable, $f_q(q)$ would be defined, and hence as noted above **A,** would be provable, which would contradict the consistency.

(The assumption that A, is provable only when true, used in showing A_q unprovable, can be replaced by the assumption that S is w-consistent, in the sense that for no formula B(x) are B(0), B(1), B(2), . . . and $\sim$(x)B(x) all provable in S, where "(x)" expresses "for all x." In verifying this, B(x) will express "at the x-th moment M, has not yet computed $f_q(q)$." Adjoining **A,** to S as a new axiom produces a formal system which is consistent but not w-consistent. if S is consistent. Barkley Rosser in 1936 modified Goedel's formally undecidable formula so that consistency sufficed; in fact, letting M_r carry out the process of searching through all the proofs in S for one of $\sim\mathbf{A}_x$ and writing o if one is found before one of A, is found, $\sim\mathrm{A}_r$ is unprovable but true and A, is unprovable, if S is consistent.)

As Goedel observed in proving his theorem, the objects employed in a formal system, say S, are countable; and after correlating natural numbers (called now Goedel numbers) effectively to them, by talking about those numbers instead of the formal objects, the metamathematics of S becomes a part of arithmetic and so expressible in S. Now consider the implication "If S is consistent, then $\sim\mathrm{A}_q$ is true," obtained above as part of Goedel's theorem. Let Consis be the formula of S which expresses "S is consistent" in S ***via*** the Goedel numbering. Then the quoted implication translated into S becomes Consis $\supset \sim\mathrm{A}_q$. Goedel claimed that, by imitating formally in S the intuitive proof of his theorem, it should be possible to prove this formula in S. (This was done in detail by Hilbert and Bernays in 1939 in their formal system of arithmetic.) But then, ii Consis were also provable, $\sim\mathbf{A}_q$ would be, which is contrary to Goedel's (first) theorem if S is consistent. Thus Goedel obtained his second theorem: If S is consistent, then the formula Consis, which says in S via the Goedel numbering that S is consistent, is unprovable in S.

Goedel's second theorem raises an obstacle to the second part of Hilbert's program. One might have supposed that the finitary methods to be used in proving consistency would be part of the methods

formalized in the system, which amounts to saying that a finitary proof of consistency of S should be formalizable as a proof in S of Consis. Only such methods appear to have been used in attempts prior to 1931. Goedel's second theorem shows that not even all the methods incorporated in S, including the non-finitary ones, would suffice.

Some mathematicians felt that this ended once and for all Hilbert's plan to make classical mathematics more secure by a consistency proof. Others thought it possible that methods might be found for proving consistency, which, though not formalizable within S, could be construed as finitary and thus as safer than some of the methods incorporated in S. Thus Gerhard Gentzen in 1936 gave a proof of the consistency of a system S of classical arithmetic, in which the non-elementary method (not formalizable in S) is an extension of mathematical induction (q v) from the natural number sequence to a certain segment of the "transfinite ordinal numbers" which Cantor had introduced for extending the counting process beyond that provided by the natural numbers.

Further Perspectives.—Goedel's (first) theorem provided confirmation for the view advanced earlier by the intuitionists on philosophical grounds that the possibilities for intuitive mathematical thinking cannot be circumscribed in advance. Taking Brouwer's interpretation of a statement "a y exists such that $P(y)$" as meaning such a y can be found, and applying Church's thesis to the case the y depends on x, Kleene in 1943 proposed the further thesis that a statement "for each x, a y exists such that $P(x, y)$" is provable intuitionistically only if such a y can be given as a computable function of x. Using this thesis, there are theorems of classical arithmetic (Kleene, 1943) and of classical analysis (Ernst Specker, 1949) which are unprovable intuitionistically (not merely in some formal system, but absolutely); so classical mathematics reinforced by a consistency proof cannot serve as a tool of intuitionistic proof, except of a very restricted class of statements. Kleene (1945) and David Nelson (1946) together showed that the intuitionistic formal arithmetic based on Heyting's intuitionistic formal logic does conform to the thesis. Goedel in 1932–33 (partially anticipated by Andrei N. Kolmogorov in 1924–25) correlated to each arithmetical formula B a classically equivalent formula B' which is provable in the intuitionistic formal arithmetic if (and of course only if) B is provable in the classical formal arithmetic. In particular, the correlation proves very simply that the classical formal arithmetic is consistent if the intuitionistic is. However, the intuitionistic arithmetic distinguishes differing degrees of indirectness among statements classically equivalent.

Using the classical law of the excluded middle, Goedel in 1930 proved a completeness theorem for the first-order functional calculus F. In one form, this says that if a formal system obtained by adjoining mathematical axioms to F is consistent, it has a model, *i.e.,* there is an interpretation which makes the axioms true. Indeed, the model can be constructed using the natural numbers as the objects *(see* LOGIC). In another form, the theorem says that in such a system every formula is provable which is true under all the interpretations of the undefined terms which make the axioms true. In view of this, when S is based on first-order functional calculus. the unprovability in S of $\sim A_q$ implies that, uhile $\sim A_q$ is true under the intended interpretation of the undefined terms, there is some other interpretation which makes the axioms true (a "non-standard model") under which $\sim A_q$ is false, This illustrates the theorem of Skolem (1933) that no list of axioms in the symbolism of the first-order functional calculus can characterize the natural numbers categorically If higher functional calculus *(see* LOGIC) is used, the deductive apparatus will he incomplete. It thus appears that the logistic method is inadequate to characterize the natural numbers categorically Peano's axioms characterize them categorically. but only through an interpretation which cannot be rendered fully through the deductive possibilities. Also we see the Goedel formal undecidability of A, as a phenomenon of the same kind as the undecidability of Euclid's parallel postulate from the other postulates of Euclidean geometry.

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MATHEMATICS, HISTORY OF. The study of the languages of primitive peoples, as well as related investigations of extinct languages. indicates that a process apparently as simple as counting passed through many stages before it reached a level that permitted the systematization that is essential for any mathematical procedure. Similar observations have been made in the study of early writing Only tortuous processes led from symbols for sets of concrete objects to a genera! notation which can be justly called a system of numerals. Mathematics originated only in a very few areas within the framework of highly developed urban civilizafions and well-organized economic conditions.

Additional material relating to the following discussion will be found under ALGEBRA, HISTORY OF; ANALYSIS; GEOMETRY: *History of Geometry;* MATHEMATICAL NOTATIONS; MATHEMATICS, FOUNDATIONS OF; NUMERALS; NUMERAL SYSTEMS; SCIENCE; and in the biographies of the various mathematicians mentioned.

Historical Outlines.—Considering four of the great civilizations of antiquity—Babylon and Egypt, Greece and Rome—two contributed little to the development of mathematics: neither Egypt nor Rome advanced beyond the level of the elementary practical arithmetic and mensuration. Priority in the development of mathematics belongs to Babylonia (and to her Sumerian heritage), where numerical, algebraic and geometrical methods existed at least since the Hammurabi dynasty (around 1700 B.C.). Little is known about the prehistory or about the subsequent period until Persian times (6th century B.C.). Nevertheless, that the tradition had been kept alive is proved by texts of the latest period of Babylonian history, when the country had come under Greek and then Parthian domination (last three centuries B.C.). Shortly before, during the 5th or 4th century B.C., the rapid development of Babylonian astronomy began, which became the main carrier of Babylonian arithmetical methods over the world—still retained today in the 60 division of hours and degrees. *(See* BABYLONIA AND ASSYRIA: *Intellectual Achievements.)*

Greek theoretical mathematics began in the 5th and 4th century B.C.—Archytas of Tarentum and Eudoxus of Cnidus were the outstanding representatives of the earliest phase which closed with Euclid in the beginning of the Hellenistic period. The climax of this development was reached about a century later with Archimedes of Syracuse and Apollonius of Perga. The period following Alexander, with the whole Persian empire from India to Egypt under Greek domination, witnessed the assimilation of Babylonian arithmetical methods, particularly in Hellenistic astronomy. Following Apollonius and Hipparchus (about 150 B.C.), geometric methods were applied to the study of eccentric and epicyclic motion, parallel with the development of trigonometry, stereographic projection, etc. The highest peak of this process was reached with Ptolemy of Alexandria in the 2nd century A.D.

Probably around A.D. 400, Hindu astronomy began under western influence. This led to two important modifications of the Hellenistic methods: the replacement of the chord function by the sine function in trigonometry, and the substitution of the decimal for the sexagesimal place-value notation.

In the Islamic period, the meeting of all the preceding forms of mathematical activities, theoretical as well as graphical and numerical methods in astronomy and optics, took place. The "Algebra" of al-Kwarizmi (9th century, Baghdad) continued the near eastern tradition rooted in ancient Mesopotamia, while his astronomy combined Indian and Greek components. After the first great scientific activity declined with the Abbasid dynasty, the centres of Islamic science followed, more or less, the political development. By A.D. 1000 one of the greatest scholars of Islam, al-Biruni, followed Mahmud of Ghazni to India, while the Fatimid court in Egypt counted Ibn Yunis and Ibn al-Haitham among its scholars. Two centuries later, under Frederick II, Sicily came into close contact with Islamic sciences and provided an important influence on the intellectual revival of Italy. Spain under the Omayyads and their successors developed into the most important source of learning to western scholars of the late middle ages.

Greek scientific tradition survived to a certain degree in Byzantium and experienced a final renaissance under the influence of Persian and Arabic works in the period of restoration between the sacking of Constantinople by the Venetians and the Crusaders (1204) and the fall of the city in 1453 under the Turkish onslaught. Islamic science flourished for the last time under Mongol rulers particularly at the court of Ulugh Beg (d. 1449), the grandson of Tamerlane (Timur). At'the same time Europe took the lead, beginning with the Italian Renaissance, which rapidly transformed the inherited methods to what was to become the foundations of modem science.

Simple categories are no longer applicable to the modern development of mathematics, though the earliest phase naturally followed closely the examples of antiquity. The development of analysis (Fermat, Descartes, Newton) soon left behind the classical methods and problems, and an enormous wealth of new discoveries revealed an interaction between theoretical mathematics and all branches of physics and astronomy. This period of often somewhat uncontrolled discovery culminated in the work of Leonhard Euler (1707–1783). Soon afterward the need for increasing rigour and abstraction became the dominant motif which remained characteristic for mathematics thereafter. This tendency not only profoundly influenced each of the traditional branches of mathematics; it likewise all but obliterated the boundaries between individual fields by uncovering their common logical and operational background. At mid-20th century the enormous importance of mathematical physics, accompanied by the development of high-speed computing machines, furnished a new incentive to mathematical research similar to the situation at the threshold of the 19th century.

ANCIENT AND MEDIEVAL

Mesopotamia. — The superiority of Babylonian mathematics is based on the place-value notation of its number system which was equally well adapted to the expression of numbers, ho ever large, or of fractions. This system is not the result of some intentional invention but emerged slowly during the 3rd millennium B.C. In the highly developed economic life of this period, a notation for the recording of monetary transactions originated in which larger and smaller units of weights of silver were expressed by simple juxtaposition of numbers, denoting units of different values, similar to the notation $5.20 as distinguished from $20.5. Thus the arrangement of the numbers determined their relative value; in our example the ratio of dollars to cents is 1 to 100. in the Babylonian monetary system it happened to be 1 to 60. This notation was then extended to numbers in general, so that one ended up with a "sexagesimal place-value system." In our example $5\ 20$ means $5+\frac{20}{100}=5+\frac{1}{5}$ (dollars) or $500+20=520$ (cents). Similarly $2,30$ in the sexagesimal system means $2+\frac{30}{60}=2+\frac{1}{2}$ or $2\times 60+30=150$. All other arithmetical rules familiar to us from the decimal system have their exact counterpart in the sexagesimal place-value system. We know by heart all products of integers up to 10 times 10. The Babylonians (and later the Greek and Arabic astronomers) tabulated the corresponding products up to 60 times 60. In this fashion all arithmetical operations, additions, subtractions, squares, cubes and square roots and cube roots, multiplications and divisions. were carried out first in Babylonian mathematics from the 2nd millennium B C. on and then — beginning around the 5th century B C. — by the astronomers of Mesopotamia, of Greece and Alexandria, of India, of the Islamic world and the Byzantines and their western pupils to the 15th century A.D. and later.

A number system which is based on a place-value notation encounters the problem of the occurrence of empty places; *e.g.,* in the sexagesimal system, this is the case when in an addition some digits total exactly 60 which then are carried as 1 to the next higher place. In the earlier period of Babylonian mathematics one had no special symbol for such cases and had carefully to watch the relative order of the digits. In the late period, however, a special sign was written for every empty place. This "zero" symbol was in common use in all astronomical computations and reached the Hellenistic mathematicians, along with the sexagesimal place-value notation. Thus in all Greek trigonometric tables, *e.g.,* in Ptolemy's Almagest (about A.D. 140), a zero sign is used exactly as we would use it. The same holds for Islamic and Byzantine tables; in these late Greek manuscripts the form ō for zero is the most common one. When Hindu astronomy was developed under western influence, beginning about the 5th century A.D., the zero symbol was transferred to a decimal place-value notation. This decimal system was well known to Islamic scholars, although the astronomical practice remained sexagesimal in most cases. In western Europe, the decimal notation gained ground very slowly and it was not until the 17th century that a consistent decimal place-value notation was developed by François Vieta (1540–1603) and Simon Stevinus (1548–1620).

The facility of numerical computations, as the result of a place-value notation, is everywhere visible in Babylonian mathematics. An Old Babylonian text (written about 1700 B.C.) investigates, for example, triples of "Pythagorean" numbers; *i.e.,* numbers which satisfy the relation $a^2+b^2=c^2$. As an example may be mentioned the triples $2,0 = 120$; $1,59 = 119$; $2,49 = 169$; or $57,36 = 3456$; $56,7 = 3367$; $1,20,25 = 4825$. Many problems were of the following type: find two numbers of given sum when also their difference, or their product, or their quotient is known. The first and the third problems are solvable linearly; the second can be reduced to the first by squaring the sum and subtracting four times the product. The resulting procedure is the normal form for the solution of quadratic equations in Babylonian mathematics. On the basis of this insight a numerical algebra was developed leading to the determination of unknown quantities from a system of linear relations. or from very elaborate quadratic equations, or equations of fourth order obtained by squaring second degree expressions. Similar problems in geometric formulation were handled (division of fields, etc.) involving the concept of similarity, the basic area relations, volumes, etc. In purely numerical respects, one went on to tables of consecutive powers of certain integers and to special cases of the inverse problem, analogous to determining the logarithm of a number. Also problems of compound interest occur. This does not exclude the study of purely geometric relations. The "Pythagorean" theorem for right triangles, the fact that a triangle inscribed in a semicircle is a right triangle, relations in regular polygons, etc., were known, leading to very good approximations of $\sqrt{2}$, $\sqrt{3}$, etc. For π the crude value 3 was often used, but $3\frac{1}{8}$ also was known. (*See* also PYTHAGORAS AND PYTHAGOREANISM.)

Egypt. — The main sources of our knowledge of Egyptian mathematics are two papyri, the so-called Rhind (or Ahmes) papyrus of the British museum (written about 1650 B.C.) and the Golenishev papyrus in Moscow (from about 1900 B.C.). Several smaller fragments confirm the impressions gathered from the two larger texts. The arithmetical operations were developed on an additive basis, repeated duplication for multiplication, with corresponding rules for division and fractions, derived from successive halvings. These often long-winded procedures were used to solve very elementary practical problems; *e.g.,* distributing in given quotas bread and beer. In the same numerical fashion were determined areas of triangular or polygonal fields, volumes of solids, in particular of a truncated pyramid (probably in the special shape of a corner block of two sloping walls). The area of a circle was found by squaring $1-\frac{1}{9}$ or $\frac{8}{9}$ of the diameter (corresponding to a value of about 3.16 for π). The oft-repeated assertion attributing to the Egyptians a knowledge of the formula for the sum of a geometric progression is based on a modern misinterpretation.

Greek and Hellenistic Mathematics. — Late antiquity attempted to supplement the dim records of the past by associating the origin of mathematical knowledge with the early philosophical schools of the 7th and 6th centuries B.C. in Ionia (Thales) and southern Italy'(Pythagoras). These claims are not confirmed by modern research. The basic facts of elementary geometry and arithmetic had for many centuries been known in Mesopotamia. On the other hand, Greek astronomical and cosmogonic concepts in the 5th century B.C. (*e.g.,* Philolaus) are still so primitive that only a very narrow margin is left for earlier discoveries. Indeed, it seems more plausible to assume that the independent development of Greek mathematics began essentially in the time from which we have the first reliable records; namely, the determination of certain areas bounded by circular arcs by Hippocrates of Chios (second half of the 5th century), and the investigation of curves in space in connection with the problem of the duplication of the volume of a cube by Archytas of Tarentum (first half of the 4th century). Whether this rapid development of scientific mathematical theory had anything to do with the increasing contact with the near east is unknown, but, offhand, it seems not very likely. Clear influence of the oriental tradition appears much

later in the writings of Heron (1st century A.D.) and Diophantus (period uncertain) although the numerical methods of astronomy reveal Babylonian influence at least since Hipparchus (c. 150 B.C.).

Although Plato's lifetime (c. 428–*c.* 348 B.C.) belonged to the most important formative period of Greek mathematics, it seems unlikely that any active role in the development was played by him. Nevertheless, philosophy was of great importance for the origin of scientific mathematics, if only for the necessity of removing mathematical argumentation from the unsafe ground of philosophical discussion. The paradoxes about the infinite divisibility of space and time (Zeno of Elea, jth century B.C.) and the related attempts of avoiding them through the assumption of atomistic structures (Democritus, *c.* 400 B.C.) led to the necessity of defining exactly the postulates to be made for the objects of mathematical discussion. These investigations soon resulted in the discovery that the rational numbers do not suffice for the measurement of geometrical quantities and thus require an independent foundation of geometry. Thus the mathematicians of the early 4th century B.C., foremost among whom were Theaetetus (d. 369 B.C.) and Eudoxus, developed a geometric theory of what we now call the irrational numbers. Similarly, the concept of area gave rise to a rigorous theory of integration.

The strictly geometric formulation of these problems directed Greek mathematics away from algebraic procedures, although a purely algebraic notation had been used by Aristotle (384–322 B.C.) in his investigation of formal logic, in spite of the continuation of the oriental tradition within elementary mathematics. Numerical and even graphical methods were used to a large extent within theoretical astronomy as we know from Ptolemy's Almagest and his minor writings, but nowhere is there visible an approach to the concept of "function," which is of such fundamental importance for the development of modern mathematics. Consequently all problems which lead to integrations are attacked as individual geometric problems since it was unknown that integration is the inverse process of finding the derivative. Similarly, the problem of finding tangents to curves, *e.g.,* conic sections, is never seen from the viewpoint of functional relationship.

As mentioned before, theoretical mathematics perhaps received its original impetus from such philosophical problems as the meaning of infinite divisibility of lines, the meaning of area and volume, or the mutual relationship between geometrical and arithmetical ratios, the latter connected with the theory of harmonies. But from a relatively early period on, two other lines of interest are also discernible; namely, curves traceable by mechanical means and conic sections. To the first group we count the problems of spherical geometry as suggested by the apparent motion of the celestial bodies. Also the second group probably has an astronomical origin; namely, the theory of sun dials. By the end of the 4th century all these areas of investigation had reached a level at which a certain codification became possible or even necessary. Eudemus. a pupil of Aristotle, wrote a history of mathematics — unfortunately it is known to us only by some short excerpts. Somewhat later appeared Euclid's Elements concerning the most refined part of theoretical mathematics, culminating in Book x, the classification of irrationals. A work on conic sections by Euclid is lost but some smaller writings have survived, notably a spherical astronomy which shows how far one still was from a spherical geometry. This is confirmed by a treatise of Aristarchus of Samos (first half of 3rd century B.C.), who clearly did not yet have standard trigonometrical procedures at his disposal.

The theory of conic sections, however, had in the meantime reached a high degree of perfection and its significance for the solution of algebraic problems had been understood. This mas amply attested by the use of conic sections made by Archimedes and, above all, by the great work of Apollonius (c. zoo B.C.). In the latter we find a systematic discussion of elementary properties of axes, chords, tangents, asymptotes, focal properties, conjugate directions, etc. But many theorems are also proved, the significance of which was recognized only with the development of projective geometry. Thus we find, for example, the relationship between harmonic quadruples utilized for the proof that five points (or three points and one tangent or one point and two tangents) determine a conic section. We find theorems of duality, transformation of co-ordinates, a discussion of evolutes and theorems which are related to the projective generation of conic sections from pencils of lines.

With Archimedes and Apollonius, theoretical mathematics had reached its climax in antiquity. From then on, astronomical problems determined the direction of further progress (see ASTRONOMY: History of Astronomy). Apollonius showed that the anomalies in the motion of sun, moon and planets can be explained as either eccentric or epicyclic motion. It is easy to see that the apparent position of a body moving on an eccentric circle can be predicted by simple trigonometric relations which, in turn, are always reducible to the solution of right triangles. The new element brought to the problem by its astronomical application consists in the need for repetitiveness, in order to describe the motion of a body by its consecutive positions. This leads to the construction of numerical tables or to graphical or mechanical devices. In the 3rd century B.C., Babylonian mathematical astronomy had reached full maturity. With Hypsicles and Hipparchus, the Babylonian numerical methods, with difference sequences as the main tool, appeared in Greek astronomy. Hipparchus is credited with the computation of a table of chords. In the same period must belong the invention of stereographic projection which transfers problems of spherical geometry to plane geometry under preservation of circles. Similarly, methods of descriptive geometry were invented, the so-called analemma, again with the purpose of treating spherical problems in the plane. This phase of the development was completed by the middle of the 1st or the end of the 2nd century B.C.

The progress of spherical trigonometry was much slower, for obvious reasons. Plane trigonometry involves no new principle beyond the Pythagorean theorem and the fact that two chords over a diameter form a right angle — both known since Old Babylonian times. Spherical trigonometry required entirely new insight, in particular the restriction to great circle arcs. The discovery of the latter fact seemed to be due to Menelaus (c. A.D. 100) and it was especially remarkable because astronomical experience suggests very strongly the consideration of parallel circles. The contrast between the work of Menelaus and the earlier *Spherics* of Theodosius (1st century B.C.) shows clearly the progress made. Inequalities and qualitative considerations were replaced by accurate solutions of spherical triangles, based on the Menelaus theorem. With Ptolemy (2nd century A.D.) this method became the standard procedure for spherical astronomy.

In the 4th century A.D., the sciences became an object of teaching and commentaries. Pappus, Theon of Alexandria and Hypatia paraphrased, commented on and edited the great classics. We owe much to their industry, and a work like the Mathematical Collection of Pappus had great influence on the revival of mathematics in the 17th century, particularly on Descartes. The philosopher Proclus (jth century) wrote an introduction to the Almagest and commented on Book i of Euclid's Elements. Eutocius (6th century) still competently discussed Archimedean treatises. But what was left of Greek mathematical literature in Byzantium had sunk to the level of elementary summaries.

The Middle Ages. — Very few details are known about the survival of ancient science during the period from the final victory of Christianity to the beginning of Islamic science in the 9th century. Persia undoubtedly played a role in this process, not only as a refuge for exiles — non-Christian as well as Christian — from orthodox persecution, but also as an intermediary with India. In the 6th century, under Sassanian rule, Jundi-Shapur (southwestern Iran, Khuzistan) was a center of learning, particularly in medicine, and the same city provided the Nestorian physician of the Abbasid caliph al-Mansur. Under this ruler's influence a project of systematic translating was begun, centred at the "House of Wisdom" in Baghdad and based on a widespread search for Greek scientific literature. In the same period, Indian astronomy had reached Baghdad, thus creating the first school of Islamic astronomy, the best-known representative of which is al-Kwarizmi (d. about 850). His name still lives in our "algorism" as well as in "algebra," which was derived from the title of one

of his works, Al-jabr, famous although of little originality since it closely follows the tradition of elementary mathematics which we can trace from Mesopotamia through the works of Heron and others. Yet, for the revival of mathematics and astronomy, al-Kwarizmi's work was of great importance.

The most significant contribution of India to medieval mathematics was the replacement of the Greek chord function by sine function (though multiplied by constant factors; *e.g.,* 3438' in order to obtain a circumference of 360° for the circle). The use of the decimal system, however, remained of much lesser importance though it occurred occasionally in Islamic, and then also in Byzantine, works. No influence on the west was exerted by the development in India of a theory of Diophantine equations, beginning in the 6th century A.D. (Aryabhatta and Bhascara I) and ending in the 12th (Bhascara II). The origin for these investigations in all probability lay in questions related to the periodicity of planetary phenomena. Thus methods had been known in India which were not rediscovered until Bachet de Mézirac (1624) in Europe. The Hellenistic theory of numbers culminated in Euclid's proof of the existence of an infinity of prime numbers and of the Euclidean algorism. What remained of Greek theory of numbers, for example in Iamblichus (A.D. 300) or Diophantus (date unknown but sometimes placed A.D. 200–300), did not form a connected theory and had little influence during the middle ages.

The progress due to Islamic mathematicians and astronomers probably lay mostly in the perfection of computational devices. Accurate tables for the sin- and tan-function were computed, and methods were devised to modify particularly the first-mentioned function in order to tabulate the equation of centre for planetary orbits. Spherical trigonometry was developed far beyond the level reached in antiquity. The use of the Menelaus theorem was replaced by more elegant methods; *e.g.,* the sin-theorem, known since about A.D. 1000 (Abu'l-Wafa al-Buzjani). At the same time the ancient tradition of descriptive geometry and graphical procedures was developed in the theory of sun dials.

Abu'l-Wafa and his contemporary Kushyar bin Labban wrote treatises on sexagesimal computation. From them proceeds a continuous tradition to al-Kashi, the first director of Ulugh Beg's observatory in Samarkand (about 1400). Among these scholars, the so-called Ruffini-Horner (1804–1819) method was developed for the determination of the nth root by means of an iteration process. Al-Kashi wrote a treatise on the computation of a in which he gives approximations both in sexagesimal and decimal fractions to 9 and 16 places, respectively, based on the comparison of an inscribed and a circumscribed regular polygon of $800{,}335{,}168 = 3 \times 2^{28}$ sides.

It is natural to measure Islamic science by its new discoveries and independent achievements. It is clear that the five centuries from A.D. 900 to 1400 cannot compete with the most creative period of Hellenistic science from 300 B.C. to A.D. 200. One must read such masterpieces of scientific analysis as al-Biruni's work on India (1030) or Ibn Khaldun's (1332–1406) sociological studies in order to understand the depth of Islamic cultures which westerners rightly regarded with the greatest of admiration.

The process of transmission of Islamic science to Europe began in the 11th century with men like Adelard of Bath who visited Syria or Leonardo Pisano in North Africa and Italy at the time of Frederick II whose court in Palermo became a centre of learning. Gerard of Cremona (c. 1114–1187), working in Toledo, was perhaps the most prolific translator of Arabic versions of Greek works (Euclid, Archimedes, Theodosius, etc.). Only a long series of names would cover the European scholars who worked in Spain during the 12th and 13th centuries, often helped by Jewish scholars, in their efforts to commit to Latin an Arabic text. Their works formed the foundation on which the science of the Renaissance was built. (O. E. N. ✗.)

MODERN PERIOD

In 1545, only two years after Copernicus had published his *De revolutionibus* and Vesalius had corrected the physiology of Galen, Girolamo Cardan published the Ars magna, a book which opened a new era in mathematics. Linear and quadratic equations had been solved for thousands of years, but the cubic had resisted all efforts until suddenly several Italian algebraists discovered a solution. First to succeed seems to have been Scipione del Ferro (c. 1510); but the formula often is named for Niccolo Tartaglia, a rediscoverer, or for Cardan, who first published it in the Ars magna, together with Lodovico Ferrari's solution of the quartic. This unexpected success gave a fillip to the theory of equations, and enthusiasm for "the great art" (algebra) spread to other lands. Simon Stevinus of Bruges gave rules for locating roots of equations and established the systematic use of decimal fractions (1585). In France, at the court of Henry IV, François Vieta gave algebra a new name (the "analytic art") and a more general form. His use of vowels for unknown quantities and consonants for known paved the way later for the important concepts of variable and parameter, as well as for the rapid rise of a truly symbolic algebra. He is remembered also for his part (1579) in continuing the efforts of Regiomontanus (1464) to establish trigonometry as more than a stepchild of astronomy.

17th Century.—Vieta died in 1603, just over the threshold of the "century of genius." Brilliant discoveries were about to crowd close upon each other. In 1614 John Napier published his discovery of logarithms; and the following year Johann Kepler devised infinitesimal methods which Bonaventura Cavalieri in 1635 fashioned into a geometry of indivisibles. In 1637 René Descartes published, along with his *Discours de* la *méthode,* his greatest discovery—analytic geometry. co-ordinates, the analytic method, graphical representation of functions and the application of algebra to geometry were not new at that time; but Descartes (and also his contemporary, Pierre de Fermat) correlated these in the basic principle that an equation in two unknown quantities represents a curve and vice versa. The ancient synthetic geometry of static figures now had a powerful and dynamic rival in the algebraic geometry of variable magnitudes.

In fact, except for isolated instances (such as the projective geometry of Gérard Desargues and Blaise Pascal in 1639), "Cartesian geometry" completely overshadowed "pure geometry" for almost two centuries. One of the immediate results of the new geometry was a tremendous increase in the variety of curves which came to be studied. So few curves previously had been known that no need had been felt for a general definition of tangent line; a tangent had been, with certain obvious exceptions, a line which touches the curve at one and only one point. It was Fermat, primarily, who introduced the modern idea of the tangent to a curve at a given point P. In essence, he took a second point Q on the curve, found the slope of the secant line PQ, and from this, by permitting Q to tend toward coincidence with P, he calculated the slope of the tangent. This method rightly earned for him the title of inventor of the differential calculus. When one notes also his share, together with Pascal, in the founding of the theory of probability (1654), his work on the quadrature of curves, his use of mathematical induction and his achievements in the theory of numbers, one appreciates why Fermat, for whom mathematics was but an avocation, has been hailed as the greatest of amateurs. Fermat found the length of the semicubical parabola in 1658, the year in which Christiaan Huygens determined the length of the cycloid—although rectifications had been anticipated by Evangelista Torricelli, student of Galileo, who had found the length of the logarithmic spiral (c. 1640). Pascal and John Wallis also studied the cycloid, a curve whose beautiful properties led to so many disputes over priority that it has been dubbed the "Helen of geometry." Huygens showed that the evolute of a cycloid is an equal cycloid, a property which led to the concept of curvature and which he applied in the construction of pendulum clocks.

Development of the Calculus—h7ewton and *Leibniz.*—Of all the mathematicians of the 17th century, none compared in power and original contributions with Sir Isaac Newton. One of his earliest discoveries was that of the binomial theorem for rational fractional exponents. The binomial formula introduced Newton to infinite series, a topic which loomed large in his invention of the calculus at about the same time (1666). Areas by integration had been found, through summations, by earlier mathematicians from

Archimedes to Wallis; and differentiations had been carried out by Fermat. It remained for Newton and Gottfried Leibniz to discover the fundamental principle of the calculus—that integrations can be performed far more easily by inverting the process of differentiation. This capital discovery was made possible, in the case of Newton, by his study of the methods of his teacher, Isaac Barrow, as well as by works of Fermat and Wallis; Leibniz seems to have been led to the calculus independently (c. 1673–76) by reading the works of Barrow and Pascal. Neither inventor was able to establish the calculus on a sound logical basis. Newton at first adopted a crude explanation in terms of infinitely small "moments"; later he had recourse to the plausible but undefined idea of "prime and ultimate ratios" of the rates of change (fluxions) of flowing quantities (fluents). Leibniz tried (unsuccessfully) to explain his method in terms of sums and quotients of infinitely small "differentials," the notation for which was so felicitous that it has been used ever since.

Newton's first publication of the calculus was in 1687 in a short scholium in the Philosophiae naturalis *principia mathematica*, conceded to be the greatest of all scientific treatises. The Principia is couched in the synthetic language of the ancients, even though the discoveries in the book were made through the new analytic devices which the author helped to develop. Newton is best known for his demonstration, in the Principia, of one of the greatest of scientific generalizations, the law of gravitation. Newton's discovery of the composite nature of white light was published in the Opticks of 1704, a treatise containing also Newton's Quadrature of Curves and his Enumeration of Cubic Curves. Where Newton's aim was to understand nature, the motive of Leibniz was to find a general pathway to knowledge. The Leibnizian search for a universal characteristic, which resulted in the first steps toward symbolic logic, failed to attract a following until the publication of George Boole's Laws *of* Thought (1854); but the method of differentials, the formal algorithmic nature of which was in accord with the aims of its inventor, became the mainspring of mathematical development in the following century.

18th Century.—The mathematical contributions of the versatile Leibniz were more modest than those of Newton, but their influence on the continent was far greater. The Bernoulli family in particular, great admirers of Leibniz, were fired with enthusiasm for the differential calculus; and the greatest and most influential pupil of Jean Bernoulli was Leonhard Euler, the most prolific mathematical author of all time. The 18th century saw few spectacular discoveries; yet this prosy age generated more new mathematics than had any earlier period—and most of this centred about the work of Euler. One of his treatises, the *Introductio in analysin infinitorum* of 1748, may be called the foremost mathematical textbook of modern times, for it fashioned the function concept and infinite processes into the third member of the mathematical triumvirate comprising geometry, algebra and analysis. The *Introductio* contains the earliest algorithmic treatment of logarithms as exponents and of the trigonometric functions as numerical ratios; in it the five proper quadrics are first recognized as members of a single family; and the book systematized the use of parametric equations, polar co-ordinates and the graphical representation of elementary functions.

Euler contributed to all analytic aspects of mathematics. His treatises on the differential and integral calculus are the source from which modern authors have drawn material; he was one of the founders of the calculus of variations and of differential geometry; he was the greatest figure in the theory of numbers since Fermat; and he contributed much to mathematical physics. The vast scope of his interests accounted perhaps for a lack of soundness in logical foundations. He based the calculus on quotients of "qualitative zeros," and he had no qualms about operating with the "sums" of divergent series.

Mathematicians of the 18th century generally were connected with a university or a royal court, and Euler, no exception, found patrons at Berlin and St. Petersburg. When in 1766 Euler resigned from the Prussian academy to return to Russia, Frederick the Great chose as his successor J. L. Lagrange, reputed the greatest mathematician of the century. The interests of Lagrange (algebra, analysis, the theory of numbers and mechanics) were much like those of Euler, but his disposition was different. Lagrange published far less, but his contributions were beautifully finished products with a sound foundation. His The'orie des fonctions analytiques of 1797 made mathematicians more keenly aware of the need for rigour; but the book which earned him greatest fame was the *Mécanique* analytique (1788), which established mechanics as a branch of mathematical analysis. Beginning with a small number of postulates, such as the principle of "virtual work," the author built up the principles of the subject without recourse to anything beyond deductive logic. The Age of Reason, typified by the mathematician and encyclopaedist Jean le Rond d'Alembert, may be thought of as culminating in Lagrange's *Mé*canique, published just one year before the opening of the French Revolution. The greatest legacy left to mathematics by the French Revolutionary period was the establishment in 1795 of the École Polytechnique, a school which boasted among its teachers the greatest mathematicians of France, including Lagrange, Pierre Simon Laplace and Gaspard Monge. Laplace established celestial mechanics as a branch of analysis, and it was through his work that such tools as potential theory, the "Laplace transform," the "Laplace equation" and orthogonal functions became the stock in trade of the analyst. His masterpiece, the *Mécanique céleste* (5 vol., 1799–1825), purported to prove the stability of the solar system, for the origin of which the author proposed the nebular hypothesis. The students of the École Polytechnique esteemed as their greatest teacher Gaspard Monge, who began an era in mathematics characterized by a resurgence of geometry. The *Géométrie* dkscriptive (1799) of Monge, originally devised for military purposes, was the first significant contribution to synthetic geometry after 1639; but the author was not a single-minded synthesist, and the emphasis at the Bcole Polytechnique upon analytic and differential geometry was in large measure the result of the successful textbook of Monge (1795). The key idea in his work was that each step in an analytic calculation corresponds to some geometrical construction. Lazare N. M. Carnot, the "organizer of victory" for the French revolutionary armies, likewise contributed both to analytic and synthetic geometry, his greatest treatise being the Gdome'trie de position (1803), although he is better known for his theorems on transversals.

19th and 20th Centuries.—Carnot had sought to avert the despotism of Napoleon, but Monge and J. B. J. Fourier were friends and ardent admirers of the emperor. Fourier's chief contribution to mathematics is typical of the originality (but not the rigour) of the new century. His classic The'orie analytique de la chaleur (1822) showed that an arbitrary function can be expanded in a "Fourier series" of sines and cosines. In the very same year, Fourier's boldness in analysis was paralleled in projective geometry by the Traitk des *propriétés projectives* des figures of J. V. Poncelet, a student of Monge. Poncelet became a centre of controversy over the "principle of continuity" and the idea of duality. His reckless charges of plagiarism antagonized a young German geometer. Julius Plucker, who turned from synthetic methods to become the greatest of analytic geometers.

In his many treatises, Pliicker developed the ideas of abridged notation, homogeneous co-ordinates (of points, lines and planes), enumerative geometry and the line as an element in a four-dimensional space. In Germany his work was not well received, for Jakob Steiner by 1832 had built up a strong following in synthetic geometry. Steiner hated analysis as thoroughly as Lagrange disliked geometry, arguing that calculation replaces thinking, whereas pure geometry stimulates it. His ideas were carried on (1847) by K. G C. von Staudt, who, with still sharper logic, examined the structure of pure geometry.

Non-Euclidean Geometry.—Probably no earlier period in the history of mathematics rivaled the 19th century either in critical spirit or in originality of development, both of which are seen in the rise of non-Euclidean geometry. Attempts to prove the parallel postulate had been so numerous as to constitute a "fourth classical problem of antiquity"—until N. I. Lobachevski (1826–29) and Johann Bolyai (1831–32) showed that it is possible to build self-consistent geometries in which this postulate is denied. In 1854

B. Riemann proposed the characterization of a geometry by the quadratic differential form for arc length, an idea essential later in general relativity. C. F. Gauss, still another independent discoverer of non-Euclidean geometry, failed to publish his thoughts on the subject. The informed consensus is that Archimedes, Newton and Gauss were the greatest mathematicians of all time. When he was not yet 19, Gauss discovered (1796) that a regular polygon of 17 sides can be constructed in the Euclidean sense. Other results (non-Euclidean geometry, the graphical representation of complex numbers, the double periodicity of elliptic functions) were entered in his diary and went unpublished until rediscovered by others. His Disquisitiones arithmeticae (1801), containing the law of quadratic reciprocity and the algorithm of congruences, is a classic in the theory of numbers; and the Disquisitiones generales circa *superficies* curvas (1828) marked a new epoch in differential geometry through the exploitation of the parametric representation of surfaces and their "Gaussian curvature." These books show a modern tinge in the meticulous attention to proofs. Gauss was also a prolific contributor to statistics (including the method of least squares, invented independently by A. M. Legendre) and to applied mathematics (especially in astronomy, geodesy and magnetism).

Theories of Groups, Functions and Complex *Variables.*—Gauss proved (1799) that every polynomial equation has at least one complex root, but it remained for two younger contemporaries, N. H. Abel and Évariste Galois, independently to demonstrate that in most cases the root cannot be expressed by means of radicals. Abel's proof (1824) that the quintic cannot be "solved" led Galois to seek general criteria of solvability. Galois (who died in 1832, before his 21st birthday) observed that every algebraic equation is associated with a certain group of substitutions and that solvability is determined by the properties of this group, thus establishing the "Galois theory" or the theory of groups. In 1872 Felix Klein, in his famous Erlanger Programm, pointed out the unifying role of the group concept in geometry; and Marius Sophus Lie, through the theory of continuous groups (about 1873), made it a part of analysis. Gauss and A. L. Cauchy, the foremost mathematicians of their day, are typical exponents of 19th-century mathematics in their rigour and inventiveness. The prolific Cauchy was the successor of Lagrange in the theory of functions, to which subject he added the theory of a complex variable. The graphical representation of complex numbers by J. R. Argand (1813–14) and the discovery by Abel (1824) of the imaginary period of elliptic functions had led up to this; but the complex variable really came into its own in 1825 with the "Cauchy integral theorem." This work later was continued in two directions: Karl Weierstrass emphasized the pure analytic aspect through the "analytic continuation" of functions defined by pouer series; Riemann made greater use of geometric intuition through a study of conformal representation and "Riemann surfaces."

Algebraic Geometry.—British mathematics had been handicapped throughout the 18th century by excessive deference to synthetic methods and the notations of Newton. In 1816, however, the Cambridge Analytical society was formed to promote the Leibnizian methods of the calculus. Moreover, the first half of the 19th century was characterized by the rise of mathematical journals (mathematical societies being chiefly a product of the latter half of the same century), and these facilitated publication and dissemination of knowledge (see MATHEMATICS, SOCIETIES OF). Hence it was not long before England, through the voluminous work of Arthur Cayley, became the stronghold of algebraic geometry. The geometry of n dimensions had been hinted at by Sir William Hamilton (1843) and Hermann Grassmann (1844), but Cayley is regarded as the true founder of this branch of geometry (1869), as well as of the theory of matrices and algebraic invariants. Algebra, overshadowed by analysis for two centuries, again was assuming a decisive role, with the application of determinants in algebra and analysis becoming one of the most fruitful lines of development. The critical spirit of the 19th century found clearest expression in the ever-greater arithmetization of mathematics. Bernard Bolzano already had taken a step in this direction in 1817 by giving an analytic proof of the location theorem; but development of the foundations of arithmetic dates especially from 1872 when definitions of irrational number were given by Weierstrass, Julius Richard Dedekind and Georg Cantor. These definitions, based on the notion of infinite classes, led Cantor (in his *Mengenlehre* of 1895–97) to one of the most strikingly original contributions of all time—the theory of transfinite numbers. After showing that the class of algebraic numbers is denumerable, Cantor was led to the startling conclusion that the "number" of points in space of n dimensions is not greater than that in a single dimension, a paradox confirmed by the Peano space-filling curve.

Influence of Science on Analysis.—Perhaps the most powerful impetus on the development of analysis came from mathematical physics and astronomy (see ANALYSIS). The common role of extremal principles for the laws of optics as well as dynamics became clear through the uork of Sir William Rowan Hamilton (1824–37) and Carl Gustav Jacobi (1837–43). The geometric interpretation of the $2n$ "canonic variables" of the dynamic differential equations led Sophus Lie (about 1873) to the concept of contact transformations and continuous groups which, in its abstract form, gained an important place in modern topology. The deep interaction between analysis and mathematical physics is also visible in the work of the almost self-taught genius James Clerk Maxwell, which ranges from the investigation of the stability of Saturn's rings to thermodynamics and his celebrated field theory of electrodynamics (1873). The theory of statistical mechanics as developed by Maxwell, Ludwig Boltzmann and Willard Gibbs opened the road to the investigation of the so-called ergodic theorems (solution by George David Birkhoff, 1932). Through the theory of probability by A. Kolmogorov and A. Khintchine (1932) it had become clear that problems of statistical mechanics are essentially problems of the theory of measure, and in this form the ergodic theory has again developed into a branch of abstract mathematics. A similar development can be observed in the theory of integral equations which slowly emerged during the second half of the 19th century from problems of electrostatics and the theory of potentials. The essential turn toward a solution originated from the investigation of determinants of infinitely many rows and columns, begun by G. W. Hill (1877) in connection with the perturbation theory of the lunar motion. This new type of approach led Erik Fredholm (1900) to the discovery of the algebraic analogue of the theory of integral equations, which was crowned by the theory of eigen-values of David Hilbert (1906) and the related theory of spaces of infinitely many dimensions ("Hilbert space" and its modern generalizations).

Fundamental Questions.—Hilbert in 1900 prophetically proposed to the second International Congress of Mathematicians at Paris a series of fundamental problems which should challenge the efforts of the new century. The first problems concerned the continuum, where the question of whether or not there is a transfinite number between that of a denumerable set and that of the continuum remained unanswered. Questions inquiring about the transcendence of certain numbers were partially solved by C. L. Siegel (about 1930) and by Gelfond's theorem, although results here still were sporadic. The problems which stimulated the most spectacular development were those lying in the relatively novel field of analysis situs or topology. Certain puzzle problems of Euler were suggestive of topology, and Gauss prophesied the rise of the new subject, but the origins are more clearly apparent in results of Henri Poincaré (1899–1904). By the middle of the 20th century the infant prodigy had burgeoned into a major branch of mathematics. Originally an offshot of geometry, topology became closely related also to algebra and analysis.

One of Hilbert's favourite questions concerned the compatibility of the axioms of arithmetic. Gottlob Frege in 1879 had given a critical definition of the word "number," and just a decade later the Peano postulates for arithmetic were proposed; but by far the most ambitious effort to establish the foundations of mathematics appeared in the Principia *Mathematica* (3 vol., 1910–13) of Bertrand Russell and A. N. Whitehead. This Principia, like that of Newton, set the fashion for decades to come, so that research in symbolic logic at mid-20th century constituted a major branch of mathematics. In fact, the greatly expanded role of the axiomatic

approach became possibly the most conspicuous aspect of 20th-century mathematics. Such studies in the foundations of mathematics engendered lively controversy in which varying orthodoxies are distinguishable—from the formalists, who assert, as did Hilbert, that mathematics is a meaningless game played with meaningless symbols, to the intuitionists, who, with L. E. J. Brouwer, hold to a more Kantian view of the "inner meaning" of the subject. One of the factors contributing to the dilemma was the persistence of deep-rooted paradoxes. By rejecting the use of impredicative definition, Poincaré, Hermann Weyl, and Brouwer were able to eliminate the antinomies; but this drastic solution, to which Brouwer (and later Weyl) added also the rejection of the law of excluded middle, cut the ground out from under much of classical mathematics. Hilbert sought to save the mathematical fortunes by rejecting the idea of mathematics as necessarily "true," clinging only to the criterion of self-consistency; but such efforts were dealt a shattering blow by Goedel's theorem. Kurt Goedel in 1931 showed essentially that if the game of mathematics actually is consistent, the fact of this consistency cannot be proved within the rules of the game itself *(see* MATHEMATICS, FOUNDATIONS OF).

The conclusion which necessarily follows from such a devastating discovery is that the ultimate foundations of mathematics remain a deep mystery—at least to mathematicians. One should expect the result of this to be a deep pessimism. On the contrary. one found everywhere in the modern period the faith that mathematics was entering a golden age surpassing even the brightest periods of the past. Theories of integration, revolutionized by H. L. Lebesgue through his concept of measure (1902), had carried the subject far beyond Archimedes, Cauchy and Riemann into the realm of abstract spaces; and the unification of analytic methods had led to the general analyses of E. H. Moore (1906) and Maurice Fréchet (1928).

The atmosphere of 20th-century algebra, with its concern for such abstract axiomatic concepts as field, ring and ideal, was far more general than that of any previous age. Geometry—no encompassing spaces of infinitely many dimensions—undertook a critical examination of its postulational basis.

See also Index references under "Mathematics, History of" in vol. 24.

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(C. B. BR.; O. E. N.)

MATHEMATICS, SOCIETIES OF. Mathematicians, like other scientists, have always felt the need to communicate their results to their colleagues and to find opportunities of discussing problems with them. Until the 17th century these needs were met by personal contact and correspondence and by the publication of books Thereafter there gre up, over the whole world, a multitude of societies devoted to the furtherance of mathematical knowledge, together with an even greater number of periodical publications containing matter of interest to mathematicians. The aim of this article is to outline the growth of these societies and periodicals.

The first regular periodicals to contain mathematical papers were the publications of the great national scientific academies *(see* ACADEMIES: *Scientific Academies),* such as the Royal society of London. the Académie des Sciences of Paris, the Accademia dei Lincei of Rome, the Preussische Akademie der Wissenschaften of Berlin and the Imperatorskaya Akademiya Nauk of St. Petersburg; later reinforced by numerous smaller local academies, especially in Germany and Italy. These will not be discussed in detail; all that needs to be said is that, even since the establishment of societies and periodicals concerned only with mathematics, the academies have continued to publish a substantial quantity of mathematical papers and remain one of the most important media for this purpose.

Other early periodicals containing important mathematical papers include the *Journal des sçavans* (1665–1792; called *Journal des Savants* [1797 *et seq.]),* published in Paris; and the *Acta eruditorum* (with *Supplementa;* 1682–1734) and *Nova acta eruditorum* (also with *Supplementa;* 1732–76), both of which were published in Germany.

Societies.—Mathematical societies began as small local bodies whose members met at intervals to discuss mathematical problems. The oldest still in existence in the latter half of the 20th century is the Mathematische Gesellschaft in Hamburg, Ger., founded in 1690 as the Kunstrechnungsliebende Societat, and continued (1790–1876) as the Gesellschaft zur Verbreitung der Mathematischen R'issenschaften. Its publications were entitled *Jahresbriefe* or *Jahres-Berichte* or *Berichte* (1723–1878) and *Mitteilungen* (1873–80, mimeographed; 1881 *et seq.,* printed).

Conditions in World War II compelled the temporary suspension of the *Mitteilungen* in 1941. The society suffered a severe blow when a great part of its archives was destroyed in an air raid in 1943.

Another early organization was the Mathematical society founded as a discussion circle in Spitalfields, London, in 1717. It continued until 1845, when it was absorbed by the Royal Astronomical society.

National mathematical societies did not appear until the second half of the 19th century, the scientific academies and the independent mathematical periodicals (discussed later in this article) having sufficed until then. One exception must be made, however: this is the Wiskundig Genootschap, founded at Amsterdam in 1778. The most important of its many periodical publications is the *Nieuw Archief voor Wiskunde* (1875 *et seq.),* a continuation of *Archief* (1856–74), which was itself a continuation of *Verslagen van het Verhandelde op de wetenschappelijke Vergaderingen* (1844–52).

The oldest of the major national societies is the Moskovskoe Matematicheskoe Obshchestvo (Moscow Mathematical society), organized in 1864 as a circle for mathematics enthusiasts and re-established on a wider basis in 1867. It publishes the important periodical *Matematicheskii sbornik (Kecueil Mathématique;* 1866 *et seq.)* and *Trudy Moskovskogo Matematicheskogo Obshchestva* ("Transactions of the Moscow Mathematical society"; 1952 *et seq.).* There are many other mathematical societies in the U.S.S.R., that at Kharkov having been established in 1879.

The London Mathematical society was founded in 1865, one year after the Moscow society. It began as a purely local society of mathematicians in London, most of the original members being at University college; its first president was Augustus De Morgan. It grew rapidly, however, and soon established itself as the national mathematical society of England. It publishes *Proceedings* (1865 *et seq.)* and a *Journal* (1926 *et seq.),* the latter containing shorter papers, records of the society's meetings and obituary notices. The Edinburgh Mathematical society was

founded in 1883 and publishes Proceedings (1883 et seq.) and Mathematical Notes (1909 et seq.). It organized occasional mathematical colloquies, lasting for a week and usually held at St. Andrews, Scot.

The Société Mathématique de France was founded in 1872, its first president being Michel Chasles. It publishes a Bulletin (1872 et seq.).

The New York Mathematical society, founded in 1888, became the American Mathematical society in 1894. With more than 5,700 members, it is one of the most important mathematical societies in the world; and its meetings are held in all parts of the United States. Its periodical publications comprise the Bulletin (1891 et seq.), containing reports of lectures, abstracts of papers presented to the society, records of the society's activities and book reviews; Transactions (1900 et seq.) for longer papers; Memoirs (1950 et *seq.*) for papers of unusually great length; and Proceedings (1950 et seq.) for short papers (before 1950 the Bulletin was used for short papers also). The society also publishes two series of monographs (the Colloquium Publications and Mathematical *Surveys*) and translations of Russian mathematical papers, and takes part in the administration of several other periodicals published in the United States.

The Deutsche Mathematiker-Vereinigung, founded in 1890, is the German national society. Its *Jahresbericht* (1892 et seq.), with Erganzungsbande (1906–30), besides short papers, book reviews and records of the society's activities, contains many extremely valuable expository surveys of progress in a number of fields of mathematics.

In Italy the Circolo Matematico' di Palermo, founded in 1884, achieved international status; its Rendiconti (1887 et seq.) was for many years one of the most important mathematical periodicals in the world. The Unione Matematica Italiana was established in 1922; it publishes a Bollettino (1922 et seq.).

By the middle of the 20th century, national mathematical societies had been formed in most of the countries of the world; two of the most important ones outside Europe and America were the Indian Mathematical society, which began in 1907 as a local club in Madras, and the Mathematical Society of Japan, which was formed after World War II as a partial continuation of the earlier Physico-Mathematical Society of Japan (founded 1884). Each publishes a journal.

Besides holding meetings for mathematical lectures and discussions, and publishing periodicals, many societies also maintain a library of books and periodicals. Many of the latter are obtained by exchanging the society's own publications for those of other societies or of universities. The main sources of income for most societies are members' subscriptions and the sale of publications; some have been the recipients of endowments from private sources, but mare and more have had to seek direct or indirect support from their governments or from other public authorities in order to keep their publications going, because of the increase in the cost of printing after World War II. Experiments aimed at reducing costs have been made with new methods for the reproduction of mathematical papers; an example is the use of a justifying typewriter combined with photolithography.

Teachers' Associations.—There are a number of societies whose primary interest is in the teaching of mathematics. The pioneer among these was the Association for the Improvement of Geometrical Teaching, founded in Great Britain in 1871; its first objective was to remove the stranglehold on the teaching of geometry in schools that had been created by the general insistence on strict adherence to Euclid's exposition. The association gradually developed a more general interest in the teaching of mathematics and changed its name to the Mathematical association in 1897. It has issued many valuable reports on the teaching of mathematics, and publishes the Mathematical Gazette (1894 et seq.), which is especially renowned for its book reviews.

There are two bodies with similar interests in the United States: the Mathematical Association of America, founded in 1915, is mainly concerned with teaching at the college level and publishes the American Mathematical Monthly, originally established in 1894 by B. F. Finkel; the National Council of Teachers of Mathematics, founded in 1920 (after 1950 a department of the National Education association), has the Mathematics Teacher (1908 et seq.) as its official journal. Similar bodies exist in many other countries.

International Organizations.—Occasional international meetings of mathematicians took place during the 19th century, but the first of the present series of international congresses of mathematicians was held in 1897. The congress has met regularly every four years after 1900, except for interruptions caused by World Wars I and II. It was at the Paris congress in 1900 that David Hilbert delivered his famous address on unsolved mathematical problems. The Proceedings of each congress have been published, usually by the mathematical society of the sponsoring country. After World War I an attempt was made to establish a permanent International Mathematical union; it was set up at the Strasbourg congress in 1920 and struggled on for some years but was eventually dissolved, its failure being largely due to political causes. The project was revived at the Harvard congress in 1950 and a new union was formed; it was admitted to the International Council of Scientific Unions in 1952.

At the Rome congress in 1908 it was decided to set up an International Commission on the Teaching of Mathematics (Internationale Mathematische Unterrichtskommission). In the years immediately before World War I this body published a valuable series of reports on mathematical teaching in various countries. The commission was revived by the International Mathematical union in 1952; and in 1953 it adopted *L'Enseignement Mathématique* (Paris, 1899–1903; Paris and Geneva, 1904 et seq.) as its official organ.

The Scandinavian Mathematical congress has met regularly since 1909, and reports of its meetings are published.

Periodicals.—Almost all periodicals devoted primarily to mathematics fall into one of four classes: publications of the large scientific academies, some of which contain special sections devoted to mathematics; publications of mathematical societies, many of which are noted above; journals sponsored by universities and usually edited by members of the mathematics faculty; and independently published journals. Because of the large number of these it will be possible to mention only a selection of the more important ones.

Older Periodicals.—The oldest major periodical still extant in the latter part of the 20th century was the Journal de *l'École* polytechnique, established in Paris in 1795 under the title Journal polytechnique, ou Bulletin du travail *fait à l'École* centrale des travaux publics. Its name was changed to *Journal* de *l'École* polytechnique, ou Bulletin du travail *fait à* cette dcole in the following year; and it assumed its present title in 1812. Its original purpose was the publication of a detailed account of the lectures given at the École Polytechnique, but even its earliest numbers contained articles of a research character.

From 1810 to 1831 the Annales de mathdmatiques *pures* et *appliquées* was published at Nimes under the editorship of J. D. Gergonne; he eventually resigned under the pressure of administrative duties, and the periodical was restarted at Paris in 1836 by J. Liouville, who gave it the present title Journal de *mathématiques pures* et *appliquées*. Known familiarly as the "Journal de Liouville," it is one of the important mathematical periodicals of the world.

A powerful stimulus was given to German mathematics when A. L. Crelle started the Journal *für* die reine und *angewandte* Mathematik at Berlin in 1826. Crelle was not himself a creative mathematician of the first rank, but he gave great encouragement to the younger mathematicians of Germany and the neighbouring countries. Among the contributors to the first three volumes of the Journal were N. H. Abel, K. G. J. Jacobi, J. Steiner, P. G. Lejeune Dirichlet, A. F. Mobius and J. Pliicker. Applied mathematics disappeared from its pages at an early date, and it was jokingly called the "Journal fur die reine, unangewandte Mathematik" ("Journal for pure, unapplied mathematics"). It has remained in the first rank of mathematical periodicals throughout its history and is still known familiarly to mathematicians all over the world as "Crelle's Journal."

From here on it will be convenient to consider the major peri-

odicals country by country.

United States.—The first two major mathematical periodicals to appear in the United States were the *American Journal of Mathematics (Baltimore,* Md., *1878 et seq.), uhich* was established by the Johns Hopkins university under the editorship of J. J. Sylvester; and the *Annals of Mathematics, a continuation of the Analyst* (1874–83), which assumed its present title in 1884 and has been published at Princeton, N.J., since 1911. Others that may be mentioned include the *Journal of Mathematics* and Physics (Cambridge, Mass., 1921 et seq.) of the Massachusetts Institute of Technology; the *Duke Mathematical Journal* (Durham, N.C., 1935 et seq.) of Duke university; the Michigan Mathematical Journal (Ann Arbor. Mich., 1952 et seq.) of the University of Michigan; the Illinois Journal of Mathematics (Urbana, Ill., 1957 et seq.); and the Pacific Journal of Mathematics (Berkeley, Calif., 1951 et seq.), published jointly by a number of universities and other organizations on the west coast of the United States.

British Isles.—The oldest of the British periodicals began as the Cambridge *Mathematical Journal,* shortly afterward becoming the Cambridge and Dziblin Mathematical *Journal* (1837–54); in 1857 it was restarted as the Quarterly Journal of Pure and Applied Mathematics, and in 1930 it became the Quarterly Jourrzal of Mathematics (Oxford series). The Oxford, Cambridge and Dublin Messenger of *Mathematics* (1861–71) was continued as the *Messenger of Mathematics* (1872–1929). Although the Cambridge Philosophical society is a general scientific society, its Proceedings (1843 et seq.) are largely mathematical in character; the Transactions (1820–1928) also contain much that is of mathematical interest. Matheinatika (1954 et seq.) is published by the department of mathematics of University college, London.

Continental Europe.—In France the Bulletin des sciences *mathématiques* was founded by J. G. Darboux and G. J. Houel in 1870, primarily as a vehicle for book reviews, translations, progress reports and similar matter; the part occupied by research papers has nevertheless steadily increased in importance. The *Annales scientifiques de l'École normale supérieure* began publication in 1864. The *Annales de l'Institut* Fourier (1949 et seq.) of the University of Grenoble are of considerable mathematical interest.

In Germany an important step was taken when A. Clebsch and C. Neumann founded the *Mathematische* Annalen in 1868; it was started as a vehicle for the publication of papers by members of the new school of mathematicians who were following up the ideas of Bernhard Riemann, and for many years it was almost boycotted by the other mathematicians of Germany. Gradually overcoming these prejudices, it grew into one of the greatest mathematical periodicals of the world. Another journal of major importance is the *Mathematische Zeitschrift* (1918 et seq.). Others that may be mentioned include the *Archiv der Mathematik* und Physik (1841–1920); the Zeitschrift fur *Mathematik* und Physik (1856–1917); the mathematical section of the *Nachrichten* of the Akademie der Wissenschaften at Gottingen (1845 et seq.); the *Abhandlungen* aus dem *mathematischen Seminar* of the Gniversity of Hamburg (1921 et seq.); and *Mathematische* Nachrichten (1948 et seq.) published by the Deutsche Akademie der Wissenschaften zu Berlin. This last academy and many others in Germany publish papers in the mathematical series of their *Abhandlungen* and *Sitzungs*berichte.

In Italy the *Annali di scienze matematiche e fisiche* (Rome, 1850–57), founded by B. Tortolini, became later the *Annali di matematica pura ed applicata* (Rome, 1858–65; Milan, 1867 et seq.). It has played an important part in the history of the Italian school of algebraic geometry. The Giornale di *matematiche di Battaglini* (Naples. 1863 et seq.) was founded by S. Battaglini as an elementary journal but has also published many research papers. Among the many other Italian mathematical journals one may mention *Rendiconti* di matematica e delle *sue applicazioni* (1913 et seq.) of the University of Rome, Rivista di matentatica (1950 et seq.) of the University of Parma, and Ricerche di *matematica* (1952 et seq.) of the University of Naples.

Sweden possesses one of the major mathematical journals of the world in the Acta *mathematica* (Stockholm, 1882 et seq.), founded by G. Mittag-Leffler, which published many important papers by the French mathematician H. Poincaré. Many substantial contributions to mathematics also appear in the Proceedings of the Royal Physiographic Society at Lund (1931 et seq.) and in the Arkiv for matematik (Stockholm, 1949 et seq.) published by the Royal Swedish Academy of Sciences; the latter is a partial continuation of the older Arkiv for *matematik,* astronomi och fysik (1903–1949). Other Scandinavian mathematical publications are the Matematisk-fysiske meddelelser (Copenhagen, 1917 et seq.) of the Royal Danish Academy of Sciences and Letters; the Annales academiae *scientiarum* fennicae, series A. I. (Helsinki, 1941 et seq.); and the Commentationes *physico-mathematicae* (1922 et seq.) of the Societas scientiarum Fennica, *Mathematica* Scandinavica (Copenhagen, 1953 et seq.) is published jointly by the several mathematical societies of the Scandinavian countries.

The Bulgarian Academy of Sciences published Izvestiya *na Matematicheskiya Institut* (Sofia, 1953 at seq.); Academy of the Rumanian People's Republic, *Studii şi cercetări matematice* (Bucharest, 1950 et seq.); the Czechoslovak Academy of Sciences, the Czechoslovak Mathematical *Journal* (Prague, 1951 et seq.) and Casopis pro *pěstování* matematiky (1951 et seq.), both deriving in part from the earlier *Časopis pro pěstování* matematiky a fysiky (1872–1950) of the Union of Czechoslovak Mathematicians and Physicists; the Hungarian Academy of Sciences, Acta mathematica academiae scientiarum hungaricae (Budapest, 1950 et seq.), *Matematikai és Természettudományi* Osztcilydnak *közleményei* (1951 et seq.) and Alkalmazott Matematikai *Intézetének közleményei* (1952 et seq.). The Polish Academy of Sciences issued Annales polonici mathematici (Warsaw, 1954 et seq.; formerly Annales de la *Société* polonaise de *mathématique,* 1922–1953); *Fundamenta mathematicae* (Warsaw, 1920 et seq.), a journal devoted chiefly to topology and the theory of sets; Studia mathematica (Lwow, 1929–1940; Wroclaw, 1948–51; *Warsaw,* 1953 et seq.), devoted chiefly to functional analysis; *Studia logica* (1953 et seq.); Colloquium *mathematicum* (1947 et seq.); *Rozprawy* matematyczne (1952 et seq.); and *Zastosowania* matematyki (1953 et seq.). The Polish Mathematical society (Polskie Towarzystwo Matematyczne) publishes Prace matematyczne (1955 et seq.) and *Wiadomości* matematyczne (1955 et seq.), descendants of Prace *matematyczno-fizyczne* (Warsaw, 1888–1951) and *Wiadomości* matematyczne (1897–1939). *Acta arithmetica* (Warsaw, 1936–39) was a journal devoted to the theory of numbers.

Hungary also has several other important periodicals: Acta *scientiarum mathematicarum* (1922 et seq.) of the Bolyai institute of the University of Szeged; and Publicationes mathematicae (1949 et seq.) of the Mathematical institute of the University of Debrecen.

Yugoslavia has a large number of periodicals with various sponsors; Publications de *l'Institut mathématique* (Belgrade, 1947 et seq.) of the Serbian Academy of Sciences may be mentioned. Many of the older journals listed above have had a number of different sponsors; thus, several of the Polish journals passed from the Polish Mathematical society to the Polish Academy of Sciences about 1952.

It has also become customary in many of these countries to write every paper in two approximately equivalent versions, one in the native language and one in an international language (English, French, German, Russian).

Soviet Union.—The greater concentration of strength in the central governments of the U.S.S.R. and of the countries under its influence after World War II resulted in a reorganization of the mathematicians and mathematical journals of these countries, in which the Institute of Mathematics of the Academy of Sciences of the country in question took over the influential role generally played by a national mathematical society, even though the latter might continue to exist. However, publication was not exclusively within its purview, and both mathematical societies and universities continued to publish journals. Thus. the Academy of Sciences of the U.S.S.R. (Akademiya Nauk SSSR) published the important Izvestiya *Akademii Nauk SSSR, Seriya matemaiickeskaya* (1937 et seq. in this form); *Prikladnaya matematika i mekhanika* (1933 et seq.) devoted to applied mathematics; *Vychislitel'naya mate-*

matika i vychislitel'naya tekhnika (1953–55), becoming *Vychislitel'naya matematika* (1957 *et seq.*), devoted to the mathematics of computation; *Teoriya veroyatnostei i ee primeneniya* (1956 *et seq.*) devoted to the theory of probability and its uses; and, jointly with the Moscow Mathematical society since 1952, *Matematicheskii sbornik* (see above; the sponsorship of this journal varied considerably), and *Uspekhi matematicheskikh nauk* (1936 *et seq.*), a journal containing long expository papers as well as research papers.

In addition, the various republics within the U.S.S.R. have their own academies with mathematical institutes and periodicals. Of particular importance are the *Trudy Tbilisskogo Matematicheskogo Instituta imeni Razmadze* (Tiflis, 1937 *et seq.*) of the Academy of Sciences of the Georgian S.S.R., and the *Ukrainskiĭ matematicheskiĭ zhurnal* (Kiev, 1949 *et seq.*) of the Academy of Sciences of the Ukrainian S.S.R. Of the numerous mathematical periodicals of individual universities, the mathematics series of the *Uchenye zapiski* ("Scholarly papers") of the state universities of Moscow, Leningrad, Kharkov and Kazan deserve special mention.

Japan and China. — The reorganization of the Japanese university system following World War II resulted in an enormous increase in the number of universities and of university-sponsored mathematical periodicals. In addition to the older Japanese Journal of Mathematics (Tokyo, 1924 *et seq.*), published by the Science Council of Japan, and the Tohoku Mathematical Journal (Sendai, 1911 *et seq.*), published by Tohoku university, one may mention the Nagoya Mathematical Journal (1950 *et seq.*) of the Mathematical institute of Nagoya university, and the Osaka Mathematical Journal (1949 *et seq.*) of the department of mathematics of Osaka university. However, the faculty of science of almost every Japanese university publishes its own journal with one section or series devoted to mathematics, and many mathematics departments publish a journal.

In China the Academia Sinica publishes *Acta mathematica sinica* (Peking, 1953 *et seq.*; vol. 1 and 2 are entitled Journal of the Chinese Mathematical Society, 1951–52) and *Scientia sinica* (1952 *et seq.*; replacing Science Record, 1942–1952).

Other Periodicals. — Other periodicals of importance include the *Monatshefte fur Mathematik* (Vienna, 1948 *et seq.*; formerly *Monatshefte fur Mathematik und Physik*, 1890–1944); *Summa brasiliensis mathematicae* (Rio de Janeiro, 1945 *et seq.*); the Canadian Journal of Mathematics (Toronto, 1949 *et seq.*) of the Canadian Mathematical congress; *Indagationes mathematicae* (Amsterdam, 1939 *et seq.*) of the Royal Netherlands Academy of Sciences; *Compositio mathematica* (Groningen, Neth., 1934 *et seq.*); *Journal d'analyse mathe'matique* (Jerusalem, 1951 *et seq.*); *Portugaliae rnathematica* (Lisbon, 1937 *et seq.*) of the Portuguese Mathematical society; *Revista matemática hispano-americana* (Madrid, 1919 *et seq.*), published jointly by the Royal Spanish Mathematical society and the "Jorge Juan" Mathematical institute; *Collectanea mathematica* (1948 *et seq.*) of the University of Barcelona; *Commentarii mathematici helvetici* (Zurich, 1928 *et seq.*) of the Swiss Mathematical society; *Archiv der Mathematik* (Karlsruhe, 1948–51; Basel and Stuttgart, 1952 *et seq.*). One could easily double the list with other journals of substantial quality devoted primarily to mathematics.

Specialized Periodicals. — After World War I there were established a number of periodicals devoted mainly to applied mathematics. Among these were the *Zeitschrift fur angewandte Mathematik und Mechanik* (Berlin, 1921 *et seq.*), which was founded by R. von Mises; the *Annales de l'Institut Henri Poincare'* (Paris, 1930 *et seq.*); and the Quarterly of Applied Mathematics (Providence, R.I., 1943 *et seq.*). Those started after World War II included *Communications* on Pure and Applied Mathematics (New York, 1948 *et seq.*), the first volume of which was entitled simply Communications on Applied Mathematics; the Quarterly Journal of Mechanics and Applied Mathematics (Oxford, 1948 *et seq.*); the Journal of Rational Mechanics and Analysis (Bloomington, Ind., 1952 *et seq.*; with a change of title to Journal of Mathematics and Mechanics in 1957) of Indiana university; the Journal of the Society for Industrial and Applied Mathematics (Philadelphia, 1953 *et seq.*); and *Zeitschrift fur angewandte Mathematik und Physik* (Basel, 1950 *et seq.*).

Some periodicals devoted to special subjects have already been mentioned among those published in Poland. Others include the Journal of Symbolic Logic (Menasha, Wis., 1936–37; Baltimore, 1938–52; Groningen, Neth., 1953 *et seq.*); the *Archiv fur mathematische Logik und Grundlagenforschung* (Stuttgart, 1950 *et seq.*); the *Zeitschrift fur mathematische Logik und Grundlagen der Mathematik* (Berlin, 1955 *et seq.*); *Tensor* (Sapporo, 1938 *et seq.*); and Mathenzatical Tables and Other Aids to Computation (Washington, D.C., 1943 *et seq.*). Of the many statistical periodicals, two that deal mainly with the mathematical aspects of the subject are mentioned: Annals of Mathematical Statistics (Ann Arbor, Mich., 1930–38; Iowa City, Ia., 1938–39; St. Louis, 1940; Baltimore, 1940 *et seq.*), and *Sankhyā* (Calcutta, 1933 *et seq.*).

Among the periodicals concerned with the history of mathematics may be mentioned Bibliotheca mathematica (Stockholm and Leipzig, 1884–1915), which was edited by G. Enestrom; *Istoriko-matematicheskie issledovaniya* (Moscow, 1948 *et seq.*); and *Scripta mathematica* (New York, 1932 *et seq.*), which also deals with philosophical and expository questions. Much of the material in this field is to be found in journals concerned with the history of science in general and in the publications of the scientific academies.

Abstracting Periodicals. — The Jahrbuch *über die Fortschritte der Mathematik* started to appear in 1871, each annual volume containing detailed abstracts or reviews of mathematical books and papers published during the relevant year, the first year covered being 1868. The *Revue semestrielle des publications mathématiques* (1893–1934), published by the Wiskundig Genootschap of Amsterdam, contained very brief abstracts, aiming at prompt publication rather than detailed analysis. The *Zentralblatt fur Mathematik und ihre Grenzgebiete* (Berlin, 1931 *et seq.*) is intermediate in character between the two; it absorbed the Jahrbuch after World War II. Mathematical Reviews (Providence, R.I., 1940 *et seq.*) is broadly similar to the Zentralblatt; its first editor, O. Neugebauer, had previously edited the Zentralblatt and had left Germany when the Nazis came to power. In 1953 the Institute of Scientific Information of the Academy of Sciences of the U.S.S.R. began publishing (in several sections) an abstracting journal entitled Referativnyi zhurnal; one section, Matematika, was devoted entirely to mathematics and was similar in organization to Mathematical Reviews and the Zentralblatt. As might be expected, coverage of Russian literature was superior to that in the other two journals; it also provided a more comprehensive subject index for each year than either of these. These five journals together give an almost complete set of abstracts of the mathematical literature since 1868.

Many of the periodicals already mentioned contain book reviews; and some also give lists of new papers published in other periodicals.

A number of periodicals permit the publication of brief notes announcing new results without giving proofs. Most such announcements, however, appear in journals published by the great scientific academies: for example, the *Comptes-rendus hebdomadaires des séances* of the Académie des Sciences of Paris; the Rendiconti of the Classe di scienze fisiche, matematiche e naturali of the Accademia Nazionale dei Lincei at Rome; the Proceedings of the National Academy of Sciences of the United States; and the Doklady Akademii Nauk S.S.S.R. of Moscow.

Surveys **of** *Special Topics.* — Publications whose purpose is to summarize recent progress in various fields of mathematics vary from true periodicals to something approaching a series of monographs. Examples include the *Mémorial des sciences mathématiques* (Paris, 1925 *et seq.*), the Ergebnisse der Mathematik und ihrer Grenzgebiete (Berlin, 1932 *et seq.*), the *Trudy Matematicheskogo Instituta imeni V. A. Steklova* (Moscow, 1932 *et seq.*), the Uspekhi matematicheskikh nauk (Moscow, 1936 *et seq.*) and the Ergebnisse der angewandten Mathematik (Berlin, 1952 *et seq.*). Approaching more nearly to series of monographs are the Cambridge Tracts in Mathematics and Mathematical Physics (1905 *et seq.*), the Rice Institute Pamphlets (Houston, Tex., 1915 *et seq.*), the various mathematical subseries of the *Actualités scientifiques et*

industrielles (Paris. 1929 *et seq.)* and the *Annals of Mathematics Studies* (Princeton, N.J., 1940 *et seq.).*

Numerous series of monographs have been published in many parts of the world; a few of the best known are the famous *Collection de monographies sur la théorie des fonctions* (Paris, 1898 *st seq.*) edited by Emile Borel; the *Colloquium Publications* (1903 *et seq.*) of the American Mathematical society; the *Grundlehren der mathematischen Wissenschaften in Einzeldarstellungen mit besonderer Berücksichtigung der Anwendungsgebiete* (Berlin, 1921 *et seq.)*; the *Monografje.matematyczne* (Warsaw, 1932 *et seq.)*; and the *Princeton Mathematical Series* (1939 *et seq.*).

BIBLIOGRAPHY.—F. Klein, *Vorlesungen über die Entwicklung der Mathematik im 19. Jahrhundert,* 2 vol. (1926–27); *World List of Scientific Periodicals,* 3rd ed. (1952); the list of abbreviations of names of journals at the end of the index numbers of *Mathematical* ***Reviews*** gives a rather complete list of periodicals containing papers of mathematical interest. (F. Ss.; J. V. W.)

MATHER, COTTON (1663–1728), American Congregational minister and author, the most celebrated of all American Puritans although an extreme example, rather than typical, of the tradition for which he stood. He lived all his life in Boston. where he was born Feb. 12, 1663, the son of Increase Mather and grandson of John Cotton and Richard Mather (*qq.v.*). He took his A.B. at Harvard in 1678, his A.M. in 1681, was made a fellow in 1690 and joined his father in the ministry of the Second church in 1685.

The prominence of Mather's ancestry, combined with a profound mystical strain, led him throughout his life to believe that he was destined to accomplish great deeds in continuation and perhaps fulfillment of the work which the first colonists had begun. But his heritage worked against him also, for to many of his contemporaries he was the embodiment of an outdated ideology. He saw his political influence dwindle as the Brattle Street church, which advocated a broad basis for church membership, was founded (1698) and prospered; his father was ousted from the presidency of Harvard in 1701, which led him to resign his fellowship in 1703; and Joseph Dudley became governor in 1702. He did not relent in the zeal with which he opposed men and institutions which he believed to be derogations from the primitive purity of Massachusetts, but his tremendous energy came more and more to be channeled into his ministry and the production of nearly 450 separate printed works.

One of Mather's chief concerns was the presence of the supernatural in daily life, and he collected instances of this in his *Memorable Providences Relating to Witchcraft and Possessions* (1689). He is, therefore, generally credited with stimulating the frenzy which culminated in the witchcraft trials of 1692. Although he believed in the presence of witches and was determined to counteract witchcraft, Mather did not generalize about the trials, but weighed each case on its own merits, believing that some had been sentenced unjustly and cautioning the judges to be scrupulous in their acceptance of evidence.

Mather produced sermons and works of scriptural explanation, scientific instruction and political morality. His most famous and valuable work is his biographical and historical collection, *Magnalia Christi Americana* (1702), which contains information about almost every significant man or deed from the founding of New England to his time. He rarely allowed any successful experiment of his to remain unpublished if he felt the information would make for a better life and, therefore, he produced numerous tracts on subjects as diverse as the christianizing of Negroes and the raising of children.

Interest in science, which at one time encouraged Mather to consider a career in medicine, furnished him with a wide European correspondence on natural and supernatural phenomena in America. This resulted in his being elected to the Royal society in 1713 and is reflected in his *Curiosa Americana* (1712–24). He was an enthusiastic leader in the campaign for inoculation against smallpox in 1721, even though popular disapproval resulted on one occasion in a bomb's being thrown into his house. His impressive scholarship and tireless writing gained him an honorary degree from the University of Glasgow in 1710, an award which he especially cherished because of his differences with Harvard. These differences led him to take an interest in the new college in Connecticut, to urge Elihu Yale to contribute to it and to suggest to Gov. Gurdon Saltonstall that the college be named for Yale. Mather appears to have been offered the Yale presidency in 1721.

Mather died on Feb. 13, 1728. He was married three times and had 15 children, only two of whom survived him. He was nervously sensitive and frequently hot-tempered, both of which qualities increased his alienation from the popular trends of his day, such as the antitheocratic political movement and the establishment of heterodox Puritan and Anglican congregations in Boston. Nevertheless, he wielded a strong personal influence, and Benjamin Franklin remembered him with warmth, attributing his own penchant for practical schemes to notions derived from Mather's essays. Mather was the first American minister to organize clubs for young people, and he initiated the practice of regular calls upon aged and ailing parishioners and upon prisoners, as well as making himself available to any who summoned him. Although his writings are saturated with archaisms and learned allusions, he was a conscious literary stylist and achieved passages of literary merit. His written work and his activities reflected his constant zeal for the betterment of his fellows and his sincere devotion to the ideal which he believed was responsible for the settlement of America and indispensable for its success.

BIBLIOGRAPHY.—Cotton Mather's *Diary,* ed. by W. C. Ford (1911–12), biographies by Samuel Mather (1729), Barrett Wendell (1891, 1926) and A. P. Marvin (1892). For bibliography: J. L. Sibley, *Biographical Sketches of Harvard Graduates,* vol. iii (1873–85) and *Literary History of the United States,* vol iii (1949). *See* also K. *B.* Murdock (ed), *Selections From Cotton Mather,* which contains a biographical and critical introduction (1926); Perry Miller, *The New England Mind: From Colony to Province,* which considers Mather in the context of his time (1953). Numerous short articles on Mather's life and activities: in the *Proceedings* of the American Antiquarian Society and of the Massachusetts Historical Society; and in *Publications,* Colonial Society of Massachusetts. (L. Z.)

MATHER, INCREASE (1639–1723), American Congregational minister, author and statesman, a determining influence in the councils of New England during the crucial period when leadership passed into the hands of the first native-born generation, was born in Dorchester, Mass., on June 21, 1639, the oldest son of Richard Mather (*q.v.*). He graduated from Harvard in 1656, took his M.A. degree at Trinity college, Dublin, in 1658 and ministered to various congregations in England. He returned to Boston in 1661, married Maria, daughter of the Rev. John Cotton (*q.v.*), in 1662, and became the father of Cotton Mather (*q.v.*) in 1663. He became teacher of the Second church of Boston in 1664, licenser of the press in 1674, fellow of Harvard in 1675 and in 1685 president of the college. The last office he lost in 1701, in great part as a consequence of political opposition to his stand on the Massachusetts charter.

When, in 1683, Charles II demanded that Massachusetts surrender the original charter by which the citizens elected their own governor, Mather took the lead in opposing the order. He perpetuated the theocratic ideal of the founders by pronouncing compliance with the royal demand to be a sin. After the charter was vacated by the court of chancery in 1686 Mather remained in the forefront of the opposition, hindering the measures of the royal governor, Sir Edmund Andros.

In 1688 Mather was sent to London as the emissary of some of the Massachusetts churches to try to regain the old colonial charter, and in 1690 he was made one of the colony's official agents in England. He stayed in London until 1692, interviewing James II, William III, Queen Mary and many others influential in politics. He enlisted in his cause the good offices not only of his Puritan brethren but also of the Quaker William Penn and of the Anglican bishops Burnet and Tillotson. When prospects of full restoration of the old charter appeared hopeless, Mather turned his energies to procuring measures favourable to the colonists in the ne charter of 1691, and so succeeded as to be allowed to nominate the royal governor and other officers for the first year under that charter. Sir William Phips, the governor of his choice, proved unpopular, as did the charter itself, so that those who longed for the liberties of the old charter refused to concede that its restoration had been an impossibility and held Mather re-

sponsible for the new restrictions.

After leaving the presidency of Harvard, Mather was less active in public affairs, but he wrote much and remained a dominating figure in Congregational councils. He published more than 150 books, most of them theological, but a few dealing with history, biography or, in part, with science. Among the more interesting are his life of Richard Mather (1670), his political tracts written in 1688–93, his *Essay for the Recording of Illustrious Providences* (1684), a collection of narratives of strange happenings in New England with discussion of a few scientific topics, his *Brief History of the Warr With the Indians* (1676) and his account of the Indian mars in New England, *A Relation of the Troubles . . .* (1677). His *Cases of Conscience* (1693) displays his attitude toward the witchcraft trials. Mather died on Aug. 23, 1723.

Harvard developed during Mather's term of office; his agency in England had important historical results; and to the fame given him by these things was added that derived from his reputation as a preacher and scholar. He manifested his interest in science by forming a scientific society in Boston in 1683. His large library reflected the wide range of his reading in politics, science, the classics and history, as well as in theology. His hot temper, his stout championing of his own doctrine — though he was more moderate in debate than most of his adversaries — and his reputed ambition made enemies, who. however, were always outnumbered at home and abroad by those who revered him as a leader. He combined leadership in both church and state with greater effect than had any other Massachusetts minister since the settlement of the colony, and is regarded as the greatest of the native American Puritans.

BIBLIOGRAPHY.—K. B. Murdock, *Increase Mather, the Foremost American Puritan,* detailed biography with a list of Mather's writings and sources of information about him (1925); Cotton Mather, *Parentator* (1724); *W*. Walker, *Ten New England Leaders* (1901); J. L. Sibley, *Biographical Sketches of Harvard Graduates,* vol. i (1873–85). For a study of Mather's time: Perry Miller, *The New England Mind: From Colony to Province* (1953). Likenesses of Mather are reproduced and discussed in K. B. Murdock, *The Portraits* of *Increase Mather* (1924). (L. Z.)

MATHER, RICHARD (1596–1669), U.S. Congregational minister, was born in Lowton, Lancashire. Eng. At 15 he began to teach at a grammar school at Toxteth Park, near Liverpool. In 1618 he attended Brasenose college, Oxford, for a few months, but in November became minister of the Toxteth chapel. His Puritan tendencies led the ecclesiastical authorities to silence him in 1634, and on Aug. 17 of the next year he arrived at Boston, Mass. A year later he became teacher of the church at Dorchester, and held that office until his death on April 22, 1669.

Mather was locally celebrated as a preacher, and his books on the principles of New England Congregationalism together with his activity in colonial church councils made him one of the most famous New England Puritans of his day. He was one of the translators of *The Whole Booke of Psalmes* (1640), the "Bay Psalm Book" designed for use in colonial churches. His greatest achievement was a statement of the creed and polity of Massachusetts Congregationalism which, with but few alterations. was printed as *A Platform of Church Discipline* (1649). This, the '(Cambridge Platform." was for years the basic document of his sect in Massachusetts. He was an active advocate of the "Half-Way Covenant," a plan which provided a modified form of church membership for those who were unable to meet the tests prescribed by the original Congregational polity.

By his first wife, Katharine Holt of Bury, whom he married in 1624, he had six sons, four of whom became ministers His second wife was Sarah Cotton, widow of the Rev John Cotton of Boston. *See* also MATHER, COTTON; MATHER, INCREASE.

BIBLIOGRAPHY.—Increase Mather, *The Life and Death of . . . Richard Mather* (1670), reprinted with Richard Mather's journal of his voyage to New England (1850); Cotton Mather, *Magnalia,* book III, pt. 2, ch 20 (1702) ; W. Walker, *Ten New England Leaders* (1901); *K*. B. Murdock, *Increase Mather,* ch. 1–4 (1925). (K. B M)

MATHEW, THEOBALD (1790–1856), Irish temperance reformer. was born at Thomastown, Ire.. Oct. 10, 1790. A member of the Capuchin order, he successfully conducted a temperance campaign at Cork, where he laboured for many years. His influence, great in Ireland, spread to England and the United States, and in 1847 he was granted a pension by Queen Victoria. He died at Queenstown on Dec. 8. 1856.

See J. F. Maguire, *Father Mathew, a Biography* (1863).

MATHEWS, CHARLES (1776–1835), English actor with a wonderful gift of mimicry, was born in London on June 28, 1776. His father was "a serious bookseller." who also officiated as minister in one of Lady Huntingdon's chapels. Mathews was educated at Merchant Taylors' school He first appeared on the stage in Dublin in 1794 and his London debut took place in 1803 at the Haymarket theatre in the roles of Jabal in *The Jew* and of Lingo in *The Agreeable Surprise.* From this time his professional career was an uninterrupted triumph. Mathews visited the United States in 1822 and 1834; his last appearance in New York city was made on Feb. 11, 1835, when he played Samuel Coddle in *Married Life* and Andrew Steward in *The Lone House.* In 1797 Mathews had married Eliza Kirkham Strong (d. 1802) and in 1803 Anne Jackson, an actress, author of the popular and diverting *Memoirs, by Mrs. Mathews* (4 vol., 1838–39). He died at Plymouth on June 28, 183j.

His son CHARLES JAMES MATHEWS (1803–1878) was born in Liverpool on Dec. 26, 1803. educated at Merchant Taylors' school and then articled to an architect. He went on the stage, appearing at the Olympic theatre, London. in 1835 as George Rattleton in his own play *The Humpbacked Lover.* In 1838 he married Madame Vestris (*q.v.*), then lessee of the Olympic. Their joint management of this and other theatres, including Covent Garden and the Lyceum, failed. Mathews visited the United States in 1838. As an actor, he held in England an unrivaled place in his own peculiar vein of light, eccentric comedy. His wife died in 1856, and Mathews visited the United States again in 1858 and married Mrs. A. H. Davenport. He was one of the few English actors who played in French successfully and was acclaimed in Paris in 1863. At the age of 65 he made a world tour. appearing again in the United States. Returning to England in 1872, he continued to act until his death on June 24, 1878. His last appearance in New York was at Wallack's theatre on June 7. 1872, and in London at the Opéra Comique on June 2. 1877. His last stage appearance was at Stalybridge, Cheshire, in 1878.

See Charles Dickens (ed.), *Life of Charles James Mathews,* 2 vol. (1879); H. G. Paine, *Actors and Actresses of Great Britain and the United States* (1886). (W. J. M.-P.)

MATHEWS, SHAILER (1863–1941), U.S. educator and theologian, one of the leaders in the Social Gospel movement of the late 19th and early 20th centuries, was born in Portland. Me., on May 26, 1863, and educated at Colby university, Waterville, Me., Newton Theological institution; Newton, Mass., and the University of Berlin. From 1884 to 1894 he taught at Colby and thereafter, until his retirement in 1933, occupied various professorial posts in the divinity school of The University of Chicago. During his tenure as dean of the divinity school (1908–33) he was constantly engaged in academic research, public lecturing, editorial responsibilities and a host of ecclesiastical, political and social activities. He held a number of high ecclesiastical and professional offices; contributed significantly to the reorganization of theological education in the United States. Mathews published more than a score of books and hundreds of articles. His major publications include *The Messianic Hope in the New Testament* (1905); *The Spiritual Interpretation of History* (1916); *The Faith of Modernism* (1924); and *Creative Christianity* (193j). His autobiography, *New Faith for Old* (1936), is a significant document for the history of the Social Gospel movement in the United States. He died Oct. 23, 1941. (W. HA.)

MATHEWS, THOMAS (1676–1751), British admiral, was born at Llandaff Court, Llandaff. He entered the navy about 1690 and after various appointments during the war with Spain (1718–20) commanded the "Kent" in the fleet of Sir George Byng (Lord Torrington). From 1722 to 1724 he had the command of a small squadron sent to repress the pirates of the coast of Malabar. He settled at Llandaff until March 1741, when he was appointed to the command in the Mediterranean and plenipotentiary to the king of Sardinia and the states of Italy. His

unfortunate engagement with a Spanish squadron of line-of-battleships near Hyeres in Feb. 1744 marked the lowest pitch reached in discipline and fighting by the fleet in the 18th century. The British fleet followed the enemy in light winds on Feb. 10, and became scattered. Mathews hoisted the signal to form the line, and then when night fell, to lie to. Lestock, who commanded in the rear, was at some distance from the body of the fleet, and obeyed the second order, with the result, apparently desired, that in the morning he was far away from Mathews. The enemy were within striking distance of the van and centre of the British fleet, and Mathews attacked their rear. Lestock never came into action at all. Several captains behaved very bad, and Mathews in anger bore down on the enemy out of his line, while the signal to keep the line was still flying at his masthead. The French and Spaniards got away, and were not pursued, although they were of inferior strength. The battle led to more than 20 courts-martial and a parliamentary inquiry. Lestock was brought to trial, and acquitted on the ground that he had obeyed orders. Mathews was condemned to be dismissed from the service on the ground that he had not only failed to pursue the enemy but had taken his fleet into action in a confused manner. Mathews died in London, Oct. 2, 1751.

See Beatson, *Naval and Military Memoirs,* vol. i (1790; and ed., 1804); Montagu Burrows, *Life of Hawke,* 3rd ed. (1904). The charges and findings at the courts-martial on both Lestock and Mathews were published at the time.

MATHEWSON, CHRISTY (CHRISTOPHER) (1880–1925), famous U.S. baseball player also known as "Matty" and "Big Six." A national league pitcher, his most outstanding achievement came in the world series of 1905 when he shut out the Philadelphia Athletics in three games. Born on Aug. 12, 1880, at Factoryville, Pa., he was one of the first of five baseball immortals voted into the National Baseball Hall of Fame at Cooperstown, N.Y., in 1936. He was one of the first college men to enter the major leagues, having been a baseball and football player at Bucknell university, Lewisburg. Pa. A right-handed thrower and batter, he pitched for the New York Giants from 1900 to 1916, and the Cincinnati Reds in 1916; he also was used in the outfield and at first base for New York. He won 372 games in his career, and was the master of the fadeaway pitch, later known as the screwball (see BASEBALL: *Pitching).* Noted as a control pitcher, Mathewson established an all-time league record of 2,499 strike-outs, and a season mark of 267 strike-outs, in 1903. He won 30 or more games in four separate seasons and 20 or more games in nine other years. He pitched a no-hit, no-run game (*v.* St. Louis) on July 15, 1901. He was manager of the Cincinnati club from 1916 to 1918, and served as president of the Boston Braves from 1923 to 1925. He died of tuberculosis at Saranac Lake, N.Y., on Oct. 7, 1925.

(D. SR.)

MATILDA (1102–1167), empress, was the daughter of Henry I of England by his first marriage. She was betrothed in 1109 and married in 1114 to the German emperor Henry V. When her husband died (1125) leaving her childless, her father, whose only surviving legitimate child she then was, persuaded his reluctant barons to accept her, on oath, as his successor (Jan. 1, 1127). The novel prospect of a female ruler was itself unwelcome; Matilda's 17-year absence in Germany (where she was not unpopular) and her apparent arrogance estranged her from her father's subjects. Difficulties also might result from her remarriage to provide for the succession. Her marriage in 1128 to Geoffrey Plantagenet, heir to Anjou and Maine (designed by Henry I, like her first marriage, for political ends), flouted the barons' stipulation that she should not marry outside England without their consent, and was unpopular in Normandy and England. On Henry I's death, his nephew Stephen (*q.v.*) by prompt action secured England and was recognized by Pope Innocent II. Matilda and Geoffrey, however, made some headway in Normandy. Matilda's subsequent challenge to Stephen's position in England mainly depended on the support of her half-brother Earl Robert of Gloucester. After the defeat and capture of Stephen at Lincoln (Feb. 1141). Matilda was elected "lady of the English" and would have been queen could she have proceeded to coronation, but active support for her cause still came mainly from the western counties. Her chance of consolidating her precarious victory was swiftly destroyed by a reaction initiated by her tactless handling of London. After her defeat at Winchester in Sept. 1141, her supporters, slowly reduced by death and defection, maintained a stubborn defense until Earl Robert died (1147) and Matilda retired (1148) to Normandy, of which her husband had gained possession. She continued to interest herself in the government of the territories of her eldest son, the future Henry II of England. She died in Normandy on Sept. 10, 1167.

See O. Rossler, *Kaiserin Mathilde* (1897); J. H. Round, *Geoffrey de Mandeville* (1892). (ER. *S.)*

MATILDA (1046–1115), countess or margravine of Tuscany, known as the GREAT COUNTESS, was a member of the great Lombard house of Canossa. Her great-grandfather Adalbert Atto (d. 988) was count of Reggio, of Modena and of Mantua; her grandfather Tedald (d. 1012) added Ferrara and Brescia to these possessions, with the title of count of the Northern march. Her father Boniface, in 1027, combined the latter march with that of Tuscany, which with the duchy of Spoleto made him one of the major princes in Italy. The house of Canossa had been traditionally loyal to the imperial cause; but after his marriage, late in the 1030s, to Beatrice of Bar, daughter of Frederick II of Upper Lorraine, Boniface began to incur the emperor Henry III's mistrust; and in 1052 was assassinated. In the next three years his elder daughter Beatrice and his son Frederick also died, leaving Matilda as sole heiress to his great estates. In 1054 the widowed Beatrice married the malcontent Godfrey the Bearded of Lower Lorraine, whom Henry III had dispossessed of his duchy. In consequence Henry took her and Matilda into custody in Germany but they were released after Henry's death (1056). Then Godfrey's brother Frederick, an adherent of the Hildebrandine policy of reform, was elected pope as Stephen X (IX) (1057–58), and the house of Canossa was further committed to the papal side against the emperor in the conflict over investiture. Throughout the reign of Henry IV, both before and after her mother's death (1076), Matilda maintained the cause of the successive pontiffs, Gregory VII, Victor III, Urban II, Paschal II, with varying fortune but with undaunted resolution. She aided Gregory against the Normans in 1074 and attended the synod at which Guibert was condemned and deprived of the archbishopric of Ravenna in 1075. Her fief of Canossa was the scene on Jan. 28, 1077, of the celebrated penance of Henry IV. She provided asylum for Henry's second wife, Praxedis, and urged his son Conrad to revolt against him. In the course of the struggle her lands were plundered and Pisa and Lucca lost, but she remained steadfast. Before her death, by means of a league of Lombard cities, Matilda had recovered all her possessions.

The donation of her lands to the Holy See, made in 1077, was renewed in 1102 but was either revoked or modified in 1111, when she made the emperor Henry V her heir. This led to a long contest between the papacy and the empire for the Matildine inheritance. Matilda was twice married, first in 1069, to Godfrey the Hunchback of Lower Lorraine, her stepfather's son, who was murdered in 1076; and then in 1088, to Welf V (later duke of Bavaria as Welf 11), from whom she finally separated in 1095. Both were marriages of policy, which counted for little in her life. Matilda, who had received an excellent education from her mother, spoke Italian, French and German fluently and wrote many Latin letters. She collected an extensive library and supervised an edition of the Pandects of Justinian. Anselm of Canterbury sent her his *Meditations.* She died at Bodeno near Modena on July 24, 1115, and was buried in the Benedictine church at Polirone, whence her remains were taken to Rome by order of Urban VIII in 1635 and interred in St. Peter's.

The contemporary record of Matilda's life in rude Latin verse, by her chaplain Domnizone (Donizo or Domenico), is preserved in the Vatican library. The best edition is by L. Bethmann in the *Monumenta Germaniae historica,* series *Scriptores,* vol. xii, 348–409; the text, with an Italian translation, was published by F. Davoli, *Vita della grande contessa Matilda di Canossa* (Reggio nell' Emilia, 1888).

See A. Overmann, *Gräfin Mathilde von Tuscien; ihre Besitzungen und ihre Regesten* (1895); A. Colombo, "Una Nuova vita della contessa Matilda," *Atti della Reale Accademia delle scienze,* vol. 39 (1904); A. Pannenborg, *Studien zur Geschichte der Herzogin Matilde von Canossa* (1872); N. Grimaldi, *La Contessa Matilde e la sua stirpe feudale* (1928); and R. de Briey, *Mathilde, duchesse de Toscane* (1934).

MATINS, a word now only used in an ecclesiastical sense for one of the canonical hours in the Roman Breviary, originally intended to be said at midnight, but sometimes said at dawn. In the modern Roman Catholic church, outside monastic services,

the office is usually said on the preceding afternoon or evening. In the Church of England the term matins is sometimes used for the order of public morning prayer.

MATISSE, HENRI EMILE BENOÎT (1869–1954), considered by many to be the most important French painter of the 20th century, was born at Le Cateau (Nord), on Dec. 31, 1869. He started studying law, but at the age of 20 took up painting while recovering from an illness. He studied first under the popular Adolphe Bouguereau but, finding him too academic, soon moved to the greater freedom of Gustave Moreau's studio. There he remained for five years, studying and copying the old masters in the Louvre. Matisse could have followed this profitable path but when he discovered the great Impressionist painters, especially Camille Pissarro. his whole outlook radically changed, and in 1897 he exhibited his first successful original picture, the large "Dinner Table" (Niarchos collection). Matisse then threw himself into the stream of the most advanced art and. although forced to live on a pittance, joined the avant-garde painters, André Derain. Georges Rouault and Maurice de Vlaminck. In 1901 he exhibited at the Salon des Indépendants, and Berthe Weill showed several of his canvases in her small gallery. In 1904 the most influential dealer in Paris, Ambroise Vollard, gave him a one-man show and also bought the "Dinner Table." Matisse was then launched. but it was not until the next year that he became a public sensation when he exhibited an astounding and brilliant portrait of his wife, "Woman With the Hat" (Hass collection, San Francisco. Calif.) at the famous 1905 Salon des Indépendants Matisse and his friends had unleashed colour so riotously that they were dubbed the *Fauves* or "wild beasts," and visitors to the "central cage," the gallery where their pictures were hung. howled and jeered. It was an American, Leo Stein, brother of Gertrude Stein, who had the courage to buy the '[Woman With the Hat."

In 1906 Matisse painted the first of a long series of masterpieces, "Joy of Life" (Barnes foundation. Merion, Pa.). A visit to Morocco gave him a new insight into colour; a trip to Italy, where he saw Giotto and the Sienese, a new vision of line; while an exhibition of Islamic art in Munich introduced him to the vivid and intricate designs of the east.

Matisse then executed three of the most important paintings of his career, for the famous Russian collector Sergei Shchukin: "Harmony in Red" (1908) and the two decorative panels for the staircase of his Moscow palace, "Dance" and "Music" (1910). Shchukin's large collection of Matisses was acquired by the Hermitage museum, Leningrad.

For the next seven years Matisse produced at least one masterpiece a year: "The Red Studio" (1911; Museum of Modern Art, New York city), "Moorish Cafe" (1912–13; Hermitage), "Mme. Matisse" (1913; Hermitage), "Mlle Landsberg" (1914; Philadelphia), "Moroccans" (1916; Marx collection, Chicago) and in 1917, perhaps Matisse's greatest year. "Piano Lesson" (Museum of Modern Art), "Music Lesson" (Barnes foundation) and the triptych "Three Sisters" (Barnes foundation). The first Matisses in the U.S. were shown by Alfred Stieglitz in 1908 at his "291" gallery, New York city. In the Armory show (1913) Matisse had 13 paintings.

After such an amazing output of important canvases with their invention and daring distortion, Matisse went to live in Nice, Fr, where the Mediterranean atmosphere proved a relaxation, reflected especially in his brilliant paintings of Moorish odalisques During this period between World Wars I and II his pictures ceased to astonish the avant-garde, but their daring colour delighted an ever-increasing group of purchasers. After a short trip to Tahiti he executed an important mural (1932–33) for the Barnes foundation. During World War II Matisse had a new burst of creative energy, and even in his 80th year produced paintings such as "Egyptian Curtain" (Phillips gallery, Washington. D.C.) and "Large Interior in Red" (Musée Nationale d'Art Moderne. Paris), both reminiscent of his finest period.

Throughout his life Matisse produced considerable sculpture, many lithographs and etchings, and illustrated numerous books. notably Podsies de *Stéphane Mallarmé* (1932). He also designed the settings for two important ballets: The Nightingale (1920) for Diaghilev, and Rouge et **Noir** (1939).

In 1943 Matisse retired to Vence, a small village in the hills behind Nice. There he designed the entire decoration of the Chapel of the Rosary for the Dominican nuns (1948–51). His work included the brilliant stained-glass windows, furniture, vestments and mural paintings on white tiles with strikingly original stations of the cross. This chapel, visited by thousands of tourists yearly, was described by Matisse himself as his masterpiece. He died in Nice on Nov. 3, 1954.

See also PAINTING: Fauvism; POSTIMPRESSIONISM.

See Alfred *H.* Barr, Jr., *Matisse: His Art and His Public,* with a complete bibliography (1951). (H. CD.)

MATLOCK, a market town and urban district in the West Derbyshire parliamentary division, Eng , 18 mi. N. of Derby by road. Pop. of urban district (1951) 17,756; area 25.9 sq.mi. Pop. of Matlock town 6,539, of Matlock Bath 1,658. In the Peak district, Matlock lies where the Derwent river enters a deep narrow valley cut in the mountain limestone. Toward the southern end of this gorge is Matlock Bath; at the northern end, beyond Matlock and over a 15th-century stone bridge. is Matlock Bank, built on a hill crowned in 1853 by a therapeutic establishment. At Matlock Bath three medicinal springs (temp. 68° F.) were discovered in the 17th century, and by the 19th century it had become celebrated for hydropathic treatment. Matlock is a holiday centre for the Peak district. Stone quarrying is carried on locally and there are cotton, wool, corn and paper mills. The mill at Cromford (pop 1,247) was built in 1771 by Sir Richard Arkwright. Formerly lead was mined; a large vein was discovered in 1953

MATO GROSSO, a state in the west-central region of Brazil, bounded north by Amazonas and Pará, east by Goiás and Minas Gerais. southeast by São Paulo and Paraná, northwest by Rondônia and Bolivia and southwest by Paraguay. Area 484,486 sq mi. Pop. (1950) 522,044. Most of Mato Grosso lies on the Brazilian plateau and marks the watershed which separates the Amazon basin from the basin of the Plata river system. The western section of the state, chiefly a flood plain (pantanal), is among Brazil's best grazing lands. In the southeast is the valley of the Paraná, along the east the valley of the Araguaia, and to the north the tableland descends to the basin of the Amazon. Elevations range from 300 to 400 ft. in the lowlands, to 3,000 ft. on the plateau. Natural vegetation consists mainly of patches of scrub growth and light forest. The annual average rainfall is 50–60 in. with a distinct dry season from May to September.

Livestock raising and agriculture represent the principal economic activities of Mato Grosso, which is one of the great frontier regions of the world. The state supports more than 6,000,000 head of cattle, many being driven to market in São Paulo each year. The state is known to have important deposits of gold, diamonds, iron, manganese and platinum. The inadequacy of transportation facilities is a major barrier to further development. Mato Grosso's 4,000 mi. of roads are largely trails, many of which are impassable during the rainy season. Paved roads are seldom found outside the limits of the principal cities of Cuiaba (pop. [1950] 23,745), the state capital, Corumbá (18,725) and Campo Grande (31,708).

Cuiabá (*q.v.*) has not attained the economic importance of Corumba (*q.v.*) or Campo Grande in modern times because of its isolation. Campo Grande and Corumbá are served by the Brazilian Northwest railroad, which provides access to Santos and Rio de Janeiro. Coast-to-coast travel is possible via the Corumbá-Santa Cruz (Bolivia) railroad.

Campo Grande is the main agricultural centre in Southern Mato Grosso, a position enhanced by the railroad communication with São Paulo, the movement of the coffee frontier toward the west and northwest of São Paulo state. and the concomitant shift of population. The existence of terra roxa and other fertile soils in the Campo Grande region and south into Dourados allows a wide diversity of crops to be grown. Coffee. rice, cotton, sugar cane and corn, the main commercial crops, are produced in that order. Colonization projects have been instituted by the federal and state governments in the Dourados region, with emphasis upon coffee cultivation.

Mato Grosso ("great woods") was settled first by pioneering Paulistas after they had been forced to retreat from Minas Gerais by the so-called war of the *emboabas* in 1709, over mining rights in the gold fields. The state was initially a district of the captaincy of São Paulo with the founding of Cuiabá in 1719, and in 1748 it became an independent captaincy. Mato Grosso became a province of the empire in 1822 and a state of the federal union in 1889. While sections of the state remained unexplored in the 1960s, the expedition of Marshal Candido Mariano Rondon in the early part of the 20th century furnished the first complete, accurate data about Mato Grosso. (J. L. TR.)

MATRIARCHY. Tales are still told of villages (always outside the ken of the narrator) where only women dwell. whose population is maintained by the admission annually of one male who is put to death when his procreative task is done. Did such exist, therein might be found that combination of female dominance, female kinship, female inheritance which (strictly speaking) alone constitutes matriarchy or the rule of the mothers. Again there are communities the bulk of whose adult male population departs periodically to engage in some seasonal industry elsewhere. There the women form a permanent element in the social and economic order, but though in a degree matripotestal. these communities are in many instances patrilineal and the authority of the males is the ultimate basis.

Distribution of **Matriliny.**—Matriliny, however, the custom of reckoning kinship, descent, succession and inheritance in the female line, still survives in various parts of the world. In Australia it is associated with a simple dual system. It is found in Sumatra, in Micronesia and Melanesia, again along with the dual organization. The primitive folk in Formosa have it. India has it in Assam among the Garos, again with a dual organization, and the Khasias. On the Malabar coast are matrilineal groups, and there are Brahmans whose succession is designated by marumakathayyam—of the sister's son, a feature of the matrilineal order. The Nairs, a warrior community which once practised polyandry. are matrilineal. It still survives in Africa about Lake Nyasa. among the Ila speaking peoples of Northern Rhodesia, in Ashanti, among lower groups in Dahomey, on the Gold and Ivory Coasts. The Iroquois in North America were matrilineal, and in their polity women played an important part—in the selection and dismissal of chiefs. It is found among many Indian tribes. (See L. Morgan, *Ancient* Society.)

Locality.—Sometimes the group is matrilineal but patrilocal, as in Africa where the wives settle in their husbands' villages. Elsewhere, as among the Rhasias, the group is matrilineal and matrilocal, the husband living in his wife's village. That the locality of marriage affects the social order profoundly, needs no elaborate proof. In those cases where marriage is matrilocal and kinship is matrilineal, the wife's kin form a definite local group, ready and able to exert supreme authority in cases of conflict, but the husband, the father, has a meed of respect in the family and in his wife's community. Every social system contains both the seeds of conflict, and devices for dealing with them as and when they may arise. In matrilineal societies where patrilocality prevails. the women as in Africa have evolved organizations on the basis of sex solidarity—secret societies (q v.).

Survivals.—Many customs have been interpreted as survivals of a former matrilineal order, such as the important social functions discharged by the maternal uncle in initiation rites, at birth, marriage and death (see AVUNCULATE). Some at least are compatible with a patrilineal system in which cross-cousin marriage was appreciated for its economic and social advantages. Here and there women are selected as priestesses, ministrants to divine beings, sometimes by reason of the demand of a male deity for a female servant—more often, by reason of the special psychological characteristics of her sex. But that may and does happen, consistently enough, in sternly patripotestal communities.

Social Theories.—From the time of Bachofen whose work on Mutterrecht was the first scientific attack on the problem, students of social theory have been tempted to see in the matrilineal system, the primitive form of society because "paternity was a matter of inference as opposed to maternity which is a matter of observation" (Maine, Early Law and *Custom*). They pointed to cases of polyandry where paternity was uncertain but laid stress on the patrilineal order of the Tibetans and Todas where paternal polyandry prevails. Ideas such as these survive, revive, die down only to reappear, sometimes reinforced by a parade of biological, psychological and sentimental argument adorned by a wealth of illustration garnered from China to Peru. which ignores the verdict of modern anthropological research that "in all parts of the world we find maternal kinship side by side with institutions of paternal authority," and "in all the matters in which the father and the mother are vitally essential to the child, kinship has to be counted on both sides." (Malinowski, Sex and Repression in Savage Society.) The family is a continuous instrument essential for the transmission of culture, and human society as we now know it, and as the earliest records of humanity portray it. is a cultural phenomenon, and the family is always a bilateral unit. It is true that everywhere descent, succession and inheritance are determined unilaterally, either by matrilineal or patrilineal reckoning, but it is also true that some of the elements which compose Status in the most marked matrilineal society are due to paternality. Speculation may lay stress on the assumed priority of matriliny, though the unilinear theory of social evolution has long been discarded. So keen a mind as that of Maine never imagined that "any amount of evidence of law or usage, written or observed. would by itself solve the problems which cluster round the beginnings of human society," and Darwin, leader of a host of profound biological thinkers, declared firmly for the conclusion proffered by the latest expert critic that "the hypothesis according to which promiscuity has formed a general stage in the social history of mankind is one of the most unscientific ever set forth within the whole domain of sociological speculation." (Westermarck, History of Hzrman *Marriage,* 5th ed.) From promiscuity through matriarchy to patriarchy was the scheme proposed. The family (the bilateral unit) exists always, everywhere, and motherhood and fatherhood are nowhere independent, exempt from the pressure of reciprocity, the primeval principle of social organization.

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MATRIX. The term matrix in mathematics is due to James Joseph Sylvester (1850), who applied it to a rectangular array of numbers "out of which determinants can be formed." The modern concept of a matrix as a hypercomplex number is due to William Roman Hamilton (1853) and Arthur Cayley (1858). Matrix theory has found application in many branches of mathematics, including algebraic and differential equations, astronomy, mechanics, electric circuit theory, quantum mechanics, relativity, nuclear physics and aerodynamics. David Hilbert (1904) introduced matrices of infinite order in connection with a theory of integral equations. The theory of infinite matrices has grown into an important branch of mathematics.

A system of linear equations such as

$$\begin{aligned} 2x + y - 2z &= -2, \\ x - 3y + 5z &= 10, \\ 3x - y + 4z &= 13 \end{aligned}$$

determines two matrices, namely

$$\begin{bmatrix} 2 & 1 & -2 \\ 1 & -3 & 5 \\ 3 & -1 & 4 \end{bmatrix}, \qquad \begin{bmatrix} 2 & 1 & -2 & -2 \\ 1 & -3 & 5 & 10 \\ 3 & -1 & 4 & 13 \end{bmatrix}.$$

The first is called the coefficient matrix, the second the augmented matrix. The system of equations is, in fact, essentially determined by the latter.

The commonly accepted definition of matrix is that of Sylvester, namely a rectangular array of numbers. Most authorities, however, feel that the definition is incomplete until the operations to which a matrix is subject have been defined and therefore, prefer to define a matrix as a number of a total matric algebra. A modern point of view consists in first defining linear transformations, or endomorphisms of a vector space, and investigating their prop-

erties. Then, since a matrix is a representation of a linear transformation, its properties may be defined from those of the linear transformation.

A total matric algebra of order n^2 is the set of all n by n arrays, or matrices,

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdot & \cdot & \cdot & \cdot \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

whose elements a_{ij} are numbers of a given field or ring R, subject to the operations to be defined. If B is another such matrix, the sum $A+B$ is obtained by adding corresponding elements. The product AXB is the matrix whose element in row r and column s is the inner product of the rth row of A by the sth column of B, namely

$$a_{r1}b_{1s} + a_{r2}b_{2s} + \cdots + a_{rn}b_{ns}.$$

A number of the field or ring R is called a scalar. The scalar product kA of the matrix A by the scalar k is obtained by multiplying every element of A by k. Addition of matrices is associative and commutative, and multiplication is associative and distributive, but is not usually commutative.

The matrix O, each of whose elements is 0, is the identity of addition, since $O + A = A + O$ for every matrix A. The matrix

$$I = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & \cdots & 0 \\ \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & \cdots & 1 \end{bmatrix}$$

having 1's in the main diagonal and 0's elsewhere, is the identity of multiplication, and is called the identity matrix. A matrix having 0's in every position outside the main diagonal is called a diagonal matrix.

Determinant theory (*see* DETERMINANT) is properly a branch of the theory of matrices. Every square matrix has associated with it a scalar, called its determinant, which serves as a norm or absolute value. Thus the determinant of the product of two matrices is equal to the product of the determinants of the factors. A matrix whose determinant is not equal to zero is said to be nonsingular, and possesses an inverse A^{-1} such that $A^{-1}A = AA^{-1} = I$. A singular matrix has no inverse, but for every singular matrix A there is a nonzero matrix B such that $AB = BA = O$.

If x is an indeterminate, the matrix $A - xI$ is called the characteristic matrix of A, and its determinant $d(A-xI) = f(x)$ is called the characteristic function. The Hamilton-Cayley theorem states that $f(A) = O$; *i.e.*, that every matrix satisfies its characteristic equation. Hence every n by n matrix satisfies an equation $m(x) = 0$ with scalar coefficients of minimum degree $\mu \leqq n$. If $\mu < n$, the matrix is called derogatory. A square matrix may be considered as an operator transforming one vector into another. (*See* VECTOR ANALYSIS.) Thus

$$\begin{bmatrix} 2 & 1 & -2 \\ 1 & -3 & 5 \\ 3 & -1 & 4 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} = \begin{bmatrix} -2 \\ 10 \\ 13 \end{bmatrix},$$

or $A\zeta = \eta$. Thus the solution of a system of linear equations is the process of finding the vector ζ when the vector η and the matrix A are given. If A is nonsingular, $\zeta = A^{-1}\eta$.

The rows of a matrix may be considered as a set of vectors, and the columns constitute another set of vectors. The number of linearly independent row vectors is equal to the number of linearly independent column vectors, and this number is called the rank of the matrix. The rank is also equal to the order of a nonsingular minor matrix of maximum order. The rank is not changed when a matrix is multiplied on either side by a nonsingular matrix. A system of linear equations in n unknowns has no solution unless the rank of the augmented matrix is equal to the rank of the coefficient matrix. If these ranks are both equal to r, there are $n - r$ linearly independent solutions, and every solution is a linear combination of these.

Calculations with matrices are much simplified by the use of elementary transformations (Hermann Grassmann, 1862, and Leopold Kronecker, 1866). Elementary transformations on the rows of a matrix are of three types: (1) the interchange of two rows; (2) the multiplication of the elements of a row by a unit of R; (3) the addition to the elements of a row of k times the corresponding elements of any other row, k being in R. An elementary matrix is obtained by applying an elementary transformation to the identity matrix I. Every elementary transformation on the rows of a matrix A can be accomplished by multiplying A on the left by the corresponding elementary matrix. Analogous results hold for columns and right multipliers. Every unimodular matrix (*i.e.*, a matrix whose determinant is a unit of R) is a product of a finite number of elementary matrices.

If P and Q are unimodular, the matrices A and $B = PAQ$ are called equivalent. Let the elements of A be either integers or polynomials in x. The quotients $h_i = d_i/d_{i-1}$, where d_i is the greatest common divisor of the i-rowed minor determinants of A, are called the invariant factors of A, and are invariant under the relation of equivalence. Two matrices are equivalent if and only if they have the same invariant factors.

A linear homogeneous transformation $x'_i = \sum a_{ij}x_j$ can be written $\zeta' = A\zeta$ where ζ is the column vector whose components are $x_1, x_2, \cdots, x_n$. The matrix A is called the matrix of the transformation. If new variables are introduced by means of the substitution $\zeta = P\eta$, $\zeta' = P\eta'$, then $\eta' = P^{-1}AP\eta$, which is a transformation of matrix $P^{-1}AP$. Such a substitution corresponds to a change of frame of reference in projective geometry.

If P is unimodular, the matrices A and $B = P^{-1}AP$ are called similar. Two matrices A and B nith element in a field are similar if and only if their characteristic matrices $A - xI$ and $B - XI$ have the same invariant factors.

A homogeneous polynomial such as

$$\sum a_{ij}x_ix_j \qquad (i, j = 1, 2, \cdots, n)$$

is called a quadratic form. Such forms arise as the elements of length in differential geometry and the theory of relativity. There is no loss of generality in assuming that $A = (a_{ij})$ is a symmetric matrix—that is, $A = A^{\mathsf{T}}$ where A^{T} (the transpose of A) is obtained from A by changing rows to columns. The quadratic form may be written $\zeta^{\mathsf{T}}A\zeta$ where ζ^{T} is the row vector $(x_1, x_2, \cdots, x_n)$ and ζ is the column vector composed of the same letters. If new variables are introduced by means of the linear substitution $\zeta = P\eta$, the new quadratic form $\eta^{\mathsf{T}}P^{\mathsf{T}}AP\eta$ has the (symmetric) matrix $P^{\mathsf{T}}AP$.

Two symmetric matrices A and B are called congruent if a nonsingular matrix P exists such that $B = P^{\mathsf{T}}AP$. If R is the real field, a matrix P can be found so that B has 0's everywhere except in the main diagonal, and with diagonal elements which are either 0 or 1 or -1. The number of nonzero elements in the diagonal is the rank, and the number of 1's diminished by the number of -1's is called the signature. These are invariants, and determine the matrix up to a congruence transformation.

In Euclidean geometry, an orthogonal transformation has a matrix P such that $P^T = P^{-1}$. Rotations are transformations of this type. An important problem is to reduce a quadratic form to diagonal form by means of an orthogonal transformation. Since $B = P^{\mathsf{T}}AP = P^{-1}AP$, this is both a similarity transformation and a congruent transformation. If R is the real field, it is possible to find an orthogonal matrix P such that B is diagonal, its diagonal elements being the (real) roots of the characteristic equation of A.

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Introduction to the Theory of Determinants and Matrices (1958); Franz E. Hohn, *Elementary Matrix Algebra* (1958); Ross A. Beaumont and Richard W. Ball, *Introduction to Modern Algebra and Matrix Theory* (1954). (C. C. M.)

MATSUDAIRA TSUNEO (1877–1949), Japanese diplomat and statesman, was born in Tokyo on April 17, 1877. In 1902, upon graduating from Tokyo Imperial university, he entered the diplomatic service. After assignments in China, England and France, he represented Japan in post-World War I discussions with the Soviet Union and also attended the Washington conference (1921–22). He then served as ambassador to Washington (1924–28), when U.S.-Japanese relations were strained by the Oriental Exclusion act passed by the United States congress. He was also ambassador to Great Britain (1929–36).

At the London Naval conference in 1930 Matsudaira helped secure an increase in Japan's allotted naval strength, which however, failed to satisfy the rabid militarists at home. From 1936 to June 1945, as imperial household minister, he was a moderate adviser of the emperor.

In 1947, being elected to the diet, he became president of the house of councilors (upper house). He died in Tokyo on Nov. 11, 1949. (HN. KN.)

MATSUE, ancient castle town of Japan on Honshu Island and capital of Shimane prefecture at 35° 28′ N., 133° 04′ E., is on a spit which cuts an arm of the Sea of Japan nearly in two. The city is a centre of land and sea communications and an important commercial centre. Political amalgamation with small adjacent villages from 1940 increased the area of the city from 3.8 sq.mi. to 57.5 sq.mi.; its population increased from 55,500 to 97,857 by the 1955 census. (C. A. MR.)

MATSUKATA MASAYOSHI, PRINCE (1835–1924), Japanese statesman, was born in Kagoshima of a Satsuma samurai family on hug. 17, 183j. As a young man he was a close friend of Okubo Toshimichi (*q.v.*), and it was in large part through the influence of Okubo that Matsukata became active in the movement to overthrow the shogunate.

In the new government Matsukata held the positions of governor of Tosa province (from 1868), assistant minister of finance (from 1874), home office (1880), and minister of finance (1881). But it was not until after Okubo's death in 1878 that Matsukata came into his own. After serving as the nation's representative at the Paris exposition of 1878, he returned to Japan to become the major advocate and executor of financial reform. The government had met the financial strain of modernization, which required great outlays, and of the suppression of the Satsuma rebellion (*q.v.*; 1877–78), by printing paper money. By the 1880s, currency was badly depreciated, specie was being hoarded, and government revenues, because of the fixed tax on land. were declining in value. Matsukata won the government over to a policy of stringent retrenchment. Government expenses were cut, factories owned by the government were sold to private buyers and paper money was redeemed. The Bank of Japan was founded with the right to issue convertible notes. In a period of three years the currency had been stabilized and government finances restored to health. Matsukata, who was created a prince in 1922. died at Tokyo on July 2, 1924. (T. C. SH.)

MATSUMOTO, an industrial city in a mountain basin of central Japan, on Honshu Island, at 36° 14′ N., 137° 58′ E., is noted for its important silk industry. Silk production dates from feudal times when it was encouraged by the feudal lord or daimyo, because the price silk commanded would compensate for the cost of transportation over the mountain passes. Mulberry and fruit are grown on terraces encircling the floor of the basin. Hot springs and skiing resorts in the surrounding mountains made the city a tourist centre. The city increased in area from 7.3 sq mi. in 1940 to 83 sq mi.; the population increased from 72,800 to 145,228 between 1940 and the 1955 census. (C. A. MR.)

MATSUO BASHŌ (pseudonym of MATSGO MUNEFUSA) (1644–1694), the greatest of the Japanese haiku poets, came from a minor samurai family of Ueno, Iga province, and was in the service of Sengin (the pen name of Yoshitada Tōdō), the son of the local lord, when he became interested in haiku (see JAPANESE LITERATURE). In 1666, after Sengin's death, Bash6 gave up his life as a samurai to devote himself to this form of verse. In 1673 he moved to Edo (modern Tokyo), where he gradually acquired a reputation as a poet and critic. He attracted wide attention with the verse:

On a withered branch
A crow has alighted:
Nightfall in autumn.

In 1684 Bash6 made the first of the journeys that figure so importantly in his work. His accounts of his travels are prized not only for the haiku that record various sights along the way but also for the equally beautiful prose passages that furnish the backgrounds. Oku no Hosomichi ("The Narrow Road of Oku," 1694), describing his visit in 1688 to northern Japan, is one of the loveliest works of Japanese literature.

The haiku previous to Bashō's emergence as a master had been subject to two evils: staleness, the result of the imposition of strangulating codes of rules intended to make this popular form of verse "respectable"; and ephemerality, the result of cramming with allusions to current gossip, supposedly so as to keep it lively and up-to-date. Bashō, deploring both, insisted that the haiku must be at once unhackneyed and eternal; he advised his pupils, "Do not seek to follow in the footsteps of the men of old; seek what they sought."

On his travels Bash6 also met local poets and engaged with them in the composition of linked verse (renga), an art in which he so excelled that some critics believe his linked verse was his finest work. When Bashō began writing in this medium the connection (or link) between successive verses had generally involved a pun or play on words, but he insisted that poets must go beyond mere verbal dexterity and link their verses by "perfume," "echo," "harmony" and other delicately conceived criteria.

One term frequently used to describe Bashō's poetry is ***sabi,*** which means the love of the old, the faded and the unobtrusive, a quality found in the verse:

Scent of chrysanthemums .
And in Nara
All the ancient Buddhas.

Here the musty smell of the chrysanthemums blends with the visual image of the dusty, flaking statues in the old capital. In still other verses a combination of the momentary and eternal suggests the Zen philosophy that underlies much of Bashō's work.

Bash6 led a life of austerity that contrasted with the general flamboyance of his time. On occasion he withdrew from society altogether. Later men, honouring both the man and his poetry, revered him as the "saint of the haiku," and, indeed, no writer in Japan has been more loved or respected.

See Kenkichi Yamamoto, *Bashō* (1957); "The Narrow Road of Oku and Other Writings," Eng. trans. by Donald Keene (ed.) in *Anthology of Japanese Literature (1955).* (DD. K.)

MATSUYAMA, seaport on the northwest coast of Shikoku Island. Japan, a tourist, industrial and communication centre and capital of Ehime prefecture, is located at 33° 50′ N., 132° 46′ E., in the rich agricultural Dogo plain. Since 1940 the city area has increased from 6.9 sq.mi. to 77.8 sq.mi.; the population rose from 117,500 to 213,457 between 1940 and the census of 1955. Cotton and synthetic textiles are the leading industries; lesser industries are chemicals, paper and machinery. The surrounding area produces citrus fruit. persimmons and loquats. Originally a castle town. Matsuyama still possesses an important castle museum and park. After World War II. the city was one of the first to use modern city planning in rebuilding. (C. A. MR.)

MATTER: see KINETIC THEORY OF MATTER; ATOM; NUCLEUS.

MATTERHORN, one of the best-known mountains (14,688 ft.) in the Alps. It rises southwest of the village of Zermatt, and on the frontier between Switzerland (canton of the Valais) and Italy. Though on the Swiss side it appears to be an isolated obelisk, it is really but the butt end of a ridge, while the Swiss slope is not nearly as steep or difficult as the grand terraced walls of the Italian slope. It was first conquered, after a number of attempts chiefly on the Italian side, on July 14, 1865, by E. Whymper's party, three members of which perished with the guide by a

slip on the descent. Three days later it was scaled from the Italian side by a party of men from Val Tournanche led by J. A. Carrel. It is frequently ascended in summer, especially from Zermatt.

MATTHES, FRANÇOIS EMILE (1874–1948), U.S. geologist and topographer of some of the most rugged and scenic features of western United States, was born in Amsterdam, Neth., on March 16, 1874. His education, begun in Holland, Switzerland and Germany, was continued at Massachusetts Institute of Technology and Harvard university. He became a U.S. citizen in 1896 and as topographer with the U.S. geological survey (1896–1913) he mapped the Bighorn mountains, Glacier and Grand Canyon National parks, Yosemite valley, Mount Rainier and other western areas. His beautiful sketching on these maps has probably never been equaled. Later (1913–48) Matthes concentrated on geologic problems, attaining distinction as geomorphologist and glacialist. Investigations widely carried on in the Sierra Nevada, California, culminated in his classic Geologic History of the Yosemite Valley (1930). He organized the program of systematic glacier observations in North America, part of a world-wide study of climatic fluctuations as indicated by changes in existing glaciers. Matthes was an unusual linguist, highly artistic, and a writer of rare excellence. He died in Berkeley, Calif., on June 21, 1948.

(F. M. FL.)

MATTHEW, SAINT, one of the Apostles of Christ. In Mark's list of the Twelve appointed by Christ (iii, 13–19), the name of Matthew is seventh, and is followed by that of Thomas. Apparently the evangelist made some attempt to arrange the names in the order of their eminence in the early church. His list may possibly indicate also that Matthew and Thomas were accustomed to work together; it was usual for Christian missionaries to work in pairs, and Mark records that Christ sent out the Twelve on a mission "two by two" (vi, 7). In the corresponding list in the third Gospel (Luke vi, 13–16) Matthew's name occurs in the same position. The first evangelist, who groups the names in pairs, gives "Thomas and Matthew" as the fourth (Matt. x, 3). A slightly different grouping is given in Luke's list of members of the primitive community in Jerusalem (Acts i, 13), "Philip and Thomas, Bartholomew and Matthew."

The first evangelist, however, when he records from Saint Mark the story of the call of Levi the tax collector, substitutes the name "Matthew" for that of "Levi the son of Alphaeus" (Matt. ix, 9; Mark ii, 14); he also adds "the tax collector" to Matthew's name in his list of the Twelve. According to tradition indeed it was Matthew himself who was the author of the first Gospel, but the tradition is undoubtedly a mistaken one. (See MATTHEW, GOSPEL ACCORDING TO SAINT.)

On the assumption that the identification of Matthew with Levi is correct, "Matthew" (probably meaning "Jehovah's gift") would appear to be the Christian name of Levi, who had been employed as a tax collector in the service of Herod Antipas, and whose call to be one of the immediate followers of Jesus Christ came to him as he sat at the tax office by the Sea of Galilee. It should be noted that Mark's story of his call resembles that of the call of Peter and Andrew and the sons of Zebedee, and one would expect to find Levi somewhere in his list of the Twelve. As a tax collector Levi would share in the distrust and contempt which these officials had earned for themselves everywhere.

According to Luke (v, 29) Levi after his call made a great feast fur Jesus in his house. But the evangelist is here rewriting Mark, whose statement that "he was sitting at meat in his house" does not necessarily bear the meaning put upon it by Luke; Mark may mean that Jesus was entertaining friends at his own table, inserting the incident here as another illustration of the attitude of Jesus toward "tax collectors and sinners."

It will be seen that the New Testament affords only scanty and uncertain information in regard to Saint Matthew. Outside the New Testament the only statement of any importance in regard to the Apostle is the passage from Papias preserved by Eusebius: "So then Matthew composed the Oracles in the Hebrew language, and each one interpreted them as he could."

Legend differs as to the scene of the Apostle's missionary labours, and as to whether he died a natural or a martyr's death. His feast day in the east is Nov. 16, in the west Sept. 21.

(B. T. D. S.; X.)

MATTHEW, GOSPEL ACCORDING TO SAINT, in canonical order the first of the four Gospels, and thus the first book of the New Testament. Though the preferred "Gospel of the Church" since the 2nd century A.D., it was not chronologically the first Gospel. As one of the three Synoptic Gospels, Matthew used the Gospel of Mark as the primary source for most of its narrative material, while most of the sayings of Jesus in Matthew were drawn from Q, the Synoptic saying-source, which was also used by Luke (see GOSPEL).

Composition. — The framework of Matthew is taken from Mark with little modification, but Matthew frequently tries to establish a closer connection between isolated units, especially by filling in gaps in the Marcan composition (cf. Matt. iv, 12 with Mark i, 14, for example). Matthew often introduces chronological sequence or connects stories by a participial construction (*e.g.*, "Jesus seeing/hearing this . . . ," v, 1, etc.). The artificiality of such secondary combinations is most obvious in xiv, 13 where Matthew has forgotten that the death of John the Baptist was told in "parentheses" (xiv, 1–12) as having already occurred some time ago. Also, the dating of the material within the limits of certain days is quite unlikely if we begin to take this dating seriously: a single day would cover the material from v, 1 (Sermon on the Mount) through viii, 17 (including three healings), and the next day would include two crossings of the lake, five healing narratives and several discussions (viii. 18–ix, 34).

Although he usually takes his scenery and geography from Mark, the author of Matthew also independently adds the lake (ix, 1), the synagogue (ix, 35) and the mountain (v, 1; xv, 29); furthermore, he gives Jesus' activity a wider locale. It is no longer a private house (as in Mark) where Jesus teaches and instructs the disciples (xv, 15; xvii, 19; xix, 9), because Matthew is not interested in the theory of the Messiah secret (see MARK, GOSPEL ACCORDING TO SAINT), but rather in stressing the public appeal of Jesus' ministry. "Great multitudes" are mentioned even more often than in Mark. The presence of the disciples is noticed more frequently, and their number, 12, is now taken for granted. Among the opponents, the Pharisees are particularly prominent and their hostility is emphasized more than in Mark (*e.g.*, Matt. xxii, 34, 41 compared with Mark xii, 28, 35; Matt. xv, 12; see also xxiii, 1 ff.).

Although Matthew did not basically change Mark's outline of Jesus' life, even a superficial examination of the former leaves the reader with an impression quite different from that derived from Mark. This is primarily because of the following factors: (1) Matthew adds further legendary materials, especially the birth narratives, and some new sections in the Passion account; (2) the author weaves the sayings taken from his second source, Q, into the Marcan framework; and (3) he arranges related materials in larger homogeneous sections—*e.g.*, the Sermon on the Mount (v–vii) and the collection of miracle stories in viii–ix.

Outline.—The outline of Matthew must therefore follow the themes of the collected material rather than the geographical sequence, which remains basically the same as in Mark. (Matt. iii–xvi, 12, in and around Galilee; xvi, 13–xx, toward Jerusalem; xxi–xxvii, last days in Jerusalem and Passion.)

i, 1–iv, 11	Messianic origins
i, 1–25:	genealogy and birth
ii, 1–23:	visit of the Magi, flight into Egypt
iii, 1–iv, 11:	John the Baptist, baptism, temptation
iv, 12–ix, 34:	the Messiah of word and work
iv, 12–25:	call of the disciples, summary of preaching and healings
v, 1–vii, 29:	the Messiah of the word (Sermon on the Mount) discourse
v, 1-48:	the entrance into the Kingdom: Beatitudes, salt and light, New Righteousness (antitheses)
vi–vii, 12:	the new conduct of life; alms, prayer, fasting, treasures, cares, judging, golden rule
vii, 12–27:	eschatological warnings; narrow gate, false prophets, self-deception, hearers and doers
viii, 1–ix, 33 (34):	the Messiah of the work
viii, 1–17:	three healings (leper, the centurion's servant, Peter's mother-in-law)
viii, 18–22:	twofollowers

viii, 23–ix, 8: three miracles (tempest, Gadarene [Gerasenes] demoniacs, man sick of palsy [paralytic])
ix, 9–17: call of Levi, question on fasting
ix, 18–33 (34): three healings (Jairus' daughter, two blind men, dumb demoniac)
ix, 35–xvi, 12: the Messiah in the world
ix, 35–xi, 1: sending out of the Twelve and *discourse* for the missionaries
xi, 2–30: about John the Baptist and Jesus' own mission
xii, 1–50: controversies (sabbath, Beelzebul, seeking for signs, real brethren)
xiii, 1–52: the parables of the Kingdom *discourse.*
(for xiii. 53–xxviii, 10 *see* also outline of MARK, GOSPEL ACCORDING TO SAINT)
xiii, 53–xiv, 12: critical events (rejection in Nazareth, death of John the Baptist)
xiv, 13–xv, 31: feeding of 5,000, discussion about clean and unclean
xv, 32–xvi, 12: feeding of 4,000, on signs and leaven
xvi, 13–xx, 28: the Messiah of the church
xvi, 13–xvii, 23: the foundation and conditions of the church (Peter's confession, transfiguration, suffering of the Messiah and the church)
xviii, 1–35: *discourse* on the church's life
xix, 1–xx, 16: further instruction of the disciples (marriage and divorce, little children, rich young man, labourers in the vineyard)
xx, 17–28: the church facing the Passion (third prediction, sons of Zebedee)
xx, 29–xxv, 46: the Messiah of the "Last Days"
xx, 29–xxi, 17: Jesus comes to Jerusalem (the two blind men of Jericho, entry into Jerusalem, cleansing of the Temple)
xxi, 18–xxii, 14: Israel in its eschatological decision (cursing of the fig tree and question about authority; parables of the two sons, the wicked husbandman and the marriage feast)
xxii, 15–xxiii, 36: Jesus overcoming the Pharisees in controversy (tribute to Caesar, resurrection, great commandment, David's son, woes against the Pharisees)
xxiii, 37–xxv, 46: the great eschatological *discourse* (the future of Jerusalem, "Synoptic Apocalypse," watchfulness of the disciples, the great eschatological parables)
xxvi, 1–xxviii, 20: the Victory of the Messiah
xxvi, 1–46: preparation for the Passion (anointing, betrayal, Last Supper, Gethsemane)
xxvi, 47–xxvii, 31: trial of Jesus (and death of Judas)
xxvii, 32–66: crucifixion and death, burial and guard at the tomb
xxviii, 1–20: the Resurrection (the empty tomb, bribing of the soldiers, appearance in Galilee and command to baptize)

Themes. — In Matthew, the adopted Marcan outline of the Gospel has been united with a thematic classification of the material. Sayings, collected into large discourses, have become the backbone of Matthew's composition. This indicates a fundamental change in the way in which Jesus is viewed in the Gospel. According to Matthew the content of the Gospel is not Jesus' life and person, but the message and teachings in which Jesus interprets the Law and proclaims the New Righteousness. These teachings are presented by Matthew in the form of ecclesiastical instructions, with Jesus himself as teacher. It is legitimate, therefore, to call Matthew's Gospel a "manual of discipline" for the church, similar in many respects to the "manual of discipline" of the Essene community of Qumran, which also had its "Righteous Teacher" (see DEAD SEA SCROLLS). But the fundamental difference from the Essene community must not be overlooked; no messianic attribute is given to the Qumranic Righteous Teacher, whereas in Matthew the authoritative interpretation of the Law is precisely the ministry of Jesus as the Messiah. Consequently, there are two main aspects in the Gospel: (1) to feature Jesus as the divine Messiah, the eschatological Lord and Judge, and (2) to unfold Jesus' interpretation of the Law and His teachings as the guide and rule of the eschatological community as it confronts the coming Kingdom of God.

Matthew emphasizes Jesus' divinity in several ways. It is already explicit in the birth narratives. Significantly, the messianic fulfillment of Old Testament prophecy is underlined throughout the Gospel by the "formula quotations": "This happened in order to fulfill what was said . . ." (i, 22; ii, 15, 17, 23, etc.). The miracle stories are significantly altered by Matthew to show Jesus not as the powerful Messiah but rather as the merciful King (compare, *e.g.,* Matt. ix, 18–26 with Mark v, 21–43) who fulfills the words of the prophets by saving His people from sickness (see viii, 16–17, ix, 35–36; xi, 2–6). The Christological titles given to Jesus are presented as testimonies that Old Testament expectations are accomplished in his person (Messiah, Son of David, Lord, King of Israel, Son of Man, Son of God). They go far beyond the titles given to a "teacher," and Jesus' disciples (except Judas; see xxvi, 25) never use this form of address, but always the title of divine majesty, "Lord" (compare Matt. viii, 25 with Mark iv, 38). Matthew, more consistently than Mark, identifies Jesus with the future Messiah and Judge (compare Matt. x, 33 with Mark ix, 37).

According to Matthew, the centre of Jesus' messianic ministry of fulfillment is His teaching. To fulfill and to re-establish the Law is the chief task of the Messiah. It is not a new law that Jesus proclaims, but the old and only Law of God as it was given through Moses and the Prophets, and which is reinforced in its entire validity including every "iota and dot" (v, 18–19). What is "new" is the righteousness Jesus requires — an obedience that recognizes God's radical demand upon man's existence as it is made clear in Jesus' interpretation of the Law (v, 21–48). This New Righteousness, which must "exceed that of the Scribes and Pharisees," is the condition for the entrance into the Kingdom (v, 20). The five great discourses in Matthew unfold this "Law" as the demand for a New Righteousness in its full eschatological dimension.

All these discourses (v–vii; x; xiii; xviii; xxiii–xxv) follow the same pattern of eschatological church instruction: (1) the announcement of the essentials of the re-established law; (2) detailed regulation for the life of each individual and the church as a whole; and (3) an eschatological appeal and warning. This pattern goes back to the Old Testament covenant formula, and in the early church is used especially in "catechisms" like the Teaching of the Twelve Apostles (see DIDACHE). Even the sequence of Matthew's various discourses follows this general pattern.

The Matthean understanding of the nature of the church also is revealed through this arrangement of the materials. For the first time, Jesus is depicted as the founder of the church in Matt. xvi, 17–19 (here and in xviii, 17 are found the only use of the word "church" in the Gospels). This debated passage (which is often used as a proof-text for the Petrine-Roman "power of keys") stresses that the church as the eschatological community possesses the promise that the doors of hell shall not be able to overcome it in its eschatological trouble. Thus the concept of the church is rooted in the eschatological perspective. The stilling of the tempest (Matt. viii, 23–27) becomes a paradigm for the church in the apocalyptic earthquakes. The relation between Jesus and His disciples prefigures the relation between the risen Lord and His church in the terrors and torments that will precede the Second Coming (xxiv, 3–8). The church, therefore, is always pictured in a situation of persecution and exposed to dangers from within and without — a feature emphasized at the end of every discourse.

It is in this eschatological setting that uncompromising obedience, the New Righteousness, becomes relevant. To do good works (vii, 16–23), to love one's enemies (v, 43–47), to refrain from retaliation (v, 38–42), to forgive continually (xviii, 21–22) — in short, the commandment of love as the fulfillment of the Law (xxii, 36–40) — is the demand upon the true disciple who aspires to achieve the eschatological quality of "perfection" (v, 48; xix, 21). Every compromise excludes from the Kingdom, but "blessed are those who are persecuted for righteousness' sake" (v, 10; this beatitude is added by Matthew to the traditional beatitudes of Jesus). This, however, does not mean blind subordination or fatalistic endurance. Matthew often stresses the necessity of real insight and understanding (compare Matt. xiii, 19–23 with Mark iv, 15–20), and eschatological watchfulness is synonymous with ethical preparedness (xxii, 11–13, etc.). Christology, ecclesiology and eschatology thus are bound together by the concept of Law

and New Righteousness. Christian life is mature responsibility in view of the final judgment of each man's works. Jesus as the Messiah is the teacher of the Law, the Lord of'the obedient church and the Judge of the Last Day. Consequently the Gospel is not presented in Matthew as the eternal doctrine about some superhuman being, but as the message of that Jesus who Himself has suffered and died as the archetype of the true disciple.

Literary History. — with its strong emphasis upon the Law and its constant dispute with the leaders of Judaism, Matthew certainly was written for a Jewish-Christian church in a strongly Jewish environment. But, although the uniquely Matthean tradition presupposes the scholarly work of teachers acquainted with the Hebrew language, the Gospel itself belongs to Greek-speaking Christianity. Its main sources are Greek writings (Mark and Q), and the author often substitutes more fluent Greek idioms for the clumsy sentences of his sources. Thus, the Gospel must have been written somewhere outside Palestine in a strong Greek-speaking Jewish community. Since Matthew probably was used first by Ignatius of Antioch (A.D. 110), the coastal district of Syria is still the best suggestion of a possible place of origin, although the city of Antioch itself is unlikely because it also was influenced by Pauline teachings, which are lacking in Matthew.

All these evidences also belie the statement of Papias that the Gospel was written first in Hebrew by the disciple Matthew *(see* GOSPEL). Since the fall of Jerusalem in AD. 70 is clearly presupposed in xxii, 6–7 *(cf.* xxiii, 37–39), and since the name of Levi the tax collector in Mark ii, 14 is changed to Matthew in Matt. ix, 9 it seems clear that the author was a later writer who claimed Matthew's authority for his Gospel, rather than the disciple himself. The dependence on written sources, school traditions and developed Christological, doctrinal and liturgical formulations point to a man of third-generation .Christianity who composed the Gospel between A.D. 75 and 100. *See* also BIBLE.

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MATTHEW, WILLIAM DILLER (1871–1930), North American vertebrate paleontologist known for his studies of fossil mammals, was born in Canada, at St. John, New Brunswick, on Feb. 19, 1871. After completing his studies at the University of New Brunswick and at Columbia university, New York city, he was associated with the American Museum of Natural History for 32 years. In 1927 he became professor of paleontology at the University of California. Matthew's initial work brought him in contact with thousands of specimens of fossil mammals in the collections of E. D. Cope. These and the work of Cope directed his life towsrd extensive studies of fossil mammals. Throughout his scientific research runs a progressive conservatism: Matthew valued facts above theories and materials above speculations His most widely known work is *Climate and Evolutzon* (1915), in which he gave strong support to the concept of holarctic radiation centres of mammals and preservation of primitive "relics" in the periphery of areas of radiation. Evolution and the importance of geological succession are ubiquitous themes in his studies. His other works include "Evolution of the Horse" (*Quart Biol Rev.,* 1915); "The Evolution of Mammals in the Eocene" *(Proc. Zool. Soc. Lond.,* 1927); "Faunas of the San Juan Basin" (*Mem. Amer. Philos. Soc.,* 1937, posth., ed. by Granger, Gregory, Colbert). (E. C. O.)

MATTHEW PARIS: *see* PARIS, MATTHEW.

MATTHEWS, (JAMES) BRANDER (1852–1929), U.S. essayist and dramatic critic, was born in New Orleans, La , Feb, 21, 1852, and educated at Columbia university (A.B., 1871; LL.B., 1873; A.M., 1874). Though admitted to the bar he never practised but turned instead to writing and the study of literature. He was professor of literature at Columbia, 1892–1900, and of dramatic literature, 1900–24. Matthews was the author of many short stories and critical essays and was a regular critic for the *New York Times* for a long period. His scholarship, revealed in such books as *Molière, His Life and His Works* (1910), *Shakespeare as a Playwright* (1913) and *French Dramatists of the 19th Century* (1881), is sound, although in his lighter essays there is much repetition.

Matthews was prominent in New York literary groups. As the chief U.S. advocate of the "well-made" plays of the Jones-Pinero school he influenced U.S. playwriting. He died in New York city on March 31, 1929.

A prolific writer and editor, Matthews published more than 40 works. These include: *The Theatres of Paris* (1880); *Pen and Ink* (1888); *Studies of the Stage* (1894); *Aspects of Fiction* (1896); *Tales of Fantasy and Fact* (1896); *American Character* (1906); *A Study of the Drama* (1910); *Introduction to the Study of American Literature* (1911); *Vistas of New York* (1912); *On Acting* (1914); *Principles of Playmaking* (1919); *The Tocsin of Revolt* (1922).

MATTHEWS, STANLEY (1824–1889), U.S. jurist, was born in Cincinnati, O., July 21, 1824. He graduated from Kenyon college in 1840 and was admitted to the bar two years later. In 1844 he became assistant prosecuting attorney of Hamilton county, Ohio; and in 1846–49 edited a short-lived antislavery paper, the *Cincinnati Herald.* He was clerk of the Ohio house of representatives in 1848–49, a judge of common pleas of Hamilton county in 1850–53, state senator in 1856–58 and U.S. district attorney for the southern district of Ohio in 1858–61. He was an officer in the Civil War but resigned from the army in 1863, and served as judge of the Cincinnati superior court in 1863–64. In 1872 he joined the Liberal Republican movement, and was temporary chairman of the Cincinnati convention which nominated Horace Greeley for the presidency, but in the campaign he supported Grant. In 1877 he appeared as counsel before the electoral commission and the same year became senator from Ohio. Because of his prominence as a railway and corporation lawyer and as one of the Republican "visiting statesmen" who witnessed the canvass of the vote of Louisiana in 1876 his nomination by Pres. Rutherford B. Hayes as associate justice of the supreme court in 1881 caused so much opposition that it was not approved until he was later renominated by Pres. James A. Garfield. He was, however, an honest, impartial and conscientious judge. He died in Washington on March 22, 1889.

See sketch in *A Biographical Congressional Directory, 1774-1903* (1903).

MATTHIAS, a shortened form of Mattathias, is the name of the disciple chosen to fill the place vacated by Judas Iscariot (Acts i. 21–26). The primitive method of choice (by lot), the Aramaic form of the name (which is not Grecized like the better-known Matthew), and the fact that Paul received a tradition which referred to "the twelve" as distinguished from "all the apostles" (I Cor. xv, 5) lead us to infer that the story is based upon actual fact. The choice of twelve disciples by Jesus points to a consciousness of a nation-wide mission, which was contained in the community after the Crucifixion. Matthias is not mentioned again in the New Testament. Clement of Alexandria refers to the "Traditions" of Matthias; some, he says, identified him with Zacchaeus the publican. The Acts of Andrew and Matthias are a romance preserved in Greek and Syriac and, in part, in Latin. Blatthias goes to the anthropophagi, where he has remarkable adventures. (W. K. L. C.)

MATTHIAS (1557–1619), Roman emperor, son of the emperor Blaximilian II and Maria, daughter of the emperor Charles V, was horn in Vienna. on Feb. 24, 1557, and educated by the diplomatist A. G. de Busbecq (*q.v.*). He was invited in 1577, soon after his father's death. to assume the governorship of the Netherlands, then in the midst of the long struggle with Spain. Entering

Brussels in Jan. 1578 he was named governor general; but he was merely a cipher, and only held the position for about three years, returning to Germany in Oct. 1581. Matthias was appointed governor of Austria in 1593 by his brother. the emperor Rudolph II; he continued the policy of crushing the Protestants, although personally he appears to have been inclined to religious tolerance; dealt with the rising of the peasants in 1595, and took part in the Turkish War. A few years later the discontent felt by the members of the Habsburg family at the incompetence of the emperor became very acute.

Obtaining in May 1605 a reluctant consent from his brother, Matthias took over the conduct of affairs in Hungary, where a revolt had broken out, was formally recognized by the Habsburgs as their head in April 1606, and was promised the succession to the empire. In June 1606 he concluded the peace of Vienna with the rebellious Hungarians, and made peace with the sultan in November. This pacific policy was displeasing to Rudolph, who prepared to renew the Turkish War; but with the support of the national party in Hungary Matthias forced his brother to cede to him this kingdom, together with Austria and Moravia, both of which had thrown in their lot with Hungary (1608). The king of Hungary, as Matthias now became, was reluctantly compelled to grant religious liberty to the inhabitants of Austria. A formal reconciliation between Rudolph and Matthias took place in 1610; but affairs in Bohemia soon destroyed this fraternal peace. In 1611 the Bohemians invited Matthias to come to their aid against Rudolph, nhose troops were ravaging their land. Accepting this invitation, he was crowned king of Bohemia in May 1611. Rudolph, however, was successful in preventing the election of Rlatthias as German king, or king of the Romans, and when he died, in Jan. 1612, no provision had been made for a successor. Matthias, however, obtained the remaining hereditary dominions of the Habsburgs, and in June 1612 was crowned emperor.

The short reign of the new emperor was troubled by the religious disserisions of Germany. His health became impaired and his indolence increased, and he fell completely under the influence of Melchior Klesl (*q.v.*), who practically conducted the imperial business, by whose advice he sought vainly to reconcile the contending religious parties. Meannhile the younger Habsburgs, led by the emperor's brother, the archduke Maximilian, and his cousin, Ferdinand, archduke of Styria, afterwards the emperor Ferdinand II, disliking the peaceful policy of Klesl, had allied themselves with the unyielding Roman Catholics, while the question of the imperial succession was forcing its way to the front. In 1611 Matthias married his cousin Anna (d. 1618), daughter of the archduke Ferdinand (d. 1595), but he was old and childless and the Habsburgs were anxious to retain his extensive possessions in the family.

Meanwhile the disputed succession to the duchies of Cleves and Julich again threatened a European war; the imperial commands were flouted in Cologne and Aix-la-Chapelle, and the Bohemians were again becoming troublesome. Having decided that Ferdinand should succeed Matthias as emperor, the Habsburgs had secured his election as king of Bohemia in June 1617, but were unable to stem the rising tide of disorder in that country. Matthias and Klesl were in favour of concessions, but Ferdinand and Maximilian met this move by seizing and imprisoning Klesl. Ferdinand had just secured his coronation as king of Hungary when there broke out in Bohemia those struggles which heralded the Thirty Years' War; and on March 20, 1619, the emperor died at Vienna.

For the life and reign of Matthias *see* J. Heling, *Die Wahl des römischen Konigs Matthias* (Belgrade, 1892); *A.* Gindely, *Rudolf II. und seine Zeit* (Prague, 1862–68); F. Stieve, *Die Verhandlungen über die Nachfolge Kaisers Rudolf II.* (Munich, *1880)*; P. von Chlumecky, *Karl von Zierotin und seine Zeit* (Briinn, 1862–79); *A.* Kerschbaumer, *Kardinal Klesl* (Vienna, *1865)*; M. Ritter, *Quellenbeiträge zur Geschiclzte des Kaisers Rudolf II.* (Munich, 1872); *Deutsche Geschichte im Zeitalter der Gegenreformation und des dreissigjährigen Krieges* (Stuttgart, *1887, srq.)* and the article on Matthias in the *Allgemeine deutsche Biographie,* Rd. xx. (Leipzig, *1884)*; L. von Ranke, *Zur deutschen Geschichte vom Religionsfrieden his zum 30-jährigen Kriege* (Leipzig, *1888)*; and J. Janssen, *Geschichte des deutschen Volks seit dem Ausgang des Mittelalters* (Freiburg, *1878 seq.)*; Eng. trans. *by* M. A. Mitchell and A. M. Christie *(1896, seq.)*.

MATTHIAS I, HUNYADI (1440–1490), king of Hungary, also known as Matthias Corvinus, second son of János Hunyadi (*q.v.*) and Elizabeth Szilágyi, was born at Cluj (Koloszvár), Transylvania, probably on Feb. 23, 1440. He shared in his father's campaigns when only twelve years of age. In 1453 he was created count of Bistercze, and was knighted at the siege of Belgrade in 1454. At fifteen he was married to Elizabeth of Cilli, but the young Elizabeth died before the marriage was consummated. On the death of his father he was inveigled to Buda by his enemies and condemned to death on the pretext of an imaginary conspiracy, but was spared on account of his youth. On the king's death he was detained for a time by George Poděbrad, governor of Bohemia, who treated Matthias hospitably and affianced him with his daughter Catherine. On Jan. 24, 1458 he was elected king of Hungary by the vast majority of the nation, despite the opposition of a section of the magnates, headed by the palatine László Garai and the voivode of Transylvania, Miklós Ujlaki; and on Feb. 14 entered Buda in state.

The situation of Hungary was at the time very dangerous, and to Matthias' numerous foreign enemies were added the magnates, headed by his own uncle and guardian Szilágyi Despite their opposition, Matthias on Feb. 9, 1458 married his bride, whose father was crowned king of Bohemia soon after. He was now able to make fight against the Turks, to invade Serbia. and to reassert his suzerainty over Bosnia; and after the malcontents had actually crowned the emperor Frederick III king of Hungary at Vienna-Neustadt (March 4, 1459), Matthias drove him out and forced him in April 1462 to restore the crown, although retaining certain Hungarian counties with the title of king and to recognize Matthias as king of Hungary. After a campaign against the Turks, during which he invaded Bosnia successfully, Matthias was cronned on March 29, 1464. In 1468 Matthias joined the Catholic league against his father-in-law Poděbrad and on May 3, 1469 was elected king of Bohemia by the Czech Catholics. Poděbrad, however, allied himself with the Poles, and after years of fighting and manoeuvring against the Polish counter-claimant, Ladislaus, and against the emperor Frederick, Matthias was forced at last to recognize Ladislaus as king of Bohemia, while he himself secured Moravia, Silesia and Lusatia until redeemed for 400,000 florins (Peace of Olmutz, July 1479).

The emperor promised to pay Matthias 100,000 florins as a war indemnity, and recognized him as the legitimate king of Hungary on the understanding that he should succeed him if he died without male issue, a contingency at this time somewhat improbable, as Matthias, only three years previously (Dec. 15, 1476), had married his third wife, Beatrice of Saples, daughter of Ferdinand of Aragon. Declaring war on Frederick a third time in 1481, Matthias was rapidly successful. He entered Vienna, which he made his capital thereafter, on June 1, 1485, afterwards conquering Styria, Corinthia and Carniola. Matthias consolidated his position by alliances with the dukes of Saxony and Bavaria, with the Swiss Confederation, and the archbishop of Salzburg, and was henceforth the greatest potentate in central Europe. His far-reaching hand even extended to Italy.

Though Matthias' policy was so predominantly occidental that he soon abandoned his youthful idea of driving the Turks out of Europe, he at least succeeded in making them respect Hungarian territory, and pushing his frontier southward in Bosnia. His last days were occupied in endeavouring to secure the succession for his illegitimate son János; but Queen Beatrice, though childless, fiercely opposed the idea and the matter was still pending when Matthias expired very suddenly on Palm Sunday, April 4, 1490.

Matthias Hunyadi was indisputably the greatest man of his day, and one of the greatest monarchs who ever reigned. Like Napoleon, with whom he has often been compared, he was equally illustrious as a soldier, a statesman, an orator, a legislator and an administrator; but unlike him a fine moral character. Although naturally passionate and repeatedly provoked by ingratitude and treachery, he never was guilty of a single cruel or vindictive action. His capacity for work was inexhaustible. Frequently half

his nights were spent in reading, after the labour of his most strenuous days. There was no branch of knowledge in which he did not take an absorbing interest, no polite art which he did not cultivate and encourage. His camp was a school of chivalry, his court a nursery of poets and artists.

See Vilmós Fraknói, *King Matthias Hunyadi* (Hung., Budapest, 1890, German ed., Freiburg, 1891); Karl Schober, *Die Eroberung Niederösterreichs durch Matthias Corvinus* (Vienna, 1879); János Huszár, *Matthias's Black Army* (Hung. Budapest, 1890); *Aeneas* Sylvius, *Opera* (Frankfort, 1707); *The Correspondence of King Matthias* (Hung. and Lat., Budapest, 1893); Marzio Galeotti, *De egregie sapienter et jocose dictis ac factis Matthiae regis (Script. reg. hung. I.)* (Vienna, 1746). *See* also HUNGARY.

MATTHISSON, FRIEDRICH VON *(1761–1831)*, German poet whose verse was praised by Schiller for its melancholy sweetness and its fine description of scenery, was born near Magdeburg on Jan. *23, 1761.*

In 1812 he was appointed intendant of the court theatre and chief librarian of the royal library at Stuttgart. In *1828* he retired and settled at Worlitz near Dessau, where he died on March *12, 1831.*

Matthisson's poems, *Gedichte,* were published in *1787.* His poem "Adelaide" remains famous in a setting by Beethoven.

BIBLIOGRAPHY.—Matthisson's *Schriften* appeared in *8* vol. (1825–29): vol. 1 collects his poems; vol. 2–8 his reminiscences. A supplementary volume (1833) contains a biography by H. Döring. There is a 2-vol. ed. by G. Bolsing (1812–13). A selection from his correspondence, ed. by F. R. Schoch, appeared in 4 vol. (1832). *See* also W. Krebs, *Friedrich von Matthisson* (1912); *A.* Heers, *Das leben Friedrich von Matthisson* (1913).

MATTING, a general term embracing many coarse woven or plaited fibrous materials used for covering floors or furniture, for hanging as screens, for wrapping up heavy merchandise and for other miscellaneous purposes. Perforated and otherwise prepared rubber, as well as wire-woven material, is also largely utilized for door and floor mats.

In the United Kingdom, under the name of "coir" matting, a large amount of a coarse kind of carpet is made from coco-nut fibre; and the same material, as well as strips of cane, Manila hemp, various grasses and rushes, is largely employed in various forms for making door mats. Large quantities of the coco-nut fibre *(see* COCONUT PALM) are woven in heavy looms, then cut up into various sizes, and finally bound round the edges by a kind of rope made from the same material. The mats may be of one colour only, or they may be made of different colours and in different designs. Sometimes the names of institutions are introduced into the mats.

Another type of mat is made exclusively from the above-mentioned rope by arranging alternate layers in sinuous and straight paths, and then stitching the parts together. It is also largely used for the outer covering of ships' fenders. Matting of various kinds is very extensively employed throughout India for floor coverings, the bottoms of bedsteads, fans and fly-flaps, etc.; and a considerable export trade in such manufactures is carried on.

The materials used are numerous; but the principal substances are straw, the bulrushes *Typha elephantina* and *T. angustifolia,* leaves of the date palm *(Phoenix sylvestris),* of the dwarf palm *(Nannorrhops [chamaerops] ritchieana),* of the Palmyra palm *(Borassus flabellifer),* of the coco-nut palm *(Cocos nucifera)* and of the screw pine *(Pandanus tectorius),* the munja or munj grass *(Saccharurn sarc)* and allied grasses, and the mat grasses *Cyperus textilis* and *C. pangorei,* from the last of which the well-known Palghat mats of the Madras presidency are made. Many of these Indian grass-mats are admirable examples of elegant design, and the colours in which they are woven are rich, harmonious and effective in the highest degree. Several useful household articles are made from the different kinds of grasses. The grasses are dyed in all shades and plaited to form attractive designs suitable for the purposes to which they are to be applied. This class of work obtains in India, Japan and other eastern countries. Vast quantities of coarse matting used for packing furniture, heavy and coarse goods, flax and other plants, etc., are made in Russia from the bast or inner bark of the lime tree. This industry centres in the great forest governments of Viatka, Nijni-Novgorod, Kostroma, Kazan, Perm and Simbirsk. (T. W.)

MATURIN, CHARLES ROBERT (1782–1824), Irish novelist and dramatist, was born in Dublin in *1782,* the grandson of Gabriel James Maturin, Swift's successor in the deanery of St Patrick. Charles Maturin was educated at Trinity college, Dublin. and became curate of Loughrea and then of St. Peter's, Dublin. His first novels, *The Fathl Revenge; or, the Family of Montorio* (1807), *The Wild Irish Boy* (1808) and *The Milesian Chief* (1812), issued under the pseudonym of "Dennis Jasper Murphy," were mercilessly ridiculed, but the irregular power displayed in them attracted the notice of Sir Walter Scott, who recommended the author to Byron. Through their influence Maturin's tragedy of *Bertram* was produced at Drury Lane in *1816,* with Kean and Miss Kelly in the leading parts. A French version by Charles Nodier and Baron Taylor was produced in Paris at the Théâtre Favart. Two more tragedies, *Manuel (1817)* and *Fredolfo* (1819), were failures, and his poem *The Universe* (1821) fell flat. He wrote three more novels, *Women* (1818), *Melmoth the Wanderer* (1820), and *The Albigenses (1824). Melmoth,* the best of them, has for hero a kind of "Wandering Jew." Honoré de Balzac wrote a sequel to it under the title of *Melmoth réconcilié à l'église* (1835). Maturin died in Dublin Oct. *30, 1824.*

See N. Idman, *Charles Robert Maturin: his Life and Works* (1923).

MATVEYEV, ARTAMON SERGEYEVICH (d. 1682), Russian statesman and reformer, was one of the greatest of the precursors of Peter the Great. His parentage and the date of his birth are uncertain. In *1671* the tsar Alexius and Artamon were already on intimate terms, and on the retirement of Orduin-Nashchokin, Matveyev became the tsar's chief counsellor. Matveyev remained paramount to the end of the reign and introduced play-acting and all sorts of refining western novelties into Muscovy. The deplorable physical condition of Alexius's immediate successor Theodore III suggested to Matveyev the elevation to the throne of the sturdy little tsarevich Peter, then in his fourth year. He purchased the allegiance of the *stryeltsi,* or musketeers. and then, summoning the boyars of the council, urged the substitution of Peter for Theodore. His arguments failed, and he was banished to Pustozersk, in northern Russia, where he remained till Theodore's death (April *27, 1682).* The first *ukaz* issued in Peter's name summoned Matveyev to return to the capital and act as chief adviser to the tsaritsa Natalia. He reached Moscow on May 5, and at once proceeded to the head of the Red Staircase to meet and argue with the assembled *stryeltsi,* who had been instigated to rebel by the anti-Petrine faction. They seized and flung Matveyev into the square below, where he was hacked to pieces by their comrades.

See R. Nisbet Bain, *The First Romanovs* (London, 1905); *M.* P. Pogodin, *The First Seventeen Years of the Life of Peter the Great* (Rus.) (Moscow, 1875); S. M. Solovev, *History of Russia* (Rus.) (vols. 12, 13) (St. Petersburg, 1895, etc.); L. Shchepotev, *A. S. Matveyev as an Educational and Political Reformer* (Rus.) (St. Petersburg, 1906).

MAUCH CHUNK: *see* JIM THORPE.

MAUCHLINE, a village and civil parish of Ayrshire, Scot., 9 mi. S.E. of Kilmarnock and 11 mi. E.N.E. of Ayr by road. Pop. (1951) *4,161.* It is situated on a gentle slope about 1 mi. from the river Ayr. On the village green a monument marks the spot where five Covenanters were killed in *1685.* Mauchline is the site of the Burns National memorial and has many links with the poet, who lived with his brother Gilbert on the farm of Mossgiel, about a mile to the north, from 1784 to *1788.* In Castle street is the house (now a museum) where Robert Burns and Jean Xrmour stayed before going to Ellisland; Mauchline kirkyard was the scene of the "Holy Fair"; the "Jolly Beggars" met at "Poosie Nansie's"—still, though much altered, a popular inn; "auld Nanse Tinnock's" house nearly faces the entrance to the churchyard; the Rev. William Auld was minister of Mauchline, and "Holy Willie," whom the poet scourged in the celebrated "Prayer," was one of "Daddy Auld's" elders; behind the kirkyard stands the house of Gavin Hamilton. the lawyer and firm friend of Burns, in which the poet was married. The braes of Ballochmyle, where he met the heroine of his song, "The Lass o' Ballochmyle," lie about a mile to

the southeast.

Mauchline's industries are coal mining and the making of curling stones, optical instruments, milk powder and agricultural implements.

MAUGHAM, WILLIAM SOMERSET (1874–), English novelist and playwright, was educated at King's school, Canterbury, Heidelberg university and St. Thomas's hospital. During World War I he served in the secret service, and used his experiences in writing *Ashenden* (1928). In his semiautobiographical novel, Of *Human Bondage* (1915), he gives fullest expression to his view of life. His characteristics are wit, cynical detachment and literary craftsmanship. He is a master of the short story and of the comedy of manners. His novels include: *Liza* of *Lambeth* (1897), *The Moon and Sixpence* (1919), *The Painted Veil* (1925), *Cakes and Ale* (1930), *Theatre* (1937), *The Razor's Edge* (1944) and *Catalina* (1948). His plays include *Home and Beauty* (1919), *The Circle* (1921), *Our Betters* (1923), *The Letter* (1927), *Tfze Sacred Flame* (1928) and *Sheppey* (1933). His collected short stories were published in three volumes in 1951. An autobiography, *The Summing Up,* appeared in 1938, and *A Writer's Notebook* in 1949.

MAULE, a coastal range province of central Chile. It was created in 1826. In 1927 Linares province (*q.v.*) was annexed, the capital moved to Linares and Itata department transferred to Ñuble province (*q.v.*). In 1936 Maule and Linares provinces were separated and Maule's capital was re-established at Cauquenes (pop., 1952, 14,486). Area 2,172 sq.mi. Pop. (1952) 72,181. Maule is the least densely populated province between the Bío-Bio and Aconcagua valleys. Its rolling hill terrain is brush covered in the east but becomes forested in the centre and west. The accessible hardwood forests have been cut over and in some areas replaced by pine and eucalyptus plantations. Sheep and cattle range everywhere. Agriculture is concentrated in the valleys, chief among them the Cauquenes. Most valuable crop is the vine. but wheat, various legumes and maize are important. The products of field, range and forest may be shipped on the Cauquenes-Parral or Constitución-Talca branches of the state railway. The latter line parallels the Maule river, one of central Chile's larger streams. Small ships enter the lower river and barges carry logs, pulp and firewood to Constitución or across the river to the railroad.

Constitución (pop., 1952, 8,285) remains a minor port although considerable effort has been made to scour the river mouth and build an artificial harbour nearby. Wooden ships and barges are constructed, and a summer vacation trade is attracted by the picturesque town, wooded hills, cliff coast and beaches. Constitución, Chanco. (pop., 1952, 1,797) and Cauquenes are departmental seats. The Maule river is said to have represented the southern limit of the Inca empire. (J. T.)

MAUNDY THURSDAY, the Thursday before Easter, commemorates the Last Supper; sometimes called Sheer or Chare Thursday, in allusion, it is thought. to the "sheering" of heads and beards in preparation for Easter, or more probably in the word's Middle English sense of "pure," in allusion to the ablutions of the day. The chief ceremony, as kept from the early middle ages onward—the washing of the feet of 12 or more poor men or beggars—was in the early church almost unknown. From the 4th century ceremonial foot washing became yearly more common, till it was regarded as a necessary rite. to be performed by the pope. all Catholic sovereigns, prelates, priests and nobles. In England the king washed the feet of as many poor men as he was years old, and then distributed to them meat, money and clothes. At Durham cathedral, until the 16th century, every charity boy had a monk to wash his feet. At Peterborough abbey, in 1530, Wolsey made "his maund in Our Lady's Chapel, having fifty-nine poor men whose feet he washed and kissed; and after he had wiped them he gave every of the said poor men twelve pence in money, three ells of good canvas to make them shirts, a pair of new shoes, a cast of red herrings and three white herrings." Queen Elizabeth I performed the ceremony, the paupers' feet, however, being first washed by the yeomen of the laundry with warm water and sweet herbs. James II was the last English monarch to perform the rite. William III delegated the washing to his almoner, and this was usual until the middle of the 18th century. After 1754 the foot washing was abandoned, and the ceremony came to consist of the presentation of Maundy money, officially called Maundy pennies. These were first coined in the reign of Charles II. The service, which formerly took place in the Chapel Royal, Whitehall, is held in Westminster abbey. It is on Maundy Thursday that in the Roman Catholic Church the sacred oil is blessed and the chrism prepared according to an elaborate ritual which is given in, the *Pontificale.*

MAUPASSANT, (HENRY RENE ALBERT) GUY DE (1850–1893), French writer of short stories and novels whose work is distinguished from that of other naturalists both by its universality and by the purity of its style and who is remembered also for the tragic circumstances of his life, was born in the château of Miromesnil, near Dieppe (Seine-Inférieure), on Aug. 5, 1850. His father, Gustave de Maupassant, who had a partnership in a Paris firm of stockbrokers, had in 1846 married Laure Le Poittevin, sister of Gustave Flaubert's friend Alfred Le Poittevin, who himself in the same year had married Gustave de Maupassant's sister Louise. This double link explains why Flaubert took so affectionate an interest in his friend's nephew after Alfred's death in 1848. Because of disagreements with her husband Mme. de Maupassant went to live on her estate Les Verguies, at Étretat, after the birth of her younger son Hervé (1856). There, in wild surroundings, Guy grew up in the company of sailors' and peasants' children. Having learned Latin from the vicar, he was sent at the age of 13 to a Catholic school at Yvetot. but was expelled after less than two years, without regret on his part, and passed to the Rouen *lycée.* His poem "Le Dieu créateur," which won a prize in the philosophy class there, shows the influence of Alfred de Vigny's pessimism, of Victor Hugo's pantheism and also of the conversations that he heard between Flaubert and Louis Bouilhet, with whom he spent his Sundays in termtime. In 1867 he matriculated at Caen university. For his holidays he used to go back to Étretat. There, in the summer of 1868, he met the English poet Swinburne and his friend George Powell. The house and the dinner to which these two invited the young Maupassant made a vivid impression on him. which was reflected in one of his first stories ("La Main d'écorché," published under the pseudonym Joseph Prunier in 1875) and reproduced in his preface to Gabriel Mourey's translation of Swinburne's *Poems and Ballads* (1891).

Enlistment in the army on the outbreak of the Franco-German War in 1870 interrupted Maupassant's work as a law student, and after his discharge (autumn 1871) he secured a post as a clerk in the ministry of marine in Feb. 1873. This gave him some insight into the office workers' way of life. which he was later to exploit in stories such as "Les Dimanches d'un bourgeois de Paris" (1882) and "L'Héritage" (1884). Meanwhile Maupassant divided his spare time between rowing on the Seine and writing. Everything that he wrote he submitted to Flaubert, who called him his disciple and proved himself an exacting critic, forbidding Maupassant to publish anything before he had formed his style and matured his personality. Flaubert moreover encouraged him to write verse, so as to make his prose style more supple. Thus it was that Maupassant's first book was a collection of poems, *Des Vers* (1880). One of these poems, which had first appeared under the title "Au bord de l'eau" in a periodical in 1876, had been threatened with prosecution or. the grounds of indecency when it mas reprinted as "Cne fille" in another periodical in 1879, but the case was dropped thanks to Flaubert's intervention. Flaubert furthermore persuaded his friend Agénor Bardoux, who was then minister of education, to give Maupassant a secretarial appointment in his office instead of his post at the ministry of marine. He had also introduced him to other writers, Zola, Daudet, Edmond de Goncourt and Turgenev.

Together with other young writers of his own age—Paul Alexis, Henry Céard, Léon Hennique and J. K. Huysmans—Maupassant used to pass his Sundays at Zola's house at Médan. Thus when Zola and his circle published *Les Soirées de Médan* (April 1880), a collective volume of stories on the Franco-German War, Maupas-

sant was a contributor to it. This book, an outspoken demonstration of naturalism in literature, provoked heated controversy. Maupassant's contribution was "Boule de suif." In this, a prostitute traveling by coach is companionably treated by her fellow passengers anxious to share her provisions of food until a German officer stops the coach and refuses to let it proceed until he has possessed her; the others then induce her to satisfy him, but ostracize her for the rest of the journey. Unanimously regarded as the best story in the book, it was described by some critics as a masterpiece. This result was the last satisfaction that Flaubert was to have before his death (May 8, 1880).

The really triumphant success of "Boule de suif" was in Maupassant's mind when he later said that his passage through the world of letters was like that of a meteor. Unfortunately, however, he was thinking not only of his brilliant arrival in that world but also the painful end that he felt to be fast approaching him. In the period between "Boule de suif" and his collapse in 1891 he wrote enough to fill 30 books. *La Maison Tellier* (1881), a book of short stories on a variety of subjects, can be regarded as typical of his achievement as a whole, but in his novels as well as in his stories he was to show himself both versatile in his choice of themes and constant in his determination to present men and women just as he saw them in the manifold aspects of life. His concern was with *l'humble vkritk — words* which he chose as the subtitle to his novel *Une Vie* (1883). This novel does in fact record what he had observed as a child, the little dramas of family relationships and the day-to-day preoccupations of real people, all drawn from life. A loyal disciple of Flaubert and of Zola, he presents his characters with strict objectivity, forgoing any expression of a personal judgment on them but noting always the word, the gesture or even the reticence that betrays the essential personality of each one and enhancing the effect by his description of the background against which they move. Conciseness, strength and the most rigorous economy are the characteristics of his art.

Collections of short stories and novels followed one another in quick succession until illness struck Maupassant down. Two years saw six new books of short stories: *Mademoiselle Fifi* (1883), *Contes de la bkcasse* (1883), *Clair de lune, Les Soeurs Rondoli, Yvette* and *Miss Harriet* (all four 1884). Yet he knew that his family had a long history of neurosis and was himself subject to eye troubles and agonizing headaches. To distract himself from his anxiety he worked like a man possessed, took overviolent exercise and indulged in sensual pleasures that wore him out. Convinced that there was no escape for him, he sought both to enjoy all that he desired and to express all his potentialities, all that he had in him for posterity. He took stimulants and narcotics in excess.

As well as shorter pieces, Maupassant wrote full-length novels. *Bel-Ami* (1885), drawn from his observation of the Parisian world of sharp businessmen and cynical journalists, is a scathing satire on a society whose members let nothing stand in the way of their ambition to "get rich quick." Bel-Ami, the hero of the novel, is now a standard literary example of that attitude. When the sale of his books enabled him to buy a yacht, Maupassant named it "Bel Ami." *Sur l'eau* (1888) and *La Vie errante* (1890) are based on the cruises that he made in it in the Mediterranean.

Maupassant's later books of short stories include *Toine* (1886), *Le Horla* (1887), *Le Rosier de Madame Husson* (1888) and *L'Inutile Beauté* (1890). In "Le Horla" he made use of the theories that J. M. Charcot was putting forward in his lectures on hysteria and psychological disorders at the Salpétrière hospital. These theories were at that moment receiving world-wide publicity. but Maupassant's use of them in "Le Horla" was mistakenly interpreted, after his subsequent confinement in a mental home, as reflecting the onset of his own madness. Four more novels also appeared: *Mont-Oriol* (1887), on the financing of a fashionable watering place; *Pierre et Jean* (1888), on a man's tragic jealousy of his half-brother, the child of his mother's adultery; *Fort comme la mort* (1889); and *Notre coeur* (1890).

Maupassant's work is all thoroughly realistic. Nevertheless it reflects at many points his deep love for the Norman countryside and the sea. Some of his stories have such tragic power that Taine compared them to the plays of Aeschylus (for instance "Le Port" and "Le Champ d'oliviers"). He does in fact present his characters, poor people or rich bourgeois, as if they were the heroes of a Greek tragedy, their lives dominated by *ananke* or ironic necessity, crushed by the fate that they have dared to defy yet still struggling against it hopelessly. Such indeed was his own life, with his obstinate self-dedication to his work. Not until his pain had become unbearable did he give way to despair. Then, on Jan. 2, 1892, at Cannes, he tried unsuccessfully to cut his throat. Sent to A. E. Blanche's nursing home in Paris, he died there on July 6, 1893, at the age of 43.

Because so many of his stories deal with madness, it has been alleged that Maupassant himself was already mad when he wrote them. Yet these stories are perfectly well balanced, and in them Maupassant treats madness as a doctor, not as a patient. Down to the last work that he wrote, all his work is characterized by a clarity of style that betrays no sign of mental disorder. The lucid purity of his French and the precision of his imagery are in fact the two features of his work which account for its success, especially outside France. In the discussion of novel writing which serves as a preface to *Pierre et Jean* he described the French language as a clear pool that affectation of style could never cloud. This is an unconscious definition of his own stylistic principles, a rejection of the "artistic" or "precious" style practised by Edmond de Goncourt (who never forgave him).

Maupassant's work is easily distinguished from that of other naturalist writers. He gives a true picture of the society of his time. in which every detail of background and behaviour is recognizable. Yet there is a universality in his view of mankind, and this explains how Benjamin Britten and the librettist Eric Crozier could turn "Le Rosier de Madame Husson," which Maupassant had set in the Vexin Normand, into *Albert Herring*, set in East Suffolk, by means of a few modifications of minor details (*e.g.*, in the matter of local customs), without any change in the presentation of the characters. Likewise film after film has been made from Maupassant's novels and stories, each one topical and contemporary however much the world has changed since his time.

BIBLIOGRAPHY.—Collections of Maupassant's work include the Ollendorf edition, illustrated, 29 vol. (1900–04), the Conard edition, with preface by Pol Neveux, 29 vol, (1908–10); and the edition by René Dumesnil, 15 vol., including his letters and previously unpublished writings (1934–38). There is also a collected edition by A. M. Schmidt and G. Delaisement of his *Contes et nouvelles*, 2 vol. (1957), and of his *Romans*, 1 vol (1959). *See* also *The Works of Guy de Maupassant*, Eng. trans. by M. Laurie, 10 vol. (1923–29), and the numerous English versions of individual works or smaller collections.

For biography *see* E. Maynial, *La Vie et l'oeuvre de Guy de Maupassant* (1906); R. Dumesnil, *Guy de Maupassant* (1947); F. Steegmiiller, *Maupassant* (1949). For personal reminiscences *see* A. Lumbroso, *Souvenirs sur Maupassant* (1905); F. Tassart, *Souvenirs sur Guy de Maupassant* (1911).

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MAUPEOU, RENÉ NICOLAS CHARLES AUGUSTIN (1714–1792), chancellor of France, was born on Feb. 25, 1714, being the eldest son of René Charles de Maupeou (1688–1775), who was president of the parlement of Paris from 1743 to 1757. He was his father's right hand in the conflicts between the parlement and Christophe de Beaumont, archbishop of Paris, who was supported by the court. Between 1763 and 1768, dates which cover the revision of the case of Jean Calas and the trial of the comte de Lally. Maupeou was himself president of the parlement. In 1768, through the protection of Choiseul, whose fall two years later was in large measure his work, he became chancellor in succession to his father, who had held the office for a few days only. He determined to support the royal authority against the parlements. The struggle came over the trial of the case of the duc d'Aiguillon, ex-governor of Brittany, and of La Chalotais (*q.v.*) procureur-général of the province, who had been imprisoned by the governor for accusations against his administration. When the parlements showed signs of hostility

against Aiguillon, Louis XV. annulled the proceedings.

Louis replied to remonstrances from the parlement by a *lit de justice,* in which he demanded the surrender of the minutes of procedure. On Nov. 27, 1770, appeared the *Édit de règlement et de discipline,* which was promulgated by the chancellor, forbidding the union of the various branches of the parlement and correspondence with the provincial magistratures. It also made a strike on the part of the parlement punishable by confiscation of goods, and forbade further obstruction to the registration of royal decrees after the royal reply had been given to a first remonstrance. This edict the magistrates refused to register, and it was registered in a *lit de justice* held at Versailles on Dec. 7, whereupon the parlement suspended its functions. After five summonses to return to their duties, the magistrates were surprised individually on the night of Jan. 19, 1771, by musketeers, who required them to sign yes or no to a further request to return. Thirty-eight magistrates gave an affirmative answer, but on the exile of their former colleagues by *lettres de cachet* they retracted, and were also exiled. Maupeou installed the council of state to administer justice pending the establishment of six superior courts in the provinces, and of a new parlement in Paris. The *cow des aides* was next suppressed.

Voltaire praised this revolution, applauding the suppression of the old hereditary magistrature, but in general Maupeou's policy was regarded as the triumph of tyranny. The remonstrances of the princes, of the nobles, and of the minor courts, were met by exile and suppression, but by the end of 1771 the new system was established, and the Bar, which had offered a passive resistance, recommenced to plead. But the death of Louis XV. in May 1774 ruined the chancellor. The restoration of the parlements was followed by a renewal of the quarrels between the new king and the magistrature. Maupeou and Terrai were replaced by Malesherbes and Turgot. Maupeou lived in retreat until his death at Thuit on July 29, 1792, having lived to see the overthrow of the *ancien re'gime.* His work, in so far as it was directed towards the separation of the judicial and political functions and to the reform of the abuses attaching to a hereditary magistrature, was subsequently endorsed by the Revolution; but no justification of his violent methods or defence of his intriguing and avaricious character is possible. He aimed at securing absolute power for Louis XV., but his action was in reality a serious blow to the monarchy.

The chief authority for the administration of Maupeou is the *compte rendu* in his own justification presented by him to Louis XVI. in 1789, which included a dossier of his speeches and edicts. These documents formed the basis of the judicial system of France as established under the consulate.

MAUPERTUIS, PIERRE LOUIS MOREAU DE (1698–1759), French astronomer and mathematician, best known for his principle of least ection, was born at St. Malo on Sept. 28, 1698, and died at Basel on July 27, 1759. He became a member of the Académie des Sciences at Paris in 1731, and the following year he introduced into France the Newtonian doctrine of gravitation. In 1736 Maupertuis led an expedition to Lapland to measure the length of a degree along the meridian, thereby verifying the Newtonian view of the earth as an oblate spheroid—a sphere flattened at the poles. Called to Berlin, he became a member of the Academy of Sciences there in 1741 and served as president from 1745 to 1753.

Maupertuis contributed mathematical papers to the *Memoires* of the Académie des Sciences of Paris and published more than half a dozen books on geography, astronomy and cosmology. In 1744, enunciating the principle of least action, he claimed that the operations of nature conform to a rule of economy in which action, defined by $\int mv\,ds$, is a minimum. The chevalier d'Arcy, however, pointed to cases in which action is a maximum rather than a minimum; and Samuel Koenig accused Maupertuis of plagiarism from Leibniz. In the ensuing polemic Euler came to the support of Maupertuis; but Voltaire, once his proselyte, satirized the "earth flattener" so mercilessly that Maupertuis, a favourite of Frederick the Great, left Berlin for Paris in 1753.

The *Oeuvres* appeared at Dresden in 1752, at Berlin in 1753, and in new four-volume editions at Lyons in 1756 and 1768.

For bio-bibliographical details *see* Pierre Brunet, *Maupertuis, l'oeuvre et sa place dans la pensée scientifique et philosophique du XVIII^e siècle* (1929). (C. B. BR.)

MAURA, ANTONIO MONTANER (1853–1925), Spanish statesman, was born in Palma de Mallorca on May 2, 1853. He was educated at Valencia and Madrid where he studied law. Though his pronunciation of Spanish was at first defective, by perseverance and force of personality he became in later years a great forensic and parliamentary orator. Elected deputy for his native city in 1881, he joined the Liberal party; but his instincts were conservative and in 1901 he went over to the Conservative party of which he eventually became leader. He was a constructive statesman, and though the chaotic state of the Spanish political fabric inspired in him a desire for reform, he always regarded the constitution as sacred. In 1903 he became Prime Minister, and his zeal for reform made him many enemies among the corrupt political factions of Spain. He negotiated with France on the subject of Spanish rights in Tangier and Morocco and with Great Britain concerning the *status* quo of the seas. In 1913 he resigned the leadership of the Conservative party, but, in response to appeals from the king, he formed governments in 1918, 1919 and 1921. True to his constitutional ideals, he refused to make common cause with the Directorate of 1923 which superseded parliamentary government in Spain. Nevertheless, Maura, who favoured "revolution from above," probably came nearer to Primo de Rivera's ideas than any considerable Spanish statesman of the old school. But he deprecated the Primo de Rivera dictatorship as arising out of an army revolt and therefore unlikely to command public confidence. He died on Dec. 13, 1925.

MAUREPAS, JEAN FRÉDÉRIC PHÉLYPEAUX, COMTE DE (1701–1781), French statesman, was born at Versailles on July 9, 1701, the eldest son of Jérôme de Pontchartrain, one of the secretaries of state. In 1715 Pontchartrain's incapacity prompted the duc de Saint-Simon to suggest that the title and emoluments of his office should be transferred to his 14-year-old son and its functions performed by his relative the marquis de La Vrillière, who was himself also a secretary of state (d. 1725). In 1718, on marrying La Vrillihre's daughter, Maurepas was given nominal control of his father-in-law's department, the royal household' and in 1723 he was assigned the marine, his father's old department. As an administrator Maurepas proved himself intelligent, disinterested and active, remaining in office until 1749, when he was disgraced by Louis XV as a result of a personal quarrel with Mme. de Pompadour. He was recalled from exile by Louis XVI on his accession in 1774, in the capacity of chief confidential adviser without portfolio. It was very largely Maurepas who was responsible for the restoration to the *parlements* of their former political powers, of which they had been deprived in 1771. This act, which was to compromise the prospects of effective fiscal and administrative reform during the remainder of the *ancien régime,* may be attributed to Maurepas' prejudices in favour of the judicial authority imbibed from his grandfather, who had been chancellor under Louis XIV, to his spiteful desire to destroy the chief political innovation of Louis XV's reign and to his shortsighted bid for popularity.

Able, shrewd and experienced, Maurepas was cynical in his use of political power and greatly accelerated the decline in the monarchy's fortunes by his abandonment of Turgot in 1776 and of Xecker in 1781, when those reforming ministers threatened to challenge his ascendancy over the king. He died at Versailles on Nov. 21, 1781. (A. GN.)

MAURER, GEORG LUDWIG, RITTER VON (1790–1872), German legal historian and statesman, one of the 19th-century German scholars inspired by the rising tide of nationalism both to investigate his country's past and to take an active part in its politics. Maurer was born at Erpolzheim near Diirkheim on Nov. 2, 1790, but spent his youth near Heidelberg and attended the university there.

The romantic movement which inspired such scholars as Jacob Grimm and Friedrich von Savigny drove him to inquire into early German institutions. In 1824 he published his *Geschichte des altgermanischen . . . öffentlich-mündlich Gerichtsverfahrens,* a

standard though superseded work. In 1826 he became professor of German civil law and legal history at Munich. His most considerable work consists of 12 monographs on German local government *(Geschichte der deutschen Gemeindeverfassung,* 1854–71). Though defective in detail it is rich in material and ideas.

Maurer's political life continued meanwhile. After holding a number of official legal posts he was appointed a member of the Bavarian *Staatsrat* in 1829. When Prince Otto of Bavaria became king of Greece in 1832, Maurer was made one of his council of regency and until his recall in 1834 he worked at the task of giving Greece a revised penal code and civil procedure. He published a book on Greece in 1835. After the fall of Karl von Abel in 1847 he was for a few months Bavarian chief minister. He died at Munich on May 9. 1872.

See K. T. von Heigel, *Denkwürdigkeiten des . . . G. L. von Maurer* (1903).

MAURETANIA, the ancient name of the northwestern angle of the African continent, bounded toward the south by the Atlas range, and extending along the coast to the Atlantic as far as the point where that chain descends to the sea, in about latitude 30° N. (Strabo p. 825). The Gaetulians to the south of the Atlas range, on the date-producing slopes toward the Sahara, seem to have owed a precarious subjection to the kings of Maui-etania, as afterward to the Roman government. A large part of the country is of great natural fertility, and in ancient times produced large quantities of corn, while the slopes of Atlas were clothed with forests which produced, besides other kinds of timber, the celebrated ornamental wood called *citrum* (Plin., *Hist. Nat.,* 13–96), for tables of which the Romans gave fabulous prices. For physical geography, *see* MOROCCO.

Mauretania, or Maurusia, as it was called by Greek writers, signified the land of the Mauri, or Moors (*q.v.*). The ethnical affinities of the race are uncertain; it is probable that all the inhabitants of this northern tract of Africa were kindred races belonging to the great Berber family *(see* Tissot, *Géographie comparée de la province romaine d'Afrique,* i, 400 *et seq.;* also BERBERS). They first appear in history at the time of the Jugurthine war (110–06 B.C.), when Mauretania was under the government of Bocchus (Sallust, *Jugurtha* 19). To this Bocchus was given, after the war, the western part of Jugurtha's kingdom of Numidia. Sixty years later, at the time of the dictator Caesar, there were two Mauretanian kingdoms, one to the west of the river Mulucha under Bogud. and the other to the east under a Bocchus. Both these kings took Caesar's part in the civil wars, and had their territory enlarged by him. In 25 B.C. Augustus gave the two kingdoms to Juba II of Numidia *(see* JUBA), with the river Ampsaga as the eastern frontier.

Claudius incorporated the kingdom into the Roman state as two provinces, viz., Mauretania Tingitana and Mauretania Caesariensis, the latter taking its name from the city Caesarea. which Juba had adopted as his capital. These provinces were governed until the time of Diocletian by imperial procurators, and were occasionally united for military purposes. Under and after Diocletian Mauretania Tingitana was attached administratively to the *dioikesis* of Spain, with which it was in all respects closely connected.

There were seven Roman colonies in Mauretania Tingitana and eleven in Mauretania Caesariensis; these were mostly military foundations situated on the coast, and served the purpose of securing civilization against the inroads of the natives, who were not suited for town life as in Gaul and Spain, but were under the immediate government of the procurators, retaining their own clan organization. Besides these there were many municipia or *oppida civium romanorum* (Plin. 5, 19 *et seq.),* but, as has been made clear by French archaeologists, Roman settlements were less frequent farther west, and Mauretania Tingitana has yielded but scanty evidence of Roman civilization. On the whole, Mauretania was in a flourishing condition down to the irruption of the Vandals in A.D. 429.

MAURIAC, FRANÇOIS CHARLES (1885–), French novelist and winner of the Nobel prize for literature in 1952, was born in Bordeaux on Oct. 11, 1885. His family had its roots deep in this region, which was to provide the framework and essential atmosphere for most of his stories. The circumstances of his childhood — strongly marked by Catholic influences which proved lasting — are admirably described in *Commencements d'une vie* (1932). He studied at the University of Bordeaux and in 1906 entered the Paris École des Chartes for a short period. His literary career began in 1909 with a volume of poems entitled *Les Mains jointes,* which brought him to the notice of Maurice Barrès. (See *La Rencontre avec Barrès,* 1945.)

Mauriac's first novels were *L'Enfant charge' de chaînes* (1913) and *La Robe prétexte* (1914), followed by *La Chair et le sang* (1920) and *Préséances* (1921). These stories, especially the first two, showed his technique as still uncertain, but they gave indications, particularly *La Chair et le sang,* of his insight into some of those troubled human relationships which he later depicted so forcibly. They deal with themes which constantly recur in his writings: the strains of adolescence, religious and emotional conflicts, the narrow materialism of commercial and middle-class life in his own part of provincial France. *Le Baiser au lépreux* (1922), describing a tragic incompatibility between husband and wife, established Mauriac as a major novelist. He showed increasing mastery in *Génitrix* (1923), a grim story of obsessive maternal affection. *Le Désert de l'amour* (1925; *grand prix du roman* of the Académie Française) and *Thérèse Desqueyroux* (1927). The heroine of this novel, a woman driven to attempt the murder of her husband for motives she does not fully comprehend, reappears in *La Fin de la nuit* (1935) and in two of the short stories contained in *Plongées* (1938). *Le Noeud de vipères* (1932) is often considered Mauriac's masterpiece. It depicts an old man's rancorous enmity toward his family and his eventual change of heart.

In 1933 Mauriac became a member of the Académie Française. His subsequent novels included *Le Mystère Frontenac* (1933), a much less sombre story than most of his works. *Les Anges noirs* (1936), *Les Chemins de la mer* (1939) and *La Pharisienne* (1941), a scathing analysis of religious hypocrisy and the desire for domination. Some shorter stories. published after World War II, met with unequal success: *Le Sagouin* (1951); *Galigaï* (1952); *L'Agneau* (1954).

In 1938 Mauriac had begun what seemed likely to be a notable career as a dramatist with *Asmodée,* a further study of religious hypocrisy. This was followed by *Les Mal Aimés* (1945) but *Le Passage du Malin* (1947) was less successful.

Mauriac was highly sensitive to criticism and anxious to justify himself as a novelist. *Le Roman* (1928), *Le Romancier et ses personnages* (1933) and the five volumes of his *Journal* (1934–53) say much about his intentions and methods. The *Journal* is a work of outstanding interest, which also records his reactions to moral and contemporary problems and his reflections on literature and music. *(See* also *Mémoires intérieurs,* 1959.)

From about 1923 to 1930 Mauriac went through a period of religious disquiet. He was faced with two problems: as an individual he had to work out his faith anew; as an artist he had to reconcile his duty as a novelist with his obligations as a Catholic — namely how to portray the evil in human nature without putting temptation into the minds of his readers. These conflicts and the convictions that emerged are recorded in *Dieu et Mammon* (1929) and *Souffrances et bonheur du chre'tien* (1931). His preoccupation with religious themes found constant expression, for instance in his *Vie de Jésus* (1936), his biographies of St. Margaret of Cortona, Racine and Pascal and the essays on literary topics contained in *Mes Grands Hommes* (1949). As a creative writer he was first and foremost an observer of mankind in the light of eternity. The doctrines of grace and redemption underlie his delineation of human passions, frustrations and weaknesses, particularly sensuality, avarice, jealousy and pride. His characters lead narrowly circumscribed lives, preoccupied with their own problems and little affected by the outside world; their relations with each other, their indwelling upon themselves and the predestined patterns of their lives are all recorded with singular intensity and concentration.

Mauriac was also prominent as a polemical writer. He intervened vigorously in the ideological conflicts of the 1930s, con-

demning totalitarianism in all its forms and denouncing fascist excesses in Ethiopia and Spain. In World War II, during the occupation of France, he worked with the writers of the Resistance. *Le Cahier noir,* published in the clandestine *Éditions de minuit* in 1943 under the pen name of Forez, was a declaration of faith in fundamental human values. After the war he became increasingly engaged in political discussion, first as an editorial writer for the *Figaro* and then as a contributor to *L'Express.*

In 1946, with *A Woman of the Pharisees (La Pharisienne),* Gerard Hopkins began a complete translation into English of Mauriac's novels.

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MAURICE (MAURITIUS), **SAINT** (d. *c.* 286), an early Christian martyr. The oldest form of his story is found in the *Passio Martyrum Acaunensium,* ascribed to Eucherius, bishop of Lyons, *c.* 450, who relates how the Theban legion (from the Thebaid in Egypt) commanded by Mauritius was sent to north Italy to reinforce the army of Maximian. Maximian wished to use them in persecuting the Christians, but as they themselves were of this faith, they refused, and for this, after having been twice decimated, the legion was exterminated at Octodurum (modern Martigny, in Valais canton. Switz.).

Critical study of the legend was stimulated by excavations carried out at St. Maurice (Celtic Agaunum, in Valais canton near Martigny) from 1944 to 1949. In 1956 appeared D. van Berchem's thorough analysis of Eucherius' *Passio,* mentioned above. Since this 5th-century bishop gives as his ultimate source the oral account of Theodore, 4th-century bishop of Octodurum (who signed the decrees of the Council of Aquileia in 381 and to whom reference again is made in 389 or 390), it is with this Theodore that Berchem is especially concerned. He believes him to have been an oriental who brought from his native east to the west the legend of St. Maurice of Apamea, a military saint, who suffered martyrdom together with the 70 soldiers under his command. Theodore may have brought relics of these martyrs with him to the west or, in an age when discovery of the relics of martyrs was not uncommon. he may have transferred the legend to the remains of several bodies which he had found and over which he dedicated a basilica. The explanation is ingenious, and though it remains pure hypothesis, all future work must begin with Berchem's keen criticism of the legend. As a specialist in the history of the Roman army, he showed that if soldiers were martyred at Octodurum they were not Thebans and certainly not a legion, for two of their officers—Mauritius, a *primicerius,* and Candidus, a *senator militum*—have the titles of cavalry officers, whereas a legion was a formation of infantrymen.

The cult of St. Maurice and the Theban legion is found in Switzerland (where two places bear the name in Valais, besides St. Moritz in Grisons), along the Rhine and in north Italy. The foundation of the abbey of St. Maurice in Valais is usually ascribed to Sigismund of Burgundy (515). Relics of the saint are preserved there and at Brieg and Turin. The feast of St. Maurice and his companions is celebrated on Sept. 22.

BIBLIOGRAPHY —*Passio Martyrum Acaunensium,* ed. by Bruno Krusch in *Monumenta Germaniae Historica, Scriptores Rerum Merovingicarum,* vol iii, pp. 20–41 (1896); M. Besson, *Monasterium Acaunense* (1913); J. M Theurillat, *L'Abbaye de Saint Maurice d'Agaune des origines à la réforme canoniale* (515–530) in *Vallesia,* vol. ix, 1–128 (1954); D van Berchem, *Le Martyre de la Légion Thtbaine* in *Schweizerische Beiträge zur Altertumswissenschaft,* vol. viii (1956). An elaborate bibliography covering the older literature, which includes many discussions of the interpolated version or versions of Eucherius' *Passio* and many studies of the diffusion of the cult of these martyrs, is to be found appended to H. Leclercq's article, "Maurice d'Agaune (Saint)," in the *Dictionnaire d'Archéologie chrétienne et de liturgie,* vol. x, col. 2699–2729 (1932). (AM. S.)

MAURICE (MAURICIUS FLAVIUS TIBERIUS) (*c.* 539–602), East Roman emperor from 582 to 602, was of Roman descent, but a native of Arabissus in Cappadocia. He joined the army and fought with distinction in the Persian War (578–581). At the age of 43 he was declared Caesar by the dying emperor Tiberius II, who bestowed upon him his daughter Constantina. Maurice brought the Persian War to a successful close by the restoration of Chosroes II to the throne (591). On the northern frontier he at first bought off the Avars, but after 595 inflicted several defeats upon them through his general Crispus. By his strict discipline he provoked to mutiny the army on the Danube. The revolt spread to the popular factions in Constantinople, and Maurice consented to abdicate. He withdrew to Chalcedon, but was put to death by his successor Phocas, after witnessing the slaughter of his five sons.

MAURICE (1521–1553), elector of Saxony, elder son of Henry, duke of Saxony, of the Albertine branch of the Wettin family, was born at Freiberg on March 21, 1521. In Jan. 1541 he married Agnes, daughter of Philip, landgrave of Hesse In that year he became duke of Saxony by his father's death. and he continued Henry's work of forwarding the Reformation. Duke Henry had decreed that his lands should be divided between his two sons, but as a partition was regarded as undesirable the whole of the duchy came to his elder son. Maurice made generous provision for his brother Augustus, and the desire to compensate him still further was one of the minor threads of his subsequent policy. In 1542 he assisted the emperor Charles V against the Turks, in 1543 against William, duke of Cleves and in 1544 against the French. The harmonious relations between the two branches of the Wettins were disturbed by the interference of Maurice in Cleves, a proceeding distasteful to the Saxon elector, John Frederick; and a dispute over the bishopric of Meissen having widened the breach, war was only averted by the mediation of Philip of Hesse and Luther. Maurice now began to covet the electoral dignity held by John Frederick, and in June 1546 he took a decided step by making a secret agreement with Charles V at Regensburg. Maurice was promised some rights over the archbishopric of Magdeburg and the bishopric of Halberstadt; immunity, in part at least, for his subjects from the Tridentine decrees; and the question of transferring the electoral dignity was discussed. In return the duke probably agreed at all events to remain neutral during the impending war. The struggle began in July 1546, and in October Maurice declared war against John Frederick, having secured the formal consent of Charles to the transfer of the electoral dignity. John Frederick (*q.v.*) hastened from south Germany to defend his dominions. Maurice's ally, Albert Alcibiades, prince of Bayreuth, was taken prisoner at Rochlitz; and the duke, driven from electoral Saxony, was unable to prevent his own lands from being overrun. But Charles V, aided by Maurice, gained a decisive victory over John Frederick at Mühlberg in April 1547, after which by the capitulation of Wittenberg John Frederick renounced the electoral dignity in favour of Maurice, who also obtained a large part of his kinsman's lands.

Maurice soon found causes of complaint against the emperor in the continued imprisonment of his father-in-law, Philip of Hesse, whom he had induced to surrender to Charles and whose freedom he had guaranteed; and in Charles's refusal to complete the humiliation of the family of John Frederick. While assuring Charles of his continued loyalty, the elector entered into negotiations with the discontented Protestant princes. In 1550 he had been entrusted aith the execution of the imperial ban against the city of Magdeburg, and under cover of these operations he was able to collect troops and to concert measures with his allies. Favourable terms were granted to Magdeburg, which surrendered and remained in the power of Maurice, and in Jan. 1552 a treaty was concluded with Henry II of France at Chambord. Mean hile Maurice had refused to recognize the Augsburg *Interim* (Rfay 1548) as binding on Saxony; but a compromise was arranged on the basis of which the Leipzig *Interim* was drawn up for his lands.. Charles aas unprepared for the attack made by Maurice and his allies in March 1552, though he may have suspected his loyalty. Augsburg was taken, the pass of Ehrenberg was forced, and in a few days the emperor left Innsbruck as a fugitive. Ferdinand undertook to make peace, and the Treaty of Passau, signed in

Aug. 1552, was the result. Maurice obtained a general amnesty and freedom for Philip of Hesse, but was unable to obtain a perpetual religious peace for the Lutherans. Charles stubbornly insisted that this question must be referred to the diet, and Maurice was obliged to give way. He then fought against the Turks, and renewed his communications with Henry of France. Returning from Hungary the elector placed himself at the head of the princes who were seeking to check the career of his former ally, Albert Alcibiades, whose depredations were making him a curse to Germany. The rival armies met at Sievershausen on July 9, 1553, where after a fierce encounter Albert was defeated. The victor, however, was wounded and died two days later.

See W. Maurenbrecher in the *Allgemeine deutsche Biographie,* Bd. xxii (Leipzig, 1885); E. Brandenburg, *Moritz von Sachsen* (Leipzig, 1898). For bibliography *see* Maurenbrecher; and *The Cambridge Modern History,* vol. ii (Cambridge, 1903).

MAURICE, JOHN FREDERICK DENISON (1805–1872), English theologian, was born at Normanston, Suffolk, on Aug. 29, 1805. He was the son of a Unitarian minister, and entered Trinity College, Cambridge, in 1823, though it was then impossible for any but members of the Established Church to obtain a degree. Together with John Sterling (with whom he founded the Apostles' Club) he migrated to Trinity Hall, whence he obtained a first class in civil law in 1827; he then came to London. He edited the *London Literary Chronicle* until 1830, and also for a short time the *Athenaeum.* He presently decided to take orders, and with this end in view entered Exeter College, Oxford. He was ordained in 1834, and after a short curacy at Bubbenhall in Warwickshire was appointed chaplain of Guy's Hospital, and became thenceforward a sensible factor in the intellectual and social life of London. In 1840 he was appointed professor of English history and literature in King's College, and to this post in 1846 was added the chair of divinity. In 1845 he was Boyle lecturer and Warburton lecturer. These chairs he held till 1853. In that year he published *Theological Essays,* and was deprived of his professorships for alleged unorthodoxy. He was at this time chaplain of Lincoln's Inn, but when he offered to resign this the benchers refused. Nor was he assailed in the incumbency of St. Peter's, Vere Street, which he held for nine years (1860–1869). During the early years of this period he was engaged in a hot and bitter controversy with H. L. Mansel (afterwards dean of St. Paul's), arising out of the latter's Bampton lecture upon reason and revelation. Maurice was a "Broad" churchman, but he often offended liberal theologians by his opposition to the Higher Criticism. His great influence arose less from his views than from the force of his personality, and the strength of his intellect, and his passionate sympathy with the oppressed.

Maurice was specially identified with two important movements for education in London. He helped to found Queen's College for the education of women (1848), and the Working Men's College (1854), of which he was the first principal. He strongly advocated the abolition of university tests (1853), and threw himself with great energy into all that affected the social life of the people. Some attempts at co-operation among working men, and the movement known as Christian Socialism, were the immediate outcome of his teaching. In 1866 Maurice was appointed professor of moral philosophy at Cambridge, and from 1870 to 1872 was incumbent of St. Edward's in that city. He died on April 1, 1872. *See* CHRISTIAN SOCIALISM.

BIBLIOGRAPHY.—His works cover nearly 40 volumes. The following are the more important works—some of them were rewritten and in a measure recast, and the date given is not necessarily that of the first appearance of the book, but of its more complete and abiding form: *Moral and Metaphysical Philosophy* (at first an article in the *Encyclopaedia Metropolitana,* 1848); *Theological Essays* (1853); *Lectures on Ecclesiastical History* (1854); *The Doctrine of Sacrifice* (1854); *The Conscience: Lectures on Casuistry* (1868); *The Lord's Prayer, a Manual* (1870). The greater part of these works were first delivered as sermons or lectures. Maurice also contributed many prefaces and introductions to the works of friends, as to Archdeacon Hare's *Charges,* Kingsley's *Saint's Tragedy,* etc.

See Sir J. Frederick Maurice, *Life of John Frederick Denison Maurice* (2 vols., 1884); B. H. Alford, *Frederick Denison Maurice* (1909) and C. F. G. Masterman, *F. D. Maurice* (1907).

MAURICE OF NASSAU, prince of Orange (1567–1625), the second son of William the Silent, by Anna, only daughter of the famous Maurice, elector of Saxony, was born at Dillenburg. At the time of his father's assassination in 1584 he was being educated at the University of Leyden, at the expense of the States of Holland and Zeeland. Despite his youth he was made stadtholder of those two provinces and president of the council of state. During the period of Leicester's governorship he remained in the background, engaged in acquiring a thorough knowledge of the military art, and in 1586 the States of Holland conferred upon him the title of prince. On the withdrawal of Leicester from the Netherlands in August 1587, Johan van Oldenbarneveldt, the advocate of Holland, became the leading statesman of the country, a position which he retained for upwards of thirty years. He had been a devoted adherent of William the Silent and he now used his influence to forward the interests of Maurice. In 1588 he was appointed by the States-General captain and admiral-general of the Union, in 1590 he was elected stadtholder of Utrecht and Overysel, and in 1591 of Gelderland.

From this time forward, Oldenbarneveldt at the head of the civil government and Maurice in command of the armed forces of the republic worked together in the task of rescuing the United Netherlands from Spanish domination (for details *see* HOLLAND). Maurice soon showed himself to be a general second in skill to none of his contemporaries. He was especially famed for his consummate knowledge of the science of sieges. The twelve years' truce on April 9, 1609 brought to an end the cordial relations between Maurice and Oldenbarneveldt. Maurice was opposed to the truce, but the advocate's policy triumphed and henceforward there was enmity between them. The theological disputes between the Remonstrants and contra-Remonstrants found them on different sides; and the theological quarrel soon became a political one. Oldenbarneveldt, supported by the States of Holland, came forward as the champion of provincial sovereignty against that of the States-General; Maurice threw the weight of his sword on the side of the union. The struggle was a short one, for the army obeyed the general who had so often led them to victory. Oldenbarneveldt perished on the scaffold, and the share which Maurice had in securing the illegal condemnation by a packed court of judges of the aged patriot must ever remain a stain upon his memory.

Maurice, who had on the death of his elder brother Philip William, in February 1618, become prince of Orange, was now supreme in the State, but during the remainder of his life he sorely missed the wise counsels of the experienced Oldenbarneveldt. War broke out again in 1621, but success had ceased to accompany him on his campaigns. His health gave way, and he died, a prematurely aged man, at the Hague on April 4, 1625. He was buried by his father's side at Delft.

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MAURISTS, a congregation of French Benedictines called after St. Maurus (d. 565), a disciple of St. Benedict and the legendary introducer of the Benedictine rule and life into Gaul. At the end of the 16th century the Benedictine monasteries of France had fallen into a state of disorganization and relaxation; and a reform was initiated by the abbey of St. Vanne near Verdun, which spread to other houses in Lorraine, and in 1604 the reformed congregation of St. Vanne was established. A number of French houses joined the new congregation; but as Lorraine was still independent of the French crown, it was considered desirable to form on the same lines a separate congregation for France. Thus in 1621 was established the famous French congregation of St. Maur. Most of the Benedictine monasteries of France, except those belonging to Cluny, gradually joined the new congregation, which eventually embraced nearly two hundred houses. The chief

house was Saint-Germain-des-Prés, Paris, the residence of the superior-general and centre of the literary activity of the congregation The primary idea of the movement was not the undertaking of literary and historical work, but the return to a strict monastic régime and the faithful carrying out of Benedictine life; and throughout the most glorious period of Maurist history the literary work was not allowed to interfere with the due performance of the choral office and the other duties of the monastic life. Towards the end of the 18th century a tendency crept in, in some quarters, to relax the monastic observances in favour of study; but the constitutions of 1770 show that a strict monastic régime was maintained until the end. The course of Maurist history and work was checkered by the ecclesiastical controversies that distracted the French Church during the 17th and 18th centuries. Some of the members identified themselves with the Jansenist cause; but the bulk, including nearly all the greatest names, pursued a middle path, opposing the lax moral theology condemned in 1679 by Pope Innocent XI., and adhering to those strong views on grace and predestination associated with the Augustinian and Thomist schools of Catholic theology; and like all the theological faculties and schools on French soil, they were bound to teach the four Gallican articles. It seems that towards the end of the 18th century a rationalistic and free-thinking spirit invaded some of the houses. The congregation was suppressed and the monks scattered at the revolution, the last superior-general with forty of his monks dying on the scaffold in Paris. The present French congregation of Benedictines initiated by Dom Guéranger in 1833 is a new creation and has no continuity with the congregation of St. Maur.

The great claim of the Maurists to the gratitude and admiration of posterity is their historical and critical school, which stands quite alone in history, and produced an extraordinary number of colossal works of erudition which still are of permanent value. The foundations of this school were laid by Dom Tarisse, the first superior-general, who in 1632 issued instructions to the superiors of the monasteries to train the young monks in the habits of research and of organized work.

The full Maurist bibliography contains the names of some 220 writers and more than 700 works. The lesser works in large measure cover the same fields as those in the list, but the number of works of purely religious character, of piety, devotion and edification, is very striking. Perhaps the most wonderful phenomenon of Maurist work is that what was produced was only a portion of what was contemplated and prepared for. The French Revolution cut short many gigantic undertakings, the collected materials for which fill hundreds of manuscript volumes in the Bibliothèque nationale of Paris and other libraries of France. When one contemplates the vastness of the works in progress during any decade of the century 1680–1780; and still more, when not only the quantity but the quality of the work, and the abiding value of most of it is realized, it will be recognized that the output was prodigious and unique in the history of letters, as coming from a single society. The qualities that have made Maurist work proverbial for sound learning are its fine critical tact and its thoroughness.

The chief source of information on the Maurists and their work is Dom Tassin's *Histoire littéraire de la congregation de Saint-Maur* (1770); it has been reduced to a bare bibliography and completed by de Lama, *Bibliothèque des écrivains de la congr. de S.-M.* (1882). The two works of de Broglie, *Mabillon* (2 vols., 1888) and *Montfaucon* (2 vols., 1891), give a charming picture of the inner life of the great Maurists of the earlier generation in the midst of their work and their friends. Sketches of the lives of a few of the chief Maurists will be found in McCarthy's *Principal Writers of the Congr. of S. M.* (1868). Useful information about their literary undertakings will be found in De Lisle's *Cabinet des mss. de la Bibl. Nat. Fonds St. Germain-des-Prés.* General information will be found in the *Catholic Encyclopaedia;* Heimhucher, *Orden und Kongregationen* (1907) i. § 36; Wetzer und Welte, *Kirchenlexicon* (ed. 2) and Herzog-Hauck's *Real-encyklopadie* (ed. 3), the latter an interesting appreciation by the Protestant historian Otto Zockler of the spirit and the merits of the work of the Maurists. (E. C. B.)

MAURITANIA (ISLAMIC REPUBLIC OF MAURITANIA), formerly an overseas territory in French West Africa, and established as an autonomous republic within the French Community in Nov. 1958. The country while remaining a member of the French Community became completely independent on Nov. 28, 1960. It is bounded on the west by the Atlantic ocean and Rio de Oro (Spanish), on the north by Rio de Oro and Algeria. on the east by the Mali Republic and also on the south by that republic and Senegal. The area is 419,229 sq.mi. The population (1955 est.) 615,381, of whom approximately 400 were Europeans. It is a Saharan region except in the neighbourhood of the river Senegal. It comprises some massifs, such as Gara Tamar (1,982 ft.) and Zednes (1,640 ft.) near which are several oases and vast plains covered by sand and dunes. The coast, 375 mi. long, is irregular between Cap Blanc and Cap Mirik and comprises the bays of Lévrier and Arguin; to the south of Cap Mirik it is flat, straight and bordered by dunes. The population is composed of a majority of Moors, with a strong Negroid mixture in the south. They are the descendants of the Zenaga, who founded the empire of the Almoravides in the 11th century. The chief resources are gum, salt, fishing around Port Etienne and the rearing of camels, horses, cattle, sheep, goats and donkeys. Cereals and dates are grown. Economically, Mauritania is the least important of the political units of former French West Africa. The principal towns are Port Étienne, Atar and Rosso, point of departure for the most important trans-Saharan route linking Mauritania with Morocco. (T. C. WN.)

MAURITIUS, an island and British colony in the Indian ocean (known while a French possession as the fle de France). It lies between long. 57° 17' and 57° 48' E., and lat. 19° 58' and 20° 32' S., 500 mi. E. of Madagascar. The island is irregularly elliptical — somewhat triangular — in shape, and is 39 mi. long and about 29 mi. broad. It is 130 mi. in circumference and its total area is about 720 sq.mi. Coral reefs surrounding the island make the ports difficult of access.

Dependent upon Mauritius and forming part of the colony are a number of small islands scattered over a large extent of the Indian ocean. These are Rodriguez (*q.v.*), 350 mi. to the east; Chagos archipelago, 1,180 mi. N.E. (the chief island of which is Diego Garcia); Agalega, 580 mi., and Cargados Carajos, 250 mi. n. of Mauritius. The area of the colony is 805 sq.mi.

The mountains of Mauritius make it a picturesque island. The most level portions of the coast districts are the north and north-east, all the rest being broken by hills, which vary from 500 to 2,711 ft. in height. The principal mountain masses are the north-western or Pouce range, in the district of Port Louis; the south-western, in the districts of the Black river and Savanne; and the southeastern range, in the Grand Port district. In the first of these, which consists of one principal ridge with several lateral spurs, overlooking Port Louis, are the Pouce (2,661 ft.) and the Pieter Both (2,690 ft.). The highest summit is in the southwestern mass of hills, the Black River mountain (2,711 ft.). The south-eastern group of hills consists of the Montagne du Bambou, with several spurs running down to the sea. In the interior are extensive fertile plains, about 1,200 ft. in height, forming the districts of Moka, Vacois and Plaines Wilhelms; and an abrupt peak, the Piton du Milieu de l'fle (1,923 ft.), rises from the centre of the island. Other prominent summits are the Trois Mamelles, the Montagne du Corps de Garde, the Signal mountain, near Port Louis, and the Morne Brabant.

The rivers are small, and in the dry season little more than brooks, in the wet season, raging torrents. The principal streams are Grand River South East and Grand River North West, 22 and 14 mi. long respectively. The island is of volcanic origin and the more recent craters (now extinct) cross the centre. The volcanic rocks are basic in character and belong to two periods of eruption, the earlier forming the mountain mass of the Black river district; the later being basalts and dolerites from craters of the central district. Many craters were partially denuded but some contain lakes; *e.g.,* Grand Bassin, Mare aux Vacois and Mare aux Joncs. Some lava-flows alternate with coral reefs. The basement rocks are represented by a mass of clay-slates in the Black river mountains and by much contorted chlorite-schists in La Selle mountain in the island's centre. There is evidence of a recent elevation of from 40 ft. (south) to 12 ft. (north), while caves and

underground rivers in the lava-flows are common.

Climate. — The climate is pleasant during the cool season of the year, but oppressively hot in summer (November to April), except in the elevated plains of the interior, where the thermometer ranges from 70° to 80° F., while in Port Louis and on the coast generally it ranges from 90° to 96°. The mean temperature for the year at Port Louis is 78.6". There are two seasons, the cool and comparatively dry season, from April to November, and the hotter season, during the rest of the year. The rainfall varies greatly in different parts of the island. At or near sea level the average annual rainfall is 50 in. or less, the minimum being about 30 in. in the western and northwestern coastal areas. The amount increases with altitude and reaches nearly 200 in. on the highest part of the central plateau, about 2,000 ft. above sea level. The mean monthly rainfall for the whole island varies from 12 in. in March to 2.6 in, in September and October. The observatory and Royal Botanical gardens are at Pamplemousses, on the dry northwest side of the island. Cyclones, with torrents of rain, occur during the summer season, with the greatest frequency in January and February. The highest average wind velocity recorded has been about 90 m.p.h., with peak velocities of 130 m.p.h.

Flora and Fauna. — At the time of the Dutch colonization the island was densely forested, but the settlers in turn — Dutch, French and British — destroyed the trees partly for their value and partly to plant the cleared areas. By the middle of the 20th century there were only a few scattered fragments of the original forests in the remoter parts and in these five species of ebony were still found. A kind of screwpine called vacoas (*Pandanus utilis*), whose leaves are used for making bags, the latanier (*Roseheria melanochaetes*), the traveller's tree (Ravenala madagascarensis) and several species of bamboo grow wherever they are allowed, and bamboo is also cultivated for hedgerows. There are no longer wild date palms, but these are cultivated for ornament. About one-fifth of Mauritius was covered with woodland, one-fifth with scrub and grassland. one-third with crops (chiefly sugar cane) and the rest was either bare rock or covered with towns and buildings by mid-20th century.

A large variety of fruit is produced, including the tamarind, mango, banana, pineapple, guava, shaddock, fig, avocado pear, litchi, custard apple and the mabolo (*Diospyros* discolor). Many of the roots and vegetables of Europe have been introduced, as well as some peculiar to the tropics, including maize, millet, yams, manioc, dal, gram, etc. Small quantities of tea, rice, sago, spices (cloves, nutmeg, ginger, pepper and allspice), cotton, indigo. betel, camphor, turmeric and vanilla are grown. The Royal Botanical gardens at Pamplemousses, which date from the French occupation of the island, contain a rich collection of tropical and extratropical species.

When Mauritius was first seen by Europeans the only animals in the islands were two species of bat, one of which was a large fruit-eating bat, some reptiles. now mostly extinct, and birds. The Portuguese introduced one species of monkey (*Macaca* irus), goats and the rats (unintentionally) Rattus *norvegicus* and R. rattus. The Dutch brought the sambur deer (Cervus rusa). The present mammals include a small hare, a shrewmouse, two kinds of pig, the tenrec from Madagascar (*Centetes* ecaudatus) and the mongoose, now a pest. By 1952, 103 species of birds had been identified and it was calculated that at least 12 endemic forms were extinct, mostly as a result of the clearing of the forest. The best known of these was the dodo (Raphus cucullatus) which, hunted by man and by the introduced wild pig, became extinct in 1681. At the same date there were 10 endemic species (most of which have been replaced in Réunion by related species and subspecies), 12 indigenous and 19 exotic species in Mauritius. Very rare birds included some partridges, quails and francolins, the Mauritius parakeet, pink pigeon, kestrel and olive white-eye — the last two being unable to adapt themselves to the lack of trees: the others being destroyed by man. The Mauritius merle and Bourbon flycatcher are among those whose numbers are decreasing but the swiftlet, manioc bird and Réunion martin have adapted themselves to the new conditions. The seabirds and waders have not altered greatly. Reptiles include two indigenous snakes on Round Island, *Casarea dus-*sumieri (a kind of boa) and Bolyeria multicarinata. The coastal seas contain great numbers of fish, the coral reefs abound with a large variety of molluscs and there are numerous land shells.

History. — Mauritius was probably visited by both Arab sailors and Malays during the middle ages, and on maps of about 1500 it is shown with an Arabic name. The first European to discover it is believed to have been Domingo Fernandez, and on many 16th-century maps the island appears with the Portuguese name of Cerné. The Portuguese made no settlement on the island and in 1598 the Dutch took possession and called it "Mauritius" after their stadholder. Maurice of Nassau. The Dutch settlers never numbered more than a few hundred and the island was abandoned in 1710. The Dutch exploited the island's ebony forests, but they introduced sugar cane, cotton, domestic animals and deer.

The French claimed the island in 1715 and called it *Île* de France. Until 1767, when the French government assumed direct control! it was governed by the French East India company. Mahé de La Bourdonnais (*q.v.*) did more than any other governor to change what was a small outpost into a prosperous and strong colony. He made sugar planting the main industry and promoted the planting of cotton and indigo. He also put down the maroons, or runaway slaves, who had long been a problem on the island. The regime introduced in 1767 divided the administration between a governor, primarily charged with military matters, and an intendant. The colony continued to rise in value during the time it was held by the French crown, and to one of the intendants, Pierre Poivre, was due the introduction of the clove, nutmeg and other spices.

During the long war between France and England, at the beginning of the 19th century. Mauritius was a continual source of harm to English Indiamen and other merchant vessels; and at length the British government determined upon an expedition for its capture. This was effected in 1810, and upon the restoration of peace in 1814 the possession of the island was confirmed to Britain by the treaty of Paris. By the eighth article of capitulation it was agreed that the inhabitants should retain their own laws, customs and religion; and thus the island is still largely French in language, habits and predilections; but its name has again been changed to that given by the Dutch.

A council of government was first constituted in 1825, consisting of the governor and four officials, but a year later the constitution was amended and a council including unofficial members was introduced. At the emancipation of the slaves (1834), Indian labourers were brought in to work in the fields, and the planters received £2,000,000 compensation for the loss of their slave labour. In spite of many calamities the island continued to prosper as an important sugar-producing country. Cholera caused the death of 17,000 persons in 1854, and 30,000 died of malaria in 1866–67. In 1892 a cyclone of terrific violence caused 1,200 deaths and immense destruction of property. In 1893 a great part of Port Louis was destroyed by fire. The epidemic of surra in 1902 killed off all the draught oxen and necessitated the introduction of mechanical transport. In 1911 the Phytalus smithi beetle was found to be attacking the sugar cane.

Prosperity resulting from the high price of sugar in World War I made possible many schemes of improvement, but the price fell once more. and at the end of 1930 the condition of the sugar industry was extremely serious. A cyclone in 1931 and a severe drought in 1934 accentuated the difficulties of the planters, but with substantial sugar crops the position subsequently improved. Importation being restricted during World War II, tens of thousands of acres formerly under sugar cane were planted with maize, manioc and sweet potatoes, and Mauritius became entirely independent of imports of rice, staple food of the people, and tea.

In 1947 letters patent were issued granting the colony a broader political franchise. Under the new constitution the number of registered electors rose from 12,000 to 71,723. There was also a regrouping of electoral districts.

Population. — Until 1834 the inhabitants consisted only of descendants of European settlers and the African slaves they had imported. With the emancipation of the slaves, Indian labour mas brought into the island and today Indo-Mauritians greatly out-

number those of European and African origin. There is also a small Chinese community. The Europeans are chiefly French and British. French is more commonly spoken than English. The vernacular is called Creole and is the lingua franca but it is unwritten. The vocabulary is derived from French, the grammar is largely Bantu. At the census of 1952 the population was 501,415, not including 15,085 inhabitants of the dependencies of Mauritius. The population was then nearly three times what it had been a century earlier, and Indo-Mauritians made up 64% of it. The island is one of the most thickly populated countries in the world. It has about 696 inhabitants to the square mile. On the central plateau there is a population density of more than 1,800 to the square mile.

Chief Towns.—The capital and seat of government, the city of Port Louis (with a population in 1952 of 69,693), is on the northwestern side of the island, in 20° 10′ S., 57° 30' E., at the head of an excellent harbour, a deep inlet about a mile long. The harbour is flanked on the north by Fort George, a military post, and on the south by Fort William, now abandoned. The harbour can accommodate ten vessels of a maximum draught of 29 ft. and four vessels of 18 ft. draught. The chief buildings are Government house, Anglican and Roman Catholic cathedrals, the Institute (comprising museum, art gallery and public library), town hall and theatre. Port Louis is surrounded by lofty hills and its unhealthful situation is aggravated by the difficulty of effective drainage because of the small amount of tide in the harbour. Curepipe (22,026), 20 mi. from Port Louis and at an altitude of 1,800 ft., is a favourite residential town, and others on the railway between that place and Port Louis are Beau Bassin (14,761), Rose Hill (13,929) and Quatre Bornes (17,707). Mahebourg (9,329) is a town on the shores of Grant Port, on the southeast side of the island, and Souillac (1,999) a small town on the south coast.

Religion and Education.--Nearly 98% of the population, other than Indo-Mauritian and Chinese, are Christians, 77% of the Indo-Mauritians are Hindus, 22% are Moslems, the remainder are Christians. The Chinese are largely Buddhists, but Confucianism and Taoism affect their religious practices. The majority of the European inhabitants belong to thk Roman Catholic faith. Anglicans. Roman Catholics and the Church of Scotland are helped by government grants. At the head of the Anglican community is the bishop of Mauritius; the chief Roman Catholic dignitary is styled bishop of Port Louis.

Education is free but not compulsory. The education law of 1934 empowered the governor in executive council to make regulations for management of government and state-aided primary schools and of aided secondary schools. Primary schools in 1953 had an enrolment of 72,158. The government paid teachers' salaries and part of the cost of maintenance of state-aided primary schools. In 1952 there were jj secondary schools, of which 3 were government- and 9 state-aided. The Royal college is a government school at Curepipe for the secondary and higher education of boys; at Port Louis is an associated institution, the Royal College school, where pupils may undergo commercial training in place of classics or science. The girls' government secondary school opened at Rose Hill in 1951. Pupils at the government secondary schools are drawn from all races and classes in the colony, and range in age from 10 to 20 years.

Government.— The governor, appointed by the British government, is assisted by an executive council and a legislative council. The former body consists of three officials and four members selected for appointment by the legislative council from among the nonofficial members. The legislative council is composed of 3 ex officio, 12 nominated nonofficial and 19 elected members, under the presidency of the governor. Debates in the legislative council may be conducted either in English or French. The normal life of a council is five years. Port Louis is represented by four members and the electoral districts each return three members. Forthcoming constitutional changes were announced in 1956. When adopted these would involve the increase of the executive council to 12 and the legislature to 25 elected members and a speaker. Members of the executive council would be ministers. It was proposed that universal adult suffrage should be introduced in 1958.

Port Louis is administered by a municipality, an institution which dates back to 1790. The mayor and the deputy mayor are appointed by the council, subject to confirmation by the governor. There are town councils in the principal townships and there are 84 village councils.

The island has largely retained the old French laws, the *codes civil, de procédure, du commerce* and *d'instruction criminelle* being still in force, except so far as altered by colonial ordinances. A supreme court of civil and criminal justice was established in 1831 under a chief judge and two puisne judges; it is also a court of admiralty, and it decides appeals from the supreme court of Seychelles, the judge in bankruptcy, the master and registrar and the inferior courts of Mauritius. A court of criminal appeal was set up in 1955 to hear appeals from the supreme court.

Industries.— The soil of the island is a fertile ferruginous red clay in which stones are abundant. About 200,000 ac. of the total area of the colony (460,800 ac.) are under cultivation and about 84,000 ac. under forest. The industries of Mauritius are almost entirely agricultural, the soil being suitable for the cultivation of almost all kinds of tropical produce. The greater portion of the plains has become a vast sugar plantation. Sugar forms 97% of the exports of Mauritius. Production for 1953 was approximately 512.076 metric tons, an increase of 55,076 tons over the average for the preceding three years. There were in 1953 27 sugar factories; in addition there were 5 tea, 39 aloe fibre, 12 wine, 2 oil and soap, 1 cigarette and 1 match factories; the total number of registered factories was 250, including biscuit, butter and ice factories and the government sack factory. Apart from sugar the principal exports are colonial spirits, aloe fibre, sugar molasses, and tea. The main imports are manufactured goods of all descriptions and many articles of food and drink.

There are three trading banks; the Mauritius Commercial bank, established in 1838, the Mercantile Bank of India, which took over the business of the Bank of Mauritius in 1916, and Barclays' bank (dominion, colonial and overseas). The Mauritius Agricultural hank was founded in 1936, the capital being provided by the government. The local unit oi currency is the Mauritius rupee, equivalent to 1s. 6d. sterling, divided into 100 cents. A new government note issue was established in 1934 and a subsidiary silver coinage introduced.

Communications.— A twice-weekly scheduled air service to Europe is maintained by Air France. A fortnightly service maintained by Qantas Empire Airways between Sydney and Johannesburg also serves Mauritius. The Messageries Maritimes steamers connect Mauritius with Marseilles, via Suez, and the vessels of Koninklijke Paketvaart Maatschappij leave the island for Durban, U. of S. Af., where they connect with Union Castle steamers for the United Kingdom. There is no regular service by sea between Mauritius and the United Kingdom. Communication with India is maintained by the K.P.M. (Dutch line) via Batavia, and by the Messageries Maritimes via Momhasa and Aden. These shipping companies also connect Mauritius with Reunion and Madagascar.

Cable and Wireless, Ltd., provides overseas telecommunication.

The Mauritius government railway network has 92 mi. of line. The first railway was opened in 1864. Extremely heavy gradients, many of them being 1 in 26, make the operation of the railways exceptional, restricting speed and limiting the weight oi trains.

The colony is well served with about 710 mi. of road, about 330 mi. of which are main tarred roads. There are 35 approved bus routes which go to every town and village in the island.

See S. B. De Burgh-Edwardes, *The History of Mauritius* (London, 1921); *R.* Philogène, *The Island of Mauritius* (Port Louis, 1928); W. H. Ingrams, *A School History of Mauritius* (London, 1931); *A.* Toussaint, *Port Louis. Deux Siècles d'Histoire, 1735–1935* (Port Louis, 1936); A. N. Combes, *The Evolution of Sugarcane Culture in Mauritius* (Port Louis, 1937); the annual *Colonial Report* and *Mauritius Blue Book*. (W. H. Is.)

MAUROIS, ANDRÉ (1885–), French writer, was born at Elbeuf, and educated at Rouen. He first became known to the English public by his *Silences du colonel Bramble* (1918), based on his experiences as an interpreter during World War I. His style is delicate but direct, and his delineation of English character has perhaps helped to make his later books also widely read in translation. He experiments in biography in the form of fiction: exemplified in *Ariel, ou la vie de Shelley* (1923), and this book, which had a great success, was followed by similar treatment of the life of Disraeli (1927), and of Byron (1930).

His other works include *Ni ange ni bête* (1919); *Les Discours du*

Docteur O'Grady (1920); *Dialogues sur le commandement* (1924); *Meïpe* (1926); *Bernard Qursnay* (1926); *Un Essai sur Dickens* (1927); *Quatre études anglaises* (1927); and *Climats* (1928).

MAURRAS, CHARLES (1868–1952), French writer and politician, was born on April 20, 1868, at Martigues, Provence of a royalist family He began his journalistic career as literary critic in the *Revue encyclope'dique* and the *Gazette de France.* He then joined *L'Action française,* where he was at first the only royalist on the staff. He soon converted almost all his colleagues. After visiting Greece and Italy he published *Trois iddes politiques* (1898); *Les Amants de Venise* (1902); and *L'Avenir de l'intelligence* (1905). This was his most productive period, during which his royalist propaganda exerted a powerful influence; he assisted Léon Daudet in transforming (1908) *L'Action française* into a daily paper. In his *Kiel et Tanger* (1910) he criticized French foreign policy. while *Le Dilemme de Marc Sangnier* (1906) dealt with religious problems. Though an avowed atheist, Maurras somewhat paradoxically favoured an alliance with the Catholic Church which he regarded as closely connected with the monarchy. Moreover. he saw in the Catholic Church an instrument for securing the political and social stability which he valued. But the strange alliance was not endorsed by the Church. *L'Action française* lost considerable influence when the French clergy withdrew their support and defeated Daudet during his candidature for parliament in 1923 and 1925. On Oct. 29. 1926. Maurras was sentenced to two years' imprisonment and a fine of 1.000 francs for an open letter to Abraham Schrameck (1925), which accused him, as minister of the interior, of favouring Communists; the letter might he read as an incitement to extreme violence. In 1927 consternation was created aniong French Catholic royalists by the promulgation of a decree (Dec. 29. 1926) placing certain of Maurras' books and *L'Action française* itself on the *Index Librorum Prohibitorum,* in view of articles by Daudet and Maurras which. it was said, attacked the Holy See. This decree was accepted by the French clergy in a declaration published in Oct. 1927.

The articles written by hlaurras during World War I appeared in eight volumes entitled *Les Conditions de la victoire* (1915–20). Though the writings of Maurras produced a profound effect on French thought. his nationalist ideas failed to take deep root in his own country, but they triumphed in Italy; and *L'Idea nazionale* with its fascist doctrines owed much to *L'Action française.* The French movement with which the name of hlaurras is associated may be regarded as an inchoate fascism. That explains his influence under the Pétain regime from 1940 to 1944. After the Liberation he was prosecuted and given a life sentence. He died on Nov. 16, 1952, in a hospital in Tours. after having been received into the Catholic Church and having published a second collection of poems: *La Balance intdrieure,* as an echo to his *La Musique intérieure* (1925). Among his numerous prose works may be mentioned the following: *Jean Moréas* (1891); *Le Chemin de paradis* (1894); *Anthinéa* (1901); *L'Enquête sur la monarchie* (1900–09); *La Politique religieuse* (1912); *Quand les Français ne s'aimaient pus* (1916).

See A. Thibaudet, *Les Idées* de *Charles Maurras* (Paris, 1920); X. Vallat, *Charles Maurras, n° d'écrou 8321* (1953).

MAURY, JEAN SIFFREIN (1746–1817), French cardinal and archbishop of Paris, the son of a poor cobbler, was born on June 26, 1746, at Valréas in the Comtat-Venaissin. He was educated at the seminary at Avignon. In 1777 he published under the title of *Discours choisis* his panegyrics on St. Louis, St. Augustine and Fénelon, his remarks on Bossuet and his *Essai sur l'éloquence de la chaire,* a volume which contains much good criticism and remains a French classic. The book was often reprinted as *Principes de l'éloquence.* He was Lent preacher at court in 1781, when King Louis XVI said of his sermon: "If the abbé had only said a few words on religion he would have discussed every possible subject."

In 1781 he obtained the rich priory of Lyons, near Péronne. and in 178j he was elected to the Academy. In 1789 he was elected a member of the states general by the clergy of the bailliage of Péronne, and from the first proved to be the most able and persevering defender of the *ancien rdgime,* although he had drawn up the greater part of the *cahier* of the clergy of Péronne, which contained a considerable program of reform. It is said that he attempted to emigrate both in July and in October 1789; but after that time he held firmly to his place, when almost universally deserted by his friends. In the constituent assembly he fought against the alienation of the property of the clergy. His life was often in danger. but his ready wit always saved it, and it was said that one *bon mot* would preserve him for a month. When he did emigrate in 1792 he was at once named archbishop in *partibus,* and extra nuncio to the diet at Frankfort! and in 1794 cardinal. He was finally made bishop of Montefiascone, but in 1798 the French drove him from his retreat, and he sought refuge in Venice and St. Petersburg. Next year he returned to Rome as ambassador of the exiled Louis XVIII. In 1806 he returned to France, and in 1810 was made archbishop of Paris. He was presently ordered by the pope to surrender his functions as archbishop of Paris. This he refused to do. At the Restoration he was expelled from the Academy and from the archiepiscopal palace. He retired to Rome, where he was imprisoned in the castle of St. Angelo for six months.

He died in 1817, a year or two after his release, of disease contracted in prison and of chagrin.

The *Oeuvres choisies du Cardinal Maury* (5 vol., 1827) contain what is worth preserving. Msgr. Ricard has published Maury's *Correspondance diplomatique* (2 vol., Lille, 1891). For his liie and character see *Vie du Cardinal Maury, by* Louis Siffrein Maury, his nephew (1828); J. J. F. Poujoulat, *Cardinal Maury, sa vie et ses oeuvres* (1855); Sainte-Beuve, *Causeries du lundi* (vol. iv); Msgr. Ricard, *L'abbé Maury* (1746–91), *L'abbé Maury avant 1789, L'abbé Maury et Mirabeau* (1887); *G.* Bonet-Maury, *Le cardinal Maury d'après ses mémoires et sa correspondance inédits* (1892); A. Aulard, *Les Orateurs de la Constituante* (1882). Oi the many libels written against him during the Revolution the most noteworthy are the *Petit carême de l'abbé Maury,* with a supplement called the *Seconde année* (1790), and the *Vie Privée de l'abbé Maury* (1790), claimed by J. R. Hébert, but attributed by some writers to Restif de la Bretonne. For further bibliographical details *see* J. M. Quérard, *La France littéraire,* vol. v (1833).

MAURY, MATTHEW FONTAINE (1806–1873), **U.S.** naval officer and hydrographer whose oceanographical research received wide recognition, was horn in Spottsylvania county. Va. In 1825 lie entered the navy as midshipman. circumnavigating the globe in the "Vincennes" during a cruise of four years (1826–30). In 1839 an accident resulted in permanent lameness and unfitted him for active service, and in 1841 he was placed in charge of the depot of charts and instruments. out of which grew the U.S. naval observatory and the hydrographic office. He laboured to obtain observations as to the winds and currents by distributing to captains of vessels specially prepared logbooks. One result was to show the necessity for combined action on the part of maritime nations in regard to ocean meteorology. This led to an international conference at Brussels in 1853, which produced great benefit to navigation as well as indirect benefit to meteorology.

In 185j he was given the rank of commander. On the outbreak of the Civil War in 1861. Maury threw in his lot with the South, and became head of coast, harbour and river defenses. He invented an electric torpedo for harbour defense, and in 1862 was ordered to England to purchase torpedo material, etc. After the war he went to Mexico. and as the imperial commissioner of immigration of the emperor Maximilian, attempted to found a Virginian colony there. While there he introduced the cultivation of cinchona. The scheme of colonization was abandoned by the emperor (1866), and Maury settled for a while in England, where he was presented with a testimonial raised by public subscriptions. In 1868 he accepted the professorship of meteorology in the Virginia Military institute, and settled at Lexington, Va., where he died on Feb. 1. 1873,

Among works published by Maury are the papers contributed by him to the *Asfronomical Observations* of the U.S. observatory; *Letters on the American and Atlantic Slopes of South America* (1853); *Physical Geography of the Sea* (1855); *Letter Concerning Lanes for Steamers Crossing the Atlantic* (1855); *Physical Geography* (1864); *Manual of Geography* (1871).

See Diana Fontaine Maury Corbin (his daughter), *Life* of *Matthew Fontaine Maury* (1888); and C. L. Lewis, *Matthew Fontaine Maury,*

the Pathfinder of *the Seas* (1927).

MAUSOLEUM: see MONUMENTS AND MEMORIALS.

MAUSOLUS (more correctly MAUSSOLLUS), satrap and practically ruler of Caria (377–353 B.C.). The part he took in the revolt against Artaxerxes Mnemon, his conquest of a great part of Lycia, Ionia and of several of the Greek islands, his co-operation with the Rhodians and their allies in the war against Athens, and the removal of his capital from Mylasa, the ancient seat of the Carian kings, to Halicarnassus are the leading facts of his history.

Mausolus is best known from the tomb erected for him by his widow Artemisia. The architects Satyrus and Pythis, and the sculptors Scopas, Leochares, Bryaxis and Timotheus, finished the work after her death. See HALICARNASSUS.

MAUVE, ANTON (1838–1888), Dutch painter, who, like his friends, Jozef Israels and the three Maris brothers, was profoundly influenced by J. B. C. Corot, J. F. Millet and the Barbizon painters, and whose work consists largely of landscapes and scenes of rural life. He was born at Zaandam, near Amsterdam, on Sept. 18, 1838, and settled at The Hague in 1870, painting in the neighbouring fishing village of Scheveningen. In 1885 he went to live in the country at Laren, near Hilversum, and died at Arnhem on Feb. 5, 1888. Mauve's pictures are subdued in colour, and close to Corot in their harmonies of grays and blues. He was an accomplished water-colourist. His wife, Jet Cabentus, was a cousin of Vincent van Gogh, whom Mauve was able to help with advice about oil painting in 1881 and 1882. (A. Bs.)

MAVIS, local British name for resident song thrush (*Turdus* ericetorum) and mistle thrush (T. viscivorus) and wintering redwing (T. musicus), used in poetry. See THRUSH.

MAVROCORDATO, MAVROCORDAT or MAVROGORDATO, the name of a family of Phanariot Greeks, distinguished in the history of Turkey, Rumania and modern Greece. The family was founded by a merchant of Chios, whose son Alexander Mavrocordato (c. 1636–1709), became dragoman to the sultan in 1673 and drew up the treaty of Karlowitz (1699). He became a secretary of state, and was created a count of the Holy Roman empire. His authority, with that of Hussein Kupruli and Rami Pasha, was supreme at the court of Mustapha II, and he ameliorated the condition of the Christians in Turkey. He was disgraced in 1703, but was recalled to court by Sultan Ahmed III. He left some historical, grammatical, etc., treatises of little value.

His son NICHOLAS MAVROCORDATO (1670–1730) was grand dragoman to the divan (1697), and in 1708 was appointed hospodar (prince) of Moldavia. Deposed, owing to the sultan's suspicions, in favour of Demetrius Cantacuzene, he was restored in 1711, and soon afterwards became hospodar of Walachia. In 1716 he was deposed by the Austrians, but was restored after the peace of Passarowitz. He was the first Greek ruler of the Danubian principalities, and established the system which for a hundred years was to make the name of Greek hateful to the Rumanians. He introduced Greek manners, the Greek language and Greek costume, and set up a splendid court on the Byzantine model. Nicholas founded libraries and was himself the author of a curious work entitled Peri kathekonton (Bucharest, 1719). He was succeeded as grand dragoman (1709) by his son John (Ioannes), who was for a short while hospodar of Moldavia, and died in 1730.

Nicholas Mavrocordato was succeeded as prince of Walachia in 1730 by his son Constantine who ruled during intervals from 1735 to 1749. He was wounded and taken prisoner at Galati during the Russo-Turkish War on Nov. 5, 1769, and died in captivity.

PRINCE ALEXANDER MAVROCORDATO (1791–1865), Greek statesman, a descendant of the hospodars, was born at Constantinople on Feb. 11, 1791. In 1812 he went to the court of his uncle Ioannes Caradja, hospodar of Walachia, with whom he passed into exile in Russia and Italy (1817). He was a member of the Hetairia Philike and was among the Phanariot Greeks who hastened to the Morea on the outbreak of the War of Independence in 1821. In Jan. 1822 he presided over the first Greek national assembly at Epidaurus.

He commanded the advance of the Greeks into western Hellas, and was defeated at Peta on July 16. but retrieved this disaster somewhat by his successful resistance to the first siege of Missolonghi (Nov. 1822 to Jan. 1823). His English sympathies brought him, in the subsequent strife of factions, into opposition to the "Russian" party headed by Demetrius Ypsilanti and Kolokotrones; and though he held the portfolio of foreign affairs for a short while under the presidency of Petrobey (Petros Mavromichales). he was in retirement until February 1825, when he again became a secretary of state. The landing of Ibrahim Pasha followed, and Mavrocordato again joined the army, only escaping capture in the disaster at Sphagia (Spakteria), on May 9, 1815, by swimming to Navarino. He was vice-president of the National assembly at Argos (July, 1832), and was appointed by King Otto minister of finance, and in 1833 premier. From 1834 onwards he was Greek envoy at Munich, Berlin, London and — after a short interlude as premier in Greece in 1841 — Constantinople. He was again prime minister in 1844 and in 1854–5. He died in Aegina on Aug. 18, 1865.

MAWER, SIR ALLEN (1879–1942), English philologist and student of place names, mas born on May 8, 1879.

A graduate of Cambridge university, Mawer taught at several provincial universities before coming to London, where he was provost of University college from 1930 until his death. His first interest was in early English and Scandinavian history and literature (The Vikings, 1913), but from 1920 all his work was in the field of English toponymy. He was one of the founders of the English Place-Name society (1924), director of its Survey of English Place Names until his death. and joint author of 14 of the 17 county surveys published by 1942, as well as of several studies concerned with English place-name research. He was knighted in 1937.

Mawer died on July 22, 1942, at Broxbourne, Hertfordshire. (M. S. BR.)

MAWSON, SIR DOUGLAS: see ANTARCTIC REGIONS.

MAX, ADOLPHE (1869–1939), Belgian politician, was born in Brussels on Dec. 31, 1869. From 1894 to 1903 he was successively provincial councilor of Brabant, councilor of the commune and alderman of Brussels, and finally burgomaster (1909). In 1914 when the German troops entered Brussels he refused to perform his duties under the authority of the German governor, and demanded complete freedom of action. He protested vigorously against the abuses of the army of occupation, and fought with indomitable energy for the rights of his fellow subjects, and for the reduction of the heavy taxes and requisitions which were imposed on the town. He further founded a central committee to deal with supplies which, under the name of Le *Comité* National, rendered invaluable services to his countrymen. But the German authorities soon took exception to his spirited resistance, and on Sept. 26. 1914 he was arrested and imprisoned in the fortress of Namur, and from there was sent into Germany, where he was closely confined.

On Nov. 13, 1918, he succeeded in escaping and returned to Belgium, where he was welcomed with great enthusiasm. Max was elected to the chamber of representatives in 1919; he was made minister of state on Nov. 21, 1918, and was also elected member of the Belgian Academy.

MAXENTIUS, MARCUS AURELIUS VALERIUS, Roman emperor from A.D. 306 to 312, was the son of Maximianus Herculius, and the son-in-law of Galerius. He was left out of account in the division of the empire which took place in 305. A variety of causes. however, had produced strong dissatisfaction at Rome with many of the arrangements established by Diocletian, and on Oct. 28, 306, Maxentius headed a rising and summoning his father Maximianus from retirement, captured and killed Valerius Severus and drove Galerius out of Italy when he attacked them. Maxentius quarreled with his father, and the congress at Carnuntum for 308 again ignored him, but nothing was done to depose him. The death of Galerius in 311 precipitated a conflict; Constantine came to terms with his other rival Licinius, crossed the Alps and struck at Rome. The decisive battle was fought at Saxa Rubra on the passage of the Tiber; Maxentius was defeated,

and drowned in the Tiber (Oct. 27, 312).

See De Broglie, *L'Eglise et l'empire Romain au quatrième siècle* (1856–66), and on the attitude of the Romans toward Christianity generally, app. 8 in vol. ii of J. B. Bury's edition of Gibbon (Zosimus ii, 9–18; Zonaras xii, 33, xiii, 1; Aurelius Victor, *Epit.* 40; Eutropius, x, 2).

MAXIM, HUDSON (1853–1927), U.S. inventor, was born at Orneville, Me., on Feb. 3, 1853, and completed his academic studies at Kent's Hill, Me. Though his education was but slight, his interest in chemistry led him to wide reading and experimentation in the subject while he worked at other jobs. In 1875 he formulated (published in *Scientific American Supplement*, 1889) an hypothesis of the compound nature of atoms not unlike the atomic theory which was later to be generally accepted by scientists.

In 1888 he began to experiment with explosives and in 1890 built a dynamite and powder factory at Maxim, N.J. There, together with Dr. R. C. Schupphaus, he developed the Maxim-Schupphaus smokeless powder, the first made in the United States and the first to be adopted by the U.S. government. He next invented a smokeless cannon powder, the cylindrical grains so perforated that it burned with a more rapid combustion, that was used in enormous quantities during World War I. In 1897 he sold his factory and powder inventions to the E. I. DuPont company, but remained with the company as consulting engineer.

He invented "maximite," a high explosive bursting powder which, when placed in torpedoes, resisted the shock of firing and the still greater shock of piercing armour plate without bursting, only to be set off by a delay-action detonating fuse; which was also his invention. Later he perfected a new smokeless powder called "stabillite," because of its high stability. "Motorite," a self-combustive substance used to propel torpedoes, was also his invention.

During World War I he was chairman of the committee on ordnance and explosives of the naval consulting board. Several, of his own inventions at this time were donated to the government.

SIR HIRAM STEVENS MAXIM (1840–1916), his brother, was the inventor of the Maxim automatic gun.

MAXIMA AND MINIMA: *see* CRITICAL POINTS.

MAXIMIANUS, MARCUS AURELIUS VALERIUS, surnamed Herculius, Roman emperor from A.D. 286 to 305, was born at Sirmium in Pannonia. He rose from the ranks to distinction in the army, and having been made Caesar by Diocletian in 285, received the title of Augustus on April 1, 286.

In 287 he suppressed the rising of the peasants (Bagaudae) in Gaul, but he had to acquiesce in the usurpation of Britain by Carausius. After 293 the empire was further divided, and Constantius Chlorus took over the Rhine, while Maximianus had Italy and Africa. In 297 he won a victory in Mauretania, and in 302 he shared at Rome the triumph of Diocletian.

On May 1, 305, the day of Diocletian's abdication, he also, but without his colleague's sincerity, divested himself of the imperial dignity at Mediolanum (Milan), which had been his capital, and retired to a villa in Lucania; in the following year, however, he was induced by his son Maxentius to reassume the purple. By allying himself with Constantine he made head against Galerius in Italy for a while, and then quarreled with Maxentius; Diocletian intervened, and Maximianus abdicated again. In Constantine's absence on the Rhine next year (311) he made another attempt: Constantine returned swiftly, drove him from Arles to Marseilles, where he surrendered. Soon afterward he was found dead.

For the emperor Galerius Valerius Maximianus *see* GALERIUS.

MAXIMILIAN I. (1459–1519), Roman emperor, son of the emperor Frederick III. and Leonora, daughter of Edward, king of Portugal, born at Vienna Neustadt on March 22, 1459. On Aug. 18, 1477, he was married at Ghent to Mary, who had inherited Burgundy and the Netherlands from her father Charles the Bold, duke of Burgundy. He at once undertook the defence of his wife's dominions from an attack by Louis XI., king of France, and defeated the French forces at Guinegatte, the modern Enguinegatte, on Aug. 7, 1479. But Maximilian was regarded with suspicion by the States of the Netherlands, and after suppressing a rising in Gelderland his position was further weakened by the death of his wife on March 27, 1482. He claimed to be recognized as guardian of his young son Philip and as regent of the Netherlands, but some of the States refused to agree to his demands and disorder was general. Maximilian was compelled to assent to the treaty of Arras in 1482 between the States of the Netherlands and Louis XI., which provided that Maximilian's daughter Margaret should marry Charles, the dauphin of France, and have for her dowry Artois and Franche-Comté, two of the provinces in dispute, while the claim of Louis on the duchy of Burgundy was tacitly admitted.

Maximilian did not, however, abandon the struggle in the Netherlands. Having crushed a rebellion at Utrecht, he compelled the burghers of Ghent to restore Philip to him in 1485, and returning to Germany was chosen king of the Romans, or German king, at Frankfort on Feb. 16, 1486, and crowned at Aix-la-Chapelle on April 9. Again in the Netherlands, he made a treaty with Francis II., duke of Brittany, whose independence was threatened by the French regent, Anne of Beaujeu, and the struggle with France was soon renewed. This war was very unpopular with the trading cities of the Netherlands, and early in 1488 Maximilian, having entered Bruges, was detained there as a prisoner for nearly three months, and only set at liberty on the approach of his father with a large force. He delayed his departure for nearly a year and took part in a punitive campaign against his captors and their allies. On his return to Germany he made peace with France at Frankfort in July 1489, and in October several of the States of the Netherlands recognized him as their ruler and as guardian of his son. In March 1490 the county of Tirol was added to his possessions through the abdication of his kinsman, Count Sigismund, and this district soon became his favourite residence.

Meanwhile the king had formed an alliance with Henry VII. king of England, and Ferdinand II., king of Aragon, to defend the possessions of the duchess Anne, daughter and successor of Francis, duke of Brittany. Early in 1490 he was betrothed to the duchess, and later in the same year the marriage was celebrated by proxy; but Brittany was still occupied by French troops, and Maximilian was unable to go to the assistance of his bride. In Dec. 1491 Anne was married to Charles VIII., king of France, and Maximilian's daughter Margaret, who had resided in France since her betrothal, was sent back to her father. Maximilian took no action, being occupied in Hungary, where the death of king Matthias Corvinus had brought about a struggle for this throne. The Roman king, who was an unsuccessful candidate, took up arms, drove out the Hungarians from Austria, and regained Vienna, which had been in the possession of Matthias since 1485; but he was compelled by want of money to retreat, and on Nov. 7, 1491 signed the Treaty of Pressburg with Ladislaus, king of Bohemia, who had obtained the Hungarian throne, agreeing that Maximilian should succeed to the crown in case Ladislaus left no legitimate male issue. Having defeated the invading Turks at Villach in 1492, the king was eager to take revenge upon the king of France; but the States of the Netherlands would afford him no assistance. The German diet was indifferent, and in May 1493 he agreed to the peace of Senlis and regained Artois and Franche-Comté.

In Aug. 1493 the death of the emperor left Maximilian sole ruler of Germany and head of the house of Habsburg; and on March 16, 1494 he married at Innsbruck Bianca Maria Sforza, daughter of Galeazzo Sforza, duke of Milan (d. 1476). Maximilian made an ineffectual appeal to the Christian sovereigns to assist him in driving the Turks from Europe. In 1494 he was again in the Netherlands, where he led an expedition against the rebels of Gelderland, assisted Perkin Warbeck to make a descent upon England! and formally handed over the Government of the Low Countries to Philip. His attention was next turned to Italy, and, alarmed at the progress of Charles VIII. in the peninsula, he signed the league of Venice in March 1495, and about the same time arranged a marriage between his son Philip and Joanna, daughter of Ferdinand and Isabella, king and queen of Castile

and Aragon. In need of help in Italian war the king called the diet to Worms in March 1495 and urged the necessity of checking the progress of Charles; proposals for the better government of the empire were brought forward at Worms as a necessary preliminary to financial and military support. Some reforms were adopted, the public peace was proclaimed without any limitation of time and a general tax was levied. The three succeeding years were mainly occupied with quarrels with the diet, with two invasions of France, and a war in Gelderland against Charles, count of Egmont, who claimed that duchy, and was supported by French troops. The reforms of 1495 were rendered abortive by the refusal of Maximilian to attend the diets or to take any part in the working of the new Constitution, and in 1497 he strengthened his own authority by establishing an Aulic Council (*Reichshofrath),* which he declared was competent to deal with all business of the empire, and about the same time set up a court to centralize the financial administration of Germany.

In Feb. 1499 the king became involved in a war with the Swiss, who had refused to pay the imperial taxes or to furnish a contribution for the Italian expedition. Aided by France they defeated the German troops, and the peace of Basle in Sept. 1499 recognized them as virtually independent of the empire. About this time Maximilian's ally, Ludovico of Milan, was taken prisoner by Louis XII., king of France, and Maximilian was again compelled to ask the diet for help. An elaborate scheme for raising an army was agreed to, and in return a council of regency (*Reichsregiment)* was established, which amounted, in the words of a Venetian envoy, to a deposition of the king. The relations were now very strained between the reforming princes and Maximilian, who, unable to raise an army, refused to attend the meetings of the council at Nuremberg, while both parties treated for peace with France. The hostility of the king rendered the council impotent. He was successful in winning the support of many of the younger princes, and in establishing a new court of justice, the members of which were named by himself.

The negotiations with France ended in the Treaty of Blois, signed in Sept. 1504, when Maximilian's grandson Charles was betrothed to Claude, daughter of Louis XII., and Louis, invested with the duchy of Milan, agreed to aid the king of the Romans to secure the imperial crown. A succession difficulty in Bavaria-Landshut was only decided after Maximilian had taken up arms and narrowly escaped with his life at Regensburg. In the settlement of this question, made in 1505, he secured a considerable increase of territory, and when the king met the diet at Cologne in 1505 he was at the height of his power. His enemies at home were crushed, and their leader, Berthold, elector of Mainz, was dead; while the outlook abroad was more favourable than it had been since his accession.

But whatever hopes of a universal monarchy Maximilian may have had were shattered by the death of his son Philip and the rupture of the Treaty of Blois. The diet of Cologne discussed the question of reform in a halting fashion, but afforded the king supplies for an expedition into Hungary, to aid his ally Ladislaus, and to uphold his own influence in the East. Having established his daughter Margaret as regent for Charles in the Netherlands, Maximilian met the diet at Constance in 1507, when the imperial chamber (*Reichskammergericht*) was revised and took a more permanent form, and help was granted for an expedition to Italy. The king set out for Rome to secure his coronation, but Venice refused to let him pass through her territories; and at Trant, on Feb. 4, 1508, he assumed the title of Roman Emperor Elect, to which he soon received the assent of pope Julius II. He attacked the Venetians, but finding the war unpopular with the trading cities of southern Germany, made a truce with the republic for three years. The Treaty of Blois which contained a secret article providing for an attack on Venice, ripened into the league of Cambray, which was joined by the emperor in Dec. 1509. He soon took the field, but after his failure to capture Padua the league broke up; and his sole ally, the French king, joined him in calling a general council at Pisa to discuss the question of Church reform.

A breach with pope Julius followed, and at this time Maximilian appears to have entertained, perhaps quite seriously, the idea of seating himself in the chair of St. Peter. After a period of vacillation he deserted Louis and joined the Holy League, which had been formed to expel the French from Italy; but unable to raise troops, he served with the English forces as a volunteer and was present at the battle of the Spurs near Thérouanne on Aug. 16, 1513. In 1500 the diet had divided Germany into six circles, for the maintenance of peace, to which the emperor at the diet of Cologne in 1512 added four others. Having made an alliance with Christian II., king of Denmark, and interfered to protect the Teutonic Order against Sigismund I., king of Poland, Maximilian was again in Italy early in 1516 fighting the French who had overrun Milan. His want of success compelled him on Dec. 4, 1516, to sign the Treaty of Brussels, which left Milan in the hands of the French king, while Verona was soon afterwards transferred to Venice. He attempted in vain to secure the election of his grandson Charles as king of the Romans. Leaving the diet of Augsburg (1518) he travelled to Wels in Upper Austria, where he died on Jan. 12, 1519. He was buried in the church of St. George in Vienna Neustadt.

Maximilian had many excellent personal qualities. Simple in his habits, conciliatory in his bearing, and catholic in his tastes, he enjoyed great popularity and rarely made a personal enemy. He was a skilled knight and a daring huntsman, and although not a great general, was intrepid on the field of battle. He reorganized the University of Vienna and encouraged the development of the universities of Ingolstadt and Freiburg. He was the author of military reforms, which included the establishment of standing troops, called *Landsknechte.* He was continually devising plans for the better government of Austria, and although they ended in failure, he established the unity of the Austrian dominions. Maximilian has been called the second founder of the house of Habsburg, and certainly by bringing about marriages between Charles and Joanna and between his grandson Ferdinand and Anna, daughter of Ladislaus, king of Hungary and Bohemia, he paved the way for the vast empire of Charles V. and for the influence of the Habsburgs in eastern Europe.

But Maximilian was at once reckless and unstable. For absurd and impracticable schemes in Italy and in other places, he at times neglected even Germany, and sought to involve its princes in wars undertaken solely for private aggrandizement or personal jealousy. Ignoring his responsibilities as ruler of Germany, he only considered the question of its government when in need of money and support from the princes. As the "last of the knights" he could not see that the old order of society was passing away and a new order arising, while he was fascinated by the glitter of the mediaeval empire and spent the better part of his life in vague schemes for its revival. As "a gifted amateur in politics" he increased the disorder of Germany and Italy and exposed himself and the empire to the jeers of Europe.

Maximilian was also a writer of books, and his writings display his inordinate vanity. His *Geheimes Jagdbuch,* containing about 2,500 words, is a treatise purporting to teach his grandsons the art of hunting. He inspired the production of *The Dangers and Adventurcs of the Famous Hero and Knight Sir Teuerdank,* an allegorical poem describing his adventures on his journey to marry Mary of Burgundy. It was first published at Nuremberg by Melchior Pfintzing in 1517, and was adorned with woodcuts by Hans Leonhard Schäufelein. The *Weisskunig* was long regarded as the work of the emperor's secretary, Marx Treitzsaurwein, but it is now believed that the greater part of the book at least is the work of the emperor himself. It is an unfinished autobiagraphy containing an account of the achievements of Maximilian, who is called "the young white king." It was first published at Vienna in 1775. He also is responsible for *Freydal,* an allegorical account of the tournaments in which he took part during his wooing of Mary of Burgundy; *Ehrenpforten, Triumphwagen* and *Der weisen Könige Stammbaum,* books concerning his own history and that of the house of Habsburg, and works on various subjects, as *Das Stahtbuch, Die Baumeisterei* and *Die Gärtnerei.* These works are all profusely illustrated, some by Albrecht Diirer.

A facsimile of the original editions of Maximilian's autobiographical and semi-autobiographical works has been published in nine volumes in the *Jahrbiicher der kunsthistorischen Sammlungen des Kaiserhauses* (Vienna, 1880–88). For this edition S. Laschitzer wrote an introduction to *Sir Teuerdank,* Q. von Leitner to *Freydal,* and N. A. von Schultz to *Der Weisskunig.* The Holbein society issued a facsimile of *Sir Teuerdank* (London, 1884) and *Triumphwagen* (1883).

See ***Correspondance de l'empereur Maximilien I. et de*** *Marguerite*

d'Autriche, 1507–1519, ed. A. G. le Glay (1839); *Maximilians I. vertraulicher Briefwechsel mit Sigmund Prüschenk,* ed. V. von Kraus (Innsbruck, 1875); J. Chmel, *Urkunden, Briefe und Aktenstücke zur Geschichte Maximilians I. und seiner Zeit.* (Stuttgart, 1845) and *Aktenstücke und Briefe zur Geschichte des Hauses Habsburg im Zeitalter Maximilians I.* (Vienna, 1854–58); K. Klupfel, *Kaiser Maximilian I.* (1864); H. Ulmann, *Kaiser Maximilian I.* (Stuttgart, 1884); L. P. Gachard, *Lettres inédites de Maximilien I. sur les affaires des Pays Bas* (Brussels, 1851–52); L. von Ranke, *Geschickte der romanischen und germanischen Völker, 1494–1514* (Leipzig, 1874); R. W. S. Watson, *Maximilian* I. (1902); A. Jager, *Uber Kaiser Maximilians I. Verhältnis zum Papstthum* (Vienna, 1854); H. Ulmann, *Kaiser Maximilians I. Absichten auf das Papstthum* (Stuttgart, 1888), and A. Schulte, *Kaiser Maximilian I. als Kandidat fur den päpstlichen Stuhl* (Leipzig, 1906); C. Hare, *Maximilian the Dreamer* (1913).

MAXIMILIAN II. (1527–1576), Roman emperor, was the eldest son of the emperor Ferdinand I. by his wife Anne, daughter of Ladislaus, king of Hungary and Bohemia, and was born in Vienna on July 31, 1527. Educated principally in Spain, he gained some experience of warfare during the campaign of Charles V. against France in 1544, and also during the war of the league of Schmalkalden, and soon began to take part in imperial business. Having in Sept. 1548 married his cousin Maria, daughter of Charles V., he acted as the emperor's representative in Spain from 1548 to 1550, returning to Germany in December 1550 in order to take part in the discussion over the imperial succession. Charles V. wished his son Philip (afterwards king of Spain) to succeed him as emperor, but his brother Ferdinand, who had already been designated as the next occupant of the imperial throne, and Maximilian objected to this proposal. At length a compromise was reached. Philip was to succeed Ferdinand, but during the former's reign Maximilian, as king of the Romans, was to govern Germany. This arrangement was not carried out, but the insistence of the emperor disturbed the harmonious relations between the two branches of the Habsburg family; and Maximilian's illness in 1552 was even attributed to poison given to him in the interests of his cousin and brother-in-law, Philip of Spain. He took up his residence in Vienna, and was engaged mainly in the government of the Austrian dominions and their defence against the Turks. The religious views of the king of Bohemia, as Maximilian had been called since his recognition as the future ruler of that country in 1549, had always been somewhat uncertain, and he had probably learned something of Lutheranism in his youth; but his amicable relations with the Protestant princes were probably due to political considerations. Maximilian remained an adherent of the older faith, although his views were tinged with Lutheranism until the end of his life. In November 1562 Maximilian was chosen king of the Romans, or German king, at Frankfort, where he was crowned a few days later, after assuring the Catholic electors of his fidelity to their faith, and promising the Protestant electors that he would publicly accept the confession of Augsburg when he became emperor. He also took the usual oath to protect the Church, and his election was afterwards confirmed by the papacy. In Sept. 1563 he was crowned king of Hungary, and on his father's death, in July 1564, succeeded to the empire and to the kingdoms of Hungary and Bohemia.

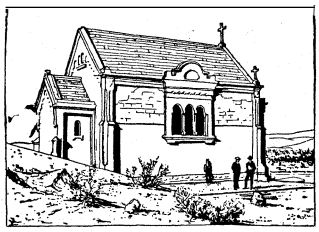
The new emperor granted religious liberty to the Lutheran nobles and knights in Austria, and refused to allow the publication of the decrees of the council of Trent. Amid general expectations on the part of the Protestants he met his first Diet at Augsburg in March 1566. He refused to accede to the demands of the Lutheran princes; on the other hand, although the increase of sectarianism was discussed, no decisive steps were taken to suppress it, and the only result of the meeting was a grant of assistance for the Turkish War, which had just been renewed. Collecting a large and splendid army Maximilian marched to defend his territories; but no decisive engagement had taken place when a truce was made in 1568, and the emperor continued to pay tribute to the sultan for Hungary. Meanwhile the relations between Maximilian and Philip of Spain had imprbved; and the emperor's increasingly cautious and moderate attitude in religious matters was doubtless due to the fact that the death of Philip's son, Don Carlos, had opened the way for the succession of Maximilian, or of one of his sons, to the Spanish throne. Evidence of this friendly feeling was given in 1570, when the emperor's daughter, Anne, became the fourth wife of Philip; but Maximilian was unable to moderate the harsh proceedings of the Spanish king against the revolting inhabitants of the Netherlands. In 1570 the emperor met the diet at Spires and asked for aid to place his eastern borders in a state of defence, and also for power to repress the disorder caused by troops in the service of foreign powers passing through Germany. He proposed that his consent should be necessary before any soldiers for foreign service were recruited in the empire; but the estates were unwilling to strengthen the imperial authority, the Protestant princes regarded the suggestion as an attempt to prevent them from assisting their coreligionists in France and the Netherlands, and nothing was done in this direction, although some assistance was voted for the defence of Austria. The religious demands of the Protestants were still unsatisfied, while the policy of toleration had failed to give peace to Austria. His last important act was to make a bid for the throne of Poland, either for himself or for his son Ernest. In December 1575 he was elected, but the diet which met at Regensburg was loath to assist; and on Oct. 12, 1576, the emperor died, refusing on his deathbed to receive the last sacraments of the Church which were offered him.

By his wife Maria he had a family of nine sons and six daughters. He was succeeded by his eldest surviving son, Rudolph, who had been chosen king of the Romans in October, 1575. Another of his sons, Matthias, also became emperor, three others, Ernest, Albert and Maximilian, took some part in the government of the Habsburg territories or of the Netherlands. His daughter, Elizabeth, eventually was married to Charles IX., King of France.

The religious attitude of Maximilian has given rise to much discussion, and on this subject *see* O. H. Hopfen, *Maximilian II. und der Kompromisskatholizismus* (Munich, 1895); C. Haupt, *Melanchthons und seiner Lehrer Einfluss auf Maximilian II.* (Wittenberg, 1897); F. Walter, *Die Wahl Maximilians II.* (Heidelberg, 1892); W. Goetz, *Maximilians II. Wahl zum römischen Könige* (Würzburg, 1891), and T. J. Scherg, *Über die religiose Entwickelung Kaiser Maximilians II. bis zu seiner Wahl zum römischen Konige* (Würzburg, 1903). For a more general account of his life and work see *Briefe und Akten zur Geschichte Maximilians II.*, edited by W. E. Schwarz (Paderborn, 1889–91); M. Koch, *Quellen zur Geschichte des Kaisers Maximilian II. in Archiven gesammelt* (Leipzig, 1857–61); R. Holtzmann, *Kaiser Maximilian II. bis zu seiner Thronbesteigung* (Berlin, 1903); E. Wertheimer, *Zur Geschichte der Türkenkriege Maximilians II.* (Vienna, 1875); L. von Ranke, *Über die Zeiten Ferdinands I. und Maximilians II.* in Band VII. of his *Sämmtliche Werke* (Leipzig, 1874), and J. Janssen, *Geschichte des deutschen Volkes seit dem Ausgang des Mittelalters,* Bände IV. to VIII. (Freiburg, 1885–94), Eng. trans. by M. A. Mitchell and A. M. Christie (1896 fol.).

MAXIMILIAN (Ferdinand Maximilian) (1832–1867), emperor of Mexico, was born in Vienna on July 6, 1832, the second son of Archduke Francis Charles, and brother of the Emperor Francis Joseph. After an excellent education, he entered the navy and as first in command was largely responsible for its rehabilitation, and for the growth of Trieste as a naval centre. He was appointed governor-general of the Lombardo-Venetian kingdom in 1857, but in 1859 was summarily relieved of his post. In 1857 he married Princess Charlotte of Belgium. As early as 1859 he was approached by Mexican exiles relative to his candidature for an imperial throne in Mexico, and in Oct. 1863 he was formally offered the crown, which had been created by French armed intervention. (See MEXICO.) He accepted it on April 9, 1864, after renouncing his imperial rights in Austria, arrived in Mexico on May 28 and entered Mexico City on June 12. From the beginning, the experiment was doomed, for politically, strategically and economically Maximilian's position was impossible. The country was opposed to him; the liberals refused to recognize his government, though he made several attempts to conciliate them; and the conservatives and clericals were immediately alienated by his liberal measures. Financially and politically he was wholly dependent upon France, without resources with which either to pay his debts or raise armies. Nor was he, personally, fitted to cope with the problem; poor judgment, vacillation and extravagance marked his administration from the first. During 1864 and 1865 his foreign troops reduced the country to subjection, driving

the constitutional government of Juárez almost to the Rio Grande, and on Oct. 3, 1865, he was induced to issue a decree declaring Juárez and his supporters bandits. But in Dec. 1865, the United States, having emerged successfully from the Civil War, demanded the withdrawal of French troops from Mexico. Napoleon acceded in Jan. 1866, and the republican forces commenced their reconquest. The Empress Charlotte went to Europe in July 1866, in a desperate attempt to re-enlist the aid-of Napoleon and the pope; she failed and the strain proved so great that she lost her mind. In October, Maximilian, determined to abdicate, fled to Orizaba, but was prevailed upon to return, and in Feb. 1867, assuming personal command of his forces, transferred his headquarters from Mexico City to Querétaro, a lonely figure in the welter of intrigue, selfishness and corruption which engulfed him. The last of the French forces retired in March; and on May 15, Querétaro was betrayed to the republican army. Napoleon's agents had made repeated efforts to secure Maximilian's escape, but he refused to save himself. He was court-martialled, convicted, and despite universal pleas for mercy, was shot on June 19. The Empress Charlotte died at the Château de Bouchout, near Brussels, Belgium, on Jan. 19, 1927, never having fully recovered her reason. See JUÁREZ, BENITO (PABLO).



BY COURTESY OF C. W, HACRETT

MAXIMILIAN CHAPEL. BUILT AT THE PLACE WHERE MAXIMILIAN WAS SHOT, FROM AN ETCHING BY FRANZ JOSEPH

There is a very good account of the whole Maximilian episode by Egon Caesar, Count Corti, *Maximilian and Charlotte of Mexico* (1928), which includes an exhaustive bibliography. (W. B. P.)

MAXIMILIAN I (1573–1651), called "the Great," elector and duke of Bavaria, eldest son-of William V of Bavaria, was born at Munich on April 17, 1573. He married in 1595 his cousin, Elizabeth, daughter of Charles II, duke of Lorraine, and became duke of Bavaria upon his father's abdication in 1597. He refrained from any interference in German politics until 1607, when he was entrusted with the duty of executing the imperial ban against the free city of Donaumorth, a Protestant stronghold. In Dec. 1607 his troops occupied the city, and steps were taken to restore the older faith. A union of Protestant princes, formed to defend their interests, was met in 1609 by the establishment of a league, in the formation of which Maximilian took an important part.

An army was collected, but his policy was strictly defensive and he refused to allow the league to become a tool in the hands of the house of Habsburg. Dissensions among his colleagues led the duke to resign his office in 1616, but he returned to the league about two years later.

After the outbreak of the Thirty Years' War Maximilian made a treaty with the emperor Ferdinand II in Oct. 1619, and in return for large concessions placed the forces of the league at the emperor's service. He made a treaty of neutrality with the Protestant union, and occupied Upper Austria as security for the expenses of the campaign. On Nov. 8, 1620, his troops under Count Tilly defeated the forces of Frederick, king of Bohemia, at the White Hill near Prague. Tilly then devastated the Rhenish Palatinate, and in Feb. 1623, Maximilian was formally invested with the electoral dignity and the attendant office of imperial steward, which had been enjoyed since 1356 by the counts palatine of the Rhine. After receiving the Upper Palatinate and restoring Upper Austria to Ferdinand. Maximilian became leader of the party which sought to bring about Wallenstein's dismissal from the imperial service. At the diet of Regensburg in 1630 Ferdinand was compelled to assent to this demand, but the sequel was disastrous both for Bavaria and its ruler. Early in 1632 the Swedes marched into the duchy and occupied Munich, and Maximilian had to place himself under the orders of Wallenstein, now restored to the command of the emperor's forces. The ravages of the Swedes and their French allies induced the elector to enter into negotiations for peace with Gustavus Adolphus and Cardinal Richelieu. He also proposed to placate the Protestants by modifying the Restitution edict of 1629; but these efforts were abortive. In March 1647 he concluded an armistice with France and Sweden at Ulm, but the entreaties of the emperor Ferdinand III led him to disregard his undertaking. Bavaria was again ravaged, and the elector's forces defeated in May 1648 at Zusmarshausen. By the treaty of Westphalia it was agreed that Maximilian should retain the electoral dignity, which was made hereditary in his family; and the Upper Palatinate was incorporated with Bavaria. The elector died at Ingolstadt on Sept. 27, 1651.

See F. A. W. Schreiber, *Maximilian I. der Katholische Kurfürst von Bayern, und der dreissigjährige Krieg* (Munich, 1868); F. Stieve, *Kurfürst Maximilian I. von Bayern* (Munich, 1882); M. Hogl, *Die Bekehrung der Oberpfalz durch Kurfürst Maximilian I.* (Regensburg, 1903).

MAXIMILIAN I (MAXIMILIAN JOSEPH) (1756–1825), king of Bavaria, the son of the count palatine Frederick of Zweibriicken-Birkenfeld, was born May 27, 1756. He took service in 1777 as a colonel in the French army, and rose rapidly to the rank of major general. From 1782 to 1789 he was stationed at Strasbourg, but at the outbreak of the revolution he exchanged the French for the Austrian service, taking part in the opening campaigns of the revolutionary wars.

On April 1, 1795, he succeeded his brother, Charles II, as duke of Zweibriicken, and on Feb. 16, 1799, became elector of Bavaria on the extinction of the Sulzbach line with the death of the elector Charles Theodore.

The sympathy with France and with French ideas which characterized his reign was at once manifested. In the newly organized ministry Count von Montgelas was the most potent influence. Agriculture and commerce were. fostered, the laws were ameliorated, a new criminal code drawn up, taxes and imposts equalized without regard to traditional privileges, while a number of religious houses were suppressed and their revenues used for educational and other useful purposes. In foreign politics Maximilian Joseph's attitude was from the German point of view less commendable. With the growing sentiment of German nationality he had from first to last no sympathy, and his attitude throughout was dictated by wholly dynastic, or at least Bavarian, considerations. Until 1813 he was the most faithful of Napoleon's German allies, the relation being cemented by the marriage of his daughter to Eugène Beauharnais.

Maximilian's reward came with the treaty of Pressburg (Dec. 26, 1805), by the terms of which he was to receive the royal title and important territorial acquisitions in Swabia and Franconia to round off his kingdom. He assumed the style of king on Jan. 1, 1806.

The new king of Bavaria was the most important member of the confederation of the Rhine, and remained Napoleon's ally until the eve of the battle of Leipzig, when by the convention of Ried (Oct. 8, 1813) he made the guarantee of the integrity of his kingdom the price of his joining the allies. By the first treaty of Paris (June 3, 1814), however, he ceded Tirol to Austria in exchange for the former duchy of Wiirzburg. At the congress of Vienna, which he attended in person, Maxirnilian had to make further concessions to Austria, ceding the quarters of the Inn and Hausruck in return for a part of the old Palatinate. The king fought hard to maintain the contiguity of the Bavarian territories as guaranteed at Ried; but the most he could obtain was an assurance from Metternich in the matter of the Baden succession, in which he was also disappointed (see BADEN: ***History).***

At Vienna and afterward Maximilian opposed any reconstitution of Germany which should endanger the independence of Bavaria, and his insistence on full sovereignty for the German reigning princes contributed to the loose and weak organization of the new German confederation. The Federal act of the Vienna congress was proclaimed in Bavaria, not as a law but as an international treaty. It was partly to secure popular support in his resistance of any interference of the federal diet in the internal affairs of Bavaria, partly to give unity to his somewhat heterogeneous territories, that Maximilian on May 26, 1818, granted a liberal constitution to his people. Montgelas had fallen in 1817, and Maximilian had also reversed his ecclesiastical policy, signing on Oct. 24, 1817, a concordat with Rome by which the powers of the clergy were restored. The new parliament proved so intract-

able that in 1819 Maximilian appealed to the powers against his own creation; but his Bavarian "particularism" and his genuine popular sympathies prevented him from allowing the Carlsbad decrees to be strictly enforced within his dominions. The suspects arrested by order of the Mainz Commission he examined himself, with the result that in many cases the whole proceedings were quashed, and in not a few the accused dismissed with a present of money. Maximilian died on Oct. 13, 1825, and was succeeded by his son Louis I.

In private life Maximilian was kindly and simple. He loved to play the part of Landesvater, walking about the streets of his capital en bourgeois and entering into conversation with all ranks of his subjects, by whom he was regarded with great affection. He was twice married: (1) in 1785 to Princess Wilhelmine Auguste of Hesse-Darmstadt, (2) in 1797 to Princess Caroline Friederike of Baden.

MAXIMILIAN II (1811–1864), king of Bavaria, son of king Louis I and of Theresa of Saxe-Hildburghausen, was born on Nov. 28, 1811. After studying at Gottingen and Berlin and traveling in Germany, Italy and Greece. he was introduced by his father into the council of state (1836). As crown prince, in the château of Hohenschwangau near Fiissen, he gathered about him an intimate society of artists and men of learning, and devoted his time to scientific and historical study. When the abdication of Louis I (March 28, 1848) called him suddenly to the throne, his choice of ministers promised a liberal régime. But he strenuously opposed the unionist plans of the Frankfort parliament. refused to recognize the imperial constitution devised by it. and assisted Austria in restoring the federal diet and in carrying out the federal execution in Hesse and Holstein. Although. however, from 1850 onwards his government tended in the direction of absolutism. he refused to become the tool of the clerical reaction, and even incurred the bitter criticism of the Ultramontanes by inviting men of learning and science (*e.g.*, Liebig and Sybel) to Munich, regardless of their religious views. Finally, in 1859, he dismissed the reactionary ministry of von der Pfordten, in favour of a moderate constitutional government. In his German policy he hoped to attain the union of the princes against the perilous rivalry of Austria and Prussia by the creation of a league of the "middle" and small states — the so-called Trias. In 1863, however. he supported the project of reform proposed by Austria at the Diet of Princes at Frankfort. The failure of this proposal, and the attitude of Austria toward the confederation and in the Schleswig-Holstein question, undeceived him; but before the outbreak of the war with Denmark he died suddenly at Munich on March 10, 1864. By his wife. Maria Hedwig, daughter of Prince William of Prussia, Maximilian had two sons. Louis II. king of Bavaria. and Otto, king of Bavaria, both of whom lost their reason.

MAXIMILIAN (1867–1929), prince of Baden. born July 10, 1867. at Baden-Baden, was a son of Prince William of Baden. As the nearest agnate to the reigning grand duke, of whom he was a cousin twice removed. he was heir presumptive to the grand ducal throne. From 1907 to 1918 he mas president of the first chamber of the Baden diet. During World War I Prince Max did much to improve conditions for British prisoners in Germany, as also for German prisoners, especially in Russia. On Oct. 3, 1918, when the old military and political system in Germany was on the verge of collapse. he was appointed imperial chancellor. It fell to his lot to initiate the negotiations for the armistice. and also to carry through in hot haste those alterations in the old constitution which had long been demanded by the Liberals and the Socialists, but which now came too late to avert the fate of the empire and the Prussian monarchy. It also became his duty to put pressure upon the emperor in order to induce him to abdicate. As the imperial decision was delayed from day to day and the revolution became imminent, he declared on Nov. 9, 1918, the abdication of William II as German emperor and as King of Prussia. It was clear that the Hohenzollern dynasty was doomed; and Prince Max handed over the government to the majority Socialist leader Ebert, who became the president of the German reich. He continued. after the abdication of the grand duke, to reside at Karlsruhe, and Schloss Salem, Lake Constance. In defence of his work he published *Erinnerungen* (1927, Eng trans.. 1928).

Maximilian died at Constance, Germany, Nov. 6, 1929.

MAXIMINUS (in English MAXIMIN), **GAIUS JULIUS VERUS,** Roman emperor from AD. 235 to 238, was a Thracian. He is said to have been a shepherd before enlisting as a private soldier in the army, where his immense strength attracted the attention of the emperor Septimius Severus Under Alexander Severus he held high command in the army of the Rhine. In March 235 Alexander was murdered and Maximin mas proclaimed emperor by the Rhine army. His three years reign was chiefly spent in campaigning on the Danube and the Rhine, and numerous milestones nith his name upon them attest his energetic reconstruction of the roads. He made many enemies in Italy and the civilian provinces of the interior, especially among the landed aristocracy, whose taxes he collected more efficaciously than his predecessor.

In 238 a group of Iandowners in Africa killed the tax collectors and rebelled, proclaiming the aged Gordian (*q.v.*) as emperor. The revolt in Africa was quickly suppressed, but in Rome the senate deposed Maximin, established a council of senators to run the state, and raised a military force from the cities of Italy. Maximin and the army crossed the Alps and besieged Aquileia. The city resisted successfully, and after some months the soldiers killed Maximin and returned home

Meanwhile the pressure of the praetorian guards and the populace in Rome had compelled the senatorial council to proclaim first two elderly senators. Maximus and Balbinus, and later Gordian's grandson, Gordian III, as emperors. Gordian III emerged as Maximin's successor. (JN. R. M.)

MAXIMINUS [MAXIMIN], **GALERIUS VALERIUS,** Roman emperor from A.D. 308 to 314, was originally an Illyrian shepherd named Daia. He rose to high distinction in the army, and in 305 he was raised by his uncle, Galerius, to the rank of Caesar, with the government of Syria and Egypt. In 308, after the elevation of Licinius, he insisted on receiving the title of Augustus; on the death of Galerius. in 311, he succeeded to the supreme command of the provinces of Asia. and when Licinius and Constantine began to make common cause with one another Maximinus entered into a secret alliance with Maxentius. He came to an open rupture with Licinius in 313, sustained a crushing defeat in the neighbourhood of Heraclea Pontica on April 30. and fled, first to Nicomedia and afterward to Tarsus, where he died in August following.

See MAXENTIUS.

MAXIMS, LEGAL. A maxim is an established principle or proposition. The Latin term maxima is not to be found in Roman law with any meaning exactly analogous to that of a legal maxim in the modern sense of the word, but the treatises of many of the Roman jurists on regulae, *definitiones* and sententiae *juris* are in some measure, collections of maxims. Fortescue (De *laudibus,* c. 8) and Du Cange treat *maxima* and *regula* as identical. The attitude of early English cominentators towards the maxims of the law was one of unmingled adulation (see Bacon's preface to his Collection of *Maxims*). A similar note was sounded in Scotland. In later times less value has been attached to the maxims of the law, as the development of civilization and the increasing complexity of business relations have shown the necessity of qualifying the propositions which they enunciate (see Stephen, *Hist. Crim.* Law, ii. 94 n: *Yarmouth* v. France, 1887, 19 Q.B.U., per Lord Esher at p. 653, and American authorities collected in Bouvier's *Law Dict. s.v.* "Maxim").

A brief reference need only be made here, with examples by way of illustration, to the field which the maxims of the law cover. Commencing with rules founded on public policy. we may note the famous principle *Salus populi suprema lex*, "the public welfare is the highest law." It is on this maxim that the coercive action of the State towards individual liberty in a hundred matters is based. Among the maxims relating to the Crown, the most important are Her *non* potest *peccare*—"the king can do no wrong"—which enshrines the principle of ministerial responsibility. and *Nullum tempus* occurrit regi—"lapse of time does not bar the Crown," a

maxim qualified by various enactments in modern times. Passing to the judicial office and the administration of justice, we may refer to the rules—Audz *alteram* partem—a proposition too familiar to need either translation or comment; Nemo debet esse *judex* in *propriâ suâ causâ*—"no man ought to be judge in his own cause"—a maxim which French law and the legal systems based upon or allied to it have embodied in an elaborate network of rules for judicial challenge. The maxim Boni *judicis* est *ampliare* jurisdzctionem is certainly erroneous as it stands, as a judge has no right to "extend his jurisdiction." If *justitiam* be substituted for *jurisdictionem,* as Lord Mansfield said it should be, the maxim is near the truth. A group of maxims supposed to embody certain fundamental principles of legal right and obligations may next be referred to: (a) *Ubi jus* ibi remedium—a maxim to which the evolution of the flexible "action on the case," by which wrongs unknown to the "original writs" were dealt with, was historically due, but which must be taken with the gloss *Damnum absque* injuria—"there are forms of actual damage which do not constitute legal injury" for which the law does not supply any remedy; (b) *Actus* Dei *nemini* facit *injuriam*—and its allied maxim, *Lex* non *cogit* ad impossibilza—upon which the whole doctrine of *vis* major (force *mejeure*) and impossible conditions in the law of contract has been built up. In this category may also be classed *Volenti non* fit *injuria,* out of which sprang the theory—now profoundly modified by statute—of "common employment" in the law of employers' liability (see *Smith* v. Baker, 1891, A.C. 325). Other maxims deal with rights of property—Qui prior *est tempore, potior est* jure, which consecrates the position of the beati *possidentes* alike in municipal and in international law, and Sic utere *tuo* ut *alienum non* laedas, which has played its part in the determination of the rights of adjacent owners (see *Rylands* v. *Fletcher,* L.R 3 H.L. 330). In the laws of family relations there is the maxim *Pater* is cst *quem nuptiae demonstrant,* on which, in most civilized countries, the presumption of legitimacy depends (see *Russell* v. *Russell,* 1924, A.C. 687). In the interpretation of written instruments, the maxim *Noscitur* a *sociis,* which proclaims the importance of the context, still applies. So do the rules *Expressio unius* est *exclusio alterius*—"often a valuable servant, but a dangerous master" (*Colquhoun* v. Brooks, 19 Q.B.D 406) and *Contemporanea* expositio est optima *et* fortissinza in *lege,* which lets in evidence of contemporaneous user as an aid to the interpretation of statutes or documents (see Van *Diemen's* Land Co. v. *Table* Cape *Marine* Board, 1906, A.C. 92, 98; and *Read* v. Lincoln, Bishop of, 1892, A.C. 644). We may conclude this sketch with a miscellaneous summary: Caveat *emptor,* "let the purchaser beware"; Qui *facit* per *alium* facit per se, which affirms the principal's liability for the acts of his agent; *Ignorantia juris neminem excusat,* on which rests the ordinary citizen's obligation to know the law, and *Actio personalis moritur cum persona,* a rule now mainly confined to actions of tort and limited by numerous exceptions. For maxims of equity see EQUITY.

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MAXIM SILENCER. A device, invented in 1908 by Hiram Percy Maxim, an American, for suppressing the sound of discharge of firearms. Attached to any tight-breech firearm, such as a rifle, it checked the sudden liberation of the powder gases into the atmosphere by imparting a whirling motion to them, which caused them to fly out from the central hole by centrifugal force. Their escape could thus not occur until they slowed down, at which time they escaped noiselessly. Meanwhile, the same mechanism that caused the powder gases to acquire a whirling motion also served as a series of acoustic resonating chambers, which acted to set up interfering resonance and trap the sound frequencies present.

Originally, the device was considered as a menace to public safety, since it was believed by many that it would chiefly serve criminals. Many of the States in the United States passed laws prohibiting its sale and use, and several countries prohibited its importation. However, this was due to the great public interest taken in the invention when it was first announced, and a lack of understanding of firearms The arms used by criminals are almost invariably small arms, such as revolvers and pistols. The revolver cannot be silenced by the Maxim Silencer because it is not a tight-breech mechanism. Having a cylinder and a barrel, and of necessity a joint between the two latter, a leak is created. When a silencer is applied to the muzzle of the barrel of a revolver, the powder gases and noise escape at this leak. The automatic pistol cannot be silenced because of the mechanical noise made by the automatic breech mechanism. Only single shot pistols and rifles can be silenced by the Maxim Silencer.

The silencing of all forms of noises that issue from a pipe was later accomplished by the Maxim Silencer, and at the present time it is the accepted means for overcoming the noise of the exhaust of Diesel engines, gas and gasolene engines, steam engines, safety valves, air and steam releases and also the intakes or suctions of air compressors and blowers. Its construction permits gases to flow freely through, but sound is trapped and caused to dissipate itself inside the device.

MAXIMUS, ST. (*c.* 580–662), abbot of Chrysopolis, known as "the Confessor" from his orthodox zeal in the Monothelite (*q.v.*) controversy, or as "the monk," was born of noble parentage at Constantinople about the year 580. He became private secretary to the emperor Heraclius in 610. In 630 he entered the monastery of Chrysopolis (Scutari), of which he became abbot. In 633 he was one of the party of Sophronius of Jerusalem (the chief original opponent of the Monothelites) at the council of Alexandria; and in 645 he was again in Africa, when he disputed with Pyrrhus, the deposed and banished patriarch of Constantinople. In the following year several African synods, held under the influence of Maximus, declared for orthodoxy. In 649 he went to Rome, after the accession of Martin I., who in October of that year held the (first) Lateran synod, by which not only the Monothelite doctrine but also the moderating *ecthesis* of Heraclius and *typus* of Constans II. were anathematized.

About 653 Maximus was apprehended (together with the pope) by order of Constans and carried a prisoner to Constantinople. In 655 he was banished to Byzia in Thrace, and afterwards to Perberis. In 662 he was again brought to Constantinople and was condemned by a synod to be scourged, to have his tongue cut out by the root, and to have his right hand chopped off. He was then banished to Lazica, where he died on Aug. 13, 662. He is venerated as a saint both in the Greek and in the Latin Churches.

The most important of the works of Maximus will be found in Migne, *Patrologia graeca,* xc., xci., together with an anonymous life; an exhaustive list in Wanenmann's article in vol. xii. (1903) of Hauck-Herzog's *Realencyklopädie* where the following classification is adopted: (*a*) exegetical, (*b*) scholia on the Fathers, (c) dogmatic and controversial, (*d*) ethical and ascetic, (*e*) miscellaneous. The details of the disputation with Pyrrhus and of the martyrdom are given very fully and clearly in Hefele's *Conciliengeschichte,* iii.

MAXIMUS, the name of four Roman emperors.

I. M. CLODIUS PUPIENUS MAXIMUS, joint emperor with D. Caelius Calvinus Balbinus during a few months of the year A.D. 238 Pupienus was a distinguished soldier, who had been proconsul of Bithynia, Achaea, and Gallia Nnrbonensis. At the advanced age of 74, he was chosen by the senate with Balbinus to resist the barbarian Maximinus. It was arranged that Pupienus should take the field against Maximinus, while Balbinus remained at Rome to maintain order. On his march, Pupienus, having received the news that Maximinus had been assassinated by his own troops, returned in triumph to Rome. Shortly afterwards, when both emperors were on the point of leaving the city on an expedition—Pupienus against the Persians and Balbinus against the Goths—the praetorians, who cherished the memory of the soldier-emperor Maximinus, seized the opportunity of revenge When most of the people were at the Capitoline games, they forced their way into the palace and put Balbinus and Pupienus

to death.

See Capitolinus, *Lives of Maximus and Balbinus;* Herodian vii. 10, viii. 6; Zonaras xii. 16; Zosimus i. 14; Aurelius Victor, *Caesares,* 26, *epit.* 26; Gibbon, *Decline and Fall,* ch. 7 and (for the chronology) appendix 12 (Bury's edition); Stuart Jones, *Roman Empire;* A. Stein in *Realencyklopädie* 4, 888–898, 3, 1258–1265.

II. MAGNUS MAXIMUS, a native of Spain, who had accompanied Theodosius on several expeditions, and from 368 seems to have had some office in Britain, where he was proclaimed emperor by the disaffected troops. Denuding, as it would seem, Hadrian's Wall of its garrison, he crossed over to Gaul, and overthrew Gratian. Theodosius being unable to avenge the death of his colleague, an agreement was made (384 or 385) by which Maximus was recognized as Augustus and sole emperor in Gaul, Spain and Britain, while Valentinian II. was to rule Italy and Illyricum. In 387 Maximus crossed the Alps and Valentinian was forced to fly to Theodosius. Advancing with a powerful army Theodosius defeated the troops of Maximus—at Siscia on the Save, and at Poetovio on the Danube. He then hurried on to Aquileia, where Maximus had shut himself up, and had him beheaded.

Full account with classical references in H. Richter, *Das weströmische Reich, besonders unter den Kaisern Gratian, Valentinian II. und Maximus* (1865); Gibbon, *Decline and Fall,* ch. 27; Tillemont, *Hist. des empereurs,* v.; A. Bauer, *Chronologie des Maximus* (1905); Collingwood, in *J.R.S.* 13, p. 74 *et seq.*

III. MAXIMUS TYRANNUS, made emperor in Spain by the Roman general, Gerontius, who had rebelled against the usurper Constantine in 408. After the defeat of Gerontius at Arelate (Arles) and his death in 411 Maximus renounced the imperial title and was permitted by Constantine to retire into private life. About 418 he rebelled again, but, failing in his attempt, was seized, carried into Italy, and put to death at Ravenna in 422.

See Orosius vii. 42; Zosimus vi. 5; E. A. Freeman, "The Tyrants of Britain, Gaul and Spain, A.D. 406–411," in *English Historical Review,* i. (1886).

IV. PETRONIUS MAXIMUS, a member of the higher Roman nobility, had held several court and public offices. He was one of the intimate associates of Valentinian III., but an outrage committed on the wife of Maximus by the emperor turned his friendship into hatred. Maximus was proclaimed emperor immediately after Valentinian's murder (March 16, 455), but after reigning less than three months, he was murdered by some Burgundian mercenaries as he was fleeing before the troops of Gaiseric who had landed at the mouth of the Tiber (May or June 455).

See Procopius, *Vand.* i. 4; Sidonius Apollinaris, *Panegyr. Aviti,* ep. ii. 13; Gibbon, *Decline and Fall,* chs. 35, 36; *Chronica Minda,* vols. 1, 2 and 3, Ed. Mommsen; Tillemont, *Hist. des empereurs,* vi.

MAXIMUS OF SMYRNA (d. A.D. 371), a member of the Pergamene school of Neoplatonists founded by Aedesius (*q.v.*), made no important contributions to Greek philosophy but had a great reputation as a theurgic wonder-worker, his most spectacular achievement being the animating of a statue of Hecate. By his wonder-working he gained a great influence over the mind of the future Roman emperor Julian and became very powerful at court when Julian succeeded to the throne. His arrogant behaviour made him many enemies, and after Julian's death he was fined, tortured and eventually executed. (A. H. Ac.)

MAXWELL, the name of a Scottish family, members of which have held the titles of earl of Morton, earl of Xithsdale. Lord Maxwell and Lord Herries. The name is taken probably from Maccuswell, or Maxwell, near Kelso, whither the family migrated from England *c.* 1100 but it is best known in the southwest of Scotland. Sir Herbert Maxwell won fame by defending his castle of Carlaverock against Edward I in 1300; another Sir Herbert was made a lord of the Scottish parliament between 1441 and 1445; and his great-grandson John, 4th Lord Maxwell, was killed at Flodden in 1513. John's son Robert, the 5th lord (*c.* 1493–1546), was a member of the royal council under James V; he was also an extraordinary lord of session, high admiral and warden of the west marches, and was taken prisoner at Solway Moss in 1542. Robert's grandson, John, 8th Lord Maxwell (1553–93), was the second son of Robert, the 6th lord (d. 1552), and his wife Beatrix, daughter of James Douglas, 3rd earl of Morton. After the execution of the regent Morton, the 4th earl, in 1581 this earldom was bestowed upon Maxwell, but in 1586 the attainder of the late earl was reversed and Maxwell was deprived of his new title. He had helped in 1585 to drive the royal favourite James Stewart, earl of Arran, from power, and he made preparations to assist the invading Spaniards in 1588. His son John, the 9th lord (*c.* 1583–1613), after a life of lawlessness, escaped from Scotland and was sentenced to death; having returned he was seized and beheaded in Edinburgh. In 1618 John's brother and heir Robert (d. 1646) was restored to the lordship of Maxwell, and in 1620 was created earl of Nithsdale, surrendering the claim to the earldom of Morton. He and his son Robert, afterward the and earl, fought under Montrose for Charles I during the Great Rebellion. Robert died unmarried in Oct. 1667, when a cousin John Maxwell, 7th Lord Herries (d. 1677), became third earl. His grandson was William, 5th earl of Nithsdale (*q.v.;* 1676–1744). On his attainder in 1716, his titles became extinct, but his estates passed to his son William (d. 1776), whose descendant, William Constable-Maxwell, regained the title of Lord Herries in 1858. Through his granddaughter the barony of Herries passed in 1945 to the 16th duke of Norfolk. Other distinguished branches of the family are Maxwells of Calderwood, of Monreith, of Munches and of Pollok.

MAXWELL, JAMES CLERK (1831–1879), British physicist, remembered for his great researches in electricity, was descended from a well-known Scottish family, the Clerks of Penicuick, and was born in Edinburgh on Nov. 13, 1831. He was educated at the Edinburgh academy, at the University of Edinburgh and at Trinity college, Cambridge. In 1856, two years after graduating from Trinity with high honours, he took the chair of natural philosophy in Marischal college, Aberdeen. This post was followed by a professorship of physics and astronomy in King's college, London, which he held from 1860 to 1865, resigning to return to the family estate of Glenlair in Kirkcudbrightshire. His reputation, however, intruded upon the seclusion he desired, and in 1871 he reluctantly yielded to the urging of his friends and accepted the newly founded chair in experimental physics at Cambridge. Under his direct supervision there was erected the famous Cavendish laboratory, which from the beginning has been one of the major scientific workshops of the world. He died at Cambridge of cancer, the disease that had killed his mother 40 years earlier, on Nov. 5, 1879.

Maxwell was a born scientist. A persistently inquisitive little boy, he not only sought to discover how everything "doos" but made his own scientific toys before he was eight. In his 14th year he wrote a paper on a method for constructing perfect oval curves; which was read to the Royal Society of Edinburgh by James Forbes; when he was 18 and still a student at Edinburgh two of his papers, one on rolling curves, the other on the equilibrium of elastic solids, were published in the society's *Transactions.* During his two postgraduate years at Trinity he engaged in original mathematical research, designed his celebrated colour top *(see* COLOUR: *The Laws of Colour Mixture),* and did work in colour sensation for which he later won the Rumford medal of the Royal Society of London.

Perhaps the most significant activity of this period was his reading of Michael Faraday's *Experimental Researches,* which marked Maxwell's entrance upon the study of electricity; and before he left Trinity, he published his first major contribution to the subject, the beautiful paper "On Faraday's Lines of Force." (*See* ELECTROMAGNETIC WAVES: *Origin of Electric Wave Concept.*)

In 1859 he interrupted his electrical studies to write a brilliant paper explaining the motion and permanence of Saturn's rings. This essay won the Adams prize of the University of Cambridge and established him as a leader among mathematical physicists. The Saturn researches, having to do with the behaviour of a large mass of disconnected particles, excited his interest in the kinetic theory of gases, which raised the problem of describing the behaviour of vast assemblages of colliding molecules.

In this field he appeared as an experimenter (in measuring gaseous friction) as well as a mathematician. He conceived a mechanical picture which made it possible to account in precise quantitative terms for various properties—viscosity, diffusion, heat conduction—of a gas. The model has been criticized, and

errors in Maxwell's reasoning have been discovered, yet his results which, as Sir James Jeans said; "ought to have been hopelessly wrong," turned out to be exactly right, and Maxwell's law of gases is in use to this day.

But his supreme achievement is in electricity. His first step, embodied in the Trinity paper. was to translate Faraday's ideas into mathematical notation. In his next paper, "On Physicai Lines of Force," the main object was to devise a model which would provide a mechanical explanation of the interrelations and effects of electricity and magnetism. Like Faraday, Maxwell was opposed to the notion of "action at a distance." He applied his extraordinary imaginative powers to the development of Faraday's concept of the field and lines of force. Gradually he discarded the simple elements of his first models and erected a system involving the hypothetical "aether," a unique material medium whose physical stresses and motions could be made to account for all electric and magnetic phenomena. The laws of the system were formulated in his two famous sets of symmetrical equations, one of which expresses the continuous nature of electric and magnetic fields, the second the principle by which changes in one field produce changes in the other.

In the course of this labour he arrived at an epochal conclusion. Confirming by experiment the finding of Wilhelm Weber and Friedrich Kohlrausch that the velocity of an electric current through a wire is about the same as the velocity of light in empty space. he boldly asserted the identity of the two phenomena. "We can scarcely avoid the inference," he said. "that light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena." The extension of the electromagnetic theory of light led to Heinrich Hertz's discovery of radio waves and to related advances in science and technology which have transformed the modern world. *(See* ELECTRICITY: *Electromagnetic Waves.)*

It is often said of Maxwell that he was the perfect pencil and paper theoretician, in contrast with Faraday, the great experimenter. This notion is a gross oversimplification. The fact is he combined a profound physical intuition, an exquisite feeling for the relations of objects, with a formidable mathematical capacity to establish orderly connections between diverse phenomena. This blending of the concrete and the abstract was the chief characteristic of almost all his researches. A striking example of his skill with the concrete is found in the fact that the basic principles of modern colour photography were derived from an experiment made by Maxwell in 1861.

First broached in communications to the Royal society in 1864, Maxwell's electrical theory appeared in finished form in 1873 in his great *Treatise on Electricity and Magnetism,* one of the most splendid monuments ever raised by the genius of a single individual. Among his other writings are an admirable textbook. the *Theory of Heat* (1871), an excellent elementary treatise on *Matter and Motion* (1876) and a valuable edition, with copious original notes, of the *Electrical Researches of the Hon. Henry Cavendish.* His collected works. edited by W. D. Niven, were issued by the Cambridge University Press in 1890.

BIBLIOGRAPHY.—The only full-scale biography is L. C. Campbell and W. Garnett, Life *of Janzes Clerk Maxwell* (1882), which is authoritative but dated. A more readable work is R. T. Glazebrook, *Jnnzes Clerk Maxwell and Modern* **Physics** (1901); for a shorter, popular account, see *Scientific Anzerican* (June 1955). (J. R. NN.)

MAXWELL, SIR JOHN GRENFELL (1859–1929), British general, was born on July 11, 1859. He entered the army in 1879. and after many years' service in Egypt was promoted to the command of a brigade during the advances up the Nile (1896–98) which closed with the reoccupation of Khartoum.

Maxwell was appointed knight commander of the Bath (1900) and companion of St. Michael and St. George for his staff services during the South African War, was promoted major general in 1906, and was in command of the British troops in Egypt from 1908 to 1912.

After a short period as liaison officer with French headquarters in 1914, Maxwell was sent to take charge of the British forces which mere arriving in Egypt. His defensive measures were most successful, as the one serious Turkish advance was decisively checked. He returned to England in March 1916. He was placed in command of the troops in Ireland when the Irish rebellion broke out, and in the autumn was transferred to the northern district of England. a command ahich he held for two years. He was promoted full general in 1919. In 1920 he went to Egypt as a member of Lord Milner's mission. Maxwell was appointed knight commander of the order of St. Michael and St. George in 1915 He died Feb. 21, 1929.

MAY, PHIL (PHILLIP WILLIAM) (1864–1903), English social and political caricaturist, was born on April 22, 1864, at Wortley, near Leeds. He was the son of an engineer who died when the child was nine years old. At the age of 12 May began to earn his living. working as timekeeper in a foundry, as a jockey and on the stage. When he was 16 he went to London, finally obtaining work as a designer with a theatrical costumer. He also drew posters and cartoons, and for about two years worked for the *St. Stephen's Review.* He went to Australia for his health and while there worked for three years for the *Sydney Bulletin.* In 1892 he returned to London and resumed his work for *St. Stephen's Review.*

May's studies of the London "guttersnipe" and the coster girl rapidly made him famous. His overflowing sense of fun, his sympathy with his subjects and his kindly wit were on a par with his artistic ability. There the extraordinary economy of line which was characteristic of his drawings was the result of a laborious process which involved numerous preliminary sketches. His later work included some excellent political portraits. He became a member of the staff of *Punch* in 1896 and in his later years his services were retained entirely for that magazine and for the *Graphic.* May died on Aug. 5, 1903. (H. Es.)

MAY, THOMAS (1595–1650), English poet and historian, son of Sir Thomas May of Mayfield. Sussex, was born in 1595. He entered Sidney Sussex college, Cambridge, in 1609, and took his B.A. degree three years later. His father having lost his fortune and sold the family estate, Thomas May. who was hampered by an impediment in his speech, made literature his profession.

In 1620 May produced the *Heir,* an ingeniously constructed comedy, and, probably about the same time, the *Old Couple,* which was not printed until 1658. His other dramatic works are classical tragedies on the subjects of Antigone, Cleopatra and Agrippina. F. G. Fleay has suggested that the more famous anonymous tragedy of *Nero* (printed 1624; reprints in A. H. Bullen's *Old English Plays* and the "Mermaid Series") should also be assigned to May. But his most important work in the department of pure literature was his translation (1627) into heroic couplets of the *Pharsalia* of Lucan. Its success led May to write a continuation of Lucan's narrative down to the death of Caesar. Charles I became his patron. and commanded him to write metrical histories of Henry II and Edward III, which were completed in 1635.

In 1646 May is styled one of the "secretaries" of the parliament, and in 1647 he published his best known work, the *History of the Long Parliament,* an official apology for the moderate or Presbyterian party. In 1650 he follotved this with another work written with a more definite bias. a *Breviary of the History* of *the Parliament of England,* in Latin and English, in which he defended the position of the Independents. He stopped short of the catastrpphe of the king's execution, and it seems likely that his subservience to Cromwell was not quite voluntary. In Feb. 16jo he was brought to London from Weymouth under a strong guard for having spread false reports of the parliament and of Cromwell.

May died on Nov. 13 in the same year, and was buried in Westminster abbey, but after the Restoration his remains were exhumed.

BIBLIOGRAPHY.—There is a long notice of May in the *Biographia Britannica. See* also *W. J.* Courthope, *History of English Poetry,* vol. *3* (1895 *et seq.*); Guizot, *Études biographiques sur la révolution d'Angleterre,* pp. 403–426 (1851).

MAY, SIR THOMAS ERSKINE: *see* FARNBOROUGH, THOMAS ERSKINE MAY.

MAY (MEY[E]), **WILLIAM** (d. 1560), English clergyman, was the brother of John May, bishop of Carlisle. He was educated at Cambridge, where he was a fellow of Trinity Hall and, in 1537, president of Queen's college. May was successively chancellor, vicar-general and prebendary of Ely.

In 1545 he was made a prebendary of St. Paul's, and in 1546 dean. His favourable report on the Cambridge colleges saved them from dissolution. He died on the day of his election to the archbishopric of York.

MAY (Lat. MAIUS), the fifth month of the modern calendar, has 31 days. As to the origin of the name the Romans were themselves uncertain, some deriving it from Maia, an obscure goddess to whom sacrifice was offered in this month, others from maiores, "elders," on the ground that this month honoured those of ripe years as June (from iuniores) honoured the young. Little is known of Maia, but probably both her name and that of the month had the original meaning of "increase," with reference to the growth of vegetation at this season. This interpretation fits with the importance attached later, in medieval and modern Europe, to the traditional May day celebrations, of which the origins are to be sought in pre-Christian agricultural rituals. Though there is wide variation in local usages, these celebrations commonly include the carrying in procession of trees, green branches or garlands, the appointment of a May king and May queen and the setting up of a May tree or Maypole. In Scotland and Ireland vestiges of old Celtic practices survived until the late 18th century in the custom of leaping over a fire or driving cattle between two fires (see BELTANE). Originally all such rites were intended to ensure fertility to the crops, and by extension also to cattle and humans, but in most cases this significance was gradually lost and the practices survived merely as popular festivities. A widespread superstition held that washing the face in the May day morning dew would beautify the skin.

In medieval and Tudor England, May day was a great public holiday. All classes of the people were up with the dawn, and went "a-maying." Branches of trees and flowers were borne back in triumph to the towns and villages, the centre of the procession being occupied by the Maypole, gaily bedecked with ribbons and wreaths. Maypoles were usually set up for the day only, but in London and the larger towns were erected permanently. They were special eyesores to the Puritans. John Stubbes in his Anatomy of Abuses (1583) speaks of them as those "stinckyng idols" about which the people "leape and daunce, as the heathen did."

May day was designated as an international labour day by the International Socialist congress of 1889; in Communist countries and elsewhere it is the occasion for important left-wing political demonstrations. See LABOUR DAY. (F. R. WN.)

MAY, ISLE OF, an island of Fife, Scot., at the entrance to the Firth of Forth, 5 mi. S.E. of Crail and Anstruther. It is 1¼ mi. long, and measures at its widest about 400 yd. St. Adrian, a Hungarian missionary, settled there and was martyred by the Danes in the 9th century. In the 12th century David I built a Benedictine monastery (now in ruins) on the site of Adrian's grave, long a place of pilgrimage.

The population (12 in 1951) is made up of the lighthouse keepers and their families. The island is now a bird observatory and field station.

MAYAGÜEZ, Puerto Rico's third largest city, is located on the west coast of the island. Pop. (1960) 50,147. The town was founded in 1763 and because of its excellent harbour soon developed into the important shipping centre for the west end of the island. Sugar, coffee and tropical fruits are the main exports from the surrounding rural area. Previously the city was an important needlework centre; however, large industries, such as electronic products and canning factories, have been established with government help. Known over the island for its pure water supply, Mayaguez is the centre for the manufacturing of beer and soft drinks.

The land-grant College of Agriculture and Mechanical Arts, a division of the University of Puerto Rico, is located in the city. A student body of over 3,000 works toward degrees in engineering, agronomy, science and liberal arts. In conjunction with the Atomic Energy commission a nuclear research centre, with an atomic reactor, has been established on campus to facilitate the granting of graduate degrees in nuclear technology. The U.S. department of agriculture maintains in Mayagiiez one of its few experimental stations in tropical agriculture.

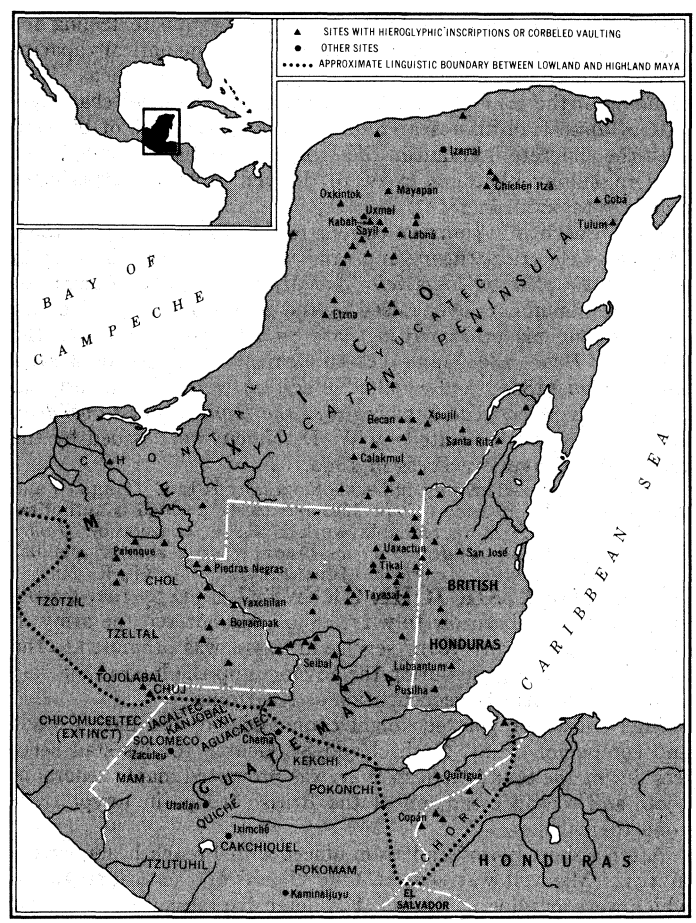
With several banks, a television station and several radio stations, a modern private hospital and numerous commercial establishments, Mayaguez is a prosperous and well-serviced community. Modern highways connect the city with Ponce on the south coast and San Juan on the north. Mayaguez has a commercial airport from which daily flights to the capital originate. (T. G. Ms.)

MAYA INDIANS, a large group of American Indians speaking altogether 17 closely related languages and dialects of the Maya linguistic family and occupying a compact area in Central America. The name Maya is also applied to the civilization which the ancestors of these Indians evolved in pre-Columbian times. Finally, it is used in a narrower sense for the branch of the Maya inhabiting the Mexican state of Yucatán and for their language, now commonly called Yucatec to avoid confusion.

Maya-speaking Indians now number more than 2,000,000, over 70% of whom live in the highlands of Guatemala. They are short, dark-skinned and with straight black hair. The Yucatec Maya are among the most roundheaded people in the world (average cephalic index nearly 86). Excavation reveals skulls of the same remarkable roundness.

HISTORY

At the time of the Spanish conquest (c. 1540) the Maya occupied a rough quadrangle about 550 mi. from north to south and 350 mi. from east to west at its widest point. This embraced almost all of Guatemala. British Honduras, the western fringes of Honduras and El Salvador and in Mexico all Yucatán, Campeche and Quintana Roo, most of Tabasco and eastern Chiapas. The Huastec people, living in northern Veracruz and adjacent parts of Tamaulipas, far from the main Maya body, are Maya in



MAYA INDIAN CIVILIZATION. SHOWING ARCHAEOLOGICAL SITES

speech but not in culture. This article does not deal with them.

The Maya region divides readily into three parts. The southern area comprises the mountainous parts of Guatemala and western El Salvador. a land of volcanoes, deep canyons, lakes and a temperate climate with appropriate fauna and flora. North of this lies the central area, embracing the southern half of the peninsula of Yucatán and the wider lowland base which supports it. This is a hot land of dense tropical forest and very heavy rainfall. The northern part of the peninsula of Yucatán forms the northern area, a plain of porous limestone with rivers and lakes only below its surface. Rainfall is much less here than in the central area, and in many places the thin soil fails to cover the limestone rock. As one travels northward, the surrounding forest changes to scrub.

The great achievements of the Maya were made, not in the southern area with its excellent climate and superior natural resources. but in the lowlands, particularly those of the central area, where the people expended so much effort in fighting the forest. The highland Maya formed a wealthy group throughout their history and some of their centres, notably Kaminaljuyu. Zaculeu and Utatlan, were large and important, but they had little or no part in the development of the hieroglyphic writing or of the distinctive styles of sculpture and architecture which bear the name of Maya. These are lowland contributions, particularly of the central area. The northern area shared in them, but with regional variations. and after the end of the classic period its development mas quite distinct from that of the centre.

Maya civilization, like the contemporary Mexican cultures of Teotihuacbn. Monte Albán and La Venta, had its roots in the long development horizon known as the formative period. By about the beginning of the Christian era Maya culture was sufficiently differentiated from neighbouring cultures to be called Maya, and this marks the beginning of the classic period. The first three centuries. sometimes called protoclassic, mark the growth of the new culture, and then comes its great efflorescence from A.D. 300 to A.D. 900 (the "old empire" in the terminology of the 1930s). The abandonment of the great ceremonial centres (described below), completed by A.D. 900, marks the end of the classic period.

The Classic Period. — During this period the whole Maya lowland was dotted with large ceremonial centres, loosely termed cities, the building of which began in the formative period. These were not residential, but were used for religious ceremonies, and as markets. as courts of justice and of civil administration. They served the surrounding countryside, in which the people lived in small scattered settlements. Except on market days and the great religious festivals, the ceremonial centres were empty save perhaps for priests and novices who had retired there for the prolonged periods of fasting and continence which preceded the festivals. The total number of centres is unknown, for some of them are quite small and they may not yet be all discovered, but there are about 110 with hieroglyphic inscriptions, and very many more important centres which are without known texts or where only plain monuments were erected. Tikal, the largest known site. has its pyramids, "palaces" and courts concentrated in an area of about one square mile, but this is encircled by smaller, detached groups of structures covering much additional land.

Typical of all ceremonial centres are the courts flanked by pyramids and lower, many-roomed buildings before which stand the large stone shafts known as steles. Some of these are plain, but they are usually carved with representations of gods, priests and dignitaries who may perhaps be rulers, and with hieroglyphic texts giving the date of their erection. Several hundred steles have been found (Calakmul has most with 103, of which one-quarter are plain), and they supply an excellent record of the spread of this custom. which appears to have had great prestige value. The earliest known stele carries a date equivalent to A.D. 292, and was found at Tikal. Guat., in 1959. The largest is a slender shaft at Quiriguá, 35 ft. high including the base and weighing 65 tons; its erection was a fine feat of engineering (The dates used in this article are according to the Goodman-Martinez-Thompson correlation of the Maya and European calendars which has been accepted for many years by nearly all students on archaeological, astronomical and historical grounds. Early carbon-14 readings of wood taken from Maya buildings supported the Spinden correlation which places all Maya dates 260 years earlier in our calendar. Refinement of the carbon-14 technique has reversed this; subsequent readings of a long series of wood samples dated in terms of the Maya calendar agree completely with the Goodman-Martinez-Hernindez-Thompson correlation.)

Buildings are usually of local stone (limestone in most districts), without windows and with a small doorway for each room. Some were flat-roofed with beams and mortar and others were thatched, but those of most importance were generally supplied with the corbeled or false vault, in which the two soffits are inclined inward until the gap between them is sufficiently narrow to be bridged by a line of capstones. The rooms thus vaulted are narrow, seldom more than 12 ft. wide. Frequently, a door in the back wall leads to a second room and there may even be a third room behind that. These inner rooms were most probably used only for storage, for they were unilluminated except by light filtering through the outer doorways, and the Maya are known to have covered these with curtains. The absence of chimneys and of hearths indicates that the buildings were never permanent residences. for which they are unsuitable. Scenes carved on their stone lintels and panels testify that high priests or rulers, seated on daises, held court and administered justice in them. From knowledge of Aztec ritual it can be deduced that the people crowded the open courts to witness ceremonies performed before the temples, which were built on the tops of the pyramids. Specialized buildings included courts for the Maya to play their sacred ball game, sweat baths and, in Yucatán, ceremonial arches resembling the Roman triumphal arch. Important persons were often buried beneath buildings, which were frequently of perishable materials. The best-known centres of the classic period in the lowlands are Tikal; Palenque, Yaxchilan and Piedras Negras, famed for their beautiful sculpture; Copán for its situation and its sculpture; Uxmal, Labná and Sayil, for their fine buildings; Bonampak for its murals; and Quiriguá for its slender steles and carved boulders.

The abandonment of the ceremonial centres, a slow process spread over the whole 9th century, marked the end of the classic period. This abandonment appears to have been occasioned by a series of revolts on the part of the peasants against the ruling group, who worked them too hard. Influences from outside and alien religious concepts (one of the latest monuments at Copán is a feathered serpent god, symbol of a non-Maya cult) were probably important factors. The priest-ruler group appears to have been slain or driven out, after which the peasants, perhaps reduced in numbers, presumably continued their normal agricultural life under village headmen. There is archaeological evidence that they continued to visit the old centres as these gradually fell into ruin. Bodies were buried, accompanied by postclassic pottery, in partly collapsed buildings; fires were made on top of the soil and debris which accumulated on the floors of abandoned rooms, and huts were built in the courts. The central area was of little importance for the remaining six centuries of Maya history.

The Mexican Period. — The subsequent Mexican or postclassic period can be best followed in Yucatán, and strong influences from central Mexico appear even before the close of the classic period in various Yucatec cities, notably Uxmal and Kabah. But at Chichén Itzá (*q.v.*), a city of some importance during the classic period, there is overwhelming evidence of the strong impact of a people deriving its culture unmistakably from Tula, the great Toltec capital 50 mi. N. of Mexico City. Resemblances in sculptured scenes, symbols and motifs, and in plans and decoration of buildings are extraordinarily close; in addition, the emblems of the cults of Quetzalcoatl, Tezcatlipoca and other deities of Tula, as well as those of the great Toltec military order of jaguars and eagles, appear at Chichén Itzá in overwhelming repetition. The new masters of the city constructed many buildings for their cults, adorning the walls with painted and carved scenes of their triumphs over the natives. Their success appears to have been partly due to their use of spear throwers and to an efficacious armour of quilted cotton.

There are good grounds for identifying these conquerors with

the ItzL who figure greatly in Yucatec traditions, and for placing their subjugation of ChichCn ItzL between approximately A.D. 950 and A.D. 1000. During this period Maya and Mexican religious cults intermingled and a hybrid culture developed, but the cults of Quetzalcoatl and of the military orders were confined to the ruling class. By the time of the Spanish conquest both these cults, at one time supreme, were almost forgotten.

The **Mayapán** Period.— About A.D. 1200 Chichén Itzá was overthrown by a certain Hunac Ceel, and its rulers were driven out. The place continued as a centre of pilgrimage because of the renown of its *cenote* (a deep underground pool exposed by the collapse of the limestone crust above it), which was a shrine of the rain gods. Archaeological evidence confirms that Chichén ItzL functioned only in this way during the remaining centuries of Maya history.

Hunac Ceel and his successors, the Cocom dynasty, established MayapLn as the capital of all Yucatán. This place, in contrast to the ceremonial centres of earlier times, was a true city. Surrounded by a defensive wall over five miles in circumference, it now contains over 4,000 mounds, nearly all of which once supported residences. The domination of MayapLn marked a serious retrogression in culture. Its sculpture is graceless and its architecture a crude copy of the style of Chichén Itzá. Government was secular, and communal religion gave place to a militarism in which pride elevated ancestor worship to a dominant position among the aristocracy. The despotism of Mayapán was ended in 1450 by revolt and by the sacking and burning of the city, events fully confirmed by archaeological evidence. In the 90 years between the fall of MayapLn and the Spanish conquest, YucatLn divided into a dozen independent and warring states. Similar weak chiefdoms occupied much of the central area.

In the highlands of Guatemala, Mexican influence had been strong from early in the classic period onward, and the local nobilities, although Maya-speaking, claimed descent from Mexican invaders. Contemporaneously with the domination of Mayapán, the Quiché Maya attained ascendancy over much of the Guatemalan highlands and the Pacific littoral, but their power was curbed by a successful revolt of the Cakchiquel, so that at the time of the Spanish conquest there were various independent states speaking differentlanguages and dialects of the Maya group such as Quiché, Cakchiquel, Mam and Pokomam.

Mayan Culture.— The outstanding intellectual achievements of the Maya were in the fields of hieroglyphics, astronomy and the calendar. Maya hieroglyphic writing is partly ideographic and partly phonetic, with much dependence on homophones (rebus writing). There are approximately 850 characters, most of which are of unknown meaning. Hieroglyphic texts were carved on stone monuments, on buildings, and on pieces of wood, jade and shell; they were also written in books, of which only three survive. One of these, the Dresden codex, contains accurate tables for predicting the dates of eclipses, although the Maya were unable to foretell which eclipses would be visible in their part of the world. Without even knowing that the moon revolved around the earth and the earth around the sun, they evolved a formula which in practice was: no solar eclipse if the new moon falls more than 18 days from node day (*i.e.,* the day when the sun intersects the moon's path). The Maya also learned the average synodical revolution of the planet Venus with extreme accuracy; their error was one day in 6,000 years, no mean success in view of the variation in length of this period. (For Maya achievement in handling time *see* CALENDAR: *Middle American Calendars;* CHRONOLOGY: *Maya and Mexican.)*

In architecture the Maya were far ahead of any other people in the new world. As noted above, they failed to develop the true arch, using in its place the corbeled vault. This severely limited the width of their rooms, but this was perhaps no defect in the eyes of a priesthood which sought secrecy for many of its rites, and it gave to their buildings a massive solidity which was very impressive and which alone has preserved many of them from the destructive tropical forest. Equally impressive is the lofty grandeur of the temples atop their pyramids, a few standing about 200 ft. above natural ground level. Maya sculpture, usually in low relief, is now acclaimed as one of the great art styles of the world. The best work is on steles and lintels and, to a lesser extent, set in the upper façades of buildings. Little wood carving has survived, but it is of superb quality. Modeled stucco was widely used on the exteriors and sometimes on the interior walls of buildings. Plastered walls were sometimes decorated with paintings of life scenes, but some designs are geometric. The finest surviving murals completely cover the walls of three rooms at the comparatively small site of Bonampak, Chiapas. Executed in brilliant colours, they depict realistic scenes of battle, ceremonial dancing, arraignment of prisoners and sacrifice.

Lapidary work, particularly in jade, is of extremely high quality. No textiles except small, poorly preserved fragments have survived, but sculptures and murals give an idea of the sumptuous dress of persons of rank. Featherwork was very elaborate, with very effective use of the long tail feathers of the quetzal.

During the classic period the Maya had no metal. Copper and gold were quite rare even at the beginning of the 16th century. Tools were of wood, bone, stone and obsidian (volcanic glass). The bow and arrow were unknown until the Mexican period.

The seed beans of the cacao tree served as currency throughout Middle America. Cacao plantations were extensive in Tabasco, along the Bay of Honduras and on the Pacific coast and, naturally, were a source of great wealth. Trade was widespread at all periods. The immense quantities of discarded obsidian blades encountered at every Maya site indicate a brisk commerce with the highlands, for there are no obsidian deposits in the lowlands. The much-valued jade was also imported by the lowland Maya (deposits of jade have been found in the Sierra de Minas, Guat.). Certain types of pottery had wide markets throughout Maya history. A pottery pipe found at Chichén ItzL was made in northern Michoacán, Mex., not far short of 1,000 mi. away in a direct line and much farther by trail and coastal canoe; gold objects were brought from Panamá, an even greater distance.

The Maya practised artificial deformation of the head, filed their teeth in various patterns and ornamented them also with inlaid disks of jade and hematite. Tattooing and scarification were common practices. Every conceivable method of disposing of the dead was used. The most spectacular burial is that found at Palenque, of a chief who lay full length, decked with massive necklaces, rings, bracelets and a mask of jade. The large mortuary chamber, in which he lay beneath a huge carved stone slab, was in the interior of a pyramid, to which led two flights of stairs, purposely blocked up in ancient times. The skeletal remains of persons presumably sacrificed at the funerary rites were by the entrance to the chamber. Cremation became common in the period immediately before the arrival of the Spaniards.

The basis of the Maya economy was maize, planted in fields temporarily wrested from the forest; the most important Maya deities were those connected with its growth. Chief of these were the rain gods, called Chacs; the moon, goddess of the soil, birth and fertility; the sun; and the maize god himself. The Chacs, like other Maya gods, are in a group of four, each associated with one of the four world directions, north, south, east and west, and with one of the colours, white, yellow, red and black, attributed to each. Maya cosmology envisaged the sky, supported by trees and by the upraised arms of the gods called "Bacabs" at the four points of the compass, as comprising 13 layers, the lowest of which was pictured as a celestial dragon decorated with the symbols of planets, stars, night and darkness. Beneath the earth were nine underworlds, in the lowest of which dwelt the death god. Throughout their history the Maya practised human sacrifice on a limited scale, usually by removal of the heart. Worshipers commonly drew blood from various parts of their bodies, particularly ears and tongue, to offer to the gods. (J. E. S. T.)

MODERN COMMUNITIES

The modern Maya-speaking Indians occupy much the same territory as did their ancestors and retain surprisingly strongly their languages and their local Indian identities. Gone with the priests are the knowledge and the organization that developed the pre-Columbian civilization; only *a* part of the presumed tradition of

the villagers of old remains, mixed with and changed by European elements. Thus, in western Guatemala the ancient calendar still governs the annual ceremonial cycle, but there is no long count, or astronomy or means of notation. Thus, also, good colour and design and technique survive in textiles in Guatemala and Chiapas, but no frescoes or codices or the like, and no monumental architecture or stonework.

Except for a very few in the lowland forest along the Chiapas-Guatemala border, the modern Indians are part of the rural populations of Mexico, Guatemala (extending a little into Honduras) and British Honduras. The community unit in the lowlands is usually a village with its surrounding cornfields; in the highlands a town is surrounded by farms which "belong" to the town and its patron saint. Each of these social-political-religious units, though embedded in the larger economy, is the "world" to its Indians, who may continue for generations to "belong" to it even after migrating to another town or plantation.

The culture of the Indians inexfricably mixes pre-Columbian Indian with European and modern elements; almost nothing in daily life is purely one or the other. Diet, for example, combines maize, beans, squash. turkey, chile and chocolate, prepared in Indian ways, with wheat bread, rice, sugar, lard, beef, pork, mutton, chicken and coffee brought by Europeans. Religion, folklore and social organization are compounds rather than mixtures. Thus Jesus often is a culture hero in a very local origin myth, and ancient gods reappear as Catholic *santos.* Also, Spanish-sounding town officials like *alcaldes, regidores, alguaczles,* and church officials like *sacristanes* and *mayordomos* are combined in each community into a single age-grading and status organization with civil and religious functions which would not be recognued by either the nation or the church.

Each community has its distinct organization, culture, dialect, even "personality." Though not well off economically or in health, they tend to ignore or to resist efforts to incorporate them into the mainstreams of Mexican and Guatemalan national life.

(S. Tx)

Languages. — At mid-20th century, more than 2,000,000 Maya Indians of Mexico, Guatemala, and British Honduras speak 20 to 25 related languages. The languages range from those number ing a few hundred to those numbering several hundred thousand speakers.

The Mayan language family probably had its origin in the highlands of northwestern Guatemala at the foot of the Cuchumatanes mountains and early split into a number of subfamilies. Of these, undoubtedly Huastec in its various subdialects and the various dialects of the Yucatec subgroup split off first from the highland Guatemala massif. Next to split off were the languages of the Gulf and Caribbean lowlands, the Chontal of Tabasco, the Chol of Tabasco and Chiapas, and the Chorti of Guatemala and Honduras. Next were the languages of the highlands of Chiapas. the Tzeltal and Tzotzil, and the Tojolabal. Those which remained behind became sharply differentiated; they are divided into Mamean (Mam, Aguacatec, Ixil), Quichean (Quiché, Cakchiquel, Tzutuhil) and Kekchian (Kekchi, Pokonchi, Pokomam). Languages such as Jacaltec, Solomeco and Kanjobal on the one hand, and Chuj on the other, form a bridge between Mamean and Tzeltalan and indicate the origin of Tzeltalan on the northern slopes of the Cuchumatanes.

Languages now extinct, such as Chicomuceltec, formerly spoken in the southeastern mountains of the Mexican state of Chiapas, may, because of its particularly close link with Huastec, indicate the point of origin for that now geographically distant language (spoken in eastern Mexico near Tampico). One of the Mayan languages, probably Yucatec, possibly Chontal-Chol-Chorti, was spoken by the vast majority of those priestly scribes who engraved the monuments and wrote the books which have been justly advanced as evidence of the high civilization of the Mayas. When such Maya hieroglyphic inscriptions have been completely deciphered, a great deal more will be known about Mayan origins and Mayan daily life. Although some speakers of Mayan languages are learning Spanish, large numbers still know no tongue other than their own native Maya.

See CENTRAL AMERICA: *Anthropology;* MIDDLE AMERICA; INDIAN. LATIN-AMERICAN; *see* also references under "Maya Indians" in the Index volume. (N. A. McQ.)

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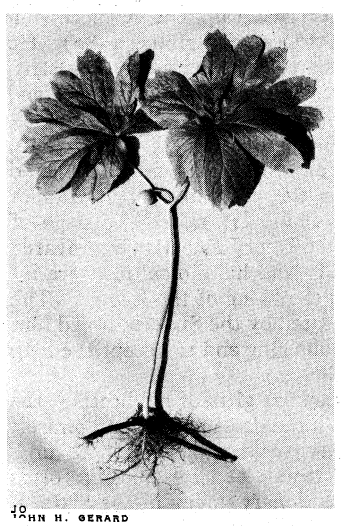
MAY APPLE (*Podophyllum peltatum*), a North American plant of the barberry family (Berberidaceae), also called American mandrake, native to low woods from Quebec to Manitoba and southward to Florida and Texas. It is an erect, perennial herb, 12 to 18 in. high, which springs from a horizontal rootstock. The stem bears two large, shield-shaped, deeply lobed leaves, sometimes nearly a foot in diameter, in the axil between which rises in May a single stout-stalked, fragrant, white flower, about two inches broad, with six or more petals. The fruit, which ripens in July, is an oval, fleshy, yellow, edible berry about two inches long. In many districts the May apple is an abundant, conspicuous wild flower and it has many local names. Its poisonous rootstalk yields the powerful drug podophyllin (*q.v.*).



JOHN H. GERARD

MAY APPLE (PODOPHYLLUM PELTATUM) SHOWING FRUIT AND ROOT SYSTEM

MAYBOLE, a small burgh in Ayrshire, Scot. 9 mi. S. of Ayr and 42 mi. S.W. of Glasgow by road. Pop. (1961) 4,677. It received a charter from Duncan II in 1193, and was made a burgh of regality in 1516, but for generations it remained under the subjection of the Kennedys, afterward earls of Cassillis and marquesses of Ailsa, the most powerful family in Ayrshire. Maybole was once the capital of the district of Carrick, and the castle of the earls of Cassillis remains.

The leading manufactures are of boots and shoes and agricultural implements.

MAYENNE, CHARLES OF LORRAINE, DUKE OF (1554–1611), second son of Francis of Lorraine, 2nd duke of Guise, was born on March 26, 1554. He was absent from France at the time of the massacre of St. Bartholomew, but took part in the siege of La Rochelle in the following year, when he was created duke and peer of France. He went with Henry of Valois, duke of Anjou (afterward Henry 111), on his election as king of Poland. On his return to France he fought under his brother, the 3rd duke of Guise, against the Huguenots. As governor of Burgundy he raised his province in the cause of the League in 1585. The assassination of his brothers at Blois on Dec. 23 and 24, 1588, left him at the head of the Catholic party. The Venetian ambassador, Mocenigo, states that Mayenne had warned Henry III that there was a plot afoot to seize his person and to send him by force to Paris. At the time of the murder he was at Lyons, where he received a letter from the king saying that he had acted on his warning, and ordering him to retire to his government.

Mayenne professed obedience, but immediately made preparations for marching on Paris. After a vain attempt to release his relatives who had been arrested at Blois, he recruited troops in his government of Burgundy and in Champagne. When Mayenne entered Paris (Feb. 1589) he formed a council general to direct the affairs of the city and to maintain relations with the other towns faithful to the League. To this council each quarter sent four representatives, and Mayenne added representatives of the various trades and professions of Paris in order to counterbalance

this revolutionary element. He constituted himself "lieutenant-general of the State and crown of France," taking his oath before the parlement of Paris. In April he advanced on Tours. Henry III. in his extremity sought an alliance with Henry of Navarre, and the allied forces drove the leaguers back, and had laid siege to Paris, when the murder of Henry III. by a Dominican fanatic changed the face of affairs and gave new strength to the Catholic party.

Mayenne was urged to claim the crown for himself, but he proclaimed Charles, cardinal of Bourbon, at that time a prisoner in the hands of Henry IV., as Charles X. Henry IV. retired to Dieppe, followed by Mayenne, who joined his forces with those of his cousin Charles, duke of Aumale, and Charles de Cossé, comte de Brissac, and engaged the royal forces in a succession of fights in the neighbourhood of Arques (September 1589) He was defeated and out-marched by Henry IV., who moved on Paris, but retreated before Mayenne's forces. In 1590 Mayenne received additions to his army from the Spanish Netherlands, and took the field again, only to suffer complete defeat at Ivry (March 14, 1590). He then escaped to Mantes, and in September collected a fresh army at Meaux, and with the assistance of Alexander Farnese, prince of Parma, sent by Philip II., raised the siege of Paris, which was about to surrender to Henry IV. Mayenne feared with reason the designs of Philip II., and his difficulties were increased by the death of Charles X., the "king of the league." The extreme section of the party, represented by the Sixteen, urged him to proceed to the election of a Catholic king and to accept the help and the claims of their Spanish allies.

But Mayenne, who had not the popular gifts of his brother, the duke of Guise, had no sympathy with the demagogues, and himself inclined to the moderate side of his party, which began to urge reconciliation with Henry IV. He maintained the ancient forms of the constitution against the revolutionary policy of the Sixteen, who during his absence from Paris took the law into their own hands and in November 1591 executed one of the leaders of the more moderate party, Barnabé Brisson, president of the parlement. He returned to Paris and executed four of the chief malcontents. The power of the Sixteen diminished from that time, but with it the strength of the League.

Mayenne entered into negotiations with Henry IV. while he was still appearing to consider with Philip II. the succession to the French crown of the Infanta Elizabeth, granddaughter, through her mother Elizabeth of Valois, of Henry II. He demanded that Henry IV. should accomplish his conversion to Catholicism before he was recognized by the leaguers. He also desired the continuation to himself of the high offices which had accumulated in his family and the reservation of their provinces to his relatives among the leaguers. In 1593 he summoned the States General to Pans and placed before them the claims of the Infanta, but they protested against foreign intervention. Mayenne signed a truce at La Villette on July 31, 1593. The internal dissensions of the league continued to increase, and the principal chiefs submitted. Mayenne finally made his peace only in Oct. 1595. Henry IV. allowed him the possession of Chalon-sur-Saône, of Seurre and Soissons for three years, made him governor of the Isle of France and paid a large indemnity. Mayenne died at Soissons on Oct. 3, 1611.

See the literature dealing with the house of Guise (*q.v.*).

MAYENNE, a department of north-western France, bounded on the north by Manche and Orne, east by Sarthe, south by Maine-et-Loire and west by Ille-et-Vilaine. Area, 2,012 sq. miles. Pop. (1936) 251,348. The department forms the eastern portion of the Armorican system of Palaeozoic rocks, with zones of granite running east and west in its northern part. The Mayenne cuts across the grain of the country in its course from north to south through the middle of the department; it receives a number of small tributaries. The Oudon runs parallel to it in the south of the department and then turns eastward to join it in the department of Maine-et-Loire. The land in the north-east rises to 1,368 feet. Varying zones of soil give sandy heaths alternating with marshes that make the air moist and foggy; the rainfall is rather above the average (32 in.) and the temperature is slightly lower than in neighbouring departments.

Large numbers of horned cattle and horses are reared, and the Craon breeds of horses and pigs are famous. Mayenne produces butter and poultry and much honey. The cultivation of the vine is very limited, and the most common beverage is cider. Wheat, barley, oats and buckwheat are the most important crops, and much flax and hemp is produced. Game is abundant. The timber grown is chiefly beech, oak, birch, elm and chestnut. The department produces vanadium, antimony, auriferous quartz and coal. Marble, slate and other stone are quarried. There are several chalybeate springs. Exports include agricultural produce, livestock, timber and stone. The department is served by the Ouest-État railway. It forms part of the circumscriptions of the IV. army corps, the académie (educational division) of Rennes, and the court of appeals of Angers. It comprises three arrondissements (Laval, Château-Gontier and Mayenne), with 27 cantons and 276 communes. Laval, the capital, is the seat of a bishopric of the province of Tours. The other principal towns are Château-Gontier and Mayenne. The following places are also of interest: Evron, which has a church of the 12th and 13th centuries; Jublains, with a Roman fort and other Roman remains; Lassay, with a fine château of the 14th and 16th centuries; and Ste. Suzanne, which has remains of mediaeval ramparts and a fortress with a Romanesque keep.

MAYER, JOHANN TOBIAS (1723–1762), German astronomer whose lunar tables greatly assisted the accurate determination of longitude at sea, was born at Marbach, near Stuttgart, on Feb. 17. 1723. A self-taught mathematician, he had already published two original geometrical works when, in 1746, he entered the cartographic establishment founded by J. B. Homann at Niirnberg. He also published calculations of the libration and equatorial inclination of the moon in the transactions of the Nürnberg cosmographic society, gaining a scientific reputation which caused his election to the chair of economy and mathematics in the University of Gottingen in 1751. Mayer became superintendent of the observatory in 1754, and worked there until his death at Gottingen on Feb. 20, 1762.

Mayer's lunar tables were published in the transactions of the Royal Society of Gottingen in 1755. In the same year he submitted to the English government an amended body of manuscript tables, which James Bradley found to be sufficiently accurate to determine the moon's place to 75″, and consequently the longitude at sea to about half a degree. A London edition of the tables (1770), produced under the supervision of Nevil Maskelyne, also contained Mayer's method of determining longitude by lunar distances (which Maskelyne developed into a practical method challenged only by John Harrison's chronometer) as well as a formula for atmospheric refraction which applied a remarkably accurate correction for temperature. A finally revised version, corrected by Charles Mason and edited by Maskelyne, appeared in 1787. (O. J. E.)

MAYER, JULIUS ROBERT VON (1814–1878), German physicist, was an independent a priori propounder of the first law of thermodynamics on the conservation of energy (*see* THERMODYNAMICS) and early and ably applied that law to the explanation of many remarkable phenomena, both cosmical and terrestrial. He was born at Heilbronn on Nov. 25. 1814, studied medicine at Tubingen. Munich and Paris. and after a journey to Java in 1840 as surgeon of a Dutch vessel obtained a medical post in his native town. His first paper on the subject, "Bemerkungen uber die Krafte der unbelebten Natur," appeared in 1842 in Justus von Liebig's *Annalen der Chemie* (vol. 42), and three years later he published *Die organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel.*

There was a good deal of controversy regarding the priority of Mayer's ideas; this, together with the lack of appreciation accorded to his work, and domestic grief, affected Mayer's mind. Following an unsuccessful suicide attempt, he was in 1851 placed in a mental institution and. although he was released, his mind never completely recovered. Ennobled in 1867. he died at Heilbronn on March 20. 1878. His papers were published in a single volume with the title *Die Mechanik der Wärme* (1867; 3rd ed., 1893)

"MAYFLOWER," the vessel which carried from Southampton, Eng., to Plymouth, Mass., the Pilgrims who established the first permanent colony in New England. It was of about 180 tons burden, and in company with the "Speedwell" sailed from Southampton on Aug. 5, 1620, the two having on board 120 Pilgrims. After two trials the "Speedwell" was pronounced unseaworthy, and the "Mayflower" sailed alone from Plymouth, Eng., on Sept. 6, with the 100 (or 102) passengers, about 41 of whom on Nov. 11 (old style) signed the famous "Mayflower compact" in Provincetown harbour, and a small party of whom, including William Bradford, sent to choose a place for settlement, landed at what is now Plymouth, Mass., on Dec. 11 (new style; 21, O.S.), an event which is celebrated as Forefathers' day on Dec. 22. A General Society of Mayflower Descendants was organized in 1894 by lineal descendants of passengers of the "Mayflower" to "preserve their memory, their records, their history, and all facts relating to them, their ancestors and their posterity." Every lineal descendant, over 18 years of age, of any passenger of the "Mayflower" is eligible to membership. Branch societies have since been organized in several of the states and in the District of Columbia, and a triennial congress is held in Plymouth.

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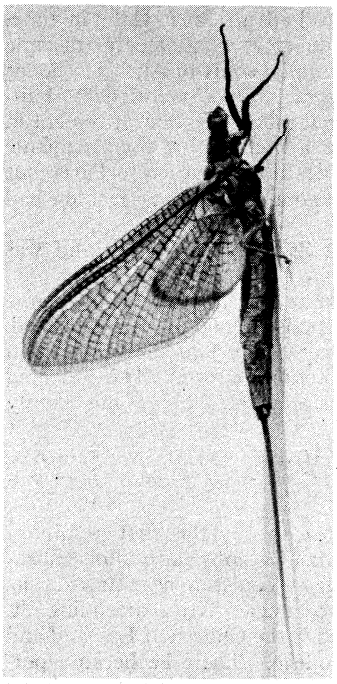
MAY FLY, common name for insects belonging to the order Ephemeroptera. Adult May flies are delicate, soft-bodied flying insects frequenting streams, rivers, ponds and lakes. They are readily recognized by their very short antennae; aborted mouth parts; triangular membranous wings, usually with many veins and cross veins, and with the hind pair greatly reduced or absent; and their two or three long taillike filaments. The common names shad fly or dayfly (in reference to the adult's short life span) have also been used for these insects.

Most species deposit the eggs on the surface of water, but some descend beneath the water to oviposit on submerged surfaces. The nymphs or naiads are found in fresh waters of all types and a few species enter brackish waters. They may be distinguished from other fresh-water insects by the greatly enlarged middle segment of the thorax (region behind the head); a single claw on each leg; and by the segmentally arranged gills on the abdomen.

The nymphs are very diverse. The most common types are minnowlike free-swimming forms, flattened forms which cling to rocks and crawling forms found in streams or on vegetation in ponds. A number of kinds burrow in the sandy bottoms of lakes and streams. The gills may be hidden under the abdomen or other protective covering such as a modified anterior pair of gills, elongated wing pads, flattened or spinous legs or extensions of the middle segment of the thorax.

The length of the life cycle may be as great as two or possibly three years, but in most species it lasts one year or less. The nymphal period in some species may be as short as 15 days, but in most it is usually six months to nearly a year, during which time more than 50 molts may occur.

When nymphal development is complete, the winged insect takes to the air after escaping through a dorsal split in the nymphal skin. This first winged stage, unique to May flies, is sexually immature and is called a subimago or dun; it also differs from the true imago or adult by its duller appearance, translucent wings and shorter appendages. The subimago usually comes to rest for a period of from a few minutes to two or three days, at which time the skin (pellicle) is cast off and the adult, imago or spinner emerges.



JOHN H. GERARD

AMERICAN MAY FLY (HEXAGENIA)

The adult stage is very short lived; in some species less than two hours, but in most, one to three days. The adults do not feed, but may take some water. Most species execute aerial dances consisting of a fluttering ascent followed by a passive descent, repeated many times. During mid spring occasional mass flights may annoy man or impede automobile traffic with the slippery crushed bodies. May flies are attracted by light and often are seen in great clusters hanging on any solid object.

May flies are generally regarded as beneficial to man, and are eagerly devoured by fishes. A large percentage of all artificial trout flies are patterned after various species of May flies. May flies also serve as important food for other animals. The phenomenally high pheasant reproduction on some islands in Lake Erie has been attributed to the large amount of protein available to young pheasants feeding on adult May flies. In some parts of the world the aquatic stages are used by man for food.

About 1,800 species of May flies are known. There are more than 500 species known from North America, and additional species are being described every year. There are 48 species in the British Isles. Asia, South America and Africa seem to be particularly rich in undescribed forms.

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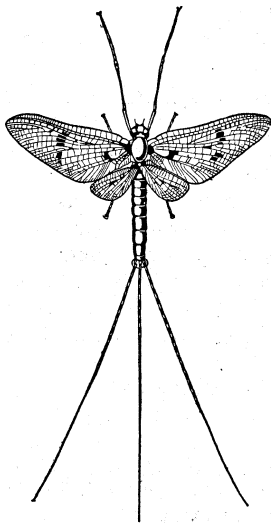

BY COURTESY OF THE (BRITISH) MUSEUM OF NATURAL HISTORY

MAY FLY (EPHEMERA VULGATA), WELL-KNOWN FLY OF EUROPEAN TROUT STREAMS

MAYHEM, an old Anglo-French term of the law signifying an assault whereby the injured person is deprived of a member proper for his defense in fight; *e.g.*, an arm, a leg, a fore-tooth, etc. The loss of an ear, jaw tooth, etc., was not mayhem. The most ancient punishment in English law was retaliative—*membrum* pro *membro*—but ultimately, at common law, fine and imprisonment. Various statutes were passed aimed at the offense of maiming and disfiguring, which is now dealt with by s. 18 of the Offences Against the Person act, 1861. Mayhem may also be the ground of a civil action.

In the United States, mayhem has been extended by statute to include "maim," which means to mutilate. It is punishable both as a felony and misdemeanour and also may be the ground for civil action.

MAYNARD, FRANÇOIS, the common misspelling of the name of the French poet FRANÇOIS MAINARD (1582/83–1646), who invariably wrote it in the latter way. This Mainard, moreover, must not be confused with the advocate FRANÇOIS MÉNARD of Nîmes (1589–1631), also a poet.

Born at Toulouse in 1582 or 1583, François Mainard went to Paris and in 1605 obtained a post in the service of Queen Margaret (Marguerite de Valois). He then wrote his pastoral poem

Philandre, but this was not printed till 1619. Meanwhile, in 1607. Mainard had attached himself to Malherbe, whose leading disciple he became. He held office in the presidia1 court of Aurillac (hence his designation as *le président Mainard)* from 1611 to 1628. Failing to win Richelieu's esteem, he spent many years in retirement in the country, though he was made a member of the Académie Française in 1634. On Richelieu's death he returned to Paris, but found that, while he still had a few admirers, literary fashion had changed.

Retiring again, Mainard died at St. Céré in Quercy and was buried there on Dec. 28, 1646.

As a poet Mainard is far inferior to Racan, with whose name his is often linked. Even his most praised epigrams are laboured. His real importance consists in his continuance of the Malherbian tradition of clarity, power and perfection of form. The collected edition of his works by G. Garrisson, 3 vol. (1885), mistakenly includes those of François Ménard.

See C. Drouhet, *Le Poète François Mainard* (1909); A. Adam *Historie de la littérature française au XVII^e siècle,* vol. i and ii (1948–51). (AE. A.)

MAYNE, CUTHBERT (1544–1577), the first seminary priest to die in England for the Roman Catholic faith under Elizabeth I, was born of humble parentage at Youlston, near Barnstaple, Devon, and baptized on March 20, 1544. After attending St. Alban's hall, Oxford, he was ordained in the Church of England and appointed chaplain to St. John's college. There he became persuaded of the truth of the Roman Catholic religion, forsook his university career and went in 1573 to the English seminary newly founded by William Allen at Douai, being ordained as a Roman Catholic priest in 1575. In 1j76 he returned to England to work among "his own people" in the west. settling in Francis Tregian's manor house at Golden, near Truro. There he passed as the steward. but pursued his priestly duties until his arrest in June 1577. After imprisonment for three months at Launceston he was tried there for high treason under an indictment which contained five principal charges, including the repudiation of the Act of Supremacy and the celebration of mass. The judges disagreed. but he was sentenced to death: judges in London also disagreed, but the sentence was upheld by the privy council and carried out at Launceston on Nov. 29, 1577, after he had refused a reprieve if he would take the oath of royal supremacy. He was beatified in 1886 and his feast day is Nov. 29. Since 1920 an annual pilgrimage at Launceston has been attended by increasing numbers.

See R. A. McElroy, *Blessed Cuthbert Mayne* (1929); *P.* A. Boyan and G. R. Lamb, *Francis Tregian* (1955). (*M. DK*)

MAYNOOTH, a small town in County Kildare. Ire., near the boundary of County Meath, 15 mi. W.N.W. of Dublin by road. Pop. (1956) 1,722.

The Royal Catholic College of Maynooth (St. Patrick's college), founded in 1795, is the chief centre for the training of the Roman Catholic diocesan clergy of Ireland, and is an affiliated college of the National University of Ireland. The building, a Gothic structure by A. W. Pugin, was erected in 1845. Near the college stand the ruins of Maynooth castle. built by Maurice Fitzgerald in 1176, besieged in the reigns of Henry VIII and Edward VI, captured in 1647 and then dismantled.

MAYO, EARLS OF. On the murder of William de Burgh. 3rd earl (see BURGH), his male kinsmen became native chieftains and adopted Irish names and customs. Their two main branches were those of "MacWilliam Eighter" in southern Connaught *(see* CLANRICARDE, EARLS OF) and "MacWilliam Oughter" to the north of them, in what is now Mayo.

In 1603 "the MacWilliam Oughter." Theobald Bourke, resigned his territory in Mayo and received it back to hold by English tenure. In 1627 he was created Viscount Mayo. The 2nd and 3rd viscounts (1629–63) suffered at Oliver Cromwell's hands, but the 4th was restored to his estates (about 50,000 ac.) in 1666.

The peerage became extinct or dormant on the death of the 8th viscount in 1767 In 1781 John Bourke, a Mayo man believed to be descended from the line of "MacWilliam Oughter," was created Viscount Mayo, and later earl of Mayo, a peerage still extant.

MAYO, CHARLES HORACE (1865–1939), U.S. surgeon, was born at Rochester, Minn., on July 19, 1865. After studying at the Chicago Medical college. then nominally connected with Northwestern university, he began the practice of surgery in 1888 at Rochester, Minn., and with his brother, William James, and father, William Worrall, founded the Mayo clinic. His methods had a strong influence in molding the practice of surgery in its various departments as these evolved with the growth of the institution. In addition to goitre, urologic and general surgery, in all of which he excelled, his early work included operations on the eye, ear, nose and throat, and neurologic, orthopedic, thoracic and plastic surgery. He made a special study of goitre and as a result succeeded in reducing the death rate in this class of cases by half. Outside of surgery, his chief interest was in focal infection and preventive medicine. He published many papers covering a wide range of subjects, mostly surgical. He was a charter member of the American College of Surgeons. He was awarded the distinguished service medal. U.S. army, in 1920. and commissioned brigadier general medical officers reserve corps in 1921. In 1912, graduate courses in medicine were first offered at the Mayo clinic in Rochester. Early in 1915. Charles Mayo and his brother founded the Mayo Foundation for Medical Education and Research at Rochester, and to it they gave $2,800,000. By mutual agreement, the funds and resources of the foundation were placed under the direction of the regents of the University of Minnesota, Minneapolis, for promoting "graduate work in medicine and research" and the foundation became a department of the graduate school of the university. Mayo died May 26. 1939.

See H. Clapesattle. *The Doctors Mayo* (1943).

MAYO, HENRY THOMAS (1856–1937), U.S. naval officer, was born in Burlington, Vt., on Dec. 8, 1856, and graduated from the United States Naval academy in 1876. Progressing through the grades, with varied sea and shore duties. he served on a number of coast surveys. He was created a rear admiral in June 1913. and in December he took over the fourth division of the Atlantic fleet. which he commanded during the 1914 affair with Mexico which led to the seizure of Veracruz. Mayo was promoted in 191j to command of the battleship squadron with the rank of vice-admiral, and a year later became admiral and commander of the Atlantic fleet. hoisting his flag on the battleship "Pennsylvania." During the entire period of World War I he held the vital post of commander in chief of the United States fleet, and on one extended journey inspected all naval activities in the European theatre of war from Scapa Flow to Trieste. When Mayo hauled down his admiral's flag on June 30. 1919, the combined fleet was again separated into the Atlantic and Pacific fleets. Mayo retired in 1920. was governor of the U.S. Naval home at Philadelphia. Pa., from 1924 to 1928, and died in Burlington on Feb. 23, 1937.

See D. W. Knox, *A History of the United States Navy (1936).* (W. B. CK.)

MAYO, RICHARD SOUTHWELL BOURKE, 6th EARL OF (1822–1872), British statesman, son of Robert Bourke, the 5th earl (1797–1867), was born in Dublin, Ire. on Feb 21, 1822, and was educated at Trinity college, Dublin. He was chief secretary for Ireland in three administrations, in 1852, 1858 and 1866, and was appointed viceroy of India in 1869. He consolidated the frontiers of India and met Shere Xli amir of Afghanistan. in durbar at Cmballa. India, in March 1869. His reorganization of the finances of the country put India on a paying basis, and he did much to promote irrigation, railways, forests and other public works

Visiting the convict settlement at Port Blair in the Andaman Islands. for the purpose of inspection. the viceroy nas assassinated by a convict on Feb. 8, 1872.

See Sir W. **W.** Hunter, ***Life*** *of the Earl* ***of*** *Mayo* (1876), and *The Earl* ***of*** *Mayo* ***in*** the *Rulers* of India Series (1891).

MAYO, WILLIAM JAMES (1861–1939**j**. U.S. surgeon, was born at Le Sueur. Minn., June 29. 1861. He graduated from the Cniversity of Michigan, Ann Arbor (M.D. 1883). From 1883 he was engaged in the practice of surgery in Rochester. Minn. A small hospital. St. Mary's. was organized under the local branch

of the Sisters of St. Francis. There he. with his father. William Worrall, and younger brother, Charles Horace (*q.v.*), developed the Mayo clinic (organized 1889). which became famous throughout the world for the number and success of operations performed. Dr. W. J. Mayo specialized in the surgery of the stomach, and published a large number of papers on gastric surgery and kindred topics.

In 1907 he was appointed a regent of the University of Minnesota, Minneapolis. He was elected president of the Minnesota State Medical society in 1893, of the American Medical association (1905–06), of the Society for Clinical Surgery in 1911, of the American Surgical association (1913–14), of the Society of Clinical Surgery (1911–12), of the American College of Surgeons (1917–19) of which he was one of the founders and of the Congress of American Physicians and Surgeons (1925). On the entrance of the U.S. into World War I he was appointed a major in the medical corps, U.S. army, and later became chief consultant for all surgical service, during the period of the war, alternating with his brother, C. H. Mayo, in this capacity (1917–19). He died July 28. 1939.

MAYO, a westerly county of Ireland, in the province of Connaught, is bounded on the north and west by the Atlantic ocean, northeast by Sligo, east by Roscommon, southeast and south by Galway. It is the third largest county in Ireland, with a land area of 2,084.2 sq.mi. The population in 1956 was 133,052.

The wild and barren west of the county, including the hills on Achill Island, is formed of Dalradian rocks, schists and quartzites, highly folded and metamorphosed, with intrusions of granite near Belmullet. Nephinbeg (2,065 ft.) and Croaghpatrick (2,497 ft.) are typical quartzite summits. The schists and gneisses of the Ox mountain axis enter the county north of Foxford. Muilrea, to the north of Killary harbour and reaching a height of 2,675 ft., is the highest mountain in Connaught. To the east of Lough Mask is a Carboniferous Limestone plain. Silurian rocks, the Old Red Sandstone over them, come out at the west end of the Curlew range at Ballaghaderreen. Clew bay, with its islets capped by glacial drift, is a submerged part of a synclinal of Carboniferous strata and Old Red Sandstone comes out on the north side of this, from near Achill to Lough Conn. The country from Lough Conn northward to the sea is a lowland of Carboniferous Limestone.

The coast, which is wild and broken, has many bays and inlets from Killala bay in the north to Killary harbour in the southwest. Blacksod bay and Broad haven form the peninsula of the Mullet. Ballina and Westport are the port towns. The most extensive islands are Inishturk near Killary harbour, Clare Island in Clew bay and Achill, the largest island off the Irish coast. The principal rivers. famous for their salmon and white trout fishing but not navigable, are the Moy which flows through the county in a northerly direction into Killala bay. the Owenmore and Owenbeg which flow westward into Blacksod bay and the Erriff river which flows southward into Killary harbour. The largest lakes are Lough Conn (10 mi, by 4 mi.) and Lough Cullin in the northeast, Lough Feagh and Lough Carrowmore in the west, Lough Mask and Lough Carra in the southeast. They are renowned for their brown trout fishing. Keel. on Achill Island, is famous for its basking shark fisheries.

Mayo village was formerly a celebrated monastery and episcopal see. The monastery was founded by St. Colman who came with English monks from Lindisfarne, Northumberland. It was for a long time known as "Mayo of Saxons." Mayo (Irish. *Magh-eo*) means the "plain of the yew trees." The county is rich in archaeological remains in the area around Cong in the south and Killala in the north.

At the close of the 12th century what is roughly the county of Mayo was granted by King John to William, brother of Hubert de Burgh. In the 14th century the land passed to a branch of the family known as "MacWilliam Eighter." Mayo was made shire ground during the first viceroyalty of Sir Henry Sydney but remained subject to the Gaelic overlordship of O'Donnell, prince of Tir-Connell. The MacWilliams continued to exercise authority, which was regularized in 1603 when "MacWilliam Eighter." Theobald Bourke, surrendered his lands and received them back, to hold them by English tenure, with the title of Viscount Mayo. Large confiscations were made in 1586, and on the termination of the wars of 1641; in 1666 the restoration of the estates of the 4th viscount Mayo involved another confiscation, at the expense of Oliver Cromwell's settlers. A French squadron under Gen. J. R M. Humbert landed at Killala in 1798 and having captured Ballina and Castlebar advanced to Longford before being defeated.

There are round towers at Killala, Turlough, and imperfect ones at Balla, Meelick and Aughagower. It is usual to find the doorway 15 ft. from the ground. The best-preserved monasteries are Rosserk and Moyne near Killala, built by MacWilliam *(Bourke Ioctair* or the Lower MacWilliam) in 1460 at the request of Nehemias O'Donuchada, the first Irish provincial vicar of the Franciscan order. Ballintubber abbey, still in use as a church, was founded in 1216 for the Augustinian Canons Regular. The island of Inishglora has ruins of a monastery founded by St. Brendan. There are ruins of a Carmelite abbey on Clare Island and of a Dominican abbey at Straid. Ballina is the seat of the Roman Catholic bishop of Killala. The village of Knock in the east is the most famous Irish shrine of the Virgin Mary; there are Sunday pilgrimages to it from May to October inclusive. Croagh Patrick near Westport is the scene of an annual national pilgrimage on the last Sunday of July.

The most notable castles are the castle of Crainne Mhaoil or Carrigaholly near Burrishoole, Deel castle near Ballina, McWilliam's castle on Lough Carra and Binghamstown castle near Belmullet.

The surface of the county varies considerably from the fertile plains in the southeast to the rugged mountains of the north and west where the farms are small and the bulk of the population supplements its earnings by migration to Great Britain. Potatoes and oats are the principal crops. Sheep, cattle, poultry and pigs are reared extensively. Small industries have been established at Ballina (flour milling), Westport (clothing), Kiltimagh (spinning), Foxford (woollens), Castlebar (bacon and headgear) and Belmullet (toys).

Irish is the everyday language of the people in the area around Tourmakeady and in the extreme northwest of the county. Near Erris, in the northwest, is the largest bog in Ireland (200 sq.mi.). Cottage industries supplement local incomes at Achill, Tourmakeady, Newport and Pontoon. The county is one of the most attractive in Ireland, particularly for fishermen. Despite the derivation of its name, the "plain of the yew trees," it lacks great forests or shelter belts.

Claremorris is the chief railway junction. The line from Athlone to Westport passes through it as does also the line from Sligo to Athenry which has a branch to Ballinrobe. Manulla is the junction for Ballina. The main roads go to Galway and to Sligo.

Castlebar, the county town and formerly the seat of the earl of Lucan. is the headquarters of the county council, judiciary and government offices. The county is administered for local government purposes by a county manager and 31 councillors elected every five years. Seven members represent the county in *dail eireann,* three for north Mayo and four for south Mayo.

(J. O'D.)

MAYOR. The mayor is, in principle, the head of the government of a municipality. The English word "mayor" and the French word *maire* are derived from the Latin word *maior* meaning "greater," from which is also derived the expression *major domus,* one who is in charge of the management of a large, usually wealthy, household. In countries outside the English- or French-speaking worlds, the mayor is called by differently derived names: *alcalde* in Spanish, *Bürgermeister* in German, *bourgmestre* in Belgian and *sindaco* in Italian. As the official head of the government of a municipality, the major is almost invariably the chairman of the municipal council and of the council executive committee. In addition he has at least one and often all three of the following roles: chief executive officer, ceremonial figurehead and local agent of the central government. His role and importance

in the local government structure thus depends largely on his relationship to the council and central government.

Though formally the mayor is the head of the government of the municipality, there are a number of countries where the power has shifted away from the mayor. This is a special phenomenon of the system in the United Kingdom where, with the rise of the influence of the popularly elected council, the power of the elected mayor has greatly diminished. In many municipalities in the United States, as well as in the United Kingdom and most of the Commonwealth countries, the office of the mayor has become virtually administratively impotent, although the prestige of the position is still great. This shifting of power from the mayor to the elected council has not so greatly affected the other countries which have elected councils and mayors. Many of these countries, however, do not have a long tradition of locally elected mayors.

In addition to the relationship between the council and the mayor, that between the mayor and the central government does much to determine his role. Originally, most mayors in Europe were appointed by the countries' central government. With the development of popularly elected councils, most mayors have taken on a dual role, serving not only as chief executive officer of the municipal administration, but also as agents of the central government charged with such functions as maintaining public security. Even after the local election of mayors developed, they continued this dual role in most countries except Switzerland, the Scandinavian and the English-speaking countries, and the Communist countries. The French mayor is probably the best-known example of a locally elected mayor whose duties as an agent of the central government greatly affect his role as a local chief executive.

Apart from English-speaking countries, where most mayors are restricted to ceremonial functions, mayors are almost universally the actual chief executive officer, the mainspring of the municipal administration and the focal point of policy. The mayor usually initiates policies and explains them to the council and to the public. As executive head of the municipal organization he is at the apex of a pyramidal administrative hierarchy, although frequently he has a second-in-command who is charged with the immediate general administrative supervision of the municipal departments.

As the representative and titular head of the municipality, the mayor welcomes visiting dignitaries, presides over civic gatherings and represents the municipality on public occasions.

Mayors may be appointed or elected. Up to the middle of the 19th century most mayors were appointed by the central government, but with the rise of the concept of representative government more and more countries adopted the practice of electing the mayor. In several the practice of appointing the mayor was abolished relatively recently: in France in 1875, in Denmark in 1919. Among countries where at mid-20th century the mayor was still appointed, though for different reasons, were the Netherlands, Portugal and Spain, as well as many of the less-developed Asian countries.

Countries having an elected mayor can be considered in two groups: those in which the mayor is elected by the council and those in which he is popularly elected. In most European countries the mayor is elected by the council from among its members; usually he is the leader of the majority party or of one of the largest parties. In Switzerland, the United States, Canada and New Zealand most, if not all, mayors are popularly elected. These are countries where local government structures have been influenced by the concepts of popular democracy and the separation of powers, as expressed by Montesquieu. Most mayors in the Philippines and in Japan and a few in Latin-American republics are also popularly elected as a result of U.S. influence in these areas.

In the countries where the mayor is centrally appointed, as well as in those in which he is locally elected but is also an agent of the central government, he will almost invariably be the actual as well as the nominal head of the local government. In these countries, in general, there is hardly any tendency to shift power, either to the municipal council or to a professional administrative official.

The British mayor is only the nominal head of the government of the municipality. He is elected by the council, generally from among its members, for a one-year term. He is the chairman of the council and the titular figurehead of the borough, but he is not the borough's chief executive. Executive functions are carried out by the committees of the council, which work in collaboration with the individual departments and the clerk of the council. The role of mayor in Canada, Australia and New Zealand has been greatly influenced by the English model.

In the United States the role of the mayor is largely determined by the form of local government structure in his municipality. There are four main forms of local government. In the first and oldest, the so-called weak-mayor council form, descended from, and closely resembling, the British form, the mayor is the council chairman and the nominal, but not the actual, head of the municipal government. The second, the so-called strong-mayor council form of government, was a later development; in this the mayor is the actual chief executive as well as the titular figurehead. In most cases he is also the chairman of the council and often has the prerogative to veto actions of the council. Thirdly, the mayor of municipalities with the so-called council-manager system is the council chairman as well as the titular figurehead of the municipality; however, the manager is the chief executive. Fourthly, in the relatively few municipalities with the so-called commission form of government, each of the members of the commission heads a municipal department; the mayor is the chairman of the commission but has no more executive authority than any other commission member.

In the Danish, Norwegian and Icelandic municipalities, the council-elected mayor is chairman of the council, also chairman of the executive committee (when there is one) of the council; to a varying extent, he is also charged with the general supervision of the executive organs. In Sweden the local chief executive officer is the chairman of the council executive committee; another council-elected official serves as chairman of the council.

The Swiss mayor is popularly elected and presides over the municipal board as well as over the popular assembly composed of all the adult male voters. The Austrian mayor is elected by the council and presides over both the council and the board. He is also the chief executive officer of the municipal administration. The local government structure in the German Federal Republic varies from *Land* to *Land*. In some municipalities the mayor resembles his Austrian counterpart; in others he is only the council chairman and titular figurehead, while a professional administrator is the chief executive officer.

In the Netherlands and Belgium the mayor is the council chairman, board chairman, ceremonial head and chief executive of a municipality. The appointments are made by the central government; however. in Belgium the royal appointment almost invariably is a ratification of the council's choice. In the Netherlands the mayor is usually an experienced administrator; although centrally appointed, he is a local official and above all an advocate and promoter of the local interests.

The French and Italian mayors are council-elected, preside over the council as well as over the board and are the chief executive officers of the municipal administrations. As agents of the central government they are directly under the head of the province (or *département*). The Spanish mayors are centrally appointed, preside over the council, if any, and are the chief executive officers as well as the heads of the local branches of the dominant national party. The Portuguese mayors are similar to their Spanish counterparts.

The mayors in Turkey, Tunisia, Iraq and Persia preside over the council and are strong chief executive officers. Those in Iraq are appointed by the central government; most of the others are locally elected, although in many cases their election must be ratified by the central government before they can assume office.

In India, Ceylon, Burma, Malaya and the Sudan. the structure of local government has been influenced by the English model. However, in many cases, the locally elected mayor is both the council chairman and the chief executive officer. In others a central government official serves as council chairman and chief executive. In some municipalities the council chairman is elected

locally, while the chief executive officer is a centrally appointed official.

In the Philippines and Japan the structure of local government reflects U.S. influence, the mayor in each country resembling the mayor in the strong-mayor council form of government in the United States. Japanese mayors and most of the Philippine mayors are popularly elected and preside over the council: the Japanese mayor, however, is the actual chief executive; the Philippine individual municipal departments are directly supervised by provincial or national officials.

Local government in many countries of Asia and Africa is in a rapid process of development, and the position of the mayor is consequently subject to change. (S. Hs.; A. F. L.)

MAYOR OF THE PALACE, an official of the western European kingdoms of the 6th–8th centuries, whose status developed, under the hlerovingian Franks, from that of an officer of the household to that of regent or viceroy. The great landowners of Roman imperial times had entrusted the administration of their domains to local managers or *majores,* over whom a *major domus* or mayor of the household was appointed to superintend the property as a whole. This system was taken over by the Merovingian kings, at whose court (*palatium*) the *major domus* came to be known also as *major palatii* or mayor of the palace. The early history of this functionary under the Merovingians is extremely obscure, but new functions and powers gradually accrued to him. The personnel of the court came under his authority; he advised the king on the appointment of counts and dukes; it was his duty to protect the *comnzendati* (persons who had been commended to the king) and the king's wards; and eventually he even assumed command of the royal army.

It was probably the long series of royal minorities following the murder of Sigebert of Austrasia in 575 and the death of Chilperic I of Neustria in 584 that enabled the mayors of the palace, as tutors of the young rulers, to gain control of the government—a control which they maintained when the kings came of age. This ascendancy, however, could not have been achieved without the support of the landowning aristocracy, which benefited from the king's liberalities and which supported the usurpations of the mayors so as to participate further in both the power and profits of government, obtaining countships and dukedoms and sending their sons to court as *commendati* for future preferment. The mayors for their part pursued varying policies toward the aristocracy. Some, such as Flaochat in Burgundy and Erkinoald in Neustria, remained on good terms with it; but others, such as Ebroi'n (*q.v.*) of Neustria and Burgundy, did the contrary. Ebroi'n pursued his personal ambitions and private animosity against the great men of the realm and even against the clergy—as is shown by the tortures that he inflicted on Léger, bishop of Autun.

In the second quarter of the 7th century, Pepin I (Pepin of Landen; d. 640), as mayor of the palace. and Arnulf, bishop of Metz (d. *c.* 640), whose families were closely bound together by marriage, held power in Austrasia. Grimoald (d. 656), Pepin's son and successor, sought in turn to assure the succession to his son, but his aims were thwarted and as a result the family lost its ascendancy until 679, nhen Grimoald's nephew Pepin II (Pepin of Herstal; d. 714) became mayor. Conflict was inevitable between the ambitious and avaricious mayors of Austrasia and Neustria. and Pepin was defeated soon after his accession by the Neustrians under Ebroi'n. In 680, however, Ebroi'n was assassinated, and in 687 Pepin defeated the Neustrians at Tertry. From this time the three kingdoms of Neustria, Burgundy and Austrasia were united under the *de facto* rule of Pepin II as mayor of the palace. His son Charles Martel (d. 741) succeeded him and when Theuderic IV died in 737, Charles allowed the throne to remain vacant and divided the kingdom between his own sons Carloman (abdicated 747) and Pepin III (d. 768). In 743 these brothers placed Childeric III on the throne, but in 751 Pepin set him aside and had himself elected king, being the first king of the Carolingian dynasty. *See* CAROLINGIANS.

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MAYOW, JOHN (1640–1679), English chemist and physiologist who identified oxygen as a distinct atmospheric entity, was born in London, May 24, 1640. In 1658 he entered Wadham college, Oxford. He graduated in law (bachelor 1665; doctor 1670), but made medicine his profession. In 1678 he became a fellow of the Royal society. He died in London in Sept. 1679. The contents of his work, *Tractatus quinque Medico-Physici* (1674), which was translated into Dutch (1684), German (1799) and French (1840), show him to have been an investigator much in advance of his time. Mayow, who gives a remarkably correct anatomical description of the mechanism of respiration, preceded Joseph Priestley and A. L. Lavoisier by a century in recognizing the existence of oxygen, under the guise of his *spiritus nitro-aereus;* he perceived the part it plays in combustion and in increasing the weight of the calces of metals as compared with metals themselves.

MAYSVILLE, a city of northeastern Kentucky, U.S., is located on the Ohio river about 60 mi. S E. of Cincinnati, o., the seat of Mason county. It is a shipping point for tobacco, livestock, wheat and dairy products; its manufactures include cotton goods, shoes, bricks, bicycles and motorcycles. Formerly it was an important hemp market. The site of Maysville was an early landing point for pioneers coming into Kentucky and in 1784 a blockhouse and double log cabin were erected. The town was laid out and incorporated in 1787. It was chartered as a city in 1833 and in 1848 it became the county seat. The turnpike from Maysville to Lexington (1835) was the first of a system of roads built with state aid.

For comparative population figures *see* table in *KENTUCKY: Population.*

MAYWOOD, AUGUSTA (b. 1825), the first American ballerina to achieve international renown, became prima ballerina at La Scala, Milan, when she was 23. Born Augusta Williams, in New York city, she adopted the name of her stepfather. the theatrical manager Robert Campbell Maywood. Trained by Paul Hazard in Philadelphia, she made her debut there. Dec. 30. 1837, in Auber's opera-ballet *Le Dieu et la Bayadkre.* Further study in Paris led to a debut at the Opéra in 1839. A brilliant dancer, she starred in Vienna, Lisbon and Milan in such ballets as *Giselle* and *La Sylphide.* She retired in 1862. (LN. ME.)

MAYWOOD, a village of Cook county, Ill., U.S., on the Des Plaines river, is 10 mi. W. of the Chicago "loop." Founded in 1869 by Col. William Nichols of Vermont, it was incorporated as a village in 1881. Maywood is predominantly a residential community, with diverse municipal facilities, considerable business and industry and a continuing culture of its own within the Cook county metropolitan area. The village government was organized under a village manager in 1952. The manufacture of tin cans was initiated as a pioneering enterprise in the 1870s. Chief industries include can and carton production, bottled soft drinks and flexible metal tubing. There are many business and cultural organizations. Maywood is the site of the Chicago Lutheran Theological seminary, founded in 1891, and the Hines Memorial hospital for veterans. For comparative population figures *see* table in ILLINOIS: *Population.* (J. L. *B.)*

MAZAGAN (EL JADIDA), a port on the Atlantic coast of hlorocco and the chief town of the region of the tribes of Doukkala, 68 mi. S.W. of Casablanca. It lies at the southern end of a sandy bay rocky at the extremities, south of the mouth of the Oum-er-Rbia Pop. (1952) 34,781, of whom 29,181 were Moslem, 3,017 Jews and 2,383 Europeans.

Founded by the Portuguese in 1502, Mazagan was the centre of their settlement in Morocco and the last place to be evacuated by them (1769). The Portuguese origin of the town can be seen in the walls, the gates surmounted by the escutcheons of the kings of. Portugal, the castle and the *salle d'armes.* The latter is the most remarkable building in Mazagan and served as a storehouse after the completion of the ramparts in 1541. The new town stretches to the north and south of the old town.

The inhabitants are mainly Arabized Berbers from the surround-

ing tribes who have settled there because of the overcrowding of the country round.

The port is small, covering only 17 ac. and containing two jetties and a wet dock. It is used for the export of agricultural produce from Doukkala. unlike the other Moroccan ports that deal chiefly with products from the mines. The remarkable development of the sardine fishery along this coast from 1945 scarcely aifected Mazagan, which had only 4 canning factories in 1950 as compared with 72 at Safi. Once important. Mazagan was overtaken as a port by Casablanca, Safi and Xgadir. Its trade had not increased between 1939, when 116 ships (132,000 tons) were handled. and 1952, when 132 ships (126,000 tons) passed through the port.

Sre J. Goulven, *La Place de Mazagan sous la domination portugaise, 1502–1769* (Paris, 1917). (M. T.)

MAZAMET, an industrial town of southwestern France in the department of Tarn, 41 mi. S.S.E. of Albi by rail. Pop. (1954) 13,705. Mazamet is situated on the northern slope of the Montagnes Noires and on the Arnette, a small subtributary of the Agout. Industries include wool spinning and the manufacture of "swanskins," flannels and hosiery, and there are important tanneries and leather-dressing, glove and dye works. Wool and raw hides are imported from outside France.

MAZANDERAN, a province or *ostan* of Iran, lying between the Caspian sea and the Elburz range and bounded east by the *ostan* of Khorasan and the governorship of Semnan and west by Gilan and Central *ostans.* Area: 18,069 sq.mi. Pop. (1956) 1,328,926, mainly Iranian with Afghan. Kurd and Baluchi minorities. The governor's seat was Barfurush *(see* BABOL), but in 1937 was transferred to Sari.

Mazanderan, like Gilan, comprises two distinct natural regions, presenting the sharpest contrasts. The northern portion consists of swampy lowlands. varying in breadth from 10 to 30 mi.. partly under impenetrable jungle and partly under crops. This belt is fringed northward by the Caspian, there almost destitute of good natural harbours. and rises somewhat abruptly inland to the second belt comprising the northern slopes and spurs of the Elburz, which are almost everywhere covered with dense forest. The lowlands, which once rose only a few feet above the sea and were subject to frequent floodings, are malarious, while the highlands, culminating in Mt. Demavend (18,580 ft.), enjoy a tolerably healthful climate; but the climate is capricious. Snow falls in the highlands, where for weeks it blocks the tracks across the Elhurz.

The rivers of hlazanderan are comparatively short and little more than mountain torrents. The chief is the Harhaz. rising in the neighbourhood of Demavend; all are well stocked with trout, salmon, perch, carp and sturgeon.

The chief natural products of the lowlands are rice, cotton of good quality, sugar cane, silk and citrus fruits. Hazar Jarib grows wheat and barley, while the hill district of Firuzkuh has extensive summer pastures. The main forests—of oak, ash. box, walnut, etc.—are in the *miyanabad,* or middle hills.

Wild boars are numerous. tigers occasional. The domestic animals are small, including the black humped cattle, sheep and goats. Mazanderan is rich in minerals, and in the Nur district iron in exploitable quantities is found in proximity to coal.

Mazanderan is divided into the ten districts of Sari, Shahsavar, Now Shahr, Suldeh, Amol, Babol, Shahi, Behshahr, Gorgan, Gonabad-e Kavus. The coastal plains are probably the most thickly-peopled tracts in Iran, especially the delta areas at the mouths of the rivers where water can be utilized for rice cultivation.

The export trade was chiefly with the port of Baku and carried on almost exclusively from Meshed-i-Sar at the mouth of the Babil river, navigable for small craft up to Barfurush. 15 mi. inland. The volume of trade in 1942–43 was 90,000 tons. Great quantities of rice are sent into the interior of Iran, principally to Tehran and Kazvin. A paved road connects the coastal plain with Tehran via Firuzkuh.

The imports in order of value were sugar, flour. tea and metals and minerals.

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MAZARIN, JULES (1602–1661), French cardinal and statesman, elder son of a Sicilian, Pietro Mazarini, the intendant of the household of Philip Colonna, and of his wife, Ortensia Buffalini, a connection of the Colonnas, was born at Piscina in the Abruzzi on July 14, 1602. He was educated by the Jesuits at Rome till he was 17 years of age, when he accompanied Jerome Colonna as chamberlain to the University of Alcala in Spain. On his return to Rome about 1622, he took his degree as doctor *utriusque juris,* and then became captain of infantry in the regiment of Colonna, which took part in the war in the Valtelline. Pope Urban VIII entrusted him in 1629 with the difficult task of putting an end to the war of the Mantuan succession. He was presented to two canonries in the churches of St. John Lateran and Sta. Maria Maggiore, although he had only taken the minor orders and had never been consecrated priest; he negotiated the treaty of Turin between France and Savoy in 1632, became vice-legate at Avignon in 1634 and nuncio at the court of France from 1634 to 1636. Seeing that he had no chance of becoming a cardinal except by the aid of some great power, he accepted Richelieu's offer of entering the service of the king of France, and in 1639 became a naturalized Frenchman.

In 1640 Richelieu sent him to Savoy, where the regency of Christine, the duchess of Savoy, sister of Louis XIII, was disputed by her brothers-in-law, the princes Maurice and Thomas of Savoy, and he succeeded not only in establishing Christine but in winning over the princes to France. He was rewarded by promotion to the rank of cardinal on the presentation of the king of France in Dec. 1641. On Dec. 4, 1642, Richelieu died and was succeeded as minister by Mazarin. The new minister ingratiated himself with the queen, who would be regent after the king's death. Louis XIII died on May 14, 1643, and Mazarin retained office. His skilful policy was shown in every arena on which the great Thirty Years' War was being fought. Mazarin had inherited the policy of France during the Thirty Years' War from Richelieu. He had inherited his desire for the humiliation of the house of Austria in both its branches, his desire to push the French frontier to the Rhine and maintain a counterpoise of German states against Austria, his alliances with the Netherlands and with Sweden, and his four theatres of war—on the Rhine, in Flanders, in Italy and in Catalonia.

During the last five years of the great war it was Mazarin alone who directed the French diplomacy of the period. He made the peace of Bromsebro between the Danes and the Swedes, and turned the latter once again against the empire; he sent Lionne to make the peace of Castro and combine the princes of north Italy against the Spaniards, and he made the peace of Ulm between France and Bavaria, thus detaching the emperor's best ally. He made one fatal mistake—he dreamed of the French frontier being the Rhine and the Scheldt, and that a Spanish princess might bring the Spanish Netherlands as dowry to Louis XIV. This roused the jealousy of the United Provinces, and they made a separate peace with Spain in Jan. 1648; but Turenne's victory at Zusmarshausen and Condé's at Lens led to the Peace of Westphalia (1648).

At home Mazarin's policy lacked the strength of Richelieu's. The *Frondes* were largely due to his own fault. The arrest of Broussel threw the people on the side of the *parlement.* His avarice and unscrupulous plundering of the revenues of the realm, the enormous fortune which he thus amassed, his supple ways, his nepotism and the general lack of public interest in the great foreign policy of Richelieu made Mazarin the especial object of hatred both by bourgeois and nobles. He had tried consistently to play off the king's brother Gaston of Orleans against Condé, and their respective followers against each other, and had also, as his *carnets* prove, jealously kept any courtier from getting into

the good graces of the queen-regent except by his means, so that it was not unnatural that the nobility should hate him, while the queen found herself surrounded by his creatures alone. Events followed each other quickly; the day of the barricades was followed by the peace of Rueil. the peace of Rueil by the arrest of the princes. by the battle of Rethel, and Mazarin's exile to Bruhl before the union of the two Frondes.

In exile at Brühl Mazarin saw the mistake he had made in isolating himself and the queen, and that his policy of balancing every party in the state against each other had made every party distrust him. So by his counsel the queen, while nominally in league with De Retz and the parliamentary Fronde, laboured to form a purely royal party, wearied by civil dissensions, who should act for her and her son's interest alone, under the leadership of Mathieu Molé, the famous premier president of the parlement of Paris. The new party grew in strength, and in January 1652, after exactly a year's absence, Mazarin returned to the court. In order to promote a reconciliation with the parlement of Paris Mazarin had again retired from court, this time to Sedan, in August 1652, but he returned finally in February 1653. He had retrieved his position by founding that great royal party which steadily grew until Louis XIV. could fairly have said "L'État, c'est moi." As the war had progressed, Mazarin had steadily followed Richelieu's policy of weakening the nobles on their country estates. Whenever he had an opportunity he destroyed a feudal castle, and by destroying the towers which commanded nearly every town in France, he freed such towns as Bourges, for instance, from their long practical subjection to the neighbouring great lord.

The Fronde over, Mazarin had to build up afresh the power of France at home and abroad. Beyond destroying the brick-and-mortar remains of feudalism, he did nothing for the people. But abroad his policy was everywhere successful, and opened the way for the policy of Louis XIV. By means of an alliance with Cromwell, he recovered the north-western cities of France, though at the price of yielding Dunkirk to the Protector. On the Baltic, France guaranteed the Treaty of Oliva between her old allies Sweden, Poland and Brandenburg, which preserved her influence in that quarter. In Germany he, through Hugues de Lionne, formed the league of the Rhine, by which the states along the Rhine bound themselves under the headship of France to be on their guard against the house of Austria. By the Treaty of the Pyrénées Spain recovered Franche Comté, but ceded to France Roussillon, and much of French Flanders; and what was of greater ultimate importance to Europe, Louis XIV. was to marry a Spanish princess. He died at Vincennes on March 9, 1661, leaving a fortune estimated at from 18 to 40 million livres behind him, and his nieces married into the greatest families of France and Italy.

Mazarin was not a Frenchman, but a citizen of the world, and always paid most attention to foreign affairs; in his letters all that could teach a diplomatist is to be found, broad general views of policy, minute details carefully elaborated, keen insight into men's characters, cunning directions when to dissimulate or when to be frank. Italian though he was by birth, education and nature, France owed him a great debt for his skilful management during the early years of Louis XIV., and the king owed him yet more, for he had not only transmitted to him a nation at peace, but had educated for him his great servants Le Tellier, Lionne and Colbert. Literary men owed him also much; not only did he throw his famous library open to them, but he pensioned all their leaders, including Descartes, Vincent Voiture (1598–1648), Jean Louis Guez de Balzac (1597–1654) and Pierre Corneille.

(H. M. St.; X.)

BIBLIOGRAPHY.—*See* P. A. Chéruel, *Histoire de France pendant la minorité de Louis XIV.*, 4 vols. (1879–1880), which covers from 1643–1651, and its sequel *Histoire de France sous le ministhre d~ Cardinal Mazarin*, 2 vols. (1881–82), which is the first account of the period written by one able to sift the statements of De Retz and the memoir writers, and rest upon such documents as Mazarin's letters and *carnets*. Mazarin's *Lettres* appeared in the *Collection des documents inédits*, 9 vols. For his early life to Cousin's *Jeunesse de Mazarin* (1865), and for the careers of his nieces to Renée's *Les Nièces de Mazarin* (1856). For the Mazarinades or squibs written against him in Paris during the Fronde, *see* C. Moreau's *Bibliographie des mazarinades* (1850), containing an account of 4,082 Mazarinades. *See* also A. Hassall, *Mazarin* (1903); Roca, *De Richelieu à Mazarin* (1908); C. Federn, *Mazarin* (Munich, 1922).

MAZAR-I-SHARIF, a town of Afghanistan, the capital of the province of Afghan Turkestan. Owing to the importance of the military cantonment of Takhtapul, and its religious sanctity, it has long ago supplanted the more ancient capital of Balkh. It is situated in a malarious, almost desert plain, 9 m. E. of Balkh, and 30 m. S. of the Pata Kesar ferry on the Oxus river. In this neighbourhood is concentrated most of the Afghan army north of the Hindu Kush mountains, the fortified cantonment of Dehdadi having been completed by Sirdar Ghulam Ali Khan and incorporated with Mazar. Mazar-i-Sharif also contains a celebrated mosque, from which the town takes its name. Built by Sultan Ali Mirza about A.D. 1420, it is held in great veneration by all Mussulmans, and especially by Shiites, because it is supposed to be the tomb of Ali, the son-in-law of Mohammed.

MAZARRÓN, a town of eastern Spain, in the province of Murcia, 19 mi W. of Cartagena. Pop. (1940), 4,618 (mun., 11,569). There are soap and flour mills and metallurgic factories in the town, and iron, copper and lead mines in the neighbouring Sierra de Almenara. A railway 5 mi. long unites Mazarrón to its port on the Mediterranean, which has important leadworks.

MAZATLAN, a Pacific port and resort in the Mexican state of Sinaloa, at 23° 11′ N. lat.. just south of the Tropic of Cancer, diagonally opposite the tip of Lower California, for which it is a chief communications link. Pop. (est. 1952) 40,000. Good beaches, warm but healthful climate, excellent game fishing and a picturesque situation on a small peninsula overlooking Olas Altas bay make Mazatlán a popular resort. Installations were completed in 1951 to permit entrance of vessels up to 10,000 tons. There is a large airport.

The port is served by the Mexican Southern Pacific railway. Local industry and commercial fishing, especially shrimp production and processing, diversify its economy. Exports include minerals and fibres. (HD. C.)

MAZE: **see** LABYRINTH.

MAZEPA-KOLEDINSKY, IVAN STEPANOVICH (1644?–1709), hetman of the Cossacks, belonging to a noble Orthodox family, was born possibly at Mazeptsina, either in 1629 or 1644, the latter being the more probable date. He was educated at the court of the Polish king, John Casimir, and completed his studies abroad. An intrigue with a Polish married lady forced him to fly into the Ukraine. There is a trustworthy tradition that the infuriated husband tied the naked youth to the back of a wild horse and sent him forth into the steppe. He was rescued and cared for by the Dnieperian Cossacks, and speedily became one of their ablest leaders. In 1687, during a visit to Moscow, he won the favour of the then all-powerful Vasily Golitsuin, from whom he virtually purchased the hetmanship of the Cossacks (July 25). He took a very active part in the Azov campaigns of Peter the Great and won the entire confidence of the young tsar by his zeal and energy. He was also very serviceable to Peter at the beginning of the Great Northern War. especially in 1705 and 1706, when he took part in the Volhynian campaign and helped to construct the fortress of Pechersk. The power and influence of Mazepa were fully recognized by Peter the Great. No other Cossack hetman had ever been treated with such deference at Moscow. He ranked with the highest dignitaries in the state; he sat at the tsar's own table.

Mazepa had no temptations to be anything but loyal, and loyal he would doubtless have remained had not Charles XII. crossed the Russian frontier. Then it was that Mazepa. who had had doubts of the issue of the struggle all along, made up his mind that Charles, not Peter, was going to win. But he proceeded cautiously. Indeed, he would have preferred to remain neutral, but he was not strong enough to stand alone. The crisis came when Peter ordered him to co-operate actively with the Russian forces in the Ukraine. At this very time he was in communication with Charles's first minister, Count Piper, and had agreed to harbour the Swedes in the Ukraine and close it against

the Russians (Oct. 1708). The last doubt disappeared when Menshikov was sent to supervise Mazepa. At the approach of his rival the old hetman hastened to the Swedish outposts at Horki, in Severia. Mazepa's treason took Peter completely by surprise. He instantly commanded Menshikov to get a new hetman elected and raze Baturin, Mazepa's chief stronghold in the Ukraine, to the ground. The metropolitan of Kiev solemnly excommunicated Mazepa from the high altar, and his effigy was publicly burned by the common hangman.

Henceforth Mazepa, perforce, attached himself to Charles. What part he took at the battle of Poltava is not quite clear. After the catastrophe he accompanied Charles to Turkey with about 1,500 horsemen (the miserable remnant of his 80,000 warriors).

The sultan refused to surrender him to the tsar, though Peter offered 300,000 ducats for his head. He died at Bender on Aug. 22, 1709.

See N. I. Kostomarov, *Mazepa and the Mazepanites* (Russ.) (1885); R. Nisbet Bain, *The First Romanovs* (1905); S. *M.* Solovev, *History of Russia* (Russ.), vol. xv (1895).

MAZURKA, a lively dance, originating in Poland, somewhat resembling the polka. It is danced in couples, the music being in $\frac{3}{8}$ or $\frac{3}{4}$ time.

MAZZINI, GIUSEPPE (1805–1872), Italian patriot, was born on June 22, 1805, at Genoa. During infancy and childhood his health was extremely delicate; but he soon began to devour books of all kinds and to show other signs of great intellectual precocity. He became a student at the University of Genoa at an unusually early age, and decided to graduate in law (1826). His exceptional abilities, together with his remarkable generosity, kindness and loftiness of character, endeared him to his fellow students.

His natural bent was toward literature, and he wrote a considerable number of essays and reviews. But he held the idea that Italians, and he himself in particular, "*could* and therefore *ought* to struggle for liberty of country." Therefore, he put aside literary ambitions, and devoted himself to politics. His articles accordingly became more and more suggestive of advanced liberalism in politics. Having joined the Carbonari, shortly after the French revolution of 1830, he was betrayed and imprisoned in the fortress of Savona for about six months. A conviction was found impracticable through deficiency of evidence, so he was released but forced to go into exile. He withdrew into France, living chiefly in Marseilles.

While in his lonely cell at Savona, he had finally become aware of the great mission or "apostolate" (as he himself called it) of his life. After his release his prison meditations took shape in the program of the organization which was destined soon to become so famous throughout Europe, that of *La Giovine Italia* or Young Italy. Its aims were the liberation of Italy both from foreign and domestic tyranny, and its unification under a republican form of government; the means to be used were education, and, where advisable, revolt by guerrilla bands. After Charles Albert succeeded Charles Felix on the Sardinian throne, in 1831 toward the close of that year Mazzini wrote the new king a letter (published at Marseilles) urging him to take the lead in the struggle for Italian independence. Representations were made by the Sardinian to the French government, which issued an order for Mazzini's withdrawal from Marseilles (Aug. 14, 1832); he ultimately found it necessary to retire into Switzerland.

In 1833 he took part in an abortive revolutionary movement in the Sardinian army; several executions took place, and he himself was laid under sentence of death. Before the close of 1833 a similar movement in Genoa had been planned, but failed through the youth and inexperience of the leaders. At Geneva, also in 1833, Mazzini began *L'Europe Centrale*, a journal of which one of the main objects was the emancipation of Savoy. The frontier was actually crossed on Feb. 1, 1834, but the attack ignominiously broke down without a shot having been fired.

In April 1834, the Young Europe association "of men believing in a future of liberty, equality add fraternity for all mankind," was formed under the influence of Mazzini, followed soon after by a Young Switzerland society. Mazzini was permitted to stay at Grenchen in Solothurn for a while, but the Swiss diet exiled him at the end of 1836. In Jan. 1837 he arrived in London, where for many months he was very poor. As he learned English he began to earn a living by writing articles, some of which are of a high literary merit. In 1839 he entered into relations with the revolutionary committees in Malta and Paris, and in 1840 he originated a working men's association, and the weekly journal *Apostolato popolare*, in which the admirable popular treatise "On the Duties of Man" was begun.

Sir James Graham, the home secretary, systematically for some months, opened Mazzini's letters as they passed through the British post office, and communicated their contents to the Neapolitan government—a proceeding believed at the time to have led to the arrest and execution of the brothers Bandiera, Austrian subjects, who had been planning an expedition against Naples. The publication of Graham's life seems to exonerate him from the charge.

Toward the end of 1847 Mazzini published a letter addressed to the new pope, Piux IX, indicating the nature of the religious and national mission which the Liberals expected him to undertake. The leaders of the revolutionary outbreaks in Milan and Messina in the beginning of 1848 had long been in secret correspondence with Mazzini; and their action, along with the revolution in Paris, brought him early in the same year to Italy, where he took a great and active interest in the events which dragged Charles Albert into a war with Austria; he actually for a short time bore arms under Garibaldi immediately before the reoccupation of Milan. In the beginning of 1849 he was nominated a member of the short-lived provisional government of Tuscany formed after the flight of the grand duke, and almost simultaneously, when Rome had, in consequence of the withdrawal of Pius IX, been proclaimed a republic, he was declared a member of the constituent assembly there. A month later, the battle of Novara having again decided against Charles Albert in the brief struggle with Austria, into which he had once more been drawn, Mazzini was appointed a member of the Roman triumvirate, with supreme executive power (March 23, 1849). Rome was then invested by the French, and Mazzini succeeded, for a long time, in adverse circumstances in maintaining a high degree of order within the turbulent city. The city surrendered on June 30, 1849; Mazzini refused at first to leave Rome where he remained hidden, but at last he was persuaded by friends to leave. He succeeded in escaping to Civitavecchia where he boarded, disguised as a steward, a steamer which took him to Marseilles, whence he went to London. He had a firm belief in the value of revolutionary attempts, however hopeless they might seem; he had a hand in the abortive rising at Mantua in 1852; and again a considerable share in the ill-planned insurrection at Milan on Feb. 6, 1853, the failure of which greatly weakened his influence.

In 1857 he was again in Italy, where, for complicity in outbreaks at Genoa, Leghorn and Naples, he was again laid under sentence of death. Undiscouraged, he returned to London, where he edited his new journal *Pensiero e Azione*, the constant burden of his message to the overcautious, practical politicians of Italy being: "I am but a voice crying *Action;* but the state of Italy cries for it also. So do the best men and people of her cities. Do you wish to destroy my influence? *Act.*" The same tone was later assumed in the letter he wrote to Victor Emmanuel, urging him to put himself at the head of the movement for Italian unity, and promising republican support. As regards the events of 1859–60, however, it may be questioned whether, through his characteristic inability to distinguish between the ideally perfect and the practically possible, he did not actually hinder more than he helped the course of events. After the irresistible pressure of the popular movement had led to the establishment not of an Italian republic but of an Italian kingdom, Mazzini could honestly enough write, "I too have striven to realize unity under a monarchical flag," but candour compelled him to add, "The Italian people are led astray by a delusion; . . . but monarchy will never number me amongst its servants or followers."

In 1865, as protest against the uncancelled sentence of death under which he lay, Mazzini was elected by Messina to the Italian parliament, but, feeling unable to take the oath of allegiance to

the monarchy, he never took his seat. In the following year, when a general amnesty was granted after the cession of Venice to Italy, the sentence of death was at last removed. In May 1869 he was again expelled from Switzerland at the instance of the Italian government for having conspired with Garibaldi. After a few months spent in England he set out (1870) for Sicily, but was promptly arrested at sea and carried to Gaeta, where he was imprisoned for two months. The occasion of the birth of a prince was seized for restoring him to liberty. In the last years of his life he attempted to organize the working classes of Italy on a democratic semimystical basis, and he entered into relations with the leading internationalists such as Marx and Bakunin. But he could not work with them and soon lost all touch with working-class circles and was deeply disappointed at the growing influence of the Socialists. Mazzini died at Pisa on March 10, 1872.

BIBLIOGRAPHY.—The published writings of Mazzini, mostly occasional, are voluminous. An edition was begun by himself and continued by A. Saffi, *Scritti editi e inediti di Giuseppe Mazzini* (1861–91); many of the most important are found in the partially autobiographical *Life and Writings of Joseph Mazzini* (1864–70) and the two most systematic—Thoughts *upon Democracy in Europe*, a remarkable series of criticisms on Benthamism, St. Simonianism, Fourierism, and other economic and socialistic schools of the day, and the treatise *On the Duties of Man*, an admirable primer of ethics, dedicated to the Italian working class—will be found in *Joseph Mazzini: a Memoir*, by Mrs. *E*. A. Venturi (1875). Many of the 40,000 letters of Mazzini were published in the monumental collection of his *Opere* ordered by the Italian government before fascism.

For Mazzini's biography *see* Jessie White Mario, *Della vita di Giuseppe Mazzini* (1886), an enthusiastic but useful and honest work; Bolton King, *Mazzini* (1903); *G*. Salvemini, *Mazzini* (1921); C. Sforza, *Mazzini* (1926); I. Bonomi, *Mazzini triunviro romano* (1936). Dora Melegari in *La giovine Italia e Giuseppe Mazzini* (1906) publishes the correspondence between Mazzini and Luigi **A.** Melegari during the early days of "Young Italy." Nello Rosselli, *Mazzini e Bakounin* (1927) is important for the last phase of his life. For the literary side of Mazzini's life *see* Peretti, *Gli scritti letterarii di Giuseppe Mazzini* (1904). (J. S. B.; L. V.; X.)

MAZZUCHELLI, SAMUEL CHARLES (1806–1864), Italian-American Dominican priest and missionary was born at Milan on Nov. 4, 1806. He entered the Dominican order in 1823, and five years later embarked for the American missions, where he completed his theological studies and was ordained on Sept. 5, 1830. Mazzuchelli's first assignment was in the north and northwest regions of the Cincinnati diocese, with headquarters on Mackinac Island. When the diocese was divided in 1833, he was attached to Detroit; he continued his missionary activity in the north and also journeyed into Illinois and Iowa. Mazzuchelli became a prominent figure around Galena and Dubuque; the first bishop of Dubuque, Matthias Loras, appointed him vicar-general in 1837. He was also first chaplain to the first legislature of the territory of Wisconsin (1836), and in 1840 the legislature of the territory of Iowa convened in his as yet unconsecrated church at Burlington.

After a visit to Milan in 1843, Mazzuchelli returned to Galena with authorization to inaugurate a new Dominican province and to establish an order of Dominican sisters. Both projects were undertaken at Sinsinawa, Wis., but in Nov. 1849 he assigned the property and college to the Dominicans of Kentucky and moved to Benton, Wis. where he made a permanent home for the religious community of women. From 1853 until his death he devoted much of his time to the development of his parish, the schools and the direction of the Dominican sisters. He died at Benton on Feb. 23, 1864.

Mazzuchelli's *Memoirs Historical and Edifying of a Missionary Apostolic*, originally published in 1844, were translated and published in 1915.

See Soeur Rosemary Crepeau, **O.P.** *Un Apôtre dominicain aux États-Unis, le père Samuel Charles Gaetan Mazzuchelli* (1932); *Golden Bells in Convent Towers: The Story of Father Samuel and Saint Clara: 1854–1904* (1904). (F. G. McM.)

Mc, M^{c}, are alphabetized as MAC in this work.

MDINA (CITTA NOTABILE or CITTA VECCHIA), a fortified city of Malta occupying a dominating rocky site 7 mi. W. of Valletta. Pop. (1957) 823. The city may have Neolithic origins; there are considerable Punic and Roman remains and the present name is Semitic (*medina* "fortification"). Named Notabile in 1427 by the Castilian rulers, it was the Maltese capital until 1570 when Valletta (*q.v.*) was nearly completed; it was then referred to by the rulers as Città Vecchia ("old city"). Mdina retains intact its remarkable fortifications with a complete wall, and contains many 15th-, 16th- and 17th-century Maltese palaces. Its chief building is the cathedral church of Malta (restored after an earthquake in 1693) said to occupy the site of the house of the governor Publius who received the apostle Paul. Beneath Mdina and its almost contiguous modern neighbour Rabat occur catacombs, partly pre-Christian, showing early Christian burials. Some damage occurred by air attack in 1941–44 but the city retains its Renaissance atmosphere. (W. B. FR.)

MEAD, RICHARD (1673–1754), English physician and collector of books, manuscripts and art objects, was born on Aug. 11, 1673, at Stepney, London. He studied at Utrecht and Leiden and in 1695 graduated in philosophy and physics at Padua, returning to London in 1696. His *Mechanical Account of Poisons* appeared in 1702 and in 1703 he was admitted to the Royal society, to whose *Transactions* he contributed in that year a paper on the parasitic nature of scabies. In the same year he was elected physician to St. Thomas' hospital. On the death of John Radcliffe in 1714 Mead became the recognized head of his profession; he attended Queen Anne on her deathbed and was physician to George II. Mead's library, the largest formed in his time, totaled 10,000 volumes.

Mead died in London on Feb. 16, 1754.

MEAD (akin to *Madhu* in Sanskrit, meaning honey) is an alcoholic drink made by the fermentation of honey mixed with water; sometimes yeast is added to accelerate the fermentation. "Metheglin" (from the Welsh *meddyglyn)* should strictly only refer to spiced mead made with the addition of such spices and herbs as cloves, ginger, rosemary, hyssop and thyme; the terms are, however, sometimes interchanged. Mead can be light or rich, sweet or dry, or even sparkling; in the middle ages it was usually similar to a sparkling table wine.

Alcoholic drinks made from honey were common among the ancients and in the middle ages, particularly in northern countries where grape vines do not flourish; the *hydromel* of the Greeks and Romans was probably like the mead drunk by the Celts and Anglo-Saxons, although the Roman *mulsum* was not mead, but wine sweetened with honey. In Celtic and Anglo-Saxon literature, such as the writings of Taliesin, and in the *Mabinogion* and *Beowulf,* mead is the drink of kings and thanes. Chaucer's miller drank mead, but by the 14th century, spiced ale and pyment (a sweetened wine similar to *mulsum)* were superseding it. The rules which King Howel the Great laid down for making mead in the 10th century are proof that the Welsh took great interest in it; they favoured spiced mead and it was from the early 16th century (when the Tudors brought elements of Welsh culture into England) that the word "metheglin" was often used for plain and spiced mead alike. But mead, once the commonest alcoholic drink of England, had lost ground to ales and beers (since the earliest days of improved medieval agriculture) and also to wines (imported from Gascony for the rich, from the 12th century onward). Finally, when West Indian sugar began to be imported in quantity (from the 17th century), there was less incentive to keep bees, and the essential honey became scarcer. (C. C. H. F.)

MEADE, GEORGE GORDON (1815–1872), U.S. soldier, was born of American parentage at Cadiz, Spain, on Dec. 31, 1815. He graduated from West Point in 1835, and served in Florida against the Seminoles. Resigning from the army in 1836 he became a civil engineer and constructor of railways, and was engaged under the war department in survey work until 1842 when he re-entered the army as second lieutenant in the corps of the topographical engineers. In the war with Mexico he was on the staffs successively of Generals Taylor, J. Worth and Robert Patterson, and was breveted for gallant conduct at Monterrey. Until the Civil War he was engaged in various engineering works, mainly in connection with lighthouses, and later as a captain of topographical engineers in the survey of the northern lakes.

In 1861 he was appointed brigadier general of volunteers, and had command of the 2nd brigade of the Pennsylvania reserves

in the army of the Potomac, under Gen. G. A. McCall. Receiving a severe wound at the action of Frazier's Farm, he was absent from his command until the second battle of Bull Run, after which he obtained the command of his division. He distinguished himself at the battles of South Mountain and Antietam, also at Fredericksburg he and his division won great distinction by their attack on the position held by Jackson's corps, and Meade was promoted to the rank of major general of volunteers. Soon afterward he was placed in command of the 5th corps. At Chancellorsville he displayed great intrepidity and energy, and on the eve of the battle of Gettysburg was appointed to succeed Hooker. In the famous three days' battle he inflicted a complete defeat on General Lee's army. His reward was the commission of brigadier general in the regular army. Grant, commanding all the armies of the United States, joined the army of the Potomac in the spring of 1864, and remained with it until the end of the war; but he continued Meade in his command, and successfully urged his appointment as major general in the regular army (Aug. 18, 1864). After the war Meade commanded successively the military division of the Atlantic, the department of the east, the third military district (Georgia and Alabama) and the department of the south. He died at Philadelphia on Nov. 6, 1872.

MEADOW BEAUTY (*Rhexia virginica*), a North American plant of the melastoma family (Melastomaceae), called also deer grass and handsome Harry, native to sandy marshes from Maine to Ontario and Iowa and southward to Florida and Texas It is a rather stout, squarish-stemmed perennial about 1 ft. high, with smooth, oval, light green, three-ribbed, somewhat pointed leaves and handsome purplish magenta flowers, 1 to 1½ in. wide, blooming about midsummer. The floral parts consist of an urn-shaped calyx with a four-lobed limb; four broad, rounded petals; eight stamens with golden anthers; and a single pistil uith a four-celled ovary, which develops into a four-valved many-seeded pod (capsule). The pistil protrudes beyond the anthers, thereby ensuring cross-fertilization, which is effected by honeybees and other insects. In the southern states there are several allied species, among which are the Maryland (R. *mariana*) and the ciliate meadow beauty (R. ciliosa).

MEADOW BEAUTY (RHEXIA VIRGINICA)

MEADOW LARK (*Sturnella magna*), a well-known North American bird which, like the skylark (*Alauda arvensis*) of Europe, frequents meadows and sometimes sings on the wing. It is about 11 in. long, with brown back and yellow breast with black crescent. The meadow lark is not related to the true larks, which are represented in America by the horned lark (Otocoris alpestris), but is an aberrant member of the American family Icteridae, which includes the blackbirds and orioles of that continent. The meadow lark has a musical whistle of three notes. It inhabits eastern North America, but is replaced in the west by the allied western meadow lark (*S. neglecta*), which has a richer song and is paler, with yellow instead of buffy-white cheek.

MEADOW RUE, the common name given to the numerous species of the genus *Thalictrum* of the buttercup family. A few species, comprising mostly tall perennial herbs with delicate dissected foliage and small flowers in usually large open terminal panicles, are grown as ornamentals, especially in the wild garden. They are of easy culture in well-drained loamy soil and are easily propagated by division of roots in early spring, and also by seeds. (J. M. Bl.)

MEADVILLE, a city and the seat of Crawford county, Pa., U.S., is on French creek, 40 mi. S. of Erie. The oldest settlement in northwestern Pennsylvania, it was foundedby David Mead and other settlers from New England in 1788. The group founded Allegheny college (Methodist-Episcopal) in 1815, the oldest college west of the Allegheny mountains and north of the Ohio river. Incorporated as a borough in 1823 and as a city in 1866, Meadville became the commercial centre of a fertile dairy region. Oil and natural gas are found directly to the east. Near the turn of the century the manufacture of slide fasteners was started in the city which became the "home of the zipper"; it remains the major industry. Other manufactures include machine and hand tools, rayon and castings. For comparative population figures see table in PENNSYLVANIA: Population. (W. A. C.)

MEAGHER, THOMAS FRANCIS (1823–1867), Irish revolutionary leader, orator and U.S. soldier, was born in Waterford, Ire., on Aug. 3, 1823. He became a member of the Young Ireland party in 1845, and in 1847 was one of the founders of the Irish confederation. In July 1848 the confederation created a "war directory" of five, of which Meagher was a member, and he and William Smith O'Brien traveled through Ireland arousing the countryside for a revolution against English rule. The attempt of 1848 proved abortive; Meagher was arrested in August, and in October was tried for high treason, found guilty and condemned to death. His sentence mas commuted to life imprisonment in Van Diemen's Land. Early in 1852 he escaped, and in May reached New York city. He made a tour of U.S. cities as a popular lecturer, and then studied law and was admitted to the New York bar in 1855. He found himself a leader of the Irish element in New York city and edited several influential Irish journals. At the outbreak of the Civil War he was made captain of a company (which he had raised) in the 69th regiment of New York volunteers and fought at the first battle of Bull Run; he then organized an Irish brigade, of whose first regiment he was colonel until Feb. 3, 1862, when he was appointed to the command of this organization with the rank of brigadier general. After Chancellorsville, where his brigade was reduced to less than a regiment, Meagher resigned his commission On Dec. 23, 1863, his resignation was canceled, and he was assigned to the command of the military district of Etowah, with headquarters at Chattanooga. At the close of the war he was appointed by Pres. Andrew Johnson secretary of Montana territory, and there, in the absence of the territorial governor, he acted as governor from Sept. 1866 until his accidental death in the Missouri river near Fort Benton, Mont., on July 1, 1867. Meagher's championship of President Johnson's principles of reconstruction and his religion made him unacceptable to the powerful vigilante organization which then ruled Montana, and in his efforts to dislodge the vigilantes from control he was unsuccessful.

MEALYWING, the name applied, from the white, powdery secretion nith which they are covered. to about 50 species of small insects comprising the family Coniopterygidae. In these forms, which are the smallest and most aberrant members of the order Neuroptera (*q.v.*), the hind wings are much reduced in size. They are beneficial to man, since their larvae feed on aphides, etc. The family occurs in parts of the old and new worlds, including the United States and Great Britain.

MEAN. The adjective "mean" is chiefly used in the sense of "average," as in mean temperature, mean birth or death rate. etc. In astronomy (*q.v.*) the "mean sun" is a fictitious sun which moves at a uniform rate in the celestial equator and has its right ascension always equal to the sun's mean longitude. The time recorded by the mean sun is mean solar or clock time; it is regular as distinct from the nonuniform solar or sundial time The "mean moon" is a fictitious moon which moves around the earth with a uniform velocity and in the same time as the real moon, The "mean longitude" of a planet is the longitude of the "mean" planet: *i.e.*, a fictitious plsnet performing uniform revolutions in the same time as the real planet (X.)

Mean in Mathematics.—The term "mean," as commonly used, is given to some function of tno or more quantities which (1) becomes equal to each of the quantities nhen they themselves are made equal. and (2) is unaffected in value nhen the quantities are reordered in any way; *i.e.*, the function is symmetric in its arguments. The four commonest means are the arithmetic, geometric harmonic and quadratic; of less importance are the contraharmonic and arithmetico-geometric.

For n quantities. the arithmetic mean is the sum of the quantities divided by their number n; their geometric mean is the nth root of the product of the n quantities; their harmonic mean

is the reciprocal of the arithmetic mean of the reciprocals of the quantities; their quadratic mean is the square root of the arithmetic mean of the squares of the quantities. A more general mean of n quantities $x_1, x_2, \cdots, x_n$ is the function

$$\varphi^{-1}([\varphi(x_1)+\varphi(x_2)+\cdots+\varphi(x_n)]/n), \qquad (1)$$

where $\varphi(x)$ is any function having an inverse $\varphi^{-1}(x)$. The arithmetic, geometric, harmonic and quadratic means are obtained from this general mean when $\varphi(x)=x$, $\varphi(x)=ln(x)$, $\varphi(x)=\frac{1}{x}$, $\varphi(x)=x^2$ respectively. The inverses of these functions are $\varphi^{-1}(x)=x$, $\varphi^{-1}(x)=e^x$, $\varphi^{-1}(x)=\frac{1}{x}$, $\varphi^{-1}(x)=\sqrt{x}$, respectively.

If, instead of forming a sequence, the quantities to be averaged are the values of a function $x(t)$ as t varies over an interval $a \leqq t \leqq b$, the finite sum in (1) becomes an integral, and the general mean can be written in the form

$$\varphi^{-1}\left(\int_a^b \varphi(x(t))dt/(b-a)\right). \qquad (2)$$

When the interval of variation for t is $a \leqq t < +\infty$, the mean is the limit as b becomes infinite of the expression in (2). There are similar modifications in (2) when the interval is $-\infty < t \leqq b$ or $-\infty < t < +\infty$.

In statistics the distribution within a "population" of an attribute of measure x is usually determined by means of a frequency distribution $f(x)$; *i.e.*, a function $f(x)$ such that $\int_a^b f(x)dx=n$, the number of individuals in the population having an attribute-measure that lies between a and b. The general mean value of x for these n individuals is given by

$$\varphi^{-1}\left(\int_a^b \varphi(x)f(x)dx/n\right). \qquad (3)$$

If the interval $a \leqq x \leqq b$ is taken so large that n is the number of individuals in the total population, the mean value of x for the whole population is obtained from (3).

The significance of the word "mean" (*i.e.*, middle) is seen by considering three quantities, x, y, z. If the arithmetic mean is y, the quantities are in arithmetic progression; *i.e.*, $y-x=z-y$ or $y=\frac{1}{2}(x+z)$. For y to be the geometric mean the quantities must be in geometric progression; *i.e.*, $x/y=y/z$ or $y^2=xz$. When y is the harmonic mean the quantities are in harmonic progression; *i.e.*, $x/z=(x-y)/(y-z)$ or $y=2xz/(x+z)$. The contraharmonic mean is y when $x/z=(y-z)/(x-y)$ or $y=(x^2+z^2)/(x+z)$.

The arithmetico-geometric mean of two quantities was introduced by Karl F. Gauss to facilitate the computation of elliptic integrals. It is computed by forming the arithmetic and geometric means of the two quantities, then forming the arithmetic and geometric means of these means, etc., indefinitely. The common limit to which the sequence of geometric means and the sequence of arithmetic means so obtained converge is the arithmetico-geometric mean of the two given quantities. (R. W. Bd.)

MEANING. The term "meaning" is used in many different senses. These may be divided into three principal types: (1) meaning as index or symptom of some occurrence; (2) meaning as intent or purpose of a deliberate action; (3) meaning as whatever is referred to, signified, or expressed by words or other symbols.

1. We use the term in the first of these three senses when we say that increased government spending means higher taxes; a falling barometer means rain; blushing means embarrassment; a certain kind of footprint in a slab of stone means that a dinosaur once walked there. In cases of this sort, the statement that one kind of fact or event, A, means another, B, is tantamount to the assertion that B is often or always associated with A, so that an occurrence of A affords more or less strong grounds for the presumption that B has occurred or will occur. Here, then, A means B in the sense that A is a symptom or an index for B.

2. The meaning of a deliberate act performed by an individual or a group—such as a specific move made by a chess player, or a decision arrived at by a planning board—is often construed as the purpose that the act is intended to serve; and individual or collective behaviour is then said to be meaningful insofar as it is governed by specifiable purposes. This second conception of meaning is sometimes extended, in a more or less metaphorical manner, to occurrences that do not in any clear sense constitute deliberate acts; this is the case, for example, when we speak of the meaning of history or the meaning of life.

3. The concept of meaning has its most important applications, however, in reference to the use and function of symbols; these may be words or more complex expressions—including sentences—of a spoken or written language, or such devices as flag or smoke signals, traffic lights, road markings, the sound signals produced by an air raid warning siren, etc. Speaking very generally, the meaning of a symbol is whatever the symbol is intended or understood to refer to or signify or express. The meaning of the "all clear" siren signal, for example, is at least twofold: it conveys the information that the immediate danger is over, and it transmits an order to return to normal activities. Similarly, a sentence or a passage consisting of several sentences may be the carrier of various meanings. Thus, (a) it may have *cognitive meaning, i.e.,* convey (true or false) information, as do, for example, the statements of mathematics and empirical science; (b) it may have *directive meaning, i.e.,* convey an order, request, or injunction, as do, for example, the Ten Commandments; (c) it may have *emotive meaning, i.e.,* express or evoke (rather than describe) a mood or attitude, as do some kinds of poetry; and (d) it may combine these and other kinds of meaning, as does, for example, a political speech or a newspaper editorial. The meaning of an expression will usually depend on, and vary with, the circumstances under which it is used and the psychological make-up of the individuals who produce it or take account of it (*e.g.,* the writer and his readers). That branch of semiotics, *i.e.,* the general theory of signs, which is concerned with the study of meaning in this broad sense is called pragmatics.

For the purposes of logic and of certain parts of linguistics—including the construction of dictionaries—it is useful to introduce a so-called semantical conception of meaning, which makes no explicit reference to the users of the symbols under study and construes the meaning of an expression simply as some object, attribute, or other entity represented by that expression. (On this and some of the following points, *see* Semantics as a Branch of Logic.) Two kinds of semantical meaning are usually distinguished: reference or denotation, and sense or connotation. The expressions "the morning star" and "the evening star," for example, have the same reference: both refer to, or denote, the planet Venus. But they have different senses; *i.e.,* they refer to that planet by means of different characterizations. Similarly, the expressions "featherless biped" and "mammal endowed with speech" have the same reference, namely, all human beings; the class of the latter is said to constitute their extension. The two phrases have different senses, however; these are given by their intensions; *i.e.,* the attributes—namely, that of being a featherless biped and that of being a mammal endowed with speech, respectively—whereby each phrase characterizes the entities to which it refers. Some expressions, such as "the largest glacier on Sicily," have a sense but no reference; they refer, or apply, to nothing. Expressions that have the same sense, such as "grandfather" and "parent's father," are said to be synonymous; such expressions always have the same reference. A customary way of stating the meaning of a word or phrase is to give a definition that provides a synonym for it and thus exhibits its sense; and dictionaries often indicate the meaning, or meanings, of an expression by listing approximate synonyms for the principal linguistic contexts in which it occurs. Expressions which, like the word "meaning," have several distinct senses are called ambiguous.

A symbol which, like a hyphen or the words "it" and "very," has no sense in isolation, but may occur as a constituent of certain other expressions that do have sense, is said to be syncategorematic. Just what kinds of words or phrases may be said to have a sense in isolation is a matter of dispute in logic; and, indeed, some logicians hold that the very notion of sense—in contradistinction to that of reference—is so unclear and problematic as to make its value for precise logical and linguistic studies highly questionable.

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MEASLES AND GERMAN MEASLES. Measles (morbilli, rubeola) is an epidemic disease of world-wide distribution, occurring in any community in outbreaks at intervals of two to four years. In each outbreak almost all persons who have never previously had the disease acquire it.

An epidemic in a large city will therefore involve many thousands of cases. Usually the epidemic occurs in late winter or early spring, although the disease may appear at any season. Commonly measles occurs in children, but may appear even in elderly persons who have for some reason escaped it in early life. Infants are immune up to four or five months of age if the mother has had the disease. Immunity to measles following an attack is usually life-long. A mild form of the disease brought about by injection of serum may not give lasting im-

munity.

The causative agent of measles is considered to be a virus. Several research workers reported cultivation of the virus and reproduction of the disease in human beings by injection of a modified or attenuated virus. This method of inducing a mild form of the disease has not come into popular use. Measles is such a highly communicable disease that the slightest contact with an active case may infect a susceptible person. Apparently the disease is spread through the secretions of the eyes and respiratory passages of the ill patient. Infectivity is greatest just before the eruption appears and subsides with fading of the rash. Uncomplicated measles is seldom fatal, and deaths attributed to measles have usually resulted from secondary bronchopneumonia caused by bacterial organisms getting into the inflamed bronchial tree. Complications caused by secondary bacterial infection will not spread measles. A form of encephalitis beginning during the acute phase of rash and probably caused by measles virus itself may be fatal or may result in permanent damage to the brain of the patient. Fortunately, this complication is rare.

Symptoms. — Afterexposure of susceptible persons to an active case, no symptoms appear for 10 or 11 days. At the end of this incubation period the patient develops fever, redness and watering of the eyes, profuse nasal discharge and congestion of the mucous membranes of the nose and throat — symptoms which are often mistaken for those of a severe cold. This period of invasion lasts from **48** to 96 hours. The fever increases with appearance of the rash, and the temperature may rise as high as 104° to 106° **F.** when the rash reaches its maximum. In the period of invasion and **24** to 36 hours before the rash develops, the disease can be diagnosed from the appearance in the mucous membranes of the mouth of typical spots, so-called Koplik spots, found most often opposite the first molar teeth or deep inside the lower lip as bluish-white specks of pin-point size, surrounded by bright red areas perhaps one thirty-second inch in diameter. Koplik spots permit the early diagnosis of measles and hence isolation of the patient at a stage when the disease is highly communicable and yet may be unsuspected. Experienced observers can also recognize the disease before the appearance of the rash by a zone of congestion occurring in the lower eyelids. In addition, there is a considerable reddening and swelling of the eyelids, a great deal of tearing and often a sensitivity to light.

The rash almost always begins **14** days after exposure, **3** or 4 days after the onset of fever and 2 or 3 days after the appearance of Koplik spots. The eruption, which lasts four to seven days, is first noticed in the hair line, behind the ears, on the neck and over the forehead. It spreads downward, gradually covering the entire body. The individual lesions appear first as tiny red elevations which rapidly enlarge, increase in number and run together to produce a blotchy appearance. The patient complains of itching and burning of the skin. The face is puffy and is covered early with rash. The eyes are swollen and red, and exposure to light is painful. There is a profuse discharge from the nose and a frequent harsh cough. The patient looks and feels miserable. After a day or two the rash becomes a deeper red and gradually fades; the temperature drops rapidly and the catarrhal symptoms disappear. If one presumed that the eruption which is observed on the body occurred in the eyes, in the throat, in the bronchial tree and in the intestinal tract, he would have a better understanding of the symptoms of the disease.

In haemorrhapic or black measles the patient develops an extremely high fever and signs of shock, and the rash may be haemorrhagic from the seepage of blood into the areas of eruption.

It is possible to produce an attenuated or mild form of measles through the injection of an exposed person with serum early in the incubation period. The incubation period may be prolonged but symptoms are milder, including a lower temperature and less intensity of rash and severity of catarrh.

Complications. — Measles lowers the resistance of the patient to secondary infections. Complications are commonly those of bacterial origin, including infections of the ears, sinuses and lungs. Laryngitis and bronchitis are characteristic features of the disease and should not be looked upon as complications. A common and dangerous complication is bronchopneumonia, which develops as the rash starts to fade, The patient does not improve; instead his fever continues and respiration becomes more rapid. The physical signs are those of a scattered or diffuse pneumonia. Without treatment the pneumonia may be fatal or may run a prolonged course up to several weeks.

Measles may also cause a flare-up of pre-existing tuberculosis, which may have subsided or was apparently cured before the attack of measles. A rare but serious complication which may follow even mild cases is encephalitis. The rash may fade, but the patient in whom encephalitis develops continues to have fever and may have signs of involvement of the nervous system, such as stupor, muscular rigidity or convulsions.

Measles must be differentiated from other disorders accompanied by an eruption. Roseola infantum is a disease seen in babies in which a measleslike rash appears after the child has had a high temperature for two or three days, but there is no fever at the time of the rash. Measles must also be differentiated from German measles (**see** below) and from the eruptions following use oi various drugs. Drugs producing rashes similar to measles are phenobarbital, dilantin, sulfonamides, yhenolphthalein and penicillin. German measles can be differentiated from real measles by the course of the disease and mildness of the symptoms. Sometimes scarlet fever, serum disease and other rashes may, on certain sections of the body, look like measles. But a careful examination of the patient serves to differentiate the disorders.

The mortality rate of measles declined steadily as improvements occurred in the health of children and infants and the effective treatment of complications became possible through the use of antibiotic and sulfonamide drugs. Isolation has not been effective in stopping the spread of the disease, since infectivity is greatest before diagnosis is made. Nevertheless isolation is required by public health laws from the time of diagnosis until the eruption has faded. Although 95% or more of the population sooner or later acquires measles, unnecessary exposure should be avoided, especially of persons in a run-down condition, those who have tuberculosis or those who have recently suffered from an acute illness, especially an involvement of the respiratory tract.

Measles may be prevented after exposure if early in the incubation period blood serum from persons who have previously had the disease is injected intramuscularly into the persons to be protected. A concentrated form of such serum, immune globulin, given early in the incubation period, will completely protect the person for a few weeks. Given later in the incubation period, the same dosage will modify the severity of the disease. There is no drug that is effective against measles. An antibiotic that is effective against a wide spectrum of bacteria or a sulfonamide drug given during the eruptive stage may prevent complications or curb those already in progress, and hence rob the disease of much of its danger.

The only treatment required is rest in bed, protection of the eyes, care of the bowels and sometimes steam inhalations to relieve irritation of the bronchial tree. The patient may be allowed water and food as required. An antipyretic drug such as aspirin may help control the temperature and render the patient more comfortable. There is no satisfactory drug treatment for measles encephalitis. Sedative drugs are indicated.

The measles virus is short-lived outside the body and will not persist for more than a few hours in the room that has been occupied by the patient if it is thoroughly exposed to light and air.

German Measles (Rubella). — German measles, sometimes called three-day measles, is an epidemic disease of mild course, quite distinct from real measles. It has a longer incubation period and is seldom followed by complications. Rubella is presumed to be caused by a virus and is transmitted by direct contact of a susceptive person with one ill of the disease. Infectivity is much lower than in the case of measles. Although the disease may occur in young children, it is more commonly seen in older children or young adults, and may be a problem in secondary schools and colleges. One attack of rubella apparently confers a lasting immunity, but there is no cross immunity between rubella and real measles. Thus many so-called second attacks of measles are actually German measles. The period of incubation in rubella is 10 to **20** days, commonly 17 or **18** days. Usually the rash is the first sign noted. The rash is of less intense colour than that of measles, but has a similar blotchy appearance. It comes out rapidly, often in the course of one day, to fade just as rapidly two days later. There are no Koplik spots, little catarrh and little conjunctivitis. The temperature is seldom high and lasts only two or three days. Often there is no fever at all. Enlargement of the lymph glands in the neck, back of the ears and perhaps elsewhere in the body is characteristic. Complications are rare, although occasionally encephalitis may follow.

The most serious aspect of German measles is its effect on unborn babies if the mother acquires the disease during the early weeks of pregnancy. Injury may occur in the unborn child in as many as 50% of these cases. Actually many other diseases in the mother probably have this type of effect on the unborn infant, but because of the rash German measles can be identified and its effect established. The baby may be born with faulty development of the eyes, of the heart or of the brain. German measles acquired by the mother later in pregnancy, after the organs oi the baby are completely formed, seems of little or no danger to the unborn infant.

German measles may be confused with scarlet fever because the rash on the second day may look like that of scarlet fever. Real measles is usually readily differentiated. German measles is such a mild disorder that little effort toward prophylaxis is needed. Obviously a woman who is in the early weeks of pregnancy should avoid exposure to German measles, and, if exposure has occurred, serum should be used in an effort to prevent the disease. There is no drug that has a curative effect and no treatment is necessary except to keep the patient comfortable until the symptoms have subsided.

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(C. F. McK.)

MEASURE, THEORY OF: *see* POINT SETS.

MEASUREMENT. The determination of the magnitude of anything in terms of a suitable unit. Such units may be quite arbitrary (*e.g.*, the pound, foot, second or degree centigrade) or may be derived from a combination of the arbitrary units (*e.g.*, pounds per cubic foot). The procedure adopted depends entirely on the nature of the quantity to be measured and on the accuracy required.

See METROLOGY.

MEASURES AND WEIGHTS: *see* WEIGHTS AND MEASURES.

MEASURING TOOLS: *see* METROLOGY; MICROMETER.

MEAT. Meat is the flesh or edible offal of domestic animals used for food. It includes beef, pork, lamb, mutton and veal. In a broad sense, the term may include poultry and game. Offal parts commonly used for food include liver, heart, tongue, brain, sweetbreads (thymus glands) and tripe.

Meat is composed essentially of muscle and connective tissue. Striated skeletal, the so-called voluntary muscle, is its principal tissue. Microscopic threadlike muscle cells are bound together into bundles which in turn are banded together into larger bundles by a framework of connective tissue. Smooth or involuntary muscle is relatively unimportant as food, being found only in tripe and natural sausage casings. Striated cardiac muscle is found only in the heart.

Areolar or undifferentiated connective tissue is found in all tissues. White fibrous tissue comprising muscle fascia, tendons and ligaments has as its essential constituent collagen. Some yellow elastic connective tissue is also found in meat. Liberally fed animals convert surplus nutrients into fat or adipose tissue.

Fats may be formed around the viscera, beneath the skin, and between and within the muscles themselves. The latter is spoken of as marbling.

Composition. — Meat is esteemed as a protein food. Not only does it contain considerable protein, but the protein is of excellent quality. Meat proteins usually contain all of the essential amino acids. However, gelatin—a protein secured from the hydrolysis of collagen—is an exception lacking two essential amino acids. The percentage of fat in meat varies widely with species, grade and cut. Fat is not only a valuable source of energy. but it also influences the juiciness, tenderness and flavour of meat.

Meat contains ample amounts of all of the mineral salts needed by the body with the exception of calcium. It is an especially good source of phosphorus and iron and contains a small amount of carbohydrates, chiefly in the form of dextrose, some of which is converted to lactic acid. Vitamin A is found in animal fats and is especially abundant in liver. Meat also contains appreciable amounts of the water-soluble vitamin B complex, including thiamine, riboflavin, nicotinic acid, vitamin B_4, vitamin B_6 and factor W.

The colour of meat is due to muscle hemoglobin, a substance quite similar to, but not identical with, blood hemoglobin. Species vary in the amount of hemoglobin; thus pork has less than beef, being pink in colour, while beef is "cherry red." Veal is also pink and as the animal grows and matures the colour becomes darker. On exposure to the air, the hemoglobin is oxidized to form oxyhemoglobin. Thus, freshly cut beef may be dark but brightens markedly for 25 minutes, usually reaching its maximum brightness three hours after cutting. Then beef again darkens due to surface drying. Colour in cured meats is usually "fixed" by the use of nitrates and nitrites in the curing formula.

Digestibility. — Meat digests slowly but very completely. Fat cuts of meat digest more slowly than lean cuts. Remaining in the stomach longer than carbohydrate foods, meat gives a satisfying feeling and delays the onset of "hunger contractions"; in common parlance, "it sticks to the ribs."

Meat in the diet stimulates the secretion of the digestive juices, particularly those secreted by the gastric glands. It is very palatable and improves the flavour and nutritive value of other foods with which it is combined.

Meat Consumption. — Meat consumption is greatest in those countries where much livestock is produced and where the human population is relatively small. It is also high in those countries having a high per capita national income.

Inspection. — Since certain diseases and parasites may be transmitted to man through meat, inspection is recognized as an important public health measure. About three-fourths of the U.S. supply is processed under federal inspection, carried on by the bureau of animal industry of the U.S. department of agriculture. All meat and meat food products shipped interstate or for export must be federally inspected. Much of the nonfederally inspected product is processed under local inspection.

Federal inspection is carried on by graduate veterinarians and trained lay inspectors selected under civil service. Plants must be constructed to maintain high sanitary standards; operatives must pass health examinations; animals are carefully inspected before, during and after slaughter; and all products must be properly labeled.

Meat Preservation. — Most beef, veal and lamb is sold as chilled carcasses and cuts. Frozen meat is used to some extent in international trade where prolonged shipment makes the handling of the fresh product impractical.

Fresh pork and veal are the most perishable. Well-fattened beef and lamb keep relatively well at temperatures slightly above freezing. If meat is to be frozen, it should be carefully wrapped in some moistureproof and vapourproof wrapping to prevent dehydration or "freezer burn." Rapidity of freezing is important to secure a high quality product.

TABLE 11.—Meat Production in Selected Countries

(In millions of pounds)

Country	Total		Beef and veal	Pork, excl. lard	Mutton and lamb
	1952	Average 1946–50	1952	1952	1952
United States	27,800	22,264	10,840	11,547	648
[illegible]	4,800	5,215	4,185	260	355
[illegible]	4,450	3,820	2,250	1,800	225
Germany, Western	4,450	2,700	1,470	2,865	33
Brazil	3,065	2,690	2,465	530	45
United Kingdom	2,880	2,025	1,360	1,150	370
Australia	2,309	2,137	1,855	[illegible]	774
Canada	1,977	2,053	[illegible]	1,180	26
Italy	1,485	1,216	640	675	115
New Zealand	[illegible]	1,201	430	87	780
[illegible]	1,203	884	369	808	3
Mexico	1	1,035	820	265	44
Netherlands	1,045	[illegible]	[illegible]	[illegible]	[illegible]
Union of South Africa	935	918	450	596	104
Yugoslavia	859	784	242	463	134
Uruguay	778	743	630	40	155
Belgium	776	559	279	393	5
[illegible]	[illegible]	537	[illegible]	391	5
Sweden	703	405	209	390	4
Cuba	425	414	385	38	2
Switzerland	424	336	205	204	4
Ireland	[illegible]	333	210	[illegible]	35
Chile	381	429	254	57	68
Portugal	[illegible]	324	64	230	49
Finland	345	220	104	120	11
Norway	228	193	96	90	35

Source: "Meat Production During 1952," F.A.S., U.S. Department of Agriculture *Circular FLM-7-53* (June 1953).

TABLE I.—Composition of Meats

(Raw basis, 100 g., edible portion)

	Reef side, medium fat	Veal side, medium fat (excluding kidney fat)	Lamb side medium fai	Pork side, medium	Chicken total, edible	
					Broilers	Roasters
Water, per cent	60	60	55.8	42.0	71.2	66.0
Food energy, calories	273	190	317	457	151	200
Protein, grams	17.5	19.1	15.7	11.9	20.2	20.2
Fat, grams	22.0	12.0	27.7	45.0	7.2	12.6
Ash, grams	.9	1.0	.8	.6	1.1	1.0
Calcium, milligrams	10	11	9	7	14	14
Phosphorus, milligrams	150	193	157	117	200	200
Iron, milligrams	2.6	2.9	2.4	1.8	1.5	1.5
Thiamine, milligrams	.08	.14	.14	.58	.08	.08
Riboflavin, milligrams	.16	.25	.20	.14	.16	.16
Niacin, milligrams	4.2	6.4	4.5	3.1	10.2	8.0

Source: Bernice K. Watt, *et al.*, "Composition of Foods—Raw, Processed, Prepared," U.S. Department of Agriculture, *Agriculture Handbook No. 8* (June 1950).

Frozen meat should be stored at 0°–10° F.

Much pork and a few beef items are cured with salt, sugar, sodium nitrate or nitrite and wood smoke. Cured pork keeps relatively well.

Both fresh and cured meats may be canned in tin or glass containers and sterilized by heat. For emergency use in military rations, boneless meat may be ground, cooked, dehydrated and compressed in cans.

Ripening or **Aging.**—Well-finished beef and lamb are improved in tenderness and flavour if permitted to age or ripen for 10 to 14 days at 34°–36° F. Enzymatic and bacterial action under these conditions tend to break down the connective tissue. Sometimes beef, especially if fat, is aged for longer periods until it develops a characteristic flavour known as "high." Unless beef is fat, it deteriorates on aging. Some beef is aged quickly at higher temperatures using special lamps to hold in check the putrefactive bacteria and moulds.

Veal and fresh pork are never aged.

Cooking. — Meat is cooked to sterilize it, to improve its flavour and for aesthetic reasons. Cooking methods may be divided into two general categories: (1) dry heat; and (2) moist heat. The first method is adapted to cuts which are inherently tender. The fundamental objective of the second method is to convert the collagen of the connective tissue to gelatin making the meat more tender. The moist-heat method should be used to cook those cuts lacking in tenderness. (W. J. L.; J. K. R.)

For meat cooking, see FOOD PREPARATION and MEAT COOKERY.

The value of meat as a basic food is discussed in DIET AND DIETETICS, and world production and supplies are covered under FOOD SUPPLY OF THE WORLD. *See* also MEAT TRADE, and for further information on production, exports, etc., *see* sections on economy in separate articles on principal producing countries.

For meat preservation, see FOOD PRESERVATION, where freezing of meat is discussed in detail, and CANNING, COMMERCIAL.

In addition to the general article AGRICULTURE, there are articles on the various kinds of livestock, such as CATTLE and PIG, and separate articles on BEEF; HAM; PORK; LAMB AND MUTTON; etc. The slaughtering of meat animals is covered under SLAUGHTERHOUSE.

TABLE III.—*U.S. Production of Red Meat and Poultry for Selected Years*

(In millions of pounds)

Year	Red Meats†					Poultry meat*	Red and poultry meat
	Beef	Veal	Lamb and mutton	Pork excluding lard	Total		
1935–39	6,037	1,038	870	7,337	16,182	2,018	18,200
1947	10,434	1,085	799	11,315	23,333	3,190	26,523
1950	9,538	1,230	597	10,714	22,079	3,782	25,861
1951	9,867	1,061	648	11,483	23,008	4,255	26,163
1952	9,667	1,173	648	11,547	23,035	4,399	27,434
1953‡	12,300	1,535	715	10,150	24,700	4,430	29,130
1954§	12,000	1,600	650	10,000	24,250	4,550	28,800

*Chicken, including commercial broilers and turkey, ready-to-cook basis.
†Production of red meats is carcass weight equivalent of production from total United States slaughter.
‡Partly forecast.
§Forecast.
Source: Largely from *The Livestock and Meat Situation,* BAE, U.S. Department of Agriculture (Oct.–Nov. 1953).

TABLE IV.—*U.S. Consumption per Person of Red Meat and Poultry for Selected Years*

(In pounds)

Year	Red meats					Poultry meat*	Red and poultry meat
	Beef	Veal	Lamb and mutton	Pork excluding lard	Total		
1935–39	54.8	8.1	6.7	55.7	125.3	15.3	140.5
1947	68.6	10.7	5.2	68.6	153.1	21.4	174.5
1950	62.5	7.9	3.9	68.1	142.4	24.0	166.4
1951	55.2	6.6	3.4	70.6	135.8	26.5	162.3
1952	61.a	7.r	4.1	71.6	144.0	27.4	171.4
1953†	75.0	9.3	4.4	63.0	151.7	26.9	178.6
1954‡	73.0	9.7	4.0	60.0	146.7	27.2	173.9

*Chicken, including commercial broilers, and turkey, ready-to-cook basis. †Partly forecast. ‡Forecast.
Source: Largely from *The Livestock and Meat Situation,* BAE, U.S. Department of Agriculture (Oct.–Nov. 1953).

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MEAT COOKERY. Butcher's meat may be roasted, baked, fried, grilled (broiled) or stewed. It may also be combined with pastry (*q.v.*) in meat pies, puddings, *vol-au-vents,* etc.; with cereals, vegetables (*see* CEREALS; VEGETABLE COOKERY); and used in soups (*q.v.*).

Roasting and Baking.—To prepare meat for roasting or baking, wipe the meat, trim and truss it into shape if necessary to prevent spreading. Certain joints need boning and rolling; *e.g.,* a breast of mutton. In this case the bones are removed by slipping a sharp knife along the bone without cutting through the flesh.

Boned meats may be spread with forcemeat. Bones should be used for stock. Basting is the most important of all requirements for roasting. Sufficient fat usually runs out of fat meats for the purpose, but in meats which are deficient in fat, *e.g.,* veal, additional fat is necessary. Dredging the joint with flour helps to seal in the juices and also improves the colour of a roast joint and makes a better gravy. (*See* GRAVIES.) Small joints may be covered with brown paper to keep them from browning too much. Hams may be covered with a flour and water paste and baked in the oven.

Pork which has a tough outer skin ought to be scored with a knife before roasting for the convenience of the carver. Stuffed meals are usually served with a thickened gravy; plain roasts with a clear gravy.

Boiling.—Joints for boiling should be securely tied with string. Fresh meats are placed in boiling salted water with pot herbs; *i.e.,* carrot, onion, ¼ turnip and a bouquet *garni* (parsley, bay leaf, thyme, etc.). Boil for ten minutes, skimming the water carefully.

Where vegetables are being boiled with the meat for serving, these should not be added until the requisite time needed for cooking. It is usual to serve special vegetables or sauces with boiled meats to give extra flavour: *e.g.,* boiled mutton and caper sauce; bacon and pease pudding; boiled beef and carrots.

Ox tongues and hams require 24 hours' soaking before cooking to draw out the salt and pickle. Salted and pickled meats should be put into cold water and brought slowly to the boil. All boiled meats should be simmered after the first ten minutes.

Boiled meats which are to be used as cold dishes should be dressed;. *e.g.,* ox tongues need skinning immediately after cooking. and when cool should be glazed. Hams also need skinning and should then he covered while warm with grated toast.

Calf's head should be cut down the middle. leaving the tongue whole. Remove the brains and soak the head in cold water for an hour. Soak the brains separately in salted water; then place them in cold water with a little lemon juice and boil for 15 minutes. When cooked mix with chopped sage and onion (one teaspoonful). Put the head into cold water, bring to a boil and rinse in cold water. Return to the fire in a pan with vegetables, spices and seasoning. and simmer until tender. Blend the brains with a melted butter sauce and pour over the head. Garnish with slices of lemon.

Stewing. — This is the most inexpensive method of meat cookery and may take the form of a white or clear stew, *e.g.,* Irish stem, hot pot, or a brown or white thickened stew. *e.g.,* stewed veal. For a clear stew place the meat directly into a pan with just enough water or stock to cover it. Season and add vegetables according to taste. For brown stew dip the meat in seasoned flour and fry in fat, then remove the meat and add sufficient flour to absorb the remaining fat in the pan and form a *roux.* Cook the *roux* until brown and add the stock which should be sufficient only to cover the meat. If onions are added these ought to be fried after the meat. A more elaborate stew is made by adding other ingredients, *e.g.,* mushrooms, vegetables, etc.. together with

special sauces.

A white stew is made with white stock. or milk and water. and the *roux* is not allowed to brown. In this case. the meat is not fried. A *blanquette* of veal is made by cutting the veal into small pieces. Place these in a pan with white stock to cover. Peel two onions. stick with cloves. add one carrot and herbs. Bring to a boil and simmer for one hour. Strain off the liquor. thicken the latter with a flour liaison, cook and cool slightly. Add the yolk of an egg and chopped parsley. Pour over the veal.

Grilling or Broiling.—Trim off surplus fat and skin. beat into shape and, if necessary, tie with string. Oil the gridiron and heat it before using. Turn the meat frequently with tongs or two spoons. Do not use a fork. Grilled meats are usually served dry with maître d'hôtel butter (parsley. lemon juice and butter blended together), or merely moistened with the fat and juice which have run out of the meat.

Frying.—Unless the meat is minced and protected in batter, meat should always be "dry" fried; *i.e.*, in a frying pan. White internal organs. *e.g.*, sweetbreads. etc.. ought to be scalded before cooking. Liver should be cut into thin strips; kidneys need skinning after washing. A "mixed grill" is commonly cooked by frying in place of grilling.

Meat is frequently reheated in the form of slices of meat warmed in good gravy, hash, curries (cold meat warmed in a curry sauce) or minced and formed into *rissoles*, etc. In all reheating the aim should be to avoid recooking. Judicious flavouring and careful cooking are the essentials in reheated meat dishes.

Galantines.—These are cold meat dishes consisting of a mixture of several boned minced meats or poultry. To prepare, pound in a mortar, add seasoning, shape into the desired form and tie in a floured cloth. Boil gently for two hours in water with pot herbs and seasoning to taste. Remove cloth, reshape if necessary and place under heavy weights. Brush with glaze. Trim off a slice from each end and garnish with parsley. See also FOOD PREPARATION; FLAVOURINGS; GRAVIES. (J. A. SI.)

MEATH, HUGH DE LACY, first LORD OF, and fifth BARON LACY (d. 1186), was one of the first English governors of Ireland. Little is known of his early life except that in the struggle for the English throne between Stephen and the future King Henry II, de Lacy took the part of the latter. In 1171 he was one of the army which accompanied Henry to Ireland, remaining behind when Henry left the following year, as governor of Dublin and thus, in effect, of the entire state. He had meanwhile become lord of Meath through Henry's grant of that territory, which included not only the modern county of Meath but almost the whole of central Ireland, a total of nearly 800,000 ac. He stayed in Ireland less than a year, returning in 1172 to England, and he remained in the service of Henry until 1178, when he was again made viceroy of Ireland. Two years after his return, he married Rose, daughter of King Roderic O'Conor of Connaught, and this, combined with the fact that he had always been popular with the Irish people because of his wise and tolerant rule, convinced Henry that de Lacy wished to become king of Ireland. He was therefore removed from office and, although he soon returned to power, was ousted again in 1184 in favour of Prince John,. Henry's young son. The latter, after an extremely hectic and unsuccessful nine months in office, returned to England, complaining to the king that de Lacy had been the cause of all his difficulties and that he had caused them intentionally in order to make himself king of Ireland. Opinion is divided on whether this charge was true, but in any case, if it was de Lacy's plan, he had little time to carry it out. In 1186 he built a castle at Durrow, tearing down what was already an ancient and venerated monastery to do so, and while inspecting the building one day was murdered by an assassin who is thought to have been avenging both de Lacy's seizure of his family's lands and the destruction of the monastery.

De Lacy is generally considered to have been a wise and just governor. He seems to have been genuinely interested in fostering good feeling between the Irish and their English conquerors, being quick to realize that this was a far more efficacious method of preventing trouble than military might. He was responsible for many administrative policies which did much to strengthen Anglo-Norman rule in Ireland, the most important of which was perhaps his recall from exile of the Irish peasants who had been dispossessed of their lands by the English lords.

His son, WALTER DE LACY (d. 1241), succeeded him as second lord of Meath, while another of his sons, HUGH, became first earl of Ulster.

MEATH, a county of Ireland, in the province of Leinster, bounded east by the Irish sea, southeast by Dublin, south by Kildare and County Offaly, west by Westmeath, northwest by Cavan and Monaghan, and northeast by Louth. Land area 577,824 ac., or 902.8 sq.mi. Pop. (1961) 65,106.

In the north is a broken country of Silurian rocks with much igneous material, partly contemporaneous, partly intrusive, near Slane. Carboniferous Limestone stretches from the Boyne valley to the Dublin border, giving rise to a flat plain especially suitable for grazing. The soil is principally a rich deep loam on limestone gravel. Outliers of higher Carboniferous strata occur on the surface; but the coal measures have all been removed by denudation. Except for a small area occupied by the Bog of Allen, the county is verdant and fertile. In some districts the surface is varied by hills and swells, which to the west reach a considerable elevation, although the general features of a fine champaign country are never lost. The coast, low and shelving, extends about 10 mi., but there is no harbour of importance. Laytown is a large seaside resort, 5 mi. S.E. of Drogheda. The Boyne enters the county in the southwest and flows northeast to Drogheda. At Navan it receives the Blackwater, which flows southeast from Cavan. Both these rivers are noted for their trout, and salmon are taken in the Boyne, which is navigable for barges as far as Navan, whence a canal is carried to Trim. The county is famous for fox and staghunting.

A district known as Meath (Midhe), including the present county as well as Westmeath and Longford, with parts of Cavan, Kildare and County Offaly was formed by Tuathal (*c.* 130) into a kingdom to serve as mensal land or personal estate of the Ard Ri or high kings of Ireland. Kings of Meath reigned until 1173, and their descendants claimed the title as late as the 15th century, but Hugh de Lacy was confirmed in the lordship of the country by Henry II. But though Meath was declared a county in the reign of Edward I (1296), it was long before it was fully subdued and its boundaries clearly defined. In 1543 Westmeath was created a county apart from that of Meath, but as late as 1598 Meath was still regarded as a province by some, who included in it the counties Westmeath, East Meath, Longford and Cavan. Early in the 17th century it was at last established as a county and no longer considered as a fifth province of Ireland.

There are two ancient round towers, the one at Kells (q.v.) and the other in the churchyard of Donaghmore. near Navan. The Book of Kells was made in the 8th century in the monastery founded at Kells by St. Columba. At Brugh-na-Boinne, on the Boyne river near Slane, there is the Bronze Age burial place of the kings of Tara, with 20 burial mounds, the largest of which is that of Newgrange, a domed tumulus erected above a circular chamber, which is entered by a narrow passage enclosed by great upright blocks of stone, covered with carvings. The mound is surrounded by remains of a stone circle, and the whole forms one of the most remarkable extant erections of its kind. Tara (*q.v.*) is famous in history as the seat of the high kings (Ard Ri) of Ireland. On Slane hill in 433 St. Patrick lit the Paschal fire, to proclaim the advent of Christianity in Ireland. Monastic buildings were very numerous in Meath, among the more important ruins being those of Duleek, a 12th century priory said to be on the site of the first stone church in Ireland; the extensive ruins of Bective abbey, founded in 1146 for Cistercians; and those of Clonard, where also were a cathedral, founded in 520 by St. Finian, and a famous college where St. Kieran and St. Columba were pupils. Of the old fortresses, the castle of Trim, built by Hugh de Lacy, first lord of Meath, in the late 12th century, still presents an imposing appearance. There are many fine old mansions.

The climate is genial and favourable for all kinds of crops, the chief of which are oats, wheat, potatoes and turnips. Cattle,

sheep and poultry are increasing, though much grazing land was converted to tillage during World War II. Agriculture is almost the sole industry, but there are a few factories for woollen goods.

The main line of the Southern railway skirts the southern boundary. From Drogheda (County Louth) a branch of the Northern railway crosses the county from east to west by Navan and Kells to Oldcastle.

The chief towns of Meath are Navan, Kells and Trim. Lesser market towns are Oldcastle and Athboy. The Roman Catholic diocese of Meath is a suffragan see of the province of Armagh. It includes most of counties Meath, Westmeath and Offaly, and the bishop's seat is at Mullingar. The constituency of Meath returns three members to *dáil* eireann.

MEAT TRADE. For many centuries meat was traded locally and consumed promptly following livestock slaughter. The discovery and practice of curing some meats by salting and smoking (particularly pork) and drying (beef) made trade over a wider area feasible. At least as early as 200 B.C. not only slaughter areas but markets (macelli) with weighing devices were well developed in ancient Rome. Only free men might trade; inspection by market police was required; offenders were subject to fine, and unfit meat was destroyed. Meat markets are known to have existed in London as early as A.D. 97 j. Butchers, who were recognized as such during the period of the Roman empire, comprised an important guild in London before 1179, and elsewhere on the continent soon thereafter.

TABLE *I.—Meat Exports of Principal Exporting Countries*
(In 000,000 *lb.)*

Country	1934–38 average	1946–50 average	1951	1952
New Zealand	594	782	623	876
Denmark	573	356	812	723
Argentina	1,460	1,309	882	640
Australia	496	491	366	511
Uruguay	324	236	222	176
Ireland	71	53	107	169
Mexico	—	57	92	115
Netherlands	86	29	129	142
United States	115	343	109	129
Canada	193	371	135	100
Brazil	214	135	40	11

Source: U.S. Department of Agriculture, *International Trade in Meat Continues Downward Trend in 1952*, Foreign Agriculture Circular, FLM 8–53, (Washington, July 27, 1953).

International Meat Trade.— Except for early international trade in cured pork and dried beef, livestock were long driven or shipped in such trade. Canned beef was exported from Australia in the late 1840s. Shipments of chilled beef were made from U.S. Atlantic ports to England beginning in 1875. Early attempts at shipping frozen meat overseas from Australia were unsuccessful, but in early 1880 the ship "Strathleven" arrived at London, 64 days out of Sydney, with 40 tons of good quality frozen beef and mutton. Shipment of chilled beef over that long route was attempted as early as 1894 but was not successful until the discovery in 1932 that a 10% CO_2 atmosphere prolonged the high quality of carefully handled beef. After 1934 export of chilled rather than frozen meat was fairly common (accounting for about one-third of the quarter beef by 1939) until it was discontinued as a wartime measure. Loss of bloom and drip when thawed remained major problems in handling frozen quarters. The history of such trade from New Zealand and Argentina to Europe differs only in detail.

TABLE *11.—Meat Imports of Principal Importing Countries*
(In 000,000 lb.)

Country	1934–38 average	1946–50 average	1951	1952
United Kingdom	3,456	3,033	2,345	2,403
United States	262	219	543	502
Germany, Western	156	142	139	100
Italy	74	56	84	95
France	52	112	100	71
Spain	5	26	2	47
Belgium	55	100	71	45
Canada	25	16	77	42
Cuba	7	24	30	42

Source: U.S. Department of Agriculture, *International Trade in Meat Continues Downward Trend in 1952*, Foreign Agriculture Circular, FLM 8–53, (Washington, July 27, 1953).

International trade in meat is largely between countries having large areas more profitably used for grazing than crop farming and countries with high per capita incomes but inadequate domestic meat production. Approximately 10% of world meat production is exported and about three-fourths of that is imported by the U.K. Argentina in normal times has supplied about one-third of the total. New Zealand about one-fifth, Australia about one-eighth, and Denmark about one-twelfth. In vaiue it is about as important as wheat and for the U.K. imports have been slightly in excess of wheat in value even in the difficult postnar years. In terms of proportion of meat output exported, New Zealand has been at an extreme top with about 70%, uhereas Argentina and Australia have sent a little less than one-third of their production overseas and Denmark about one-fourth. As to types of meat exported. about two-thirds or more of the beef comes from Argentina, whereas about two-thirds of the lamb and mutton originates in New Zealand and one-half the pork exports come from Denmark. In the prewar period about half of the international trade in meat consisted of beef and nearly one-third pork; the post-World War II trade was about three-fifths beef, one-fourth mutton and lamb, and less than one-sixth pork. International trade in mutton and lamb prior to World War II averaged about 350,000 metric tons per year. After the war the average was higher, about 440,000 metric tons. The major importer was the U.K., with something like 400,000 tons.

Long-term agreements are prominent in the international meat trade, with roots extending as far back as the Ottawa conference of 1932, as a result of which the U.K. meat imports from Commonwealth countries were increased. The International Beef conference of 1939 sought to establish quarterly allocations by sources. The meat trade of the World War II period, under the advisory jurisdiction of the combined food board, resulted in an increased movement of frozen boneless beef and widespread rationing.

Postwar meat trading largely revolved around the government meat boards of Australia, New Zealand, and Argentina, the ministry of foods of U.K. and the co-operatives of Denmark, with long-term government-to-government bilateral agreements subject to periodic review and revision. Mixed systems of trading also existed. Australia in October 1953 put meat exports, except to U.K., on a trader-to-trader basis after having discontinued such trade in 1950 because of the wide differences between North American meat values and the value of Australian livestock.

Meat Trade in the United States.— Swine were early fattened in areas of surplus corn or mast, then butchered locally or at some near-by river port, after which the pork was cured and "packed" to be marketed down river, in growing urban areas or even in the West Indies. The crude facilities utilized for slaughter. curing of meat and packaging for shipment nere "packinghouses " Cattle, however, were more often driven, sometimes long distances, overland to be slaughtered near the point of consumption. Beginning in the 1850s hauling of live cattle by rail car to growing population centres was prominent. Then, in the 1860s, experimental railroad shipment of fresh beef began from the midwest to eastern markets in refrigerated cars. After that, the movement of livestock into the meat trade gradually took on much of its present rather complex pattern. Shift from rail transportation of live animals moving to slaughter and of meat to truck transportation became pronounced after 1935.

Though the distribution pattern of the smaller, local slaughterhouses continued to somewhat resemble the wide distribution of the consuming population, the larger plants, particularly those offering refinements such as federal inspection tended to develop between the livestock supply source and major agglomerations of the consuming population. In considerable part this pattern resulted from the fact that the average dressed yield of meat is only about 62% of the live weight of the animal, ranging from 73% for hogs to 47% for sheep and lambs.

By the 1950s, some 300,000 persons were employed in U.S. meat products processing with annual wages and salaries of more than $1,000,000,000. Wages paid amounted to about 11% of the sales dollar. Something like 70% of the products handled by the industry must he moved into consumption channels promptly. hence

inventory turnover is as high as 15 times per year and a relatively low capital investment is required. Four major companies were especially prominent in the U.S. meat trade, though smaller companies were active. Profits in the industry in most years tended to be modest. The larger companies apparently had become dominant as a result of assured supplies resulting from well distributed operation of packing plants and superior ability to serve distant and diverse markets effectively. Approximately three-fifths of the product volume was moved by direct shipment in refrigerator trucks. Distributing branch houses with cooler facilities were operated, some with pork curing and smoking facilities as well. Except for some pork cuts, which may be cured and retained in processing and storage for weeks or months, decision is made within five days after livestock are processed into carcass meat as to the form in which the meat will be sold. It may be sold in the carcass, in fresh cuts of several types (hotel trade, retail, etc.), either bone-in or bone-out,, frozen, cured, dried. smoked, or cooked. It may be manufactured into sausage or canned meats or combined with other foods. The decision is based in part on the grade of carcass and in part on an acute awareness of differential demand. It may be marketed through branch houses, on federal contracts, to institutions, to chain stores, supermarkets, small retailers, or even to other processors.

If it were to be marketed as fresh meat of high quality it must move through retail channels in not more than about three weeks. A typical disposition of a 1,000 lb. choice grade beef steer gives a salable carcass of 590 lb., plus 150 lb. of by-products (hide, tallow, offal, etc.), and 260 lb. of slaughter waste of no value. Of the 590 lb. carcass there are about 445 lb. of retail beef cuts salable to consumers and 146 lb. of salvage and waste of minor value.

The U.S. meat trade was considerably restricted during World War II and the early postwar period by rationing, ceiling prices, rollbacks, etc. Exports were increased to aid Allied nations. Production was well maintained, even much increased in the case of hogs and cattle, partly as a result of feed grains imported from Canada. Government grading of meat (optional) became more common. Younger beef, well beyond the veal stage, sometimes called "baby beef," was increasingly found in the market and demanded especially by smaller urban families. New methods of increasing tenderness and adding flavour to meats were developed and the grading system was revised in favour of the younger beef animal. The lard type hog declined in favour, and leaner bacon was in demand. The smaller, specialized meat market found competition much increased. Cuts suitable for self-service packaging for use in the meat counters of chain stores and in frozen food lockers were in increasing demand.

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(J. K. R.)

MEAUX, a town of northern France, capital of an arrondisse*ment* in the department of Seine-et-Marne, and chief town of the agricultural region of Brie, 28 mi. E.N.E. of Paris by rail. Pop. (1954) 15,334.

In the Roman period Meaux was the capital of the Meldi, a small Gallic tribe, and in the middle ages of the Brie. It formed part of the kingdom of Austrasia, and afterward belonged to the counts of Vermandois and Champagne, the latter of whom established important markets on the left bank of the Marne. Its communal charter, received from them, is dated 1179. A treaty signed at Meaux in 1229 after the Albigensian War sealed the submission of Raymond VII, count of Toulouse, to Louis IX, king of France. The town suffered much during the Jacquerie, the peasants receiving a severe check there in 1358; during the Hundred Years' War; and also during the Religious Wars, in which it was an important centre. In the winter of 1421–22, it was under siege by Henry V of England, and although the city was eventually forced to surrender, the privations of the winter were responsible for Henry's death in 1422. Meaux was the first Protestant community in France and in Sept. 1567 was the scene of an attempt made by the Protestants to seize the French king Charles IX and his mother, Catherine de Medici. The plot, which is sometimes called the "enterprise of Meaux," failed, the king and queen with their courtiers escaping to Paris. This conduct on the part of the Huguenots, however, doubtless had some share in influencing Charles to assent to the massacre of St. Bartholomew. Meaux was the first town which opened its gates to Henry IV in 1594.

On the highroad for invaders marching on Paris from the east of France, the town saw its environs ravaged by the army of Lorraine in 1652, and was laid under heavy requisitions in 1814, 1815 and 1870. Not far from Meaux the two World War I battles of the Marne took place in Sept. 1914 and in July 1918.

The town proper stands on the right bank of the Marne; on the left bank lies the old suburb of Le Marché.

MECCA (Arabic Makka, Bakka in ancient times, and Makoraba in Ptolemy) is the metropolis of Islam and capital of the Saudi Arabian province of Hejaz (*q.v.*). It lies (Long. 39° 49′, Lat. 21° 25′) some 45 mi. due east of Jidda, its sea port on the Red sea, with which it is now connected by a tarmac road, built in 1943 by Egyptian technicians and local labour. The road follows the ancient pilgrim camel track from Jidda across the sandy coastal plain and through a broad band of arid hills into the wide, sandy and fertile valley of Wadi Fatima, beyond which, at Shumaisi, it passes into the foothills of the main Hijaz mountain range across the sandy valley of Wadi Sharif, a tributary of Wadi Fatima, in which stand the 'Alamain, or two pillars, marking the limit on this side of the *Haram,* or sacred territory of Mecca. Beyond this point no non-Moslem is allowed to go, nor is the killing of any living creature allowed, except domestic animals required for food, and criminals duly condemned to death by the *shar'* court. The limits of this territory have never been exactly defined, but pillars ('Alamain) mark every point of entry into it, namely at Tan'im, Bazan, Bab Aqsa, and a point on the Najd road, as well as Shumaisi. The *Haram* area forms a rough diamond, about 25 mi. long from Shumaisi to Bazan, near 'Arafat, and about 12 mi. across from Tan'im or the Najd (Nejd) road pillars to Bab Aqsa on the Yaman road. There are no pillars at this last point, which is marked by a narrow pass through a low ridge. The pilgrim camp area of 'Arafat, beginning about two miles east of the Bazan pillars, is similarly marked out by pillars on the Mecca side, and is limited on the farther side by a low ridge along the right bank of Wadi Na'man. Between the two taboo areas lies the valley of Wadi 'Arana with the mosque of Namira, where the noon prayers are said and a sermon preached on the day of pilgrimage before the pilgrims enter 'Arafat for the "standing" (Waqfa) from 2 p.m. until sunset. In practice most of the pilgrims miss this part of the ceremony and remain in their tents on the 'Arafat plain; but the king and his entourage always camp by Namira until the appropriate moment for entry into the "standing" area.

The city of Mecca is situated near the eastern end of the *Haram* enclave: Shumaisi (14 mi.) being the most distant of all the points of entry above noted, while Tan'im is only three miles away, and Bazan six. The main axis of the city is formed by the bed of Wadi Ibrahim, running northeast to southwest, and becoming Wadi Misfala in its lower reach beyond the Great Mosque, known as *al-Haram.* This channel is joined at right angles by the beds of numerous freshets from the hills which flank it on either side: Jabal Khandama on the east and Jabal Turk (formerly Jabal Quai'qa'an) on the west. The chief of these affluents descends through the gully of Ajyad past the bluff from which the castle of Ajyad dominates the mosque. In this gully and round its outlet stand most of the principal buildings of Mecca: the government press, the ministry of the interior, the ministry of finance, the Egyptian hotel, the Isma'ili hostel (Rabat), the holy carpet factory

(now used as a religious school), and numerous private mansions. The Hamidiya building, which housed the public security department, and the Egyptian Takiya (charitable institution) have been demolished to make room for the widening of the mosque and the improvement of traffic amenities: an ambitious scheme launched by King Sa'ud and carried out over a period of several years. The *Haram* quarter, surrounded by Ajyad, Misfala, Suwaiqa (the principal shopping centre for piece goods), Marwa, Mas'a, Safa and Abu-Qubais (with the Mosque of the Moon on its summit), must always have been the central core of the city, in which religion and commerce maintained an easy partnership without prejudice to their respective prerogatives. By the time of the Prophet Mohammed this core must have expanded considerably: northward along the parallel shopping lanes of al Ghashshashiya and al Jaudariya to the main cemetery of Ma'la, outside the gate of that name; and westward up a low spur of Jabal al-Turk, separating the Suwaiqa area from Misfala, to a gate, whose memory is preserved in the name of the quarter which has grown up around it, Harat al-Bab (or Bab al-'Umra). In addition to the two gates mentioned, a third stood at the southern end of Misfala; and it is probable that in former times walls lay across the valleys at these three points only. There seems to be no evidence that the whole periphery of the old town was surrounded by a wall at any time.

Outside the three gates lay the camping grounds of the pilgrim caravans. coming from south, west and northeast, in lower Misfala (Birkat Majid), Jarwal and Ma'abida respectively. All three areas. and particularly the last two, have become flourishing residential suburbs of the city, adorned with gardens. The sharifian palace (al-Baiyadhiya) was in Ma'abida, and was incorporated by Ibn Sa'ud in his palace, which occupies most of the quarter. Misfala, with a few mansions of the wealthy, was developed as a market garden, based on the reservoir of Birkat Majid. And Jarwal, with the larger reservoir of Sharif 'Aun and numerous mansions, soon became a veritable slum of wattle huts and tin shanties to accommodate the poorer classes, who also spread over the adjacent suburb of al-Shuhada. whose name commemorates some descendants of the Prophet who fell in the battle of al-Fakhkh during a rebellion in A.D. 786. Both Jarwal and Shuhada have become fashionable residential quarters, with modern houses, blocks of flats and other amenities. In Shuhada a palace, al-Za'farana, was built about 1950 in anticipation of the visit of King Farouk, but was not completed by the time of his fall in 1952. This area is covered with spacious mansions of the Sa'udi princes, and a large modern maternity hospital. The space available in these two western suburbs was not sufficient for the ever-growing population of the metropolis; and development has created the outer suburbs of al-Hindawiya and al-Tandhubiya, while the Mecca municipality has sold building sites beyond them along the main Jidda road as far as Bir Bustan. In addition, the well area of Umm Dud on the same road, and the village of Muna, formerly used only during the pilgrimage, have been developed as residential areas.

During World War II a census, made for the purpose of a fair distribution of bread and flour, showed a permanent population of 105,000. With the influx of settlers from other countries, the population (1956 est.) was 200.000. in addition to which the city accommodates a floating population of about the same size during the pilgrimage. Formerly it was customary for pilgrims, especially from India and the Netherlands Indies, to spend six months in the Hijaz: arriving in time to spend the month of Ramdhan at Mecca, after which the interval between the fast and the pilgrimage would be spent in a visit to Madina (Medina). In modern times more rapid means of transport have tended to shorten the pilgrims' visit; and the average sojourn is not much more than a month. During that time the accommodation problem is acute and expensive. The main problem has always been water; and up to 1950, apart from wells of variable quality, the supply depended entirely on the aqueduct of Queen Zubaida: an ancient subterranean *kariz* channel restored or reactivated by her in 858. The water from this source frequently proved insufficient and during the last years of King 'Abdul-'Aziz ibn Sa'ud the supply was reinforced and doubled by a new aqueduct emanating from 'Ain Jadida in Wadi Fatima. The Zubaida channel issues from the base of the main range at the head of Wadi Na'man, whose bed has been raised 100 ft. in 1,100 years by the silt of seasonal floods. Advantage was not taken of excavation work in Mecca to study the stratification of the city area, which was exposed to heavy flooding at intervals through the ages until the damming and diversion of Wadi Ibrahim at a point above Ma'abida. The last great flood was experienced in Ibn Sa'ud's jubilee year. 1950, when the courtyard of the Great Mosque was flooded to a depth of seven feet. The kindred problem of sewage and drainage has caused anxiety at times as the main drain of the central area runs parallel with the aqueduct; but schemes have been considered for insuring against accidental pollution of the water supply, The bathing of pilgrims in the reservoirs of Birkat 'Aun. Birkat Majid and al-Shuhada has introduced the bilharzia snail into the area; but suitable precautions have been taken to minimize this danger to public health. Mecca has three good hospitals, with competent doctors and nurses, mainly from Egypt and the Levant, for the service of its citizens and its pilgrims. The absolutely clean record of the pilgrimage during the years since the occupation of the city by Ibn Sa'ud in 1924 redounds to the credit of king and government. The construction of a new quarantine station near Jidda, in replacement of the former accommodation on the islands of the harbour, and of a modern pier with berths for ocean-going vessels has greatly increased the amenities of the pilgrimage, to say nothing of the provision by Ibn Sa'ud. since 1926, of motor transport and of a first-class airport, since 1950, at Jidda. Air routes have been so devised as to avoid passing over Mecca, where there are no landing facilities. The lighting of the metropolis is adequately furnished by a power station at Tan'im, where the European staff to operate the plant is accommodated in bungalows; and the supply of gasoline and kerosene has been assured by the erection of large tanks between Hindawiya and Bir Bustan on the Jidda road. The Madina road starts at the Ma'la quarter, passing through the cemetery and the col of Ri' Hujun (camel pass) to Shuhada and Tan'im (tomb of the Prophet's wife 'Ayisha), where it continues past the tomb of Maimuna (another wife of the Prophet), which has been demolished, to Jumum in Wadi Fatima, and beyond that to the village of Thuwal on the main Jidda-Madina tarmac road.

The life of Mecca revolves round the Ka'ba and the pilgrimage, both relics of a very ancient past, about which we know little in the historical sense. But legend, mostly apocryphal. fills some of the gaps; and there can be no doubt that at a very early period Mecca was a commercial and religious centre of the pagan Arabs. The Ka'ba (meaning "cube") is traditionally believed to have been built by Abraham, at the command of God, as a replica of God's house in heaven. Frequently destroyed by floods and reconstructed, it would seem, nevertheless, to have preserved its original shape of a double cube, twice as high as it is long and broad. The loner part is a solid plinth of large rough stones cemented together. A single door, about eight feet above ground level, admits to a single room, the holy of holies, with a stairway in one corner leading to the roof. From this is suspended the ***Kiswa*** (holy carpet) which is renewed annually at the pilgrimage and completely covers the building except for gaps at the eastern and southern corners, where are set respectively the Black Stone (which pilgrims kiss) and the Yamani Stone (which they touch in passing during the rite of circumambulation).

The first meeting on record was indeed that of Adam and Eve at 'Arafat, whose name commemorates their mutual recognition after long separation since the fall. Eve died and was buried at Jidda, and the apocryphal shrine built in Turkish times over the supposed site of her navel survived until 1928, when it was destroyed by the Wahhabi regime. The next contact of the area with legend was c. 1800 B C., when Abraham brought Ishmael and his mother Hagar to the valley which still bears his name. It was here that Hagar, searching frantically for water for her child between the hillocks of Safa and Marwa. found the famous source of Zamzam. It was from here that Abraham took Isaac to Muna, to sacrifice him at the bidding of God. uhen his hand was stayed by the substitution of a ram, after he had thrice demonstrated

his loyalty by resisting temptation by the devil. The stoning of the three obstacles ('Aqaba) in commemoration of this incident is an essential part of the pilgrimage ceremonies, while a rough shrine covers the spot where the ram appeared. So much for legend unsupported by any historical evidence. It was not until about A.D. 570 that Mecca emerged on the fringe of history, though the name seems to occur as an ethnical attribute (Makki, *Makkiyat*) in some Thamudic inscriptions of 500 B.C. It was in A.D. 570 that the Abyssinian king Abraha of the Yaman (Yemen) led an expedition against the city, which was saved by a miracle, celebrated in Sura 105 of the Quran (Koran). At this time there was more than one Ka'ba in Arabia, attracting pilgrims for the ceremony of circumambulation (seven circuits of the Ka'ba). There was one at Najran, another at al Khalasa (near Bisha), and a fourth at San'a, besides the one in Mecca. And it has been suggested that Abraha, having proclaimed Christianity as the state religion of Yaman, wished to destroy the Meccan shrine as the then principal counterattraction to his cathedral (*al-Qalisa*) at San'a. The story is probably partly apocryphal, though the event is linked in Islamic tradition with the birth of the Prophet in the same year. He was thus 40 years old when he embarked on his mission of salvation in A.D. 610 and 52 when in A.D. 622 his emigration with his companions from the "City of God," where he was born, to Yathrib in the north (soon to be known as the "City of the Prophet," Madina al-Nabi) established Islam as a permanent factor in world politics and human culture. Although Mohammed came to terms with the people of Mecca (the truce of al-Hudaibiyah, probably the modern Shumaisi) some seven years later, it was not until the last year of his life, A.D. 631–632, that he himself made the pilgrimage in celebration of the "perfection of Islam."

The Pilgrimage. — It was then that the pattern of the pilgrimage ceremonies was established for all time, though of course there have been variations in the program from time to time according as the presiding authorities dealt with tradition strictly or perfunctorily. The traditional pattern was, however, re-established by Ibn Sa'ud on the basis of strict Hanbalite interpretation; and it may be well to state the sine qua non elements of the pilgrimage proper, which are (1) the assumption of the Ihram garments (two white seamless sheets or towels, one wrapped round the loins and the other covering the upper body); (2) the Waqfa, or "standing" on the plain of 'Arafat on the afternoon of the 9th of *Dhul-Hijja;* (3) the stoning (Rami) of the "Great Devil" ('Aqabat al-Kabir) early the following morning; (4) the descent to Mecca, then or after the holidays at choice, to perform the Tawaf (circumambulation of the Ka'ba) and the Sa'i (running between Safa and Marwa seven times, beginning at the former and ending at the latter); and (5) shaving the head (snipping off a wisp of hair is sufficient) and resuming ordinary garments before returning to Muna for the sacrifice and holidays. The pilgrim is of course bare-headed, though he may carry a parasol and wear sandals or shoes, during the performance of the first four of these requirements, of which the first three must be done at the proper time, while the fourth and fifth may be deferred till after the holidays, though a pilgrim remaining in a state of Ihram must abstain from hunting, killing (except the sacrificial lamb) and sexual intercourse until his pilgrimage is complete. Apart from these essential requirements, the pilgrim should, without any actual obligation, endeavour as far as possible to conform with the practice of the Prophet on the occasion of his only pilgrimage. On arrival from abroad or from a distance in the neighbourhood of the holy territory, he should bathe and don the pilgrim garb at one of the stations (Miqat) prescribed for the purpose (Wadi Mahram, Sail Kabir, Abyar 'Ali, Rabigh, Jidda or Lith). There or at his starting point he should express his intention of making the pilgrimage; and, on donning the Ihram, he should say a two-bow prayer. And from that moment, being in a state of ceremonial purity, he must refrain from all forbidden acts until he has performed the 'Umra or the Hajj, as the case may be. The latter is the pilgrimage proper, which is obligatory for every Moslem once in his life, provided he is financially and otherwise capable of performing it. He or she may also perform it by proxy, appointing a relative or friend going on the pilgrimage to "stand" for him or her. The 'Umra (or little pilgrimage) is incumbent on every person entering Mecca at any time, whether strangers or citizens returning home after an absence of any length. Such persons must assume the Ihram at the appropriate Miqat on their way to Mecca, and remain in that state until they have performed the Tawaf and Sa'i, after which they shave their heads and resume ordinary garments and the freedom of everyday life. The 'Umra is also considered desirable and meritorious, though optional, in the case of persons residing in Mecca: in which case the citizen or visitor rides or drives out to Tan'im or the well of Ja'rana, performs the prescribed ablutions, dons the pilgrim garb, says the two-bow prayer (including the expression of intention to perform the 'Umra) and returns to the Mosque for the rites of Tawaf and Sa'i. The strict program of the main pilgrimage (not very strictly adhered to by the mass of pilgrims, who find it more convenient to proceed to 'Arafat directly to avoid the pressure of traffic) requires the pilgrim to depart from Mecca after the afternoon prayer on the 8th of Dhul-Hijja, and to spend that night at Muna, performing at sunset the combined and shortened sunset and evening prayers, as prescribed for travelers at all times. On the morning of the 9th (the day of pilgrimage), when the sun has risen a spear's length above the enclosing hills, he leaves Muna, passes through Muzdalifa and the Bazan boundary pillars, and camps in the "free" territory of Wadi 'Arana and the Namira mosque. At the last he should attend the noon service and traditional sermon, after which he can proceed to 'Arafat for the "standing" from 2 P.M. till sunset. Then follows the rush (daf'a or nafr) to Muzdalifa, where the pilgrim performs the sunset prayer and the evening prayer, with a short interval between the two to permit the unsaddling of his camel (or in modern times the collection of his kit from his truck or car). The night should be spent here, and after the evening meal the little stones required for the stoning of the "devils" should be gathered from the bed of Wadi Muhassab, 49 stones in all for each pilgrim, who uses seven of them next morning on the "Great Devil" ('Aqabat al-Kabir) and 21 (seven against each of the three "devils") at or after noon on each of the two following days. For this one night each year Muzdalifa is a brilliantly lighted city of tents, never seen in daylight as the pilgrims leave at dawn, after a second "standing" at the *Mashhad* or minaret of Muzdalifa in the dark. In former times Muzdalifa was known as "the minaret without a mosque" just as Namira was known as "the mosque without a minaret"; but neither description is now applicable, as reconstruction and additions have changed the appearance of both. There is also a royal palace at Muzdalifa for the accommodation of the king and his family, as there is also at Muna, which is a considerable town. Here the whole concourse of pilgrims assembles for the three days of the feast, some in ordinary garments if they have gone to Mecca for the Tawaf and Sa'i, but the great majority in Ihram. The first day of the holiday sees the sacrifice, while the rest of the time is devoted to pageantry of various kinds (military parades and the like) and to mutual visits of congratulation on the completion of the pilgrimage.

History. — In pre-Islamic times Mecca was a centre of purely Arab gatherings and celebrations: commercial, cultural and religious; and various localities in its neighbourhood became specially identified with certain activities. There was Taif with its trio of female deities; 'Ukaz with its poetic competitions; Dhul-Majaz with its fair, possibly the actual forerunner of the 'Arafat gathering; and various other unidentified places. To this day, both in the Hijaz and the Yaman, every principal village has a special day of the week set aside for its market gathering; and some of them are known simply by such names as Suq *al Ahad,* Suq *al* Ithnain, Suq *al* Sabt, etc. But, as the arms of Islam spread the tentacles of the Arab empire over a large part of the world in rapidly widening ripples, Mecca tended to recede into the political background, though it always retained its prestige as the religious metropolis of the Moslem world, for which the annual pilgrimage served as a rallying point. By the end of the century which had witnessed the birth of Islam, Mecca, in spite of sporadic attempts to assert its leadership of the growing empire in rivalry with the Umaiyad (Omayyad) caliph of Damascus, had to acknowledge defeat and to rest content with its religious primacy, shared in

great part by Madina. Thereafter the history of the Hijaz becomes entirely parochial, though the Abbasid caliph of Baghdad and the Fatimids of Egypt seized every opportunity of enhancing their own prestige by lavishing on the two holy cities the wealth accruing to them from their world-nide dominions. The decay of the Baghdad caliphates in the 10th century A.D. created chaotic conditions in the empire generally and in Arabia particularly. The Carmathian schismatics who had settled on the Persian gulf coast now sought to extend their sway over the whole peninsula. They attacked, captured and sacked Mecca itself in AD. 930, carrying anay with them the Black Stone of the Ka'ba, which was not restored to its rightful place till two decades later when the prestige of its actual possession failed to shake the historic claim of Mecca to the religious leadership of Islam. The ***Ka'ba*** and the pilgrimage remained the loadstones of the expanding Arab empire, assuring the commercial prosperity of the city and its merchants, while the surrounding Badawin (Bedouin) tribes profited substantially by providing camel transport for the annual influx of visitors and the merchandise needed for their sustenance during their sojourn in the holy land A new class of pilgrim agents (*Mutawwifs*) developed rapidly to guide the pilgrims in the observance of the prescribed rites. while the hoteliers and houseowners of the city made a substantial living by providing accommodation for the visitors In general it may be said that the traditional organization of the pilgrimage has remained intact. The substitution of motor and air transport for the camels, the improvement of the medical services and a tighter governmental control of the operations of the money changers and others interested in the exploitation of the pilgrims, have certainly tended to adjust the proceedings to modern requirements. But the cost of the pilgrimage to the pilgrim of today is substantially greater than of old, though the increase in all charges does little more than reflect the steadily decreasing value of money. Even the Badawin who strongly resented the intrusion of alien amenities in favour of their old customers, now find that they can earn more in a day as unskilled labourers than they did in a week or more in their traditional activities. The trend of the tribes away from the desert to the fringes of the many new towns in course of development is perhaps the saddest casualty of the westernization of Arabia.

Ibn Jubair's description, in the 12th century A.D., of Mecca and its markets during the pilgrimage differs but little, if at all, from the accounts of the great European travelers of the 19th century: 'Ali Bey (1807), J. L. Burckhardt (1814), Sir Richard Burton (1853), J. F. Keane (1877) and Snouck Hurgronje (1885). And even in 1925, the first year of the pilgrimage under the auspices of Ibn Sa'ud. Eldon Rutter found everything very much as it had been through the ages. It was in the following year that the first signs of modernization appeared with the introduction of motor traffic; and since then the pace of change has been ever more rapid.

The numerous progeny of the Prophet Mohammed all stem from Hasan and Husain, the two sons of his daughter Fatima by his cousin the caliph 'Ali. All descendants of Hasan are known as *Sharifs*, who thus form a clan of the Prophet's family divided into many branches; all descendants of Husain are known as *Saiyids*. Under the Ottoman caliphate the person regarded as the senior, or chief, member of the sharifian clan was officially appointed as amir of Mecca, though there was never any actual right of succession to the office. Thus the amir of Mecca was known as the sharif (or grand sharif) of Mecca; but the sharifian clan contains every grade of social standing.

After the Carmathian incident, Mecca seems to have been left alone under its local chiefs for a space, though its prestige was soon to tempt the Fatimid caliphs of Cairo (969–1171) into sporadic efforts to include the Hijaz in the sphere of their political influence. These attempts were not encouraged by the Meccan sharifs, ambitious to preserve their independence and the more solid perquisites deriving therefrom, while the Yamani sultans. who still sought confirmation of their authority from the declining caliphate of Baghdad, vigorously opposed the pretensions of Egypt. The Hijaz remained independent throughout this period in spite of increasing cultural and economic contacts with the Fatimid regime, and this situation persisted through the century of Aiyubid (Ayyubite) rule in Egypt. beginning with the distinguished reign of Saladin It was not indeed until the final liquidation of the Baghdad caliphate by Hulagu Khan in 1258 that the position of the sharifian rulers of Mecca became untenable; and. in 1269, the Mameluke sultan, Baibars, was able to establish effective Egyptian sovereignty over the Hijaz. This lasted for two and a half centuries until Egypt in turn was conquered in 1517 by the Ottoman sultan, Salim I. to whom the prestige and insignia of the caliph were duly transferred. The Turks were destined to rule the Hijaz and the holy cities for exactly four centuries until the Arab revolt of 1916; and the peace treaties following the victory of the Allied Powers in World War I finally extinguished their pretensions to sovereignty over any part of the Arabian peninsula. hfeanuhile their administration had been conducted nith varying degrees of efficiency and effectiveness according as the pendulum of personalities swung between the Sublime Porte and Mecca, where the prestige of descent from the Prophet frequently encouraged and enabled outstanding members of the sharifian clan to claim and maintain a status indistinguishable from independence in the face of weak and inefficient representatives of the sultan. On various occasions during the first three centuries of this period the reigning sharif of Mecca, always appointed by the Sublime Porte as amir of Mecca, was able to extend his effective influence far and wide over the whole peninsula, his deputy for the administration of the desert being known as sharif of Najd. And it is to the credit of many of the sultans, notably Salim and Mohammed IV, that they not only lavished their resources on the beautification of the two holy cities, but also paid special attention to the protection and comfort of pilgrims proceeding there. Many of the splendid castles erected at intervals on the pilgrim way, equipped with reservoirs to ensure an adequate water supply, bear witness to the services rendered to the faithful by their princes, the sultan-caliphs of the Ottoman empire

Toward the end of the 18th century, the rapid rise of the Wahhabi movement in Najd and the accession in 1788 to the amirate of Mecca of an outstanding personality in Sharif Ghalib ibn Muhsin seemed to presage the dawn of a new era of Arab renaissance and Turkish decline. It was Ghalib who now took the lead in an effort to stem the advance of the Wahhabis, but the task was beyond his powers. The first five years of the 19th century saw the sack of Karbala, the capture of Mecca and the surrender of Madina to Sa'ud II and his fanatical armies In 1827 the ruling clan of Dhawi Zaid, to which Ghalib had belonged, was set aside in favour of the Dhawi 'Aun sharifs. Thenceforward Turkish authority was seldom effective in spite of the presence of a *wali* (provincial governor) and Turkish garrisons in Mecca itself and other centres.

At the beginning of the 20th century Sultan 'Abdul-Hamid made a determined effort to establish more effective Turkish rule in Arabia. Concealing his strategic aims with the cloak of anxiety for the comfort of the pilgrims to Mecca, he summoned the faithful of the Islamic world to subscribe to the construction of a railway from Damascus to the holy land. A German engineer, Meissner Pasha, formerly concerned with the project of the Berlin-Baghdad railway, was duly commissioned to survey and construct the new line, on which work began in 1902. By 1908 it had reached Madina; but all the blandishments of the Sublime Porte failed to shake the determination of the sharifs of Mecca to resist its extension to God's own city. By this time the reigning sharif, 'Aun al-Rafiq, had died (1905); and Sharif 'Ali Pasha was recalled from exile in Egypt to take his place, in the hope that he would co-operate in the sultan's plans. He opposed them, and was deposed, while the sharif appointed to succeed him died before taking up his post. 'Abdul-Hamid then turned to Husain ibn 'Ali, long in honourable exile in Constantinople and now 60 years of age. It was a bold experiment, and did not have the desired effect in so far as the railway was concerned. When World War I broke out. Husain came to terms with the British government, which, in return for his declaration of war against the Turks, recognized him as king of the Hijaz in 1916. Mecca, Jidda and Taif, the principal centres of Turkish influence, soon fell to the sharifian

forces, provided with British arms and money, and supported by a naval demonstration at Jidda which was mildly bombarded. Madina however remained in Turkish occupation until the end of the war, when it was formally surrendered to the king's son, Amir 'Abdullah; by this time, the railway had been largely destroyed by Colonel Lawrence's dynamiters, and has been virtually out of commission to this day, in spite of intermittent efforts to restore it.

The Macmahon-'Abdullah negotiations of 1915–16 recognized the right of all Arab elements in the peninsula to complete independence. And King Husain had somewhat prematurely assumed the title of "King of the Arab Countries," thus incurring the open hostility of Ibn Sa'ud.

The British government engaged in an effort to secure some sort of agreement between King Husain and Ibn Sa'ud; but the Kuwait conference of 1923–24 proved abortive, and it was just at this moment that Mustafa Kemal decided to abolish the caliphate altogether.

King Husain grasped frantically at the Prophet's mantle, but the reaction of the Moslem world to his assumption of the title of caliph was generally unfavourable to his pretensions, while Ibn Sa'ud made up his mind that the time had come for a final settlement with his rival.

In Sept. 1924 the Wahhabi armies fell upon Taif, defeating the king's son, Amir 'Ali, at the battle of Hada near the great escarpment. King Husain was forced by public opinion to abdicate and leave the Hijaz in favour of 'Ali; Mecca was occupied by the Wahhabis without opposition, and Ibn Sa'ud entered the holy city in December, presiding over the pilgrimage for the first time in the summer of 1925. Jidda and Madina fell to the Wahhabis at the end of the same year.

The sharifian dynasty came to an end, and the Wahhabi flag flew once more over the holy cities of Islam. From that day on the history of Mecca was merged in the wider sphere of Saudi Arabia, with all its prestige as the metropolis of Islam intact in spite of the inevitable decline of its political significance in the international field. With the final termination of the once sovereign status of the sharifs in Arabia, it will be appropriate to list those members of the clan who held the distinguished title of "Amir of Mecca" as mediatized vassals of the Ottoman caliph-sultan from the conquest of the Hijaz by Mohammed 'Ali Pasha in the second decade of the 19th century until 1925, the year of the Wahhabi triumph: (1) 1788–1814, Sharif Ghalib ibn Musa'id Muhsin, of Dhawi-Zaid clan; (2) 1814–1827, interregnum of direct Turkish (Egyptian) rule; (3) 1827–1851, Sharif Mohammed ibn 'Aun of the Dhawi-'Aun clan; (4) 1851–1856, Sharif 'Abdul-Muttalib ibn Ghalib, of Dhawi-Zaid; (5) 1856–1857, Sharif Mohammed ibn 'Aun (number three above); (6) 1857–1877, Sharif 'Abdullah ibn Mohammed ibn 'Aun, son of the above; (7) 1877–1880, Sharif Husain ibn Mohammed ibn 'Aun, brother of the above; (8) 1880–1882, Sharif 'Abdul-Muttalib ibn Ghalib (number four above); (9) 1882–1905, Sharif 'Aun al-Rafiq ibn Mohammed ibn 'Aun, son of number five above; (10) 1905–1908, Sharif 'Ali Pasha ibn 'Abdullah ibn Mohammed ibn 'Aun, son of number six above; (11) 1908, short interregnum; (12) 1908–1924, Sharif Husain ibn 'Ali; and (13) 1924–1925, Sharif 'Ali ibn Husain, son of the above and last of the sharifian rulers of the Hijaz. He abdicated his throne and left Jidda to the Wahhabis in Dec. 1925.

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MECHANICAL DRAWING: see DRAWING, ENGINEERING.

MECHANICAL MAN: see AUTOMATION; ROBOT.

MECHANICS. This subject is concerned with the motions of bodies and the special circumstances that arise with a body at rest. It may be regarded as a branch of mathematics or of physics and, as we shall see, this distinction raises important considerations. Traditionally, by "mechanics" is meant Newtonian mechanics. a science based on certain postulates whose nature and use will be discussed in this article.

The word mechanics implies a connection with machinery and the subject is of fundamental importance in engineering science. It is usual, however. to refer to its practical applications as falling within the scope of "applied mechanics" and this title is frequently used to cover such subdivisions of mechanics as strength of materials (see MATERIALS, STRENGTH OF), and elasticity, ballistics (*q.v.*), fluid mechanics (see MECHANICS. FLUID), etc.

The foundation of all these subjects is analytical mechanics and it can be divided into two related parts, namely dynamics (*q.v.*) and statics. Dynamics is concerned with the motions of bodies and is, itself, commonly subdivided into two branches: the first, called kinematics, deals with the geometrical aspects of dynamics — that is, with the motions of bodies without reference to what causes them; the second, called kinetics, is concerned with the effects of forces as they condition these motions. Statics, on the other hand, deals with bodies which are at rest; while it can be developed separately, as a science which is independent of dynamics, it may be regarded as a special branch of dynamics and this standpoint will be adopted here.

Some of the various subjects of applied mechanics are concerned with the different types of body to which theoretical mechanics refers. The subjects of elasticity. plasticity and strength of materials. for instance, refer to particular types of deformable solids. The "bodies" may be fluid, however, giving rise to the subjects of fluid mechanics, namely, aerodynamics, lubrication, etc. (*qq.v.*). In this article, an attempt is made to present the essential features of the parent subject, that is, of Newtonian (or "classical") mechanics. This raises problems of presentation on account of the subject's many ramifications. For this reason. it will be helpful to outline briefly the layout of this article and to explain how it stands in relation to dynamics and statics.

The article commences with a preliminary discussion of (1) the nature of mechanics. It seems logical then to take up the simplest problems of kinematics, namely those concerning (2) the motion of a point. By introducing the concept of mass, it then becomes possible to explain the substance of (3) Newton's laws relating to a massive point or particle. Special cases arise which demand some development, namely (4) the statics of a particle and (5) the kinetics of a particle. Now the restriction of the theory to that of a "small" body must be relaxed and its removal introduces important considerations as to the nature of the real body under discussion — it may, for instance, be an elastic solid, a viscous fluid or a gas. Now certain principles of mechanics apply to all these and they relate to (6) the mechanics of collections of particles and. in particular, (7) the principle of virtual displacement. These matters, and (8) the application of mechanics to real bodies, occupy the remainder of the article with the exception of a short description of (9) the breakdown of Newtonian mechanics and (10) a short bibliography.

In this way it is possible to lay a foundation for the articles on all the various branches of applied mechanics. It is also possible, then, to develop separately the subjects of statics and dynamics as they apply to rigid bodies. these being departments of mechanics whose special significance will be explained later.

NEWTONIAN MECHANICS AS AN ABSTRACT SCIENCE AND AS A BRANCH OF PHYSICS

One way of regarding theoretical mechanics is to visualize it as a purely abstract science. As such, it may legitimately be

founded on any set of assumptions which is neither incomplete nor self-contradictory. These assumptions refer to the nature of the bodies and to their dynamical behaviour and, provided that the rules of mathematics are followed correctly, a valid body of theory may be built up from them. In this way, theoretical mechanics may be developed as a branch of applied mathematics. The question of how far it is in accordance with experimental observation is a separate matter and, by regarding it in this way, we are under no obligation to verify that each step in its development is strictly in agreement with experiment.

Although any consistent set of initial assumptions is suitable as a starting point in this scheme, preference will clearly be given to the simplest set from which the most accurate descriptions of observable data can be derived. Sir Isaac Newton (1642–1727) (*q.v.*) devised an analytical theory of dynamics based on three fundamental assumptions (which are usually referred to as "Newton's laws") and this theory has come to be known as "classical" or "Newtonian" mechanics.

Newton's theory does not explain physical phenomena; it describes them. It does so in terms of concepts which are intuitively acceptable but are incapable of exact definition. For these and other reasons, some of which will be mentioned later, Newton's assumptions cannot possibly be verified by direct experimentation. Nor can they reasonably be described as self-evident. But if theoretical mechanics is regarded as a purely abstract science, there is no necessity to verify Newton's assumptions directly or, indeed, at all.

The suggestion that mechanics may be regarded merely as an abstract branch of mathematics is open to the serious objection that, since all physical phenomena involve motion, mechanics occupies an important position in physics. Indeed, the subject has been developed, historically, as a branch of physics so that the suggestion demands some explanation.

The assumptions of the abstract science permit excellent predictions to be made of physically observable results. The excellence of this agreement between classical mechanics and the physical universe is so great that discrepancies are usually quite undetectable by ordinary means. They do exist. however, and their investigation and explanation has occupied physicists since the latter half of the 19th century.

While some progress has been made in elucidating these inconsistencies, there can be no question of discarding Newtonian mechanics, in favour of some more "exact" theory, for general use. This is partly on account of the smallness of the discrepancies and partly because of the much greater complexity of any known substitute. Briefly, and roughly, it has been found that attention need only be paid to the lack of completeness of Newtonian mechanics when investigating the motions of bodies which either are of subatomic size or have a velocity comparable with that of light. (See QUANTUM MECHANICS; RELATIVITY.)

If mechanics is regarded strictly as a branch of physics which is constructed, by induction, on the results of experiments, then modern physics demands that experimental data must be interpreted more conservatively than they were by Newton. For instance, the theory of relativity reveals that it is by no means easy to define exactly what is meant by the statement that two events occur "at the same instant," although we should not hesitate to use the concept of simultaneity in Newtonian mechanics. And under any normal conditions the accuracy of a calculation in which this notion is used would not suffer perceptibly on that account.

Newton's laws must be regarded as capable of furnishing excellent predictions of physical results under almost any, but not quite all, conditions.

KINEMATICS OF A POINT

As mentioned earlier. kinematics is concerned with the motions of bodies without reference to the ways in which these motions can be brought about or modified. Its object is the description and measurement of these motions.

Some elementary considerations of kinematics are dealt with in this article and, to simplify the discussion as much as possible, it is convenient to start by considering the motion of a single point, that is of a body whose size may be neglected in comparison uith the distances it traverses. These considerations of the kinematics of a point are of immediate use in many practical problems such as navigation; they also occupy an important place in the development of the wider subject of dynamics as a whole.

Kinematics of a Point Moving Along a Given Path.— The position of a point P which moves along some given definite path may be specified by its distance *l* from some point O which is fixed in that path. The distance l is measured along the path, so that the straight line between O and P will have a length which is less than l if the path is not straight. By specifying the value of 1, in some suitable units, we can describe the position of P relative to O without reference to the way in which the path itself may be moving. Thus when we say that a railway train (P) is 20 miles (l) along the track from some station (O), we are not concerned with the way in which the railway track moves on account of its attachment to a far from stationary globe. It should be noticed that the implied reference to a train as a "point" is quite legitimate in view of our definition of a point.

The notion of speed is a familiar one, and we come now to examine the speed at which P moves along its path, either away from. or toward, O. Suppose that, at some instant of time t_1, P is distant l_1 from O and that, after an interval δt, at a time t_2, P has progressed a further distance δl and is distant l_2 from O. The average speed of P in this interval of time is defined as

$$\frac{l_2-l_1}{t_2-t_1} \text{ or } \frac{\delta l}{\delta t}$$

Now the specification of an average speed gives no information as to how the distance to which it refers was traversed; thus it is not clear whether P stood still or not on the path for any portion of the interval δt, or if it moved quickly and then more slowly. Kinematics gives a precise meaning to speed by diminishing the time δt over which the average speed is measured. The instants t_1 and t_2 are made to converge until they both represent effectively the same instant of time, t. The instantaneous speed at time t, which will be denoted by s, is thus

$$s=\lim_{\delta t\to 0}\left(\frac{\delta l}{\delta t}\right)=\frac{dl}{dt}$$

In the language of the calculus, then, the speed of P along its path is found by differentiating the distance l with respect to time t.

Variation of the distance l as time passes leads us to the definition of speed. In the same way, the speed of P along its path may vary with time and this suggests the definition of a new quantity, rate of change of speed or "the acceleration along the path." Let the speed at some instant t_1 be s_1 and let it have the increased value s_2 at time t_2. If the corresponding changes of speed and time are δs and δt respectively, then the average acceleration along the path over this period is

$$\frac{s_2-s_1}{t_2-t_1} \text{ or } \frac{\delta s}{\delta t}$$

By diminishing the time interval indefinitely, we can find the instantaneous acceleration along the path at time t, which may be denoted by a. It is

$$a=\lim_{\delta t\to 0}\left(\frac{\delta s}{\delta t}\right)=\frac{ds}{dt}=\frac{d^2l}{dt^2}$$

The acceleration along the path is therefore the derivative of the speed s with respect to time t; alternatively, it is the second derivative of the distance 1 with respect to time.

In the same-way, we could proceed to a discussion of higher derivatives of l with respect to t. But we shall see that they have not the importance of the first two in Newtonian mechanics.

Kinematics of a Point **Moving** in a Plane.— By confining the point under consideration to motions along a given path, we rid ourselves of the necessity of discussing the direction of the motion. Direction is of no account except in so far as P may move toward O or away from it; that is to say, the speed may merely be positive or negative. If the motion is not limited in this way,

however, but is confined to a plane, then the position of the point cannot be specified with a single quantity as it could be before (by the distance l). Further, when the point moves in the plane the direction, as well as the speed of its motion, is important. The idea of a train moving along its track provided an illustration of motion along a given path. In the same way, the idea of motion in a plane can be thought of as that of a boat moving on a lake.

Previously, an arbitrarily chosen point O on the path served as a reference point for the measurement of l. A convenient way of specifying the position of a point P in plane motion is to construct perpendicular axes OX and OY in the plane of motion and to measure its position relative to them. The axes serve as a frame of reference. In the problem of the boat, for instance, these axes would be imagined fixed to the earth.

Let AB in fig. 1 represent a length of the path which happens to be followed by P, and let OXY be the perpendicular axes. The distances x and y, measured parallel to OX and OY respectively can be used to specify the position of P. As P moves, x and y vary so that these measurements, which define the positions of the projections P_x and P_y of P on the axes, are time-dependent. Evidently the motions of P can be regarded as being capable of deduction from the motions of P_x and P_y.

Suppose that, in the interval $\delta t = t_2 - t_1$, P moves from point 1 to point 2 in fig. 1, a distance δl. The average speed of P in this interval is

$$\frac{\delta l}{\delta t}$$

and it is convenient now to associate with it the notion of direction. Point P is said to have an average velocity which is directed along the chord 1,2 and is of magnitude

$$\frac{\delta c}{\delta t}$$

where δc is the length of the chord (*see* fig. 1). This could be represented by a line of length equal to

$$\frac{\delta c}{\delta t}$$

which is drawn parallel to this chord. If this line were drawn, its projections on the axes OX, OY would be of lengths

$$\frac{\delta c}{\delta t}\cdot\frac{\delta x}{\delta c}=\frac{\delta x}{\delta t}$$

$$\frac{\delta c}{\delta t}\cdot\frac{\delta y}{\delta c}=\frac{\delta y}{\delta t}$$

respectively. That is to say, the projections of the line representing the average velocity of P themselves represent the average velocities of the projections P_x and P_y along the lines OX and OY respectively.

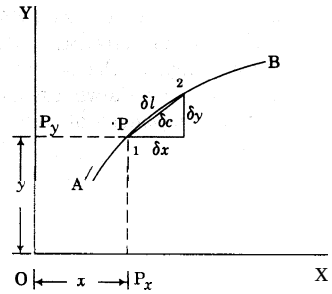


FIG. 1.—(SEE TEXT FOR EXPLANATION OF ALL FIGURES)

Generally speaking, the greater the interval δt, the more will the chord depart from the curve joining points 1 and 2 in fig. 1. The description of the motion along δl will be less precise as a consequence and the greater will the discrepancy become between the average speed

$$\frac{\delta l}{\delta t}$$

and the magnitude

$$\frac{\delta c}{\delta t}$$

of the average velocity. Kinematics again gives precision to these considerations by requiring δt to be diminished indefinitely so as to give the instantaneous velocity or, more usually, simply the velocity of P. The magnitude of this velocity is

$$\lim_{\delta t\to 0}\left(\frac{\delta c}{\delta t}\right)=\lim_{\delta t\to 0}\left(\frac{\delta l}{\delta t}\right)=\frac{dl}{dt}$$

which is, of course, the speed. The direction of this velocity will evidently be that of the tangent to the curve AB at the point where the velocity is being measured.

The line which we referred to as representing the average velocity (and whose projections represented the average velocities of P_x and P_y) can be thought of as being modified during the limiting process $\delta t \to 0$. By this means it is readily shown that the line which, by its length and direction, represents the instantaneous velocity of P, has projections which give the instantaneous velocity of P_x along OX and P_y along OY. The velocity v of P is said to have components.

$$\left.\begin{aligned} v_x &= \frac{dx}{dt}, \text{ in the direction OX} \\ v_y &= \frac{dy}{dt}, \text{ in the direction OY} \end{aligned}\right\} \qquad (3)$$

A change of velocity of the point P implies either an alteration of its speed or of its direction of motion, or both. These possible changes lead us to define the acceleration of the point P. To do this. it is again useful to think of the line whose length and direction represent the magnitude and direction of an instantaneous velocity.

Fig. 2(A) shows the axes OXY, the path AB and the points 1 and 2 which lie on it. The velocity at point 1 is v_1, directed along the tangent at 1. It is represented, to a suitable scale, by the line CD labeled v_1 in fig. 2(B); this line describes the velocity at time t_1. Equally the line CE. labeled v_2, represents the velocity of P when it has reached point 2 at time t_2. The x component of the velocity at 2 is evidently greater than that at 1 by the amount δv_x, which is given by the line FE in fig. 2(B). Similarly, the y component of velocity at 2 is greater than that at 1 by the negative amount δv_y, shown in the diagram as DF.

These two changes of velocity parallel to the axes can be regarded as components of the total change of velocity and fig. 2(C) shows how the magnitude and direction of this change may be found by our previous method. It is a line which we signify by δv and it will be seen that this line just fits across the gap DE in fig. 2(B). The change of velocity during the interval δt is given then by the line DE whose direction is not along the curve AB but across it, as shown by the arrow in fig. 2(A). During its passage from 1 to 2, the point P is said to have an average acceleration

$$\frac{\delta v}{\delta t}$$

(where δv denotes the change of velocity) whose direction is that of the arrow in fig. 2(A).

This average acceleration could be represented by a line of length

$$\frac{\delta v}{\delta t}$$

which is parallel to the arrow of fig. 2(A), that is, which is parallel to DE. The projections of this line on the axes OX and OY would be, respectively,

$$\frac{\delta v}{\delta t}\cdot\frac{\delta v_x}{\delta v}=\frac{\delta v_x}{\delta t}$$

and

$$\frac{\delta v}{\delta t}\cdot\frac{\delta v_y}{\delta v}=\frac{\delta v_y}{\delta t}$$

In words, then, these projections of the line representing the average acceleration of P themselves represent the average accelerations of P_x and P_y (in fig. 1) along OX and OY respectively.

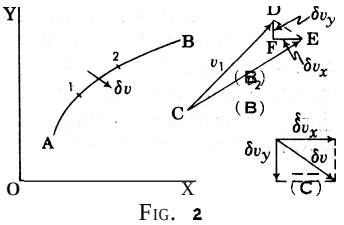


FIG. 2

Once again, kinematics gives precision to this definition by introducing the instantaneous acceleration or, more usually, the acceleration at time t. This is found, as usual, by diminishing δt indefinitely so that its magnitude is

$$\lim\left(\frac{\delta v}{\delta t}\right)=\frac{dv}{dt}$$

The direction of the average acceleration becomes modified as δt tends to zero, that is, as point 2 is taken closer to 1. It will not normally be changed, however, to the extent of becoming tangential to the path AB and will, in fact, remain directed towards the concave side of the path AB. The line which can be drawn to represent the average acceleration in magnitude and direction will usually be modified during the limiting process. Its projections on the axes OX and OY become. respectively,

$$\lim_{\delta t \to 0}\left(\frac{\delta v_x}{\delta t}\right) = \frac{dv_x}{dt} = \frac{d^2x}{dt^2}$$

$$\lim_{\delta t \to 0}\left(\frac{\delta v_y}{\delta t}\right) = \frac{dv_y}{dt} = \frac{d^2y}{dt^2}$$

These projections give the accelerations of P_x along OX and P_y along OY. The acceleration of P is said to have components

$$\left.\begin{aligned} a_x &= \frac{dv_x}{dt} = \frac{d^2x}{dt^2}, \text{ in the direction OX} \\ a_y &= \frac{dv_y}{dt} = \frac{d^2y}{dt^2}, \text{ in the direction OY} \end{aligned}\right\} \quad (4)$$

The line representing the acceleration may be projected in any direction and, in particular, its projection in the direction tangential to the path at point 1 is of interest. It gives the component of the acceleration of P in the direction of its motion. It is this component which is given by equation (2), assuming that the given path, to which that result refers, lies entirely in the plane that is now under discussion.

Velocity and Acceleration as Vectors.—If the components v_x and v_y of the velocity v of P are known, the magnitude and direction of the total velocity may easily be deduced since these components are the projections parallel to OX and OY of the line representing this velocity. Thus, the diagonal GJ of the rectangle GHJK shown in fig. 3 gives the required total velocity v when GK and GH are drawn to a suitable scale to represent v_x and v_y.

The figure GHJK is a rectangle only because we elected to take perpendicular axes OXY as the frame of reference in fig. 1. Suppose now that these axes are oblique as shown in fig. 4. As the point P moves along the path AB, its position at any instant can be deduced from those of P_x and P_y by the construction lines shown dotted in fig. 4. Just as before, the movement of P from a point 1 to a point 2 during an interval δt leads to the definition of average velocity which can again be represented by a line parallel to the chord joining points 1 and 2. The projections of this line on the new axes OX, OY are again

$$\frac{\delta x}{\delta t} \text{ and } \frac{\delta y}{\delta t}$$

respectively, so that the average velocities of P_x and P_y along their axes are still given by the appropriate projections of the line. Similarly, the projections parallel to OX and OY of the line representing the instantaneous velocity v of P are equal to the instantaneous velocities v_x and v_y of P_x and P_y respectively. If the component velocities are specified, then the total velocity may be found, not from a rectangle as in fig. 3, but from a parallelogram as in fig. 5.

Consider now the problem of a point P which has some velocity relative to a frame of reference which is itself moving. This arises, for instance, with a man walking in a moving ship. P may be said to have two velocities simultaneously at any instant. One of these is that which would be measured by an observer traveling with the frame of reference (or, in our illustration, by a passenger in the ship). The other velocity is that of the point, fixed in the moving frame, with which P coincides momentarily (the ship's velocity).

These two velocities (which are also referred to as components) can be compounded to give the total velocity of P relative to fixed axes and the formal method of doing this is the same as that for finding v from its components v_x and v_y (see fig. 5). That is. the resultant velocity is found from the components by the parallelogram rule. The justification for'this may be seen from the following argument which involves reinterpretation of fig. 4. Suppose that P moves through the distance δx (fig. 4) relative to the frame of reference while the frame itself shifts so that all points of it move through the distance δy parallel to OY. Evidently the total displacement of P (from 1 to 2) can be found from the parallelogram rule by the use of lines δx and δy, parallel to OX and OY. This would still be true if the lengths were small. if they were traversed simultaneously during an interval δt and if the lengths of all the lines of the parallelogram were not the displacements but (to a fresh scale) the displacements divided by δt. The lengths of the lines of this new figure represent velocities if δt is taken indefinitely small; the components are the velocity parallel to OX of P relative to the frame and the velocity of all points of the frame parallel to OY and the diagonal is the resultant velocity.

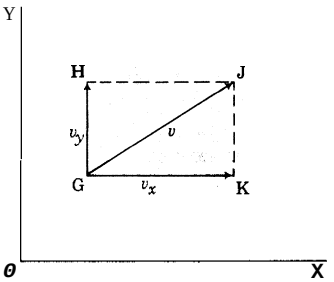


FIG. 3

Any quantity, like velocity, which has magnitude and direction and which also obeys this parallelogram rule is called a vector quantity (see VECTOR ANALYSIS). The process of combining the components in the manner of fig. 5 is called vector addition. By tracing these arguments through, using the lines which represent acceleration instead of velocity, it will be found that acceleration is also a vector quantity. An acceleration may be found by adding its components by the parallelogram law.

Kinematics of a Point Moving in Three Dimensions.—If the point P is entirely free to move in space. and is not confined to motion in a plane, then the foregoing theory must be extended. The reference frame OXY of fig. 1 must be replaced by a three-dimensional frame OXYZ. like that shown in fig. 6, whose axes have been chosen so as to be perpendicular to each other. One set of measurements which now serve to define the position of P at any instant as it moves along its path AB are the distances x, y and z. The motion of an airplane might be described with axes of the type shown; it would then be convenient to imagine the frame attached to the earth with, say, the axis OZ pointing upward. By simple extensions of the previous theory, it may be shown that P will have a component of velocity parallel to OZ, which is

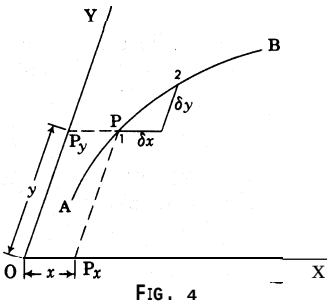


FIG. 4

$$v_z = \frac{dz}{dt} \quad (5)$$

Similarly there will be a component of acceleration given by

$$a_z = \frac{dv_z}{dt} = \frac{d^2z}{dt^2} \quad (6)$$

The total velocity v of P is given by the sum of the three components v_x, v_y and v_z and the total acceleration is found as the sum of a_x, a_y and a_z. While the former is necessarily tangential to the path of P at all instants, the latter is not. These sums are found by adding the components in the manner shown in fig. 7; that is to say, the rectangle of fig. 3 now becomes a rectangular parallelepiped. In the same way. it can be deduced that oblique components which were previously added by the parallelogram rule (fig. 5) must now be added by the use of a parallelepiped with edges parallel to the corresponding components.

By extending the previous arguments it can easily be shown that, if P moves relative to a three-dimensional frame of reference which is itself moving, then the resultant velocity and acceleration may be found by the vector law. That is to say, the components must be added by means of the parallelepiped construction.

NEWTON'S LAWS

In general, the subject of mechanics relates to the ways in which the motions of bodies are affected by interaction between them.

The interaction between bodies may arise from contact between them or by mutual attraction or repulsion. If a man throws a stone, the motion of the latter is first conditioned largely by its contact with the man's hand and then, during its flight, mainly by its interaction with the earth. This standpoint is too general for practical use and it is often desirable to investigate the motion of an isolated body rather than to examine both the body and its environment. The first step in solving such a problem in mechanics is thus to decide exactly what body is under discussion and then to consider it as being isolated by an imaginary boundary. If the motion of the stone is to be analyzed. then, this boundary would be the surface of the stone.

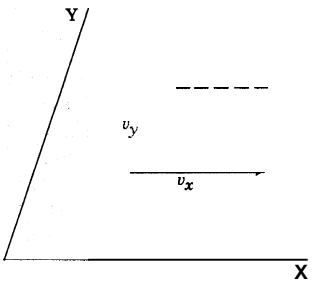


FIG. 5

Something must act across the boundary as a consequence of the interaction of other bodies and so the concept of force is introduced in Newtonian mechanics for the purpose of analysis. A force is of the nature of a push or a pull and may be of two sorts, a surface traction or a body force. The force exerted by the man on the stone is a surface traction since it is applied at the surface of the body. On the other hand, the pull of the earth is a body force since it is exerted on all parts of the stone within the chosen boundary.

Newton's laws are assumptions made as to the relations that exist between forces and the effects produced by them and it will simplify our development of the theory if, in describing Newton's assumptions, we relate them to a particular type of body upon which the forces act. The body is supposed to be so small in comparison with all other lengths that enter into a discussion of its motion that its dimensions are negligible. The body is called a particle and the geometry of its motion will be covered by the foregoing theory of kinematics of a point. For the purposes of some astronomical problems, it is adequate to treat such vast bodies as the earth. the other planets and the sun as particles since their dimensions are negligible compared with the distances between them

Newton's First Law.—The first of Newton's set of assumptions deals with the motion of a particle which is not acted upon by any force. It tells us that the particle will remain in a state of rest or of uniform velocity (that is of motion in a straight line at constant speed) until it is compelled to change that state by an impressed force. This law is due. in fact, to Galileo (*q.v.*) (1564–1642).

It is first necessary to explain what is meant by "a state of rest or of uniform velocity." Suppose we choose a frame of reference OXYZ (as in fig. 6) to describe the motion in accordance with the previous theory. This law states that the component velocities v_x, v_y and v_z will be either zero or constant when the axes are "fixed." In engineering. and most other applications of mechanics, the axes may be imagined as being fixed to the earth. Certain phenomena, however, cannot be described accurately in this way and, as in astronomy, it is found expedient to adopt new "improved" frames of reference. Thus the origin of the axes may be transferred to the sun for greater accuracy and comprehensiveness; and further improvement might be obtained by using axes determined by the "fixed" stars. The basic assumption is that some system of axes exists with respect to which Newton's assumptions are exactly correct. It may be mentioned that such a system would not be uniquely determined because, if any system of axes can be found for which Newton's laws are true, the laws will also be true of any other system which moves with constant velocity relative to it in such a way that corresponding axes remain parallel.

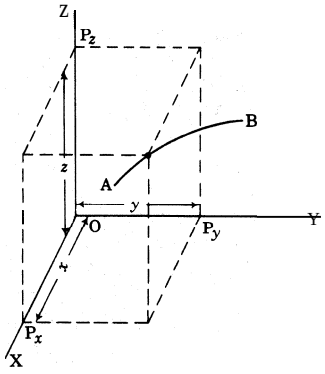


FIG. 6

In his assumptions, Newton not only postulates the existence of a fixed frame of reference in space, but is also concerned with the measurement of time as a fundamental process. As time enters into kinematics, it might be any continuous independent variable. But there is certainly no assurance that this is all that is required in dynamical theory. In effect, then, Newton also postulates the existence of some absolute scale of time. It must be accepted as fortunate that the practical methods of measuring time which we use, and which are based on the earth's rotation, appear to suit Newton's requirement with accuracy sufficient for most purposes.

From a logical standpoint, this law raises serious difficulties, quite apart from those relating to the definitions of space and time. In the first place. it cannot be verified directly by experiment, no matter with what refinement the experiment is performed. We have no access to a body which is free from all applied force (if only because of the earth's attraction). Moreover, all the forces acting on a body cannot be "balanced out" without appeal to the very laws that it is wished to verify. Again. it is asserted that the velocity of a particle which is not acted upon by any force will remain constant. If this is presented as an induction from experiment, then it is open to the objection that the only way of ascertaining whether the particle is or is not without any applied force is to observe whether or not its velocity is constant. In short, we are constantly reminded that Newtonian mechanics, if it is to be regarded as a branch of physics, should be accepted as depending upon empirical rules whose merit lies in the great accuracy of prediction that they permit. Adopting this standpoint we use a "fixed" co-ordinate system and an absolute scale of time measurement and accept the first of Newton's assumptions.

Newton's Second Law.—According to the first law, if a particle does not remain in a state of rest or of uniform velocity. that is, if it accelerates, it must be acted upon by a force. Evidently the force and the acceleration are related and it is this relation which is the subject of Newton's second assumption (the "second law").

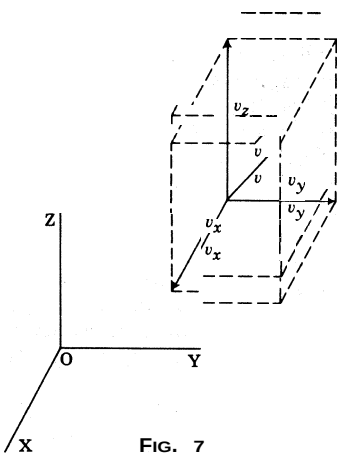


FIG. 7

This law states (in effect) that the acceleration of the particle is proportional to the impressed force **f** and takes place in the same direction as the force. This can be expressed in symbols in the form

$$f = ma \tag{7}$$

where m is a constant of proportionality and, it must be remembered, f and a are in the same direction.

If the acceleration occurs solely in the direction of the axis OX, and is of magnitude a„ this law asserts fhat a force acts on the particles in this same direction. This force is given by

$$f_x = ma_x$$

Equally, accelerations a, or a, alone would require the application of forces

$$f_y = ma_y$$
$$f_z = ma_z$$

Suppose now that the particle possesses these three component accelerations simultaneously. Its total acceleration a is the vector sum (the resultant) of $a_,$, a, and a, and is thus found from a parallelepiped of the type shown in fig. 7. If all the sides of this parallelepiped are multiplied by m, a second parallelepiped is obtained which may be thought of as that giving the sum of the forces f_x, $f_,$ and $f_,$. We infer that forces are vector quantities

which can be compounded and resolved in the same way as accelerations can, by the vector law. As we shall see, this result is fundamental to the subject of statics and adds precision to our original conception of force merely as a "push" or a "pull."

By hypothesis, the validity of Newton's laws is not affected if the particle referred to is exchanged for another. There is no requirement, however, that the constant of proportionality m should remain the same if this is done. This quantity must therefore be regarded as a property of the particle and is referred to as its inertia. If the same force were to be applied to two particles, that having the greater inertia (or "sluggishness") would have the smaller acceleration. The numerical value of a particle's inertia is usually referred to as its mass and the question of what units must be employed to specify this quantity will be entered into later.

Newton's Third Law.—The first two laws concern a particle and it is frequently required to examine particles, not in isolation, but in relation to each other. For instance, we shall see that particles may be imagined as being joined together to represent larger bodies. And under these circumstances it is necessary to frame some rule as to the forces which are called into play when two particles interact. This is the function of the third law which is to the effect that, if two particles A and B interact, then the force f which is experienced by A as a result of this interaction is equal in magnitude but opposite in direction to that experienced by B. This. moreover. does not depend upon the relative motions of A and B. As we shall see. this law enables us to deal with the motions of more complicated systems than simple particles because it refers to the way in which two (or more) particles interact when they are both enveloped by the boundary which determines the system.

Newton's "Law of Gravitation." — In the succeeding notes, the way in which the structure of dynamical theory is erected will be explained in terms of the three laws that have been mentioned. A fourth postulate was made by Newton! however, and it concerns the magnitude of the force of attraction between particles. This "law of gravitation" is to the effect that two particles of masses m_1 and m_2 attract each other with a force proportional to

$$\frac{m_1 m_2}{r^2}$$

where r is the distance separating them, and that this force acts in the direction of the line joining the particles. By introducing a constant of proportionality γ, called the constant of gravitation. we may write an expression for the magnitude of this force; it is

$$f = \frac{\gamma m_1 m_2}{r^2} \qquad (8)$$

Like the others, this law is obtained by induction from experiment and an account of the reasoning leading up to it may be found in Lamb's Dynamics (2nd ed.. p. *216).*

Units of Measurement. — If the fundamental result given in equation (7) is to be used in a quantitative sense, then it is necessary to define a suitable system of units by which the quantities of force, mass and acceleration may be measured. Now, in framing the lams of motion, we postulated accelerations of a particle and only introduced the notions of force and mass as conceptions which explain the incidence of these accelerations. It will be well therefore to start by defining a unit of acceleration.

The definition of acceleration shows that a point possesses unit acceleration when its velocity is increased by one unit in unit time; in the same way the point will have unit velocity when it moves through one unit of distance in unit time. It is necessary. then, to define units of length and time and these fundamental units may be chosen arbitrarily. If we select the foot as the unit of length and the second as that of time, then the derived units of velocity and acceleration (which may not be chosen arbitrarily) are the foot per second (ft./sec.) and the foot per second per second (ft./sec.^{2}) respectively.

In the Newtonian scheme, inertia has been defined as a constant which is associated with a given particle and whose value is independent of its motion. It follows that the unit of mass is also fundamental (and therefore arbitrary). It is defined as the mass of a particular body such as the standard pound (lb.) or the kilogram (kg.). Thus, if a particle is said to have a mass of 1 lb., it is implied that it would acquire the same acceleration as the standard pound if both were acted upon by the same given force.

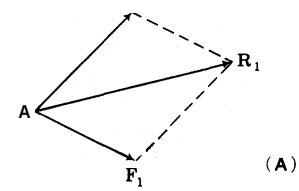
When units have been specified for length, time and mass, the corresponding unit of force may be derived. According to the second law as it is expressed in equation (7), a given force always produces the same product of mass and acceleration whatever the body on nhich it acts. This product is a characteristic of the force and can conveniently be taken as a measure of it. The unit force is thus one which produces unit acceleration in a particle of unit mass. The force which accelerates a mass of one pound at the rate of one foot per second per second is known as a poundal. The accompanying table shows the names given to the units, defined in this way, under the systems in common use.

System of Units	Length	Mass	Time	Force
F.P.S.	ioot	pound	second	poundal
C.G.S.	centimetre	gram	.second	dyne
M.K.S.	metre	kilogram	second	newton

It is common, particularly in engineering practice, to use a unit of force known as the pound weight or pound force or (rather confusingly) simply the pound. A force of 1 lb. weight is exerted upon a mass of 1 lb. as a result of the earth's gravitational attraction and is found to be 32.1 *j4* poundals when it is measured at the National Physical laboratory, Teddington, Eng. When exerted upon a mass of 1 lb., a force of 1 lb. weight thus produces an acceleration of 32.174 ft./sec.^{2} If a unit of mass is adopted, equal to 32.174 lb., then it will acquire an acceleration of 1 ft./sec.^{2} when acted upon by a force of 1 lb. weight. The system of units which is arrived at in this way is frequently used by engineers, the unit of mass being called the "slug."

STATICS OF A PARTICLE

Statics of a particle refers to the conditions under which a body will remain at rest, the size of the body being of no consequence. While the subject is of somewhat limited technical importance, a short introduction to it will serve to fix ideas.



The Composition of Forces. —The condition under which a particle will remain at rest is explained in Newton's first law; it is that no force shall act upon it. Now it is necessary that we should contemplate the simultaneous action, on a particle, of several forces so that the law requires their sum (that is, their resultant) to be zero. Suppose that two forces are applied to the particle and that they are represented in magnitude and direction by the lines AF, and AF_2 in fig. 8(A). Their resultant can be found by the parallelogram rule and will be given in magnitude and direction by AR_1. Now the point R_1 could have been found by drawing AF_1 to represent the first force and then F_1R_1 to represent the second so that AF_2 and F_2R_1 need not have been drawn. If a third force, represented by AF_3, acts on the particle, as well as the first two, the resultant may be found by two methods. Fig. 8(B) shows the determination of the resultant force, represented by the line AR,, using the parallelepiped rule. It will be seen, however, that this is unnecessarily complex since, having found AR_1, we have only to add R_1R_2 (representing the third force) to find the resultant.

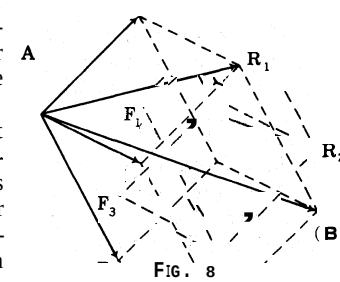


FIG. 8

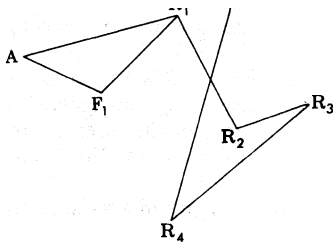


FIG. 9

This process may be repeated for other applied forces and the successive resultants are given by the lines AR_1, AR_2, AR_3, . . . as indicated in fig. 9 where, in general, the figure will not lie in a plane. The condition of equilibrium is that the sum of the forces shall vanish so that the last point found in this way must coincide with A. Thus, if AF_1, F_1R_1, R_1R_2, R_2R_3 . . . are drawn to represent the various forces acting, they must form the sides of a closed polygon. This is called the polygon of forces and, in forming it, there is evidently no necessity to follow any particular order in taking the component forces.

Analytical Composition of Forces.— The process of adding forces is fundamental in statics and, as we have seen, it may be thought of as a graphical process. In practice it is often convenient to use an algebraic approach. particularly when the polygon of forces is not confined to a plane. For the purpose, a rectangular system of axes OXYZ can best be used.

We have seen that two forces can be combined to give a single resultant force and that a given force can be resolved into components along the three axes. Consider the force, f_1 say, which is represented hy AF, in fig 10. The component of this force in the direction of OX is $(f_1)_x$ as shown in fig. 10, its value being

$$(AF_1)\cos\theta$$

where 8 is the angle between AF_1 and a line through A which is parallel to OX. In the same way, the components $(f_1)_y$ and $(f_1)_z$ may be found.

Suppose now that the first step in the polygon construction were to be performed by the vector addition of F_1R_1 (representing a force f_2) to AF_1 so that AR_1 can be found in the manner of fig. 8(B). If the components of f_2 are

$$(f_2)_x,\ (f_2)_y,\ (f_2)_z$$

then the components of the resultant of f_1 and f_2 will be seen to be

$$[(f_1)_x+(f_2)_x],\ [(f_1)_y+(f_2)_y],\ [(f_1)_z+(f_2)_z]$$

This is illustrated in fig. 11.

The result may be generalized so that, if forces $f_1, f_2, f_3 \ldots f_n$ act on a particle, the condition of equilibrium may be stated in the form

$$\left.\begin{aligned}(f_1)_x+(f_2)_x+(f_3)_x+\ \ldots\ +(f_n)_x&=0\\(f_1)_y+(f_2)_y+(f_3)_y+\ \ldots\ +(f_n)_y&=0\\(f_1)_z+(f_2)_z+(f_3)_z+\ \ldots\ +(f_n)_z&=0\end{aligned}\right\} \qquad (9)$$

This is an alternative way of stating that the resultant force must be zero; that is, it must have zero components.

Equilibrium of a Particle Under Constraint.— In problems involving the statics of a particle, it is common for the body to be constrained in some way. That is to say, if the particle were to leave its position of equilibrium, it could only do so in certain definite ways. If it lies on a horizontal table, for instance, the possibility of movement downward is precluded. The forces exerted on the particle by constraints of this sort must, of course, be included among the remaining acting forces in determining the state of equilibrium. Now the postulated properties of the constraint determine what force it can exert on a particle so that these properties may need to be known in analysis of the statics of the particle that is constrained.

By a "smooth" constraint is meant a surface (or, possibly, a curve) which can only exert a force on the particle that it constrains in the direction of the normal to itself at the position of the particle. In fact. the force will usually be oblique to the surface and, when this is so, it can be resolved into a component which is normal to the surface and one which is tangential to it. The latter is termed the force of friction.

An empirical law, which is often attributed to C. A. Coulomb (1781) but which was known to Leonardo da Vinci (1452–1519) and was rediscovered by G. Amontons (1699), is usually assumed to govern the magnitude of a force of friction. This is to the effect that equilibrium can be maintained at a constraining surface provided that the magnitude of the force of friction which is needed for the condition of equilibrium to exist is not greater than a certain number (μ, the coefficient of friction) multiplied by the normal component of force. If F is the force of friction and N is the normal component, then

$$F \gtrless \mu N \qquad (10)$$

KINETICS OF A PARTICLE

Having discussed the particular case which arises when both sides of equation (7) are zero, we now take up the wider subject of particle dynamics in which this limitation is removed. This aspect of dynamics is concerned with the motions of bodies whose dimensions are much smaller than all the other distances involved in their motion. It is of considerable technical importance and can be used for bodies ranging in size from the electrons in devices such as the cathode ray tube to the heavenly bodies whose motions are studied in physical astronomy. Not only is direct use made of equation (7); this subject also introduces certain new conceptswhich must now be explained.

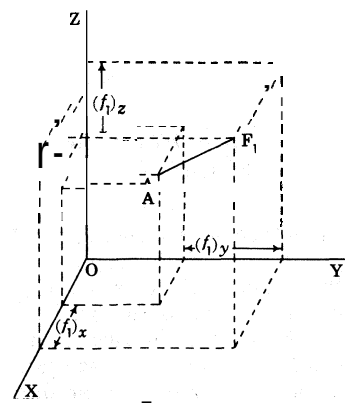


FIG. 10

Impulse and Momentum.— We shall find, later on, that considerations of momentum play an important part in the mechanics of real bodies. By the momentum of a particle is meant the product of its mass and its velocity and, just as with force, it is to be regarded as a vector quantity. Momentum can be resolved and added by means of the vector law. If v_x, v_y, v_z are the components of the total velocity v of a particle. then the total momentum is mv and mv_x, mv_y, mv_z are its components in the directions OX, OY and OZ. respectively.

Evidently, the application of a force causes a change of the momentum and we now examine the nature of this effect. Consider first the motion of a particle in a straight line, which can conveniently be identified with the fixed axis OX Such a motion can be maintained provided that, at all instants, the resultant applied force acts in the direction of motion. The equation governing the motion is

$$f_x = ma_x = m\frac{dv_x}{dt}$$

or, since m is constant,

$$f_x = \frac{d}{dt}(mv_x)$$

It follows that the force acting on the particle is equal to the rate of change of the momentum. The total effect of the force f_x during an interval of time $t_B - t_A$ is found by integrating this result. This shows that the change of the momentum $[(mv_x)_B - (mv_x)_A]$ in this interval is given by

$$\int_{t_A}^{t_B} f_x dt = (mv_x)_B - (mv_x)_A \qquad (11)$$

The integral on the left hand side of equation (11) is called the impulse (or time effect) of f_x during the prescribed interval.

Let us now remove the limitation to motion along the axis OX and consider general motion of the particle. The resultant forte f which acts on it can be resolved into components f_x, f_y and

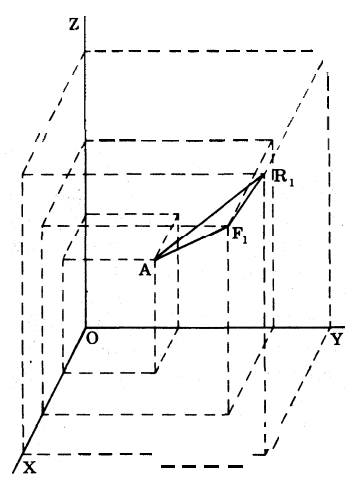


FIG. 11

f_z at any instant and each of these may be considered separately. By the same reasoning as before, it is found that the gain of momentum of the particle in the direction of OX in a given interval is equal to the corresponding impulse of the component f,, and similar results hold for the directions OY and OZ.

The significance of the notion of momentum is particularly apparent in the treatment of interacting bodies when, for instance, they collide. We shall be concerned with considerations of this sort when we come to discuss compound systems mhich contain more than one particle.

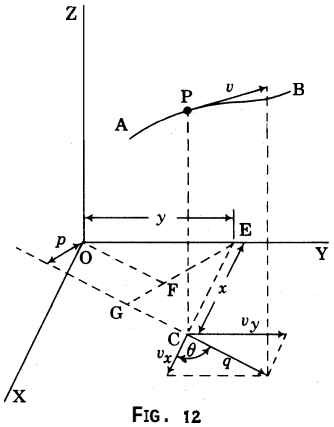


FIG. 12

Moment of Momentum. — Just as momentum becomes important in the mechanics of collections of particles, so too does the concept of moment of momentum. Let the resultant velocity of a particle moving along a path AB be v, such that two of its components, v, and v, may be compounded to give the velocity q in the plane OXY (see fig. 12). We now discuss the projection of the motion of the particle on this plane, as it would be seen by an observer looking down parallel to the axis ZO. Let the distance between the line containing the q vector and the origin O be denoted by p. The product of the component mq of the momentum and the distance p is called the moment of momentum of the particle about the fixed axis OZ. By a suitable choice of axes, the line about which the moment of momentum is reckoned may have any position and direction; it is only necessary that it be fixed.

On referring to fig. 12 it will be seen that

$$\begin{aligned} m(xv_y - yv_x) &= mq(x \sin\theta - y\cos\theta) \\ &= mq(EG - EF) \\ &= mqp \end{aligned}$$

In words, the moment of the momentum about OZ is equal to the sum of the moments about this axis of the components of momentum. The rate of change of moment of momentum is thus

$$\begin{aligned} m\frac{d}{dt}(xv_y - yv_x) &= m\left[\left(x\frac{dv_y}{dt} + v_y\frac{dx}{dt}\right)\right. \\ &\qquad \left. -\left(y\frac{dv_x}{dt} + v_x\frac{dy}{dt}\right)\right] \\ &= m[(xa_y + v_yv_x) - (ya_x + v_xv_y)] \\ &= m(xa_y - ya_x) \end{aligned}$$

since m is a constant.

The components a, and a, of the acceleration of P are associated with components f, and f, of applied force in accordance with the component form of equation (7). It follows, therefore, that the rate of change of the moment of momentum about OZ is given by

$$\frac{d}{dt}(mqp) = xf_y - yf_x \qquad (12)$$

Now the expression on the right-hand side of this equation is capable of interpretation by analogy with the moment of momentum. The former quantity, $(xf_y - yf_x)$, is obtained if mv, and mv, are replaced by f, and f_y in the expression $m(xv_y - yv_x)$. But $m(xv_y - yv_x)$ is the moment about OZ of the total momentum. In the same way, therefore, $(xf_y - yf_x)$ is the moment about OZ of the total applied force. This may be visualized by thinking of the vectors of fig. 12 as representing forces instead of velocities, remembering that in general the force applied to the particle P will not be tangential to the path AB. The moment of the applied force about OZ is equal to the sum of the moments of its components about this axis by the argument applied previously to momentum.

The moment of momentum of P, about OZ is shown by equation (12) to be of constant magnitude if the momept (about the same axis) of the applied force is zero. This circumstance arises if the force is itself zero, if the line of action of the force intersects the axis OZ or if the force is parallel to the axis so that f_z is its only non-zero component.

The concept of moment of momentum is particularly useful, as we shall see, in the analysis of systems containing more particles than one. It has been introduced here mainly in the interests of simplicity although the basic result (12) is often of direct importance, particularly in astronomy.

Work and Energy. — The concept of momentum was seen to introduce the notion of the time effect of a force. We come now to examine the space effect; by analogy with the result (11), we wish now to evaluate the quantity

$$\int_{x_A}^{x_B} f_x dx$$

and to do so, we start again from equation (7) in its component form.

Consider first the motion of a particle in the direction of the OX axis under the influence of a force f_x. The acceleration is

$$a_x = \frac{dv_x}{dt} = \frac{dv_x}{dx}\frac{dx}{dt} = v_x\frac{dv_x}{dx} = \tfrac{1}{2}\frac{d(v_x^2)}{dx}$$

so that

$$f_x = \frac{m}{2}\frac{d(v_x^2)}{dx}$$

But, since m is a constant, this may be written

$$f_x = \frac{d}{dx}(\tfrac{1}{2}mv_x^2)$$

so that the required integration may now be performed. That is to say, if the particle moves from a point A for which $x = x_A$ to a point B where $x = x_B$, then

$$\int_{x_A}^{x_B} f_x dx = (\tfrac{1}{2}mv_x^2)_B - (\tfrac{1}{2}mv_x^2)_A$$

The integral in this equation (the space effect) is referred to as the ***work*** done by f, over the specified displacement $(x_B - x_A)$; it is equal to the increase of the quantity $\frac{1}{2}mv_x^2$.

The theory can be extended without difficulty to motion in three dimensions. Corresponding to this result for motion along OX, the following results may be found for motion along OY and OZ:

$$\int_{y_A}^{y_B} f_y dy = (\tfrac{1}{2}mv_y^2)_B - (\tfrac{1}{2}mv_y^2)_A$$

$$\int_{z_A}^{z_B} f_z dz = (\tfrac{1}{2}mv_z^2)_B - (\tfrac{1}{2}mv_z^2)_A$$

Now, if v,, v, and v_z are the three orthogonal components of a total velocity v of magnitude s, an application of Pythagoras' theorem to the parallelepiped of vectors shows that

$$v_x^2 + v_y^2 + v_z^2 = s^2$$

It follows, by addition of the three work equations, that if a particle moves from a point $A(x_A, y_A, z_A)$ to a point $B(x_B, y_B, z_B)$,

$$\begin{aligned} &\int_A^B (f_x dx + f_y dy + f_z dz) \\ &= (\tfrac{1}{2}ms^2)_B - (\tfrac{1}{2}ms^2)_A \end{aligned} \qquad (13)$$

where $\frac{1}{2}ms^2$ is called the kinetic energy.

By extending the definition of work, this term can be made to cover the integral in this last result so that the increase of the kinetic energy is still a measure of the work done on the particle by the applied force. The necessity for extending the definition of work arises because the general motion of a particle is such that displacement does not necessarily occur in the direction of the resultant applied force. Suppose that the particle moves the short

distance 61 between points 1 and 2 on its path from A to B; this portion of the path is shown in fig. 13 whose plane is chosen to contain both the short arc, 1, 2 and the line containing the force vector which may be supposed to emanate from the particle P and which is drawn for the instant when P is at 1. If 61 is very small. the force f will remain sensibly constant in magnitude and direction during the journey from 1 to 2. If δx, δy, δz are the projections of δl on the axes OX. OY, OZ and f_x, f_y, f_z are the corresponding components of f, it may be shown that

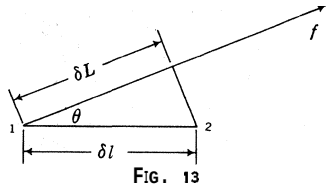


FIG. 13

$$f_x\delta x+f_y\delta y+f_z\delta z=f.\delta l\cos\theta=f.\delta L$$

where δL and θ have the meanings indicated in the figure. That is to say, the product of the force and the resolved part of the small displacement in the direction of the force is a measure of the work done as P proceeds from 1 to 2. We may now pass to the limit and sum up the small contributions to the work done, so that

$$\int_A^B f\,dL=(\tfrac{1}{2}ms^2)_B-(\tfrac{1}{2}ms^2)_A \qquad (14)$$

This integral defines the total work done during the motion of the particle from point A to point B.

The importance of the fundamental ideas of work and energy is most apparent in the analysis of composite systems containing more than one particle. They are used on occasion, however, in particle dynamics, largely as a means of shortening calculations.

SYSTEMS CONTAINING MORE THAN ONE PARTICLE

The restriction must next be removed of the foregoing theory to bodies whose dimensions are negligible compared with all other distances involved in a discussion of their motion. The bodies which exist in nature. and to which the theory has to apply, are continuous (or apparently continuous) distributions of matter and they may be solid liquid or gaseous. Our next step is thus to extend the theory for discrete particles to these continua and, to accomplish this, use is commonly made of Boscovich's hypothesis (1758). This is to the effect that a continuous body may be regarded for certain purposes of analysis as an aggregate of particles; these particles are supposed to be very numerous although their number is finite. They are separated by small but finite intervals and interact merely by forces of direct attraction or repulsion. We now show that certain general properties may be deduced for these aggregates of particles. The supposition will subsequently be made that. in making use of these properties, the assumption of an aggregate of particles can be discarded.

Henceforth, it mill be necessary to distinguish between internal and external forces. It was remarked earlier that the first step in a particular problem'of mechanics is to define the system under discussion by means of a suitable bounding surface. A force is given the adjective "external" if it acts across this boundary and is described as "internal" if it does not. Thus the motion of the moon is determined largely by the earth's attraction and this attractive force is "external" in any calculation that is concerned only with the moon. But this same force is "internal" if the earth-and-moon is regarded as an isolated system (whose motion is determined largely by the sun).

Principle of Conservation of Linear Momentum.—Let (x_1, y_1, z_1), (x_2, y_2, z_2), . . . etc., be the co-ordinates of particles whose masses are $m_1, m_2, \ldots$ etc.. respectively, all of them lying within the boundary defining a system. These particles may be subjected to external forces whose components parallel to the fixed axes OX, OY, OZ are

$$(f_x)_1,\ (f_y)_1,\ (f_z)_1,$$
$$(f_x)_2,\ (f_y)_2,\ (f_z)_2,$$
etc.

They will also be subject to the internal forces whose existence is due to the actions of the particles upon each other; let the components of these forces on $m_1, m_2, \ldots$ etc., be

$$(f'_x)_1,\ (f'_y)_1,\ (f'_z)_1$$
$$(f'_x)_2,\ (f'_y)_2,\ (f'_z)_2,$$
etc.

Equations of motion for the particle m_1 may be written in the component form as follows:

$$\left.\begin{aligned}(f_x)_1+(f'_x)_1&=m_1(a_x)_1\\(f_y)_1+(f'_y)_1&=m_1(a_y)_1\\(f_z)_1+(f'_z)_1&=m_1(a_z)_1\end{aligned}\right\} \qquad (15)$$

and similar equations may be written, in sets of three, for each of the other particles. Imagine that all the equations for each particle have been written in this form. If all the x, y and z equations are now added together, it is found that

$$\left.\begin{aligned}\Sigma ma_x&=\Sigma(f_x+f'_x)\\\Sigma ma_y&=\Sigma(f_y+f'_y)\\\Sigma ma_z&=\Sigma(f_z+f'_z)\end{aligned}\right\} \qquad (16)$$

where the symbol Σ is to be interpreted as meaning "the sum of all terms like this, a typical one."

The third of Newton's laws, however, tells us that the internal forces between the particles exist in equal and opposite pairs so that the sum of their components in any direction must vanish; that is to say,

$$\Sigma f'_x=0;\ \Sigma f'_y=0;\ \Sigma f'_z=0$$

It follows, then, that

$$\left.\begin{aligned}\Sigma ma_x&=\Sigma f_x\\\Sigma ma_y&=\Sigma f_y\\\Sigma ma_z&=\Sigma f_z\end{aligned}\right\} \qquad (17)$$

For any particle m, the quantity ma, is equal to

$$\frac{d}{dt}(mv_x)$$

since m is constant; and similar relations hold for ma, and ma_z. The result (17) can thus be expressed in words as follows: "The rate of change of the total linear momentum of the system in any of the directions OX. OY, OZ is equal to the sum of the resolved parts of the external forces in those directions."

If there is a direction in which the sum of the components of the external forces is zero, then the total momentum in that direction is constant. Let this direction be identified, for instance, with the direction of the axis OX; we now assert that, if

$$\Sigma f_x=0$$

then

$$\Sigma ma_x=0$$

or, by integrating,

$$\Sigma mv_x=\text{constant} \qquad (18)$$

This is known as the principle of conservation of linear momentum. One outcome of this principle may be noted immediately. If two bodies move in the same direction and collide, then the sum of their total momenta remains constant. This is because their interaction can only cause equal and opposite forces to act between pairs of particles. These forces, being internal to the system comprising the two bodies, can therefore produce no increment of total momentum.

These considerations of linear momentum are fundamental in all branches of applied mechanics. The principle may be readily applied to all types of fluids. deformable solids and rigid bodies.

The Principle of Conservation of Moment of **Momentum.**—In the previous section we saw that the rate of change of moment of momentum of a particle about a fixed axis is equal to the moment about that axis of the applied forces. Thus, if attention is fixed on a typical particle m, and it is remembered that all forces applied to it must then be regarded as external to the particle, equation (12) shows that

$$m(xa_y-ya_x)=x(f_y+f'_y)-y(f_x+f'_x)$$

Three equations of this sort can be written for each individual particle since, while this equation is obtained when the moments are reckoned about OZ, the same procedure may be used for OX

or OY.

Imagine that the three equations like the last are written for each particle and that they are then added together. In this way it is found that

$$\left.\begin{aligned}\Sigma m(xa_y-ya_x)&=\Sigma(xf_y-yf_x)+\Sigma(xf'_y-yf'_x)\\ \Sigma m(ya_z-za_y)&=\Sigma(yf_z-zf_y)+\Sigma(yf'_z-zf'_y)\\ \Sigma m(za_x-xa_z)&=\Sigma(zf_x-xf_z)+\Sigma(zf'_x-xf'_z)\end{aligned}\right\} \quad (19)$$

The expression

$$\Sigma(xf'_y-yf'_x)$$

is the sum of the moments about the axis OZ of the internal forces of the aggregate. These forces. however, occur in pairs of which the members are equal in magnitude, colinear and opposite in direction. The moment of one member of such a pair is thus equal and opposite to that of the other so that the total effect of the sum is zero. Equations (19) can therefore be written in the simpler form

$$\left.\begin{aligned}\Sigma m(xa_y-ya_x)&=\Sigma(xf_y-yf_x)\\ \Sigma m(ya_z-za_y)&=\Sigma(yf_z-zf_y)\\ \Sigma m(za_x-xa_z)&=\Sigma(zf_x-xf_z)\end{aligned}\right\} \quad (20)$$

The quantity $m(xa_y-ya_x)$, relating to a particular particle has been shown to equal

$$\frac{d}{dt}[m(xv_y-yv_x)]$$

the rate of change of moment of momentum about OZ. Similar results hold for the other two axes. It follows, then, that equations (20) state that the rate of change of the total moment of momentum of an aggregate of particles about a fixed axis is equal to the sum of the moments of the external forces about that axis.

The principle of the conservation of moment of momentum can now be stated. It is that if the sum of the moments of the external forces about a fixed axis is zero, then the total moment of momentum of the aggregate of particles about that axis is constant.

These considerations of inoments of momentum are fundamental in the discussion of the motions of solid bodies (see DYNAMICS).

The Centre **of** Mass **of a** System **of** Particles. — Let the total mass of a system of particles

$$\Sigma m=m_1+m_2+\ \ldots.$$

be denoted by M and let $\bar{x}$ be defined by the equation

$$M\bar{x}=m_1x_1+m_2x_2+\ \ldots\ =\Sigma mx$$

In just the same way, quantities $\bar{y}$ and $\bar{z}$ can be defined, so that

$$\left.\begin{aligned}\bar{x}&=\frac{\Sigma mx}{M}\\ \bar{y}&=\frac{\Sigma my}{M}\\ \bar{z}&=\frac{\Sigma mz}{M}\end{aligned}\right\} \quad (21)$$

If these equations are differentiated with respect to time, it is found that

$$\begin{aligned}M\frac{d\bar{x}}{dl}&=\Sigma m\frac{dx}{dt}=\Sigma mv_x\\ M\frac{d\bar{y}}{dt}&=\Sigma m\frac{dy}{dt}=\Sigma mv_y\\ M\frac{d\bar{z}}{dt}&=\Sigma m\frac{dz}{dt}=\Sigma mv_z\end{aligned}$$

That is to say, the total momentum of the system in any of the directions OX, OY, OZ is precisely that of a hypothetical particle whose mass is M (the total mass) and which occupies the position defined by the co-ordinates $(\bar{x}, \bar{y}, \bar{z})$. This position is termed the centre of mass of the system. As we shall see. this notion of imagining the total mass to be concentrated at the centre of mass is a useful one.

Another differentiation of these equations reveals that

$$\begin{aligned}M\frac{d^2\bar{x}}{dt^2}&=\Sigma m\frac{d^2x}{dt^2}=\Sigma ma_x\\ M\frac{d^2\bar{y}}{dt^2}&=\Sigma m\frac{d^2y}{dt^2}=\Sigma ma_y\\ M\frac{d^2\bar{z}}{dt^2}&=\Sigma m\frac{d^2z}{dt^2}=\Sigma ma_z\end{aligned}$$

and these results permit us to rewrite equations (17) in a more compact form. To do this, let the sums of all the external forces acting on the system be denoted by

$$\begin{aligned}F_x&=\Sigma f_x\\ F_y&=\Sigma f_y\\ F_z&=\Sigma f_z\end{aligned}$$

It now follows that

$$\left.\begin{aligned}F_x&=M\frac{d^2\bar{x}}{dt^2}\\ F_y&=M\frac{d^2\bar{y}}{dt^2}\\ F_z&=M\frac{d^2\bar{z}}{dt^2}\end{aligned}\right\} \quad (22)$$

The idea of imagining the mass of the system as being concentrated at its centre of mass can non- be taken a stage further. For equations (22) are precisely those of the hypothetical particle when it is imagined as being acted upon by the resultant of all the external forces. these forces all being supposed to act in their correct directions on the hypothetical particle.

An immediate deduction can be made from this. If a system is acted upon by external forces which are such that the sums of their components in the directions OX, OY, OZ are all zero, then the centre of mass of that system must either be at rest or moving with uniform velocity in accordance with Newton's first law. A special case of this arises with a system of particles which is entirely free from external forces.

Since the centre of mass is defined by the co-ordinates $\bar{x}, \bar{y}, \bar{z}$, the co-ordinates of any particle within the system can be measured relative to that point. For instance, the position of the particle m_1 may be specified either as x_1, y,, z_1 or by the co-ordinates

$$\bar{x}+\xi_1;\bar{y}+\eta_1;\bar{z}+\zeta_1$$

That is, if a set of axes, parallel to OX, OY, OZ, were erected with the centre of mass as origin, then the corresponding co-ordinates of m_1 would be ξ_1, η_1, ζ_1. From the definitions of $\bar{x}, \bar{y}, \bar{z}$ it follows that

$$\Sigma m\xi;\Sigma m\eta;\Sigma m\zeta$$

together with their derivatives, must be zero.

If $\bar{x}+\xi, \bar{y}+\eta, \bar{z}+\zeta$ are substituted for x, y, z, in the expressions for the moments of momentum about the fixed axes, it is found that they give

$$\left.\begin{aligned}\Sigma m(xv_y-yv_x)&=M\left(\bar{x}\frac{d\bar{y}}{dt}-\bar{y}\frac{d\bar{x}}{dt}\right)\\ &\quad+\Sigma m\left(\xi\frac{d\eta}{dt}-\eta\frac{d\xi}{dt}\right)\\ \Sigma m(yv_z-zv_y)&=M\left(\bar{y}\frac{d\bar{z}}{dt}-\bar{z}\frac{d\bar{y}}{dt}\right)\\ &\quad+\Sigma m\left(\eta\frac{d\zeta}{dt}-\zeta\frac{d\eta}{dt}\right)\\ \Sigma m(zv_x-xv_z)&=M\left(\bar{z}\frac{d\bar{x}}{dt}-\bar{x}\frac{d\bar{z}}{dt}\right)\\ &\quad+\Sigma m\left(\zeta\frac{d\xi}{dt}-\xi\frac{d\zeta}{dt}\right)\end{aligned}\right\} \quad (23)$$

for the axes OZ, OX, OY respectively.

Consider the first of these results. The quantity

$$M\left(\bar{x}\frac{d\bar{y}}{dt}-\bar{y}\frac{d\bar{x}}{dt}\right)$$

is the moment about OZ of the momentum of a single particle of mass equal to the total mass and which lies at the centre of mass. Again, by analogy with the expression on the left hand side,

$$\Sigma m\left(\xi\frac{d\eta}{dt}-\eta\frac{d\xi}{dt}\right)$$

is the moment of momentum of the aggregate about an axis which passes through the centre of mass and is parallel to OZ. Similar conclusions may be drawn for the other two members of equations (23).

Let the new expressions $\bar{x}+\xi$, etc., be substituted for the x, y and z co-ordinates in equations (20). If the equations are then simplified in the light of the foregoing remarks, they reduce to

$$\left.\begin{aligned}\Sigma m\left(\xi\frac{d^2\eta}{dt^2}-\eta\frac{d^2\xi}{dt^2}\right)&=\Sigma(\xi f_y-\eta f_x)\\ \Sigma m\left(\eta\frac{d^2\zeta}{dt^2}-\zeta\frac{d^2\eta}{dt^2}\right)&=\Sigma(\eta f_z-\zeta f_y)\\ \Sigma m\left(\zeta\frac{d^2\xi}{dt^2}-\xi\frac{d^2\zeta}{dt^2}\right)&=\Sigma(\zeta f_x-\xi f_z)\end{aligned}\right\} \quad (24)$$

These results do not contain the co-ordinates of the centre of mass and we deduce therefore that the motion of the system relative to its own centre of mass can be analyzed independently of the motion of the centre of mass. The latter motion is determined by equations (22). Equations (24), which govern motion relative to the centre of mass, have the same analytical form as equations (20) and they are consequently capable of immediate interpretation. Evidently the rate of change of the total moment of momentum of the system about axes through the centre of mass and parallel to OX, OY, OZ is equal to the total moment of the applied forces about those axes.

The practical significance of a centre of mass is most apparent in the theory of solid bodies. This is demonstrated in the article DYNAMICS and it will be found to have additional significance in the science of statics.

Work and Energy Relations. — When a single particle moves from one position to another, the total work done on it is equal to its increase of kinetic energy. If that particle is one of an aggregate, the forces acting on it will in general be both "external" and "internal." It follows from equation (13) that, for the particle,

$$\Delta(\tfrac{1}{2}ms^2)=\int(f_x+f'_x)dx+\int(f_y+f'_y)dy+\int(f_z+f'_z)dz$$

In words, the increase of the kinetic energy is equal to the total work of the external and internal forces during the displacements in the x, y and z directions (so that appropriate limits are implied on the integrals).

If equations such as this are now added for all the particles, it is found that

$$\Sigma\Delta(\tfrac{1}{2}ms^2)=\Sigma\{\int(f_x+f'_x)dx+\int(f_y+f'_y)dy+\int(f_z+f'_z)dz\} \quad (25)$$

That is to say, the total increase in the kinetic energy of all the particles is equal to the whole work done by all forces as the system moves from one configuration to another.

This important conclusion may be reached in an alternative way. Let each equation of the type (15) be multiplied by the relevant velocity component of the particle concerned. If this is done for all particles and all the resulting equations are added together, it is found that

$$\Sigma m(v_xa_x+v_ya_y+v_za_z)=\Sigma[(f_x+f'_x)v_x+(f_y+f'_y)v_y+(f_z+f'_z)v_z]$$

Now for any particle,

$$v_xa_x=v_x\frac{dv_x}{dt}=\frac{d}{dt}(\tfrac{1}{2}v_x^2)$$

and similar relations hold for v_ya_y and v_za_z. We therefore find that, since the masses m of the particles are all constants, the left hand side of the above equation reduces to

$$\frac{d}{dt}\left\{\Sigma\tfrac{1}{2}m(v_x^2+v_y^2+v_z^2)\right\}$$

But, as we have seen previously, this can be written as

$$\frac{d}{dt}\left\{\Sigma\tfrac{1}{2}ms^2\right\}$$

where

$$\Sigma\tfrac{1}{2}ms^2$$

is the total kinetic energy of all the particles in the system. We therefore have

$$\frac{d}{dt}\left\{\Sigma\tfrac{1}{2}ms^2\right\}=\Sigma[(f_x+f'_x)v_x+(f_y+f'_y)v_y+(f_z+f'_z)v_z] \quad (26)$$

According to this equation, the rate of increase of the kinetic energy of a system is equal to the rate at which the internal and external forces do work. It follows that the increase of kinetic energy in a given period of time is equal to the work done by all the forces in that time.

The centre of mass of a system has importance, not only in momentum — but also in energy considerations. In our previous notation, the kinetic energy of the system is

$$\Sigma\tfrac{1}{2}m\left\{\left[\frac{d}{dt}(\bar{x}+\xi)\right]^2+\left[\frac{d}{dt}(\bar{y}+\eta)\right]^2+\left[\frac{d}{dt}(\bar{z}+\zeta)\right]^2\right\}=T \text{ (say)}$$

If this expression is now simplified by the previous method, it is found that the kinetic energy reduces to

$$T=\tfrac{1}{2}M\left[\left(\frac{d\bar{x}}{dt}\right)^2+\left(\frac{d\bar{y}}{dt}\right)^2+\left(\frac{d\bar{z}}{dt}\right)^2\right]+\Sigma\tfrac{1}{2}m\left[\left(\frac{d\xi}{dt}\right)^2+\left(\frac{d\eta}{dt}\right)^2+\left(\frac{d\zeta}{dt}\right)^2\right] \quad (27)$$

The kinetic energy of a system of particles is therefore equal to that of the hypothetical particle M which is placed at the centre of mass (as explained before) plus the kinetic energy of the particles as it would be calculated by an observer moving with the centre of mass.

The notion of work done by the external forces acting on a system is of very great importance. In particular. it provides a link between mechanics and the more general subject of thermodynamics and the nature of this connection will next be described very briefly.

The thermodynamic state of a body, isolated as before by a chosen boundary. is determined by the values of the properties (such as temperature) of its parts whereas its mechanical state is determined merely by the motions or configurations of its parts. In mechanics, we conceive of external forces acting on this system (*i.e.*, on the body) which can do work; this work is done "on the system" and may be thought of as crossing the bounding surface. In thermodynamics (*q.v.*), on the other hand, "heat" is also conceived of as being able to cross this surface.

Let the heat flow into the system be Q and the work done on it by the external forces be W, both processes being measured over some given period. The First Law of Thermodynamics states (in effect) that

$$Q+W=\Delta E \quad (28)$$

where ΔE represents the gain of total internal energy of the system. This increase of E may be manifested in several ways. of which one is an increase of kinetic energy. Its value will, in general. alter as a result of work done against internal forces. Thus, in mechanics, it can be said that we merely take account'of W on the left hand side of equation (28) and certain forms of internal energy E on the right. This being so, we make the reservation that our theory may be incomplete since heat flows Q and extraneous forms of internal energy are not accounted for. For instance, if a piece of metal is struck repeatedly, its temperature is found to rise with the result that heat flows out of the body; under these circumstances, it is not possible to account completely, in equation (25), for all the work done by the external forces.

The concept of work done by internal and external forces is of fundamental importance in all branches of applied mechanics. An

important extension of the concept is dealt with in the next section and the treatment is again given in terms of collections of particles. That is. the results given may be further refined and adapted for use in particular branches of applied mechanics.

THE PRINCIPLE OF VIRTUAL DISPLACEMENTS

In considering the mechanics of collections of particles, we have deduced certain general results (such as the principle of conservation of linear momentum) which furnish a basis for the study of the mechanics of various types of body. We come now to discuss another principle of mechanics which serves the same purpose; it is that of virtual displacements. This principle is sometimes regarded as being axiomatic, but we shall explain it by reference to the foregoing theory: Thus we shall continue to consider collections of particles and shall derive results with some generality.

The principle of virtual displacements is concerned essentially with systems of particles which are in equilibrium, that is, with statics. But it may be noticed, parenthetically, that this does not preclude its use in' dynamics; for it is possible, by invoking D'Alembert's principle (see DYNAMICS), to solve dynamical problems by the methods of statics.

Statement of the Principle for a System of Particles.— The validity of equations (15) is not impaired if they are multiplied throughout by some numerical factor. Thus if the particle m_1 is in static equilibrium, they give

$$\left.\begin{aligned} a_1[(f_x)_1+(f'_x)_1]&=0\\ b_1[(f_y)_1+(f'_y)_1]&=0\\ c_1[(f_z)_1+(f'_z)_1]&=0 \end{aligned}\right\}$$

Similar equations may be written in sets of three for each of the other particles. If these equations are added together, they give, for an aggregate of particles at rest

$$\left.\begin{aligned} \Sigma[a(f_x+f'_x)]&=0\\ \Sigma[b(f_y+f'_y)]&=0\\ \Sigma[c(f_z+f'_z)]&=0 \end{aligned}\right\} \qquad (29)$$

We may give a physical interpretation to the numbers a, b, c if we wish. For instance, they can be regarded as components of displacement. Thus a_1, b_1 and c_1 can be thought of as displacements of the particle of mass m_1 in the directions OX, OY and OZ respectively. These displacements are not to be confused with the actual displacements of which the body is capable because we do not contemplate the changes of the force components which usually accompany a change of position. They are therefore referred to as virtual displacements.

Equations (29) tell us that the total work done by external forces plus the total work done by internal forces is nil for any arbitrary virtual displacement of the constituent particles, if the system is in equilibrium. Conversely, we can deduce that a system of particles is in equilibrium if the total work done by all external and internal forces is nil during any arbitrary virtual displacement.

may very well seem unnecessarily complicated to use this last result as a criterion of equilibrium instead of the simpler one from which we started — that is, instead of the equations

$$\left.\begin{aligned} f_x+f'_x&=0\\ f_y+f'_y&=0\\ f_z+f'_z&=0 \end{aligned}\right\} \qquad (30)$$

relating to each particle separately. The purpose of doing so becomes more apparent, however, if we introduce the concept of constraints. In fact, the principle of virtual displacements is capable of considerable development and is one of the most powerful tools of applied mechanics, being notably useful in structural analysis.

Imposition of Constraints.— In order to establish, by the method of virtual displacements, that a system of discrete particles is in equilibrium it is necessary to consider a number of arbitrary displacements, the number being dependent on the number of particles. If there are n particles, then $3n$ independent virtual displacements must be examined.

Normally, however, problems do not present themselves in this form because constraints exist between particles. Suppose for instance that a body may be regarded as rigid. That is to say, constraints are imposed on the constituent particles so as to fix their relative positions. Now virtual displacements of the particles can be chosen in such a way as to conform with these constraints. so that the relative positions of the particles remain unaltered. (Some writers prefer to reserve the adjective "virtual" for displacements of this restricted type.) But if this is the case, and there is no rotation, the work of the internal forces is zero because

$$\Sigma af'_x = \Sigma bf'_y = \Sigma cf'_z = 0$$

The principle of virtual displacements for a single rigid body then states that the work of the external forces in a virtual displacement that does not involve rotation from a position of equilibrium must be zero.

As a simple example of this method's use, consider the equilibrium of a pencil which is assumed to be rigid and which is lying on a horizontal table. The pencil is subject to the reaction R of the table and to the attraction W of the earth (its weight) and is known to be in equilibrium. If the pencil were to be pressed down onto the surface, the reactive force would increase to compensate for the added downward thrust; only a slight depression of the surface would account for a large increase of R.

If, in contrast, the displacement is a virtual one of magnitude a, the forces R and W remain constant and the virtual work is $Wa - Ra = 0$. Since a is not zero: we conclude that W and R are of equal magnitude in the equilibrium position.

Some idea of the importance of this principle can be seen when the methods of statics are applied to several connected bodies, as in a mechanism. In the first place, the entire mechanism can be regarded as a collection of particles so that the theory of the preceding section still holds good. The forces between adjoining bodies are internal to the whole system and, in the absence of friction, may even be such as not to do work during a virtual displacement of the whole system. In this event, there is no need to determine the forces between individual parts when examining the equilibrium condition of the whole mechanism by the method of virtual displacements; this would be necessary, on the other hand, if the equilibrium of the various component bodies had to be analyzed separately and then the conditions examined by which they fit together. It may be mentioned that. for reasons which need not concern us here. it is usually convenient to make the virtual displacements small in problems of this sort.

THE APPLICATION OF MECHANICS TO REAL PROBLEMS

Certain principles governing the motion of the bodies which are to be found in nature have been deduced from Newton's laws under the assumption that the bodies may be regarded, for the purposes of analysis, as aggregates of particles. Having deduced these principles we now suppose that, in making use of them, we may discard the assumption and treat bodies as if they were continuous. We now examine briefly some of the matters that this raises.

The ways in which the principles of mechanics can best be applied in a given problem depend upon the nature of the system concerned. For instance, fluid "bodies!' have no characteristic shape so that the methods of fluid mechanics differ somewhat from those of solid mechanics. For detailed descriptions of the various techniques of applied mechanics, reference should be made to the appropriate entries in this encyclopaedia. Certain elementary matters may properly be dealt with here, however, in order that the reader may gain some idea of the ways in which analytical mechanics is used; and, for the purposes of discussion, we shall merely distinguish crudely between fluids and solid bodies.

Solid Bodies.—The assumption that bodies may be regarded as being continuous leads to the concept of stress. Suppose that a body B (fig. 14) has a distribution of force (that is, of "surface traction") applied to its bounding surface. Consider a small area δA of this surface and suppose that a resultant force δF acts upon it. In general this force will not be normal to the surface so that it can be resolved into components δF_n and δF_t which are normal and tangential to δA respectively. The ratios

$$\frac{\delta F_n}{\delta A} \text{ and } \frac{\delta F_t}{\delta A}$$

are referred to as the average normal stress and average shear stress respectively at the point of the surface of B where δA is selected. By taking δA indefinitely small, we arrive at the definition of normal stress a and shear stress τ. They are given by

$$\sigma=\lim_{\delta A\to 0}\left(\frac{\delta F_n}{\delta A}\right);\quad \tau=\lim_{\delta A\to 0}\frac{\delta F_t}{\delta A} \tag{31}$$

The body B of fig. 14 is determined entirely by the position of the chosen bounding surface. This surface can, in fact, isolate complete components, assemblies of components, or parts of components. Thus we can discuss the mechanics of, say, a vibrating bridge composed of many members, of a single member taken from the bridge or of a portion of the bridge which is imagined as being cut from the remainder by severing several of the members.

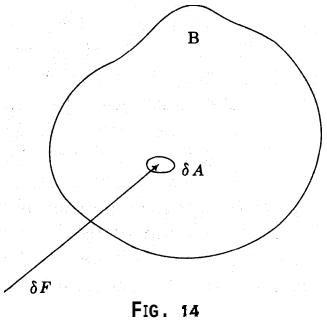


FIG. 14

Imagine an actual body A to be separated into parts B and C in this way. The distribution of force acting on B at the cut must evidently be applied by C. The stresses at any point of the cut are internal to the entire system A and a knowledge of their numerical values may be of technical importance in calculations of strength. Thus it is sometimes necessary to investigate the distribution of force acting at one of these imaginary divisions. The systems B and C (which, together, form A) have each to satisfy conditions like those of equations (17) and (20), no matter where the division of A is made; these are sometimes called conditions of equilibrium.

The internal stresses of A are associated with distortion so that both B and C are distorted. The two portions of A must obviously be distorted in such a way that they always fit together. (This is so that they can always be combined again to form A. They are only separated in imagination.) The conditions of equilibrium are evidently not enough and it is necessary that B and C should also satisfy conditions of compatibility.

The relationships that may exist between the stresses in **A** and its distortion are dealt with in the articles on ELASTICITY; MATERIALS, STRENGTH OF, etc.

All the bodies found in nature are capable of being distorted. To some extent, this will usually influence the conditions under which the bodies move. or remain at rest under the influence of external forces. Very often, however, the effect is small and can be disregarded so that for the purposes of analysis a body may sometimes be regarded as rigid.

Consider, for instance, the flight of a bullet. In calculating the trajectory of a bullet, we are not interested in the internal distortions which may occur while it is in flight and, since these are not likely to affect its path materially, we make the assumption that the bullet is rigid. But if the process of impact of this same bullet is to be analyzed, then clearly the assumption of rigidity must be discarded. It is not uncommon to treat bodies as if they are rigid in some parts of a calculation and to make allonance for their deformation in others where it matters.

It is worth recalling that we do not set out to find anything so complicated as the complete solution of a physical problem. Indeed, even if this could be done. most of the data found would be quite valueless.

The importance of the assumption of rigidity in mechanics is due to the great simplification that it permits of the general equations that we have derived for a system of particles. In fact, the six momentum equations of the types (1;) and (20) become sufficient in number completely to determine the motion of a rigid body Further, the kinetic energy of a rigid body, like its momentum, is not influenced by the internal forces. These matters are taken up in the article on DYNAMICS.

Fluid Mechanics. — Problems of fluids at rest are dealt with in the science of hydrostatics (see MECHANICS, FLUID); they introduce no fundamentally new concepts. We now refer briefly to the flow of fluids.

When a fluid flows, it must satisfy certain kinematical conditions and conform with the principles of kinetics which have been discussed. These requirements are dealt with in greater detail in the article MECHANICS, FLUID and we shall merely confine our attention here to one particular concept, namely that of a control volume, which is particularly suited to problems of fluid flow.

For the purposes of discussion consider the momentum equation (17) in the form

$$F_x=\frac{d\mathcal{M}_x}{dt} \tag{32}$$

In words, the resultant external force F, in the x direction is equal to the rate of increase of the total momentum $\mathcal{M}_x$ in the x direction of the system upon which it acts. In order to apply this result to a body of fluid in motion. it is necessary first to decide what is to be the system. Following the previous arguments, attention can be focused upon individual elements of fluid and their history is then made the object of analysis. It is usually more profitable in fluid mechanics to investigate, rather, the conditions at points in the flow at any instant. Let the system be defined therefore as the matter lying within a fixed boundary surface A (which determines a control volume) at some instant t_1 (fig. 15). Conditions within the control volume can now be adopted as the object of investigation. Consider the change of momentum that this system suffers in some arbitrarily chosen direction x during a short time interval δt $(=t_2-t_1)$.

At time t_2, the boundary of the system will no longer coincide with A, but will occupy some other position B. The value of $\mathcal{M}_x$ relating to that part of the system (shown hatched) which lies outside A at time t_2 will be referred to as $(\delta\mathcal{M}_x)_{\text{out}}$. The fluid which has entered A at time t,, (shown crosshatched), but which is not part of the system, will be said to have total x momentum equal to $(\delta\mathcal{M}_x)_{\text{in}}$.

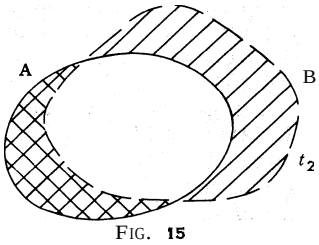


FIG. 15

If the momentum in the x direction of all the fluid occupying A at any instant is denoted by $\mathcal{M}'_x$, the change of momentum of the chosen system may be expressed in the form

$$\delta\mathcal{M}_x=(\mathcal{M}_x)_2-(\mathcal{M}_x)_1=[(\mathcal{M}'_x)_2+(\delta\mathcal{M}_x)_{\text{out}}-(\delta\mathcal{M}_x)_{\text{in}}]-(\mathcal{M}'_x)_1$$

When divided throughout by δt, this becomes

$$\frac{\delta\mathcal{M}_x}{\delta t}=\frac{(\mathcal{M}'_x)_2-(\mathcal{M}_x)_1}{\delta t}+\frac{(\delta\mathcal{M}_x)_{\text{out}}-(\delta\mathcal{M}_x)_{\text{in}}}{\delta t}$$

If we now proceed to the limit as $\delta t\to 0$ we have the rate of change of momentum of the system in the x direction expressed as the sum of the rate of change within the stationary control volume and of a derivative which may be regarded as representing a net rate of flow of x momentum out through the surface A. The result can be written

$$F_x=\frac{d\mathcal{M}'_x}{dt}+\frac{d(\mathcal{M}_x)_{\text{net out}}}{dt} \tag{33}$$

The nature of a flow of fluid may be such as to permit some simplification of this result. To take a very simple problem, consider the steady flow of a fluid round a horizontal right-angle bend in a uniform pipe, as in fig. 16. Since the fluid changes direction, it must suffer a change of momentum and hence be subjected to forces; these act on the wall of the pipe and. if the bend is to remain stationary, they must be balanced by forces transmitted from the adjoining lengths of pipe and distributed over the ends of the wall of the bend at sections 1 and 2. The control volume can conveniently be selected so that it includes both the bend in the pipe and the fluid contained in it. Let the force which must be exerted on the bend by the adjacent pipes have a component R_x acting in the direction indicated.

The x component F, of the resultant external force is given by

$$F_x = (\sigma_1 - \sigma_a)A - R_x$$

Here σ_1 is the compressive stress or pressure of the fluid at section 1, supposed uniform over the cross-sectional area A, and σ_a is the air pressure. The first of the two derivatives on the right hand side of equation (38) is zero if steady. The second represents the net rate at which x momentum leaves the pipe bend and this is equal to $-\rho AV$ (the mass entering the control volume per unit time) multiplied by its velocity V (which is assumed to be uniform across the cross section); the density p of the fluid is here assumed to be constant. We therefore reach the conclusion that

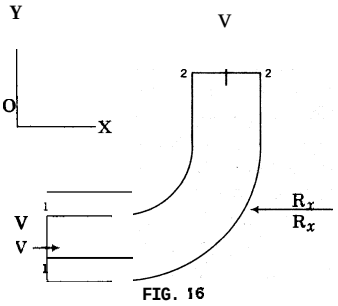


FIG. 16

$$(\sigma_1 - \sigma_a)A - R_x = -\rho A V^2$$
$$R_x = (\sigma_1 - \sigma_a)A + \rho A V^2$$

The notion of a control surface is widely used in fluid mechanics, not only in considerations of momentum, but also in energy equations which are concerned with work and considerations of continuity in which expression is given to the fact that fluid is neither created nor destroyed during the course of its motion.

THE BREAKDOWN OF NEWTONIAN MECHANICS

In spite of its immense successes, classical—that is, Newtonian—mechanics breaks down, and it does so when it is applied to motions of the very large, of the very small and to motions of very high speed. These failures of the theory have given rise to relativity theory and to quantum mechanics (*qq.v.*). Both of these new theories arose mainly out of conflicts between the predictions of classical mechanics and the observed behaviour of electromagnetic waves and, in particular, of light.

Relativity Theory.—In early electromagnetic theory, it was postulated that some transmitting medium was necessary for the transmission of light. This transmission was supposed to be in the form of light waves which were undulations in an all-pervading medium called the ether. By supposing this medium to have certain mechanical properties, and in particular that of elasticity, certain properties of these waves were deduced on the basis of classical mechanics. It was supposed that the velocity of light relative to the medium mas the same in all directions. If this velocity is denoted by *c*, then, according to elementary kinematics. an observer moving relative to the ether along the track of a light wave with velocity v should observe that the light has a velocity $c - v$ along his direction of motion because he is tending to overtake the wave. In the opposite direction it should be $c + v$, and at right angles the unchanged velocity *c*.

This lends itself to experiment. Suppose that two pulses of light are sent out in directions at right angles to each other. one along the direction of motion and one at right angles to it (as in fig 17) from a source O which is in motion uith velocity v. Then if M_1 and M_2 are two mirrors, each at a distance d from 0, the times t_1 and t_2 for the two pulses to return to O are

$$t_1 = \frac{d}{c+v} + \frac{d}{c-v}\,;\; t_2 = \frac{2d}{}$$

Unless v = o, t_1 differs from t_2 so that we have a possible way of measuring v. Experiments based upon this idea were performed by A. A. Michelson and E. W. Morley just before the end of the 19th century to determine the value and direction of v, the velocity of their terrestrial source O. They found that their laboratory was stationary with respect to the ether. Now the earth moves round the sun at about 18½ mi. per second so they waited six months, when they expected that the laboratory would be moving at 37 mi, per second through the ether. But again they found no evidence of motion.

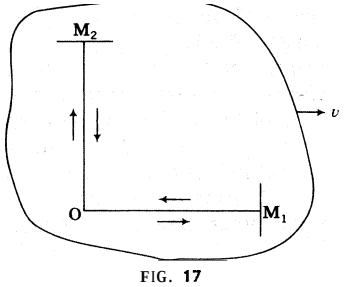


FIG. 17

This paradox nas resolved by Einstein in his Special Theory of Relativity. In this theory, the relative velocity of two bodies moving along the same track with velocities v_1 and v_2 is not $v_1 - v_2$, in accordance with elementary kinematics, but

$$\frac{v_1 - v_2}{1 - \left(\frac{v_1 v_2}{c^2}\right)}$$

with c the velocity of light. If v_1 = c, the relative velocity is c also. So the velocity of light is the same relative to all observers, which is the explanation of the Michelson-Morley ,experiment. For two airplanes moving in opposite directions with velocities of 1,000 m.p.h., the correction is about 2 parts in a million million. This, of course, is quite negligible. However, the consequences of the new law of composition of velocities are very important in discussions of the motion of high-speed atomic particles and the law is then found to be in complete agreement with experiment. Other experiments have yielded abundant proof of the truth of Einstein's theory, although its observable consequences are largely, though not wholly, confined to the behaviour of bodies moving with a velocity approaching that of light.

Modern physical theory no longer requires the existence of an ether for the transmission of light so that classical mechanics is not now used to explain the passage of light waves in terms of the wave motions of an elastic medium. But, in disposing of the need for using the Newtonian theory, Einstein introduced results (such as that quoted for a relative velocity) which do not conform with classical mechanics.

Einstein also extended his theory to the so-called General Theory of Relativity. This is essentially a theory of gravitation. Some of the motions of the planets, especially of Mercury, cannot be completely explained by Newton's laws. It was suggested by U. J. J. Leverrier that the anomalous motion of Mercury could be explained by the influence of a small planet nearer the sun. However, that planet has never been seen and it was thought in the late 1950s that it is more likely that the explanation lies in the breakdown of Newton's law of gravitation. Although far from certain, Einstein's General Theory of Relativity appears to give the most probable explanation at the present time.

Quantum Mechanics.—The breakdown of Newtonian mechanics when it is applied to very small bodies was discovered by Lord Rayleigh and Sir James Jeans, again on the basis of calculations relating to the ether. Their calculations referred, in fact, to the energy of electromagnetic waves (*i.e.*, light waves, radio waves, etc.) when they are propagated through the ether. They found the energy to be infinite. As this infinite energy was associated with the very short wave (*i.e.*, ultraviolet) region of the spectrum, the result was picturesquely termed the "ultraviolet catastrophe."

The explanation of this anomaly was given by M. Planck in 1902 and it is concerned with the so-called "quantization of energy." Although it is in contradiction with certain of the concepts of Newtonian mechanics, Planck's theory has been found to be in accord with experimental observations made on very small systems such as electrons or atoms. Its usefulness has not been impaired by the iact that the notion of an ether has now been generally discarded.

Later physical researches have led to the conclusion that Planck's theory, which has given rise to the study of quantum mechanics, is a refinement of the Newtonian scheme and that the latter can be regarded as a sort of "average" theory, valid for all bodies except those which are very small (and those whose behaviour requires use of relativity theory).

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(1929), an advanced textbook which may be regarded as a continuation of the previous two. J. C. Hunsaker and B. G. Rightmire, *Engineering Applications of Fluid Mechanics* (1947), an advanced textbook devoted to the practical aspects of fluid mechanics; it has a good introduction to the principles involved. René Dugas, *A History of Mechanics*, trans. by J. R. Maddox (1957). This is an advanced book devoted to the history of all branches of mechanics. (R. E. D. B.)

MECHANICS, FLUID, is the branch of engineering science dealing with the motion of fluids and the conditions governing such motion. The general term mechanics includes both kinematics and dynamics. Kinematics, which deals with the geometry of motion, is concerned with how fluids move; dynamics, with the forces involved in the motion. Sometimes a particular phase of fluid mechanics is given a particular name. The word hydraulics may refer to the study of some liquid, such as water or oil; pneumatics, to the study of compressed air; and hydrodynamics, to the purely theoretical study of some type of flow, such as that of an incompressible fluid.

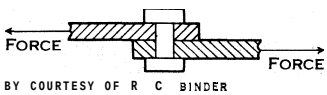

FIG. 1.—FORCES ACTING ON TWO PLATES JOINED BY A PIN

A fluid is a substance which cannot sustain tangential or shear forces when in static equilibrium. This property of action under shear forces distinguishes between the solid and fluid states. Fig. 1 illustrates two plates joined by a solid pin, bolt or rivet. The two parallel forces tend to slide one plate with respect to the other; these are shear forces. For small forces the solid pin or bolt sustains shear forces in static equilibrium. If a fluid such as water, oil or air were substituted for the solid pin, there would be relative motion of the plates, even for extremely small forces. The fluid could not sustain the shear forces and keep a static equilibrium. Fluids are usually divided into two subclasses: liquids and gases. A liquid occupies a definite volume independent of the dimensions of the container which holds it. A gas, however. expands to fill any container in which it is placed. In a liquid the spacing between molecules is closer than that in a gas.

In many cases liquids may be regarded as incompressible. In some cases, however, the compressibility of a liquid is important and cannot be neglected. In most cases gases are regarded as compressible. In some cases the pressure change and velocity is so small that the gas may be regarded as incompressible.

It is customary in fluid mechanics to regard fluids as continuous media. Actually, gases and liquids consist of molecules and atoms. Fluid properties and actions are directly related to molecular behaviour. In most cases of flow, however, the mean free path of the molecule is small in comparison with the distances involved; thus the flow actions can be studied by reference to bulk properties.

Historical Background.— Edme Mariotte, a priest and one of the founders of the French Academy, by his interest in the ornamental waterworks at Versailles was stimulated to some of the first important contributions to the study of fluid friction. His *Traité du mouvement des eaux et des autres corps fluides* appeared in 1686, one year before the publication of Isaac Newton's *Principia.* In this treatise, Mariotte dealt with the theory and practice of hydrodynamics, offering not only mathematical formulas but experimental data on such problems as the measurement of the strength of water pipes. Mariotte devised the hydrodynamic technique by which a model is held stationary in a stream of fluid and the drag is measured by a weighing instrument.

Newton, analyzing the phenomenon later known as the internal friction of fluids. used the term attrition to identify it. In *Hydrodynamics* (Dover Publications, Inc., New York, 1956). by H. L. Dryden, F. D. Murnaghan and H. L. Bateman, Bateman points out: "The use of the word attrition has now gone out of fashion in this country, and the word friction is generally used instead. The use of the word friction is, perhaps, unfortunate because, in the first place, the laws of fluid friction are quite different from those of solid friction, and secondly, because there are really two types of internal friction in a fluid, the molar and the molecular." (Molar friction is characteristic when the motion of the fluid is irregular or turbulent. Molecular friction is characteristic nhen the motion of the fluid is of the steady type described as streamline or laminar flow.)

Daniel Bernoulli, who made important contributions to modern hydrodynamics, constructed his theories around the concept of a continuous fluid supposedly having no viscosity. For the "ideal" fluid he established the Bernoulli equation, a mathematical interpretation of the law of the conservation of energy. The equation, published in his *Hydrodynamica* in 1738, offers a method of calculating the potential energy in motion of fluids.

The mathematical formulas of Bernoulli and others, to gauge the resistance of a theoretical ideal or perfect fluid, have been productive of results remarkably close of those observed in actual fluids under experimental conditions. In this connection, Theodore von Kármán says in *Fluid Mechanics and Statistical Methods in Engineering,* p. *26* (University of Pennsylvania Press, Philadelphia, 1931): "One of the most surprising developments in modern fluid mechanics is the successful application of the theory of potential motion of ideal incompressible fluids to the actual flow of air around airfoils and streamlined bodies. A few decades ago the potential theory was considered as a purely mathematical discussion."

The following discussion is divided into two main parts. The first section, *Basic Relations,* covers laws and features that hold in any case of flow; the second, *Applications,* deals with special cases of flow, and shows applications of the basic relations.

See also AERODYNAMICS; HYDRAULICS, APPLIED.

BASIC RELATIONS

Definitions — The specific weight w of a fluid is defined as weight per unit volume. Specific weight depends on the particular fluid, the pressure and the temperature. Water at 14.7 lb. per square inch absolute and 59° F. has a specific weight of about 62.4 lb. per cubic foot. Air at 14.7 lb. per square inch absolute and 59° F. has a specific weight of 0 0765 lb. per cubic foot.

A path line is a line made by a single particle as it moves over a period of time. The trace made by a single carbon particle as it leaves a smokestack, for example. would be a path line. A streamline is a line that gives the fluid velocity direction at each point along the line. Imagine a group of particles at an instant in a body of flowing fluid. Imagine that a straight line is drawn at each point showing the direction of the instantaneous velocity at each point. A continuous curve tangent to each of these straight lines would be a streamline. Steady flow is defined as a flow in which the velocity, pressure, specific weight and other such characteristics at a point do not change with time. Streamlines and path lines are identical in steady flow.

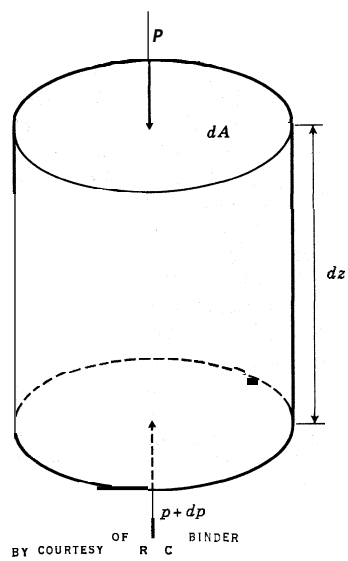

FIG. 2.— INFINITESIMAL ELEMENT IN A STATIC FLUID (*see* TEXT FOR FURTHER EXPLANATION)

Fluid Statics.— Statics refers to a study of the conditions under which a body or a particle remains at rest. The state of rest may be regarded as a special case of motion. If a body or particle is at rest with a certain set of forces, the forces are said to be in equilibrium or the body is said to be in static equilibrium.

Imagine a body of any static fluid. Picture an infinitesimal element in this fluid, as illustrated by fig. 2; dA is an infinitesimal area, dz is a change in vertical distance z, with z measured positively upward, p is the pressure on the top surface and $p + dp$ is the pressure on the bottom surface, the pressure increase dp being due solely to the fluid weight. The weight of the element is $wdzdA$. Balancing forces in a vertical direction gives

$$dpdA = -wdzdA$$
$$dp = -wdz \qquad (1)$$

The minus sign indicates that the pressure decreases with an increase in height. Equation (1) is the basic equation of fluid statics. It shows that the pressure decreases in the upward direction, the decrement per unit length being equal to the weight per unit volume. The pressure change dp is zero when dz is zero; the pressure is constant over any horizontal plane in a static fluid. Equation (1) can be used for any fluid and any application in statics.

Buoyancy. — When a body is completely or partly immersed in a static fluid, every part of the surface in contact with the fluid is pressed on by the fluid; the pressure is greater on the parts more deeply immersed. The resultant of all the forces exerted by the fluid pressure is an upward, buoyant or lift force.

The fluid pressure on each part of the surface of the body is independent of the body material. Imagine the body, or as much of it as is immersed, to be replaced by fluid of the type surrounding the body. This substituted fluid will experience the pressures that acted on the immersed body; the substituted fluid will be at rest. Therefore, the resultant upward force on the substituted fluid will equal its weight, and will act vertically through its centre of gravity.

Thus, following Archimedes' principle, a body immersed in a fluid is acted upon by a buoyant or lift force equal to the weight of the displaced fluid. This static lift force acts through the centre of buoyancy, which is the centre of gravity of the displaced volume.

There are various applications of Archimedes' principle. The volume of any solid body can be determined by measuring its apparent loss of weight when the body is completely immersed in a liquid of known specific weight. Let W_2 be the weight of the body in the liquid, let W_1 be the weight of the body in air, let w be the specific weight of the liquid and V the volume of the body. The buoyant force of the liquid equals $W_1 - W_2$, or wV. Thus. the volume can be found from the relation $V = (W_1 - W_2)/w$.

Another application is the hydrometer, a convenient instrument for measuring the specific weight of a liquid. The usual hydrometer has a hollow glass chamber, weighted at the bottom, with a graduated stem at the top. When placed in liquid, the hydrometer sinks until it displaces its own weight of liquid. If the hydrometer is properly calibrated, the specific gravity of the liquid can be read directly where the stem projects through the liquid surface. The specific gravity is defined as the ratio between the specific weight of a substance divided by the specific weight of some standard substance, as water.

Imagine a body at rest partly or completely immersed in a static fluid. There are two forces acting on this body; the downward force of the body ueight and the upward buoyant force. The body weight acts vertically downward through the centre of gravity of the body, whereas the buoyant force acts vertically upward through the centre of buoyancy. The term static stability refers to the initial tendency of the body to move away or to return to the equilibrium condition after a disturbance.

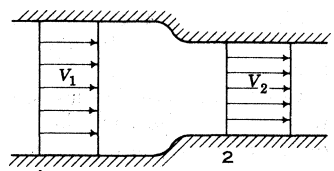

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FIG. 3.—FLOW CHANNEL

A body is statically stable when there is an initial tendency to return the body toward its equilibrium position after being slightly displaced. The equilibrium of a completely immersed body is stable when the centre of buoyancy is above the centre of gravity. It such a body is tilted, forces are developed which tend to swing the body back to its original position. Examples of such bodies are submarines and balloons.

A body is unstable if it continues moving away from the balanced state after being slightly displaced. A partly immersed body, as a marine vessel, may be unstable.

Equation of Continuity.-Fig. 3 illustrates the steady flow through a channel. At section 1 the area is A_1, the velocity at each point over the area is V_1 and the specific weight is w_1. At section 2 the area is A_2, the velocity at each point over the area is V_2 and the specific weight is w_2. The general physical law of the conservation of matter gives the so-called equation of continuity

$$A_1 V_1 w_1 = A_2 V_2 w_2 \tag{2}$$

If the area A is in square feet, the velocity V in feet per second and the specific weight w in pounds per cubic foot, then the product AVw is in pounds per second; this is weight rate of flow. For steady flow, with no destruction or creation of matter, the weight rate entering must equal the weight rate leaving. For liquids and gases which can be regarded as incompressible, w is constant and equation (2) takes the special form

$$A_1 V_1 = A_2 V_2 \tag{3}$$

If the area A is in square feet and the velocity V in feet per second, then the product AV is in cubic feet per second. This product is volume rate of flow.

Dynamic or Momentum Equation. — Let m represent the mass of a body, F the net or resultant of the external forces acting on a body, V the instantaneous linear velocity, t time and dV/dt the acceleration. Then a basic relation in both solid-body and fluid mechanics is the dynamic equation

$$F = \frac{m dV}{dt} \tag{4}$$

In one set of units, a force of one pound acting on a mass of one slug accelerates the mass one foot per second each second; this relation might be considered a definition of the unit slug. In another set of units, a force of one dyne acting on a mass of one gram accelerates the mass one centimetre per second each second. Equation (4) can be put in an alternate form. The product mV is called linear momentum. Then

$$F = \frac{d}{dt}(mV) \tag{5}$$

Force equals the time rate of change in linear momentum.

Fig. 4 illustrates the steady flow of a jet or stream of fluid from a fixed nozzle. The stream strikes a fixed vane or blade and is deflected. The velocity of the fluid before striking the fixed vane is V_1, the velocity after leaving the vane is V_2. The force F of the vane on the fluid is in the same direction as the vector difference $V_2 - V_1$. Let Δt represent the time interval in which the mass m has its velocity changed from V_1 to V_2. Then the dynamic equation becomes

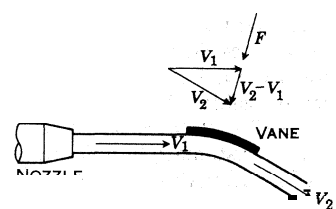

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FIG. 4.—JET AND VANE ACTION

$$F = \frac{m}{\Delta t}(V_2 - V_1) \tag{6}$$

Force equals mass rate of flow times velocity change.

In the preceding discussion the net force F is an external force acting on the fluid. In some treatments it is convenient to deal with the inertia force. The inertia force refers to the resistance of an inert mass to acceleration. The magnitude of the inertia force is equal to the product of particle mass and the particle acceleration. The direction of the inertia force is opposite to the direction of the particle acceleration.

Density. — A body of mass m has a weight of mg, where g is the gravitational acceleration. In one set of units g is usually taken as 32.2 ft. per second per second. In another set of units g is usually taken as 981 cm. per second per second. Density p is defined as mass per unit volume; p could be expressed in slugs per cubic foot or in grams per cubic centimetre. The relation between density and specific weight w is

$$\rho = \frac{W}{g} \tag{7}$$

Air at 59° F. and 14.7 lb. per square inch absolute has a density of 0.002378 slug per cubic foot.

Energy Equation. — The technical term "work" is defined as

the product of a force times displacement, with the force acting in the direction of the displacement. Work may be expressed in such units as foot-pounds or centimetre-dynes. The energy of a body is defined as the capacity of the body for doing work. A body may have energy because of a variety of states or conditions of the body. The potential energy of a body is the energy of that body due to its position. A body of weight W at a height z above some arbitrary datum has potential energy equal to Wz with respect to that datum. If the body were moved to a lower level, potential energy could be converted into work. Consider a body of mass m moving with the velocity V with respect to some reference, as the earth. This body has a certain kinetic energy; it has the capacity to do work against forces which change its motion. Application of the dynamic equation shows that the kinetic energy is $\frac{1}{2}mV^2$; if the body were brought to rest, the amount $\frac{1}{2}mV^2$ would be available for conversion to work. The internal or intrinsic energy of a substance is thermal energy stored within the substance, and is due to the spacing and activity of the molecules. Heat or heat transfer is defined as thermal energy in transition as a result of a temperature difference between two bodies. A unit of quantity of heat is the British thermal unit, B.Th.U. This is defined as the heat which must be transferred to raise the temperature of one pound of water one degree Fahrenheit. Measurements indicate that *1* B.Th.U. is approximately equal to 778 ft.lb.; this quantity is sometimes called the heat equivalent of work.

Fig. 5 shows the notation for the steady flow of any fluid through any apparatus. Fluid enters at section 1 and leaves at section 2. An energy balance will be made for unit weight of fluid passing through. An accounting of energy and work shows that the heat added to the fluid plus the total work done on the fluid must equal the total gain in energy of the fluid. Let q represent the heat transfer to the fluid, p the pressure. w the specific weight, W the net mechanical shaft work done on the fluid by external machines, u the internal energy, V the linear velocity at each point over a section, z the elevation above some datum, g the gravitational acceleration and J the heat equivalent of work. Subscript *1* refers to inlet; subscript 2 refers to exit. The energy equation then becomes

$$q + \frac{p_1}{w_1 J} - \frac{p_2}{w_2 J} + \frac{W}{J} = u_2 - u_1 + \frac{V_2^2 - V_1^2}{2gJ} + \frac{z_2 - z_1}{J} \qquad (8)$$

As an example of units, let us take q in B.Th.U. per pound, p in pounds per square foot, w in pounds per cubic foot, V in feet per second, g as 32.2 ft. per second per second and z in feet. Then J is approximately 778, and each term in equation (8) is in B.Th.U. per pound of fluid flowing from section 1 to section 2.

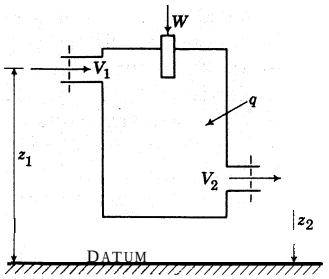

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FIG. 5.—NOTATION FOR ENERGY EQUATION

Work W is positive for a pump, fan or compressor and negative for a fluid turbine. The term p_1/w_1 is called flow work, or the work done in pushing unit weight of fluid across the inlet. The term p_2/w_2 is the work done in pushing unit weight of fluid across the exit.

In some cases it is convenient to regroup certain terms. The term enthalpy h is defined as

$$h = u + \frac{p}{wJ}$$

Enthalpy is simply a quantity established by arbitrary definition for the sake of convenience. Equation (8) can be written in the alternate form

$$q + \frac{w}{J} = h_2 - h_1 + \frac{V_2^2 - V_1^2}{2gJ} + \frac{z_2 - z_1}{J} \qquad (9)$$

In an adiabatic process no heat is added or removed from the fluid; this means that q = 0. Consider the special case of an adiabatic process, no shaft work, no change in internal energy and an incompressible fluid with a constant specific weight w. Then equation (8) can be written

$$\frac{p_2}{w} + \frac{V_2^2}{2g} + z_2 = \frac{p_1}{w} + \frac{V_1^2}{2g} + z_1 \qquad (10)$$

Equation (10) is sometimes called Bernoulli's equation.

Viscosity or Internal Friction.— In some cases it is permissible to assume that the fluid has no friction, or resistance to relative motion. In other cases friction must be taken into account.

Consider any fluid between the two parallel plates in fig. 6. The lower plate is stationary, while the upper plate moves with the velocity V. A thin layer of fluid adheres to the lower plate; the velocity of this fluid layer is zero. A thin layer of fluid adheres to the upper plate; this fluid layer has the velocity V. R is the shear force required to maintain the flow, to slide the different layers relative to each other. The force R overcomes the internal fluid resistance due to the action of the molecules. In this so-called laminar flow the fluid flows in parallel layers or iaminae; only the molecules cross from layer to layer of fluid. The absolute or dynamic viscosity of the fluid μ is defined as the ratio

$$\mu = \frac{\text{shear stress}}{\text{rate of shear strain}} \qquad (11)$$

The shear stress is the force R divided by the area of the plate in contact with the fluid. The rate of shearing strain is V/h, where h is the distance between plates.

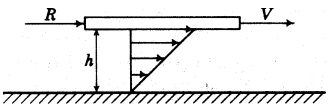

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FIG. 6.—FLOW BETWEEN PARALLEL PLATES. WITH LOWER PLATE STATIONARY

The units of dynamic viscosity can be determined by reference to equation (11). Dynamic viscosity can be expressed in the following units: pound-seconds per square foot; dyne-seconds per square centimetre; slugs per foot-second; and grams per centimetre-second. The poise is defined as

$$1 \text{ poise} = \frac{1 \text{ dyne-second}}{\text{square centimetre}} = \frac{1 \text{ gram}}{\text{centimetre-second}}$$

A conversion from one set of units to another is

$$1 \text{ poise} = 2.089 \times 10^{-3} \frac{\text{slug}}{\text{foot-second}}$$

Kinematic viscosity v is defined as the ratio of dynamic viscosity to density

$$\nu = \frac{\mu}{\rho} \qquad (12)$$

Kinematic viscosity can be expressed in feet squared per second or centimetres squared per second. One centimetre squared per second is sometimes called a stoke. Table I shows some viscosity values at 59° F. and 14.7 lb. per square inch absolute.

TABLE I.—Some Viscosity Values

Fluid	Dynamic viscosity slugs/ft.sec.	Kinematic viscosity (ft.)²/sec.
Air	0.0373×10^{-5}	1.57×10^{-4}
Water	2.391×10^{-5}	1233×10^{-5}
Castor oil	3160×10^{-6}	1.692×10^{-2}

Dimensional Analysis.— Many flow phenomena are so complicated that a purely mathematical solution is impossible, incomplete or impractical, and it is necessary to resort to experimental measurements. Dimensional analysis (*q.v.*) and dynamic similarity are two tools which have proved very helpful in the organization, correlation and interpretation of experimental data. The present section will cover dimensional analysis; the next, dynamic similarity. Dimensional analysis is a mathematical method useful in determining a convenient arrangement of variables in a physical relation and in planning systematic experiments. The first step is to list all the variables involved. This step may be the result of experience or judgment. The actual dimensional analysis, the next step, can be made by following a formal procedure.

Let the letter L represent the dimensional symbol for length, M the dimensional symbol for mass, F the dimensional symbol for force and T the dimensional symbol for time. If length is selected arbitrarily as the primary or fundamental dimension of space, then

units of area and volume can be devised as derived or secondary units. Area can be represented by the dimensional symbol L^2; volume can be represented by the dimensional symbol L^3. If time is selected arbitrarily as a primary dimension, then linear velocity can be taken as a derived or secondary unit. The dimensional symbol for linear velocity is LT^{-1}; in a similar fashion, the dimensional symbol for acceleration is LT^{-2}. The selection of force or mass as a primary dimension is solely a matter of convenience; either one could be selected. If one is selected, then the other becomes a derived or secondary dimension. Since force equals mass times acceleration, the dimensional relation between force and mass can be written as

$$F = MLT^{-2} \quad or \quad M = FT^2L^{-1}$$

This treatment will deal solely with physical equations which are dimensionally homogeneous. All the terms of a dimensionally homogeneous equation have the same dimensions. It is most convenient to have a physical equation arranged with the variables in dimensionless groups or combinations. 'Buckingham's a theorem can be used to organize variables in the smallest number of significant groups. This theorem is particularly useful when the number of variables is large.

Let $A_1, A_2, A_3, \ldots A_n$ be n physical quantities which are involved in some physical phenomenon. Examples of these physical quantities are pressure, velocity, viscosity and density. Let m represent the number of all the primary or fundamental units (such as force, length and time) involved in this group of physical quantities. The functional relation between these quantities, or the physical equation, can be written as

$$f(A_1, A_2, A_3, \ldots A_n) = 0$$

which means that some function involving all the variables equals zero. Buckingham's π theorem states that the foregoing relation can be written alternately as

$$\phi(\pi_1, \pi_2, \ldots \pi_{n-m}) = 0$$

where each π is an independent dimensionless product of some of the A's. The number of the terms in the physical equation has been reduced from n to $n - m$. For example, if there are five variables in a case (n is 5), and there are three fundamental units (m is 3), the physical equation has $5 - 3 = 2$ dimensionless ratios.

As an illustration, consider a case in which there are three primary dimensions, as mass, length and time. In this case, $m = 3$ and the maximum number of independent dimensionless products can be obtained by expressing the products in the form

$$\begin{aligned}
\pi_1 &= A_1^{x_1} A_2^{y_1} A_3^{z_1} A_4 \\
\pi_2 &= A_1^{x_2} A_2^{y_2} A_3^{z_2} A_5 \\
&\cdots\cdots\cdots \\
\pi_{n-m} &= A_1^{x_{n-m}} A_2^{y_{n-m}} A_3^{z_{n-m}} A_n
\end{aligned}$$

There will be m + 1 variables in each term; only one variable need be changed from term to term. In each product there are three unknown exponents. A consideration of the three primary dimensions, M, L and T, yields three separate equations. A simultaneous solution of these three equations gives numerical values for the three exponents. For example, in the π product, the values x_1, y_1 and z_1 can be determined from the three conditions that all the length dimensions must cancel out. all the mass dimensions must cancel out and all the time dimensions must cancel out.

Dynamic Similarity. — In order to obtain information about the flow around or through a structure or machine called the original or prototype, it is often convenient and economical to experiment with a copy or model of the prototype. The model may be smaller than, larger than or equal in size to the prototype. Tests with models provide an advantage in research and design which cannot be obtained from theoretical calculations alone.

The flow around the model is similar to the flow around the prototype if the model is geometrically similar to the prototype and if the streamline pattern around the model is similar to the streamline pattern around the prototype. Considering corresponding points with respect to the bodies. the velocity direction in one flow must be the same as the velocity direction in the other flow. The velocity direction at any point in a flow field is determined by the ratio of the forces acting on the fluid at a point. Therefore dynamic similarity betueen model flow and prototype flow is realized when the ratio of the forces acting at a point in the model flow is the same as the ratio of forces acting at a corresponding point in the prototype flow.

Reynolds Number. — There are various cases of flow in which three types of forces predominate: viscous (or shear force due to viscosity or internal friction of fluid); inertia; and pressure. Examples are completely enclosed flows, as in pipes, fans, pumps and turbines. Further examples are flows in uhich bodies are fully immersed in a fluid, as vehicles, submarines, aircraft and structures. If there are only three forces involved, specifying two of the three forces automatically specifies the third force because the three forces are in equilibrium. Thus, a significant pair of forces can be taken as viscous and inertia. Similarity between model and prototype is realized if, at points similarly located with respect to the bodies, the ratios of the inertia forces to the viscous forces are the same.

The product of mass times acceleration is proportional to

$$(\text{volume})(\text{density})(\text{velocity/time})$$

Thus the inertia force is proportional to

$$\frac{l^3 \rho V}{t} = l^2 \rho V^2$$

where V is some typical velocity (as the average velocity in a pipe or the velocity of a vehicle), l is some characteristic length (as pipe diameter) and p is density. The viscous force (see equation [11]) is proportional to μVl. Then the dimensionless ratio (inertia force)/(viscous force) is proportional to

$$\frac{l^2 \rho V^2}{\mu V l} = \frac{\rho V l}{\mu}$$

The dimensionless ratio $\rho Vl/\mu$ is commonly called Reynolds number. If viscous, inertia and pressure forces determine the flow for a prototype, then dynamic similarity between model and prototype is realized when the Reynolds number for the model equals the Reynolds number for the prototype. The experimental data for various flows are expressed as a function of Reynolds number.

Froude's Number. — There are various cases of flow which involve inertia, gravity and pressure forces. Examples are flows in open channels and the surface waves produced by a ship or seaplane hull. If there are only three forces involved. specifying two of the three forces automatically specifies the third force. A significant pair of forces can be taken as inertia and gravity. A model of a ship will produce the same shape of surface waves as the prototype ship if the ratio of inertia force to gravity force is the same at similarly located points with respect to the prototype and the model. The gravity force equals the mass times the gravitational acceleration g. The gravity force is proportional to $\rho g l^3$, where l is some typical length, as the length of a ship. The ratio (inertia force)/(gravity force) is proportional to

$$\frac{\rho l^2 V^2}{\rho l^3 g} = \frac{V^2}{lg}$$

The ratio $V/\sqrt{lg}$ is frequently called Froude's number.

Weber's Number.—Surface tension is a molecular property of liquids which produces certain phenomena at liquid surfaces. By liquid surfaces is meant surfaces of separation, such as that between water and air. Surface tension σ can be expressed in such units as dynes per centimetre or pounds per foot. There are various cases of flow which involve surface tension, inertia and pressure forces. Examples are the formation of drops in liquid jets and the action of bubbles rising in a liquid. A significant pair of forces can be taken as surface tension and inertia forces. The surface tension force is proportional to σl. The ratio (inertia force)/(surface tension force) is proportional to

$$\frac{\rho l^2 V^2}{\sigma l} = \frac{\rho l V^2}{a}$$

The ratio $\rho lV^2/\sigma$ or the square root of this ratio is sometimes called Weber's number.

Other Dimensionless Numbers. — The foregoing sections dealt with certain force ratios. Other force ratios could be devised, depending on the forces determining the particular flow.

Laminar and Turbulent Flow. — There are two different types of flow—laminar and turbulent. In laminar flow the fluid moves in laminae or layers. In turbulent flow secondary irregular motions and velocity fluctuations are superimposed on the main or average flow. A common occurrence showing these types of flow is found in the rising column of smoke from a cigarette or cigar lying on an ash tray in a quiet room For some distance the smoke rises in smooth filaments which may weave around but do not lose their identity; this flon is laminar. The filaments suddenly break up into a confused eddying motion at some distance above the cigarette; this flow is turbulent. The transition between laminar and turbulent flow moves closer to the cigarette when the air in the room is disturbed.

Imagine a fluid along a fixed surface or solid boundary, as shown in fig. 7. There is a thin layer of fluid which adheres to the surface and thus has zero velocity with respect to the fixed surface. At some distance away from the plate. in the y-direction, the fluid has the constant velocity U. There is a region, normal to the wall, in which there is a velocity variation from u = 0 to $u = U$. This region in which there is a velocity variation is called the boundary layer.

Consider the state of flow at a distance from the wall, in the boundary layer, where the indicated velocity is u. If the flow is laminar the shear stress T is given by the expression

$$T = \mu \frac{du}{dy}$$

where du/dy is the velocity gradient or change in u with respect to y. This shear is due only to molecular action; there is no transfer of fluid masses between adjacent layers.

If the flow is turbulent, however, there is molecular friction plus an additional interaction due to the momentum transfer of fluid masses between adjacent layers. The term turbulence implies irregular fluctuations, not a regular motion. For the case shown in fig. 7, if the flow were turbulent, u would be the average or mean velocity at a point; velocity fluctuations would be superimposed on this mean velocity.

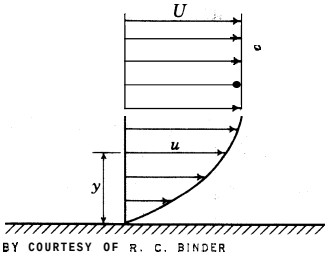

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FIG. 7. — BOUNDARY LAYER

The exact nature of mechanism of turbulent flow has not been completely established. Some concepts have been established, however, which provide some guide in studying turbulent flow.

For turbulent flow the total shear stress T can be written as

$$T = (\mu + \epsilon) \frac{du}{dy}$$

where ϵ has the dimensions of dynamic viscosity; ϵ is variously called exchange coefficient and eddy viscosity. There is also the concept of eddy stresses. Referring to fig. 7, let u' represent the velocity fluctuation in the direction of the main flow, and let v' be the velocity fluctuation in the y-direction. Then a momentum study shows that the total shear stress can be written as

$$T = \mu \frac{du}{dy} - \rho \overline{u'v'}$$

where the bar over $\overline{u'v'}$ denotes the time mean value of the product.

Another concept is that of mixing length. For molecular motion there is defined a term, mean free path of the molecule. which means the average distance a molecule travels between collisions. Mixing length is similar to mean free path. In the turbulent exchange the fluid masses displaced perpendicularly to the direction of the mean flow carry momentum over a certain length perpendicular to the mean flow. The mixing length is defined as the average distance perpendicular to the main flow covered by the mixing particle. The total shear stress is then

$$T = \mu \frac{du}{dy} + \rho L^2 \frac{du}{|dy|} \frac{du}{dy}$$

where $\left|\frac{du}{dy}\right|$ is the absolute magnitude of the velocity gradient, and L is the mixing length. The mixing length is determined indirectly from measurements of velocity distribution. The mixing length can be expressed in the form

$$L = k \left| \frac{\frac{du}{dy}}{\frac{d^2u}{dy^2}} \right|$$

where k is a universal numerical constant determined experimentally, and $\frac{d^2u}{dy^2}$ is the change in $\frac{du}{dy}$ with respect to y.

Momentum Study of **Boundary** Layer. — Fig. 8 illustrates two-dimensional flow along a surface; in this case the flow is identical in planes parallel to the plane of the figure. Upstream from the leading edge of the plate, the uniform velocity is U. The indicated force F parallel to U is called a skin-friction force. If the fluid were frictionless, then F would be zero. With real fluids, however, F is definitely not zero.

Let b represent the width of the plate perpendicular to the plane of flow. Picture the flow through the area bdy. The mass rate of flow through this area is pubdy. Ahead of the plate the fluid velocity is U; at the section, a distance x from the leading edge, the fluid velocity is u. The case will be taken in nhich there is no change in static pressure in the direction of flow. If p is static pressure and x is the distance along the plate, then the pressure gradient dp/dx is zero for this case. The force dF acting on the fluid equals the mass rate of flow times the velocity change, or

$$dF = \rho u b dy (U - u) \tag{13}$$

At section x there is a velocity variation normal to the plate. At $x = 0$, the velocity distribution is uniform. The total force of the plate on the fluid is then

$$F = b \int_0^\infty \rho u (U - u) dy \tag{14}$$

Theoretically speaking, the integral should be taken from zero to infinity. For practical purposes, however. it is accurate enough to integrate from zero to some finite distance 6; 6 is so selected that the velocity defect $(U - u)$ is very small for values of y greater than 6. The distance 6 is called the disturbance thickness of the boundary layer. It is the region in which the major part of the velocity variation occurs. Then equation (14) can be written as

$$F = b \int_0^\delta \rho u (U - u) dy \tag{15}$$

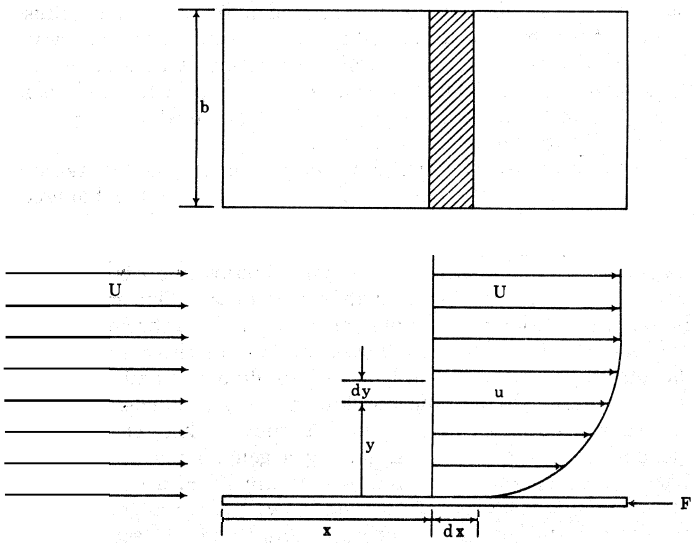

FIG. 8. — FLOW ALONG A SURFACE

If the velocity distribution as a function of y at section x is known, this functional relation can be put in equation (15), the integration carried out and the friction force F calculated.

Separation. — Let p represent the static pressure at a point and let x be a distance measured positive in the direction of flow. The passage between streamlines may be such that the velocity of the fluid is increased in the direction of flow and the pressure is reduced. In this case, the pressure gradient dp/dx is negative. Such streamlines may be formed in the flow around a body. such as a turbine blade or some craft. Such streamlines may be formed by a solid mall; in which case the device may be called a nozzle. Nozzles are found in various applications in fluid machines, ejectors, propulsion systems, rockets and some fluid meters. For an incompressible fluid, a nozzle-type channel is formed by converging streamlines. The fluid is accelerated in the converging passage and some of the pressure energy is converted into velocity or kinetic energy. In general, this conversion is a stable process and can be made with low losses.

The passage between streamlines can be such that the velocity of fluid is decreased in the direction of flo and the pressure is increased. In this case, the pressure gradient dp/dx is positive; sometimes this gradient is called adverse. Such streamlines may be found in the flow around a body, such as a compressor blade or a ship's hull. These streamlines may be formed by a solid wall; in this case, the passage may be called a diffuser. Diffusers are found in various applications, such as machines involving a pressure rise, propulsion systems, Venturi meters and piping systems. For an incompressible fluid, a diffuser-type channel is formed by diverging streamlines. Flow in a diffuser is one of the most common, most important and most troublesome problems in practice. The energy conversion in a diffuser is more difficult than the reverse conversion in a nozzle.

Fig. 9 illustrates the boundary layers at successive points along the wall in a diffuser-type channel. At section A there is a certain velocity distribution in the boundary layer. A boundary layer with flow toward the right could be maintained if all the kinetic energy were available for conversion. However, some kinetic energy is dissipated into unavailable thermal energy, with the result that the velocity in the boundary layer is less than what it would be without friction. At point B the flow velocity is reduced. At point C the velocity distribution curve is normal to the wall. Point C is the so-called point of separation. Separation of the main flow from a surface is accompanied by a reversal in direction of the flow very close to the surface behind the separation point and by the formation of a wake in which the velocity is much reduced. At D the fluid stream has separated from the wall and an eddy is formed. The formation of eddies represents further dissipation of available into unavailable energy.

Thus flow in a diffuser passage may be an unstable, inefficient process, accompanied by large energy losses and appreciable eddying regions. If the streamlines around a body form a diffuser channel, there may be a marked separation and an eddying wake. For lifting vanes. such as airfoils, separation is associated with the so-called stall. The stall represents a drop in lift and an increase in resistance as compared with the case in which there is no separation and consequently no stall.

Types of Flow. — Picture flow along a surface, as illustrated in fig. 8. At the leading edge of the plate ($x = 0$) the boundary layer thickness is zero. At successive positions along the plate the boundary layer grows in thickness. At small values of x the flow in the boundary layer is laminar. Picture the case in which there is a turbulent flow at high values of x. This means that there is a transition region along the plate, in which the flow changes from laminar to turbulent. There are certain characteristic flow phenomena which are found in various fluid machines, the flow around different bodies and the flow in many channels. The flow pattern may be simple or complex. A study of these characteristic phenomena is very useful in gaining a general understanding of flow. These characteristic phenomena are listed as: (1) formation of boundary layers; (2) laminar flow; (3) turbulent flow; (4) transition from laminar to turbulent flow; and (5) separation.

There are various possibilities. In some cases the entire flow around a body or through a channel may be laminar. The flow in other cases may be laminar or turbulent with a transition region. In some cases the laminar flow may separate. In still other cases the turbulent boundary layer may separate.

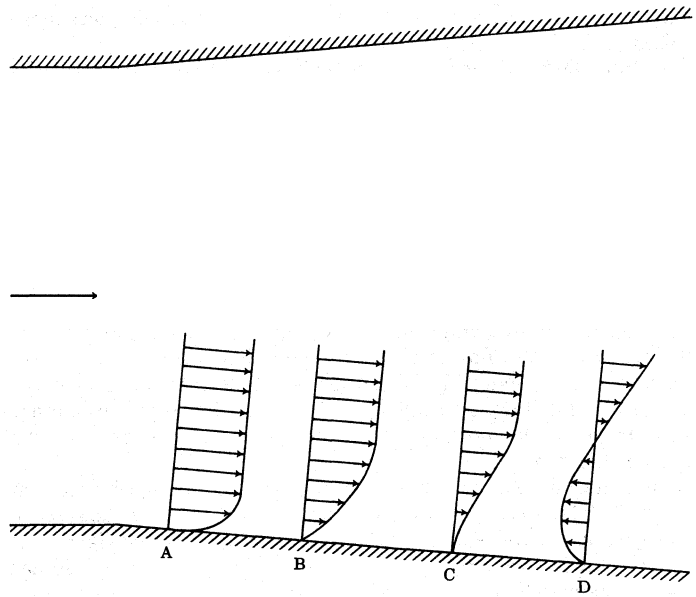

FIG. 9. — BOUNDARYLAYERS IN A DIFFUSER

FLOW IN THREE DIMENSIONS

In some cases the flow can be studied by using one-dimensional relations, such as the equation of continuity (2) and the energy equation (8). In other cases, however, it is necessary to take into account the three-dimensional aspects of the flow.

Methods of Describing Motion. — Two methods of describing motion have been established. The Lagrangian method (after J. L. Lagrange) gives a description of the behaviour of individual fluid particles. A description of the velocities of individual fluid particles would be an example of the Lagrangian method. Similar descriptions could be given for displacements, accelerations and other characteristics. The Eulerian method (after L. Euler) gives a description of the velocity, pressure and other characteristics at certain points or at a section in the fluid. The Eulerian method is the more familiar and common. Fig. 3 is an example of the Eulerian method. In this example, it is not known just what particles pass section 1 or section 2, but the description gives the velocity distribution at each of these sections. Let x, y, z represent the rectangular space co-ordinates and t time. Let V represent the resultant linear velocity at any point in a body of fluid, u the x-component of the resultant velocity V, v the y-component and w the z-component. The notation is illustrated in fig. 10. As an example of the Eulerian method, the velocity can be expressed symbolically as

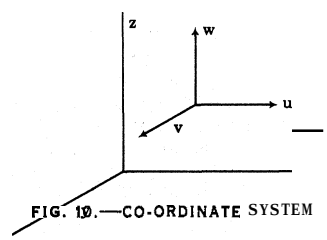

FIG. 10.—CO-ORDINATE SYSTEM

$$\begin{aligned} u &= f_1(x,y,z,t) \\ v &= f_2(x,y,z,t) \\ w &= f_3(x,y,z,t) \end{aligned} \qquad (16)$$

The first relation in equation (16) can be stated in words as: the velocity component u is some function of the space co-ordinates x, y, z and t. For a certain value of x, y, z and the time t, there is a corresponding value of u. Equation (16) is a general symbolic statement of the velocity relation. If the flow is steady, then the velocity at a point is not a function of time. Similar expressions could be written for acceleration, pressure, temperature and other flow characteristics.

Velocity and Acceleration. — In the most general case of fluid

movement the resultant velocity V is a function of both the distance s along a streamline and the time t, that is

$$V = f(s,t) \tag{17}$$

The velocity changes from point to point in space in one instant of time, and also from moment to moment of time at any one point in space. Thus the total derivative dl' can be written

$$dV = \frac{\partial V}{\partial s} ds + \frac{\partial V}{\partial t} dt \tag{18}$$

Note that the partial differential quotient is taken with respect to one variable only. keeping all other variables constant. For example, $\partial V/\partial s$ is the derivative of V with respect to s only, with time t constant.

Acceleration is defined as the time rate of change in velocity. Thus the total acceleration dV/dt is

$$\frac{dV}{at} = \frac{\partial V}{\partial s}\frac{ds}{dt} + \frac{\partial V}{\partial t} = V\frac{\partial V}{\partial s} + \frac{\partial V}{\partial t} \tag{19}$$

The term $\partial V/\partial t$ is frequently called the local acceleration and the term $V\dfrac{dV}{\partial s}$ the convective acceleration. The local acceleration represents the change in the local velocity with respect to time at a fixed point. If the flow is steady, then $\dfrac{\partial V}{at} = 0$.

Velocity and acceleration are vector quantities; each has both a magnitude and a direction. In some cases, it is convenient to deal with components of the resultant vector. Differentiation of equation (16) gives the corresponding components of the resultant or total acceleration

$$\begin{aligned}
\frac{du}{dt} &= u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} + \frac{\partial u}{\partial t} \\
\frac{dv}{dt} &= u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} + \frac{\partial v}{\partial t} \\
\frac{dw}{dt} &= u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z} + \frac{\partial w}{\partial t}
\end{aligned} \tag{20}$$

Continuity Equation.——Fig. 11A shows an infinitesimal parallelepiped in a body of fluid; the sides have the lengths dx, dy and dz. Consider first the mass flow per unit time in the x-direction. The mass per unit time entering the left face is $\rho udydz$; this flow is indicated by the vector "In" in fig. 11A. As indicated by the vector "Out" in fig. 11A, the mass leaving the opposite face is

$$\left[\rho u + \frac{\partial}{\partial x}(\rho u)dx\right]dydz$$

The net gain in the x-direction is

$$\frac{\partial}{\partial x}(\rho u)dxdydz$$

Calculating in a similar manner for the other directions gives the gain

$$\left[\frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) + \frac{\partial}{\partial z}(\rho w)\right]dxdydz$$

The above expression considers only a space variation. In the most general case, there is also a time variation or gain

$$\frac{\partial}{\partial t}(\rho)dxdydz$$

The mass rate of flow across the closed boundary surface from without to inward must equal the mass rate of flow from within to outward if there is to be no creation or destruction of mass. If inflow is taken as positive and outflow as negative, then the total or net mass rate of flow across the closed boundary must be zero. Thus the equation of continuity in three dimensions becomes

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) + \frac{\partial}{\partial z}(\rho w) = 0 \tag{21}$$

If the fluid is incompressible (p is constant), then the equation of continuity takes the special and common form

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0 \tag{22}$$

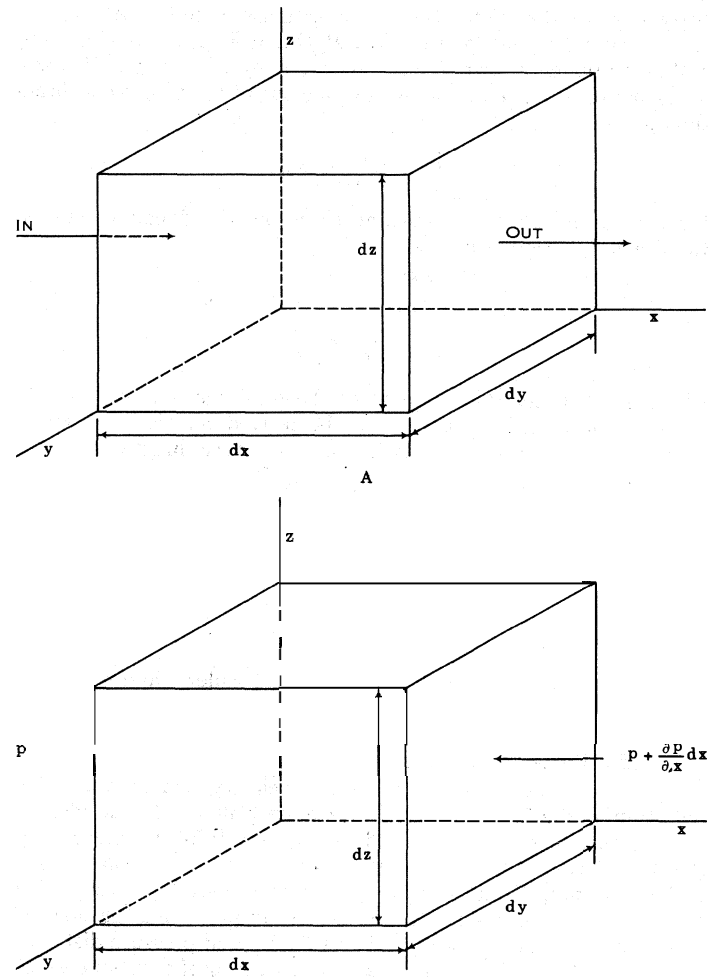

FIG. IIA-118. — INFINITESIMAL PARALLELEPIPED OF FLUID

Dynamic Equation for a Frictionless Fluid.— The foregoing relations are purely kinematic: that is, they refer only to the geometry of motion without regard to the forces causing that motion. The next relation to be derived is simply a statement in mathematical form that the resultant force acting on a small element of fluid equals the product of the mass of the element and the acceleration involved. Note that both force and acceleration are vector quantities. The following derivation is limited to flow with no friction (this assumes that the dynamic viscosity of the fluid is zero). Fig. 11B shows an infinitesimal parallelepiped in a body of fluid; the sides have the lengths dx, dy and dz. Imagine first the forces acting on this element in the x-direction. The pressure on the left face is p; the pressure force acting on the left face is $pdydz$. The pressure on the right face is

$$p + \frac{\partial p}{\partial x}dx$$

The pressure force on the right face is

$$\left[p + \frac{\partial p}{\partial x}dx\right]dydz$$

The net pressure force acting on the element in the positive x-direction is

$$-\frac{\partial p}{\partial x}dxdydz$$

Imagine that some force other than that due to static pressure is acting on the fluid; such a force might be a gravity force. The attraction of the earth Is an example of a body force. A body

force is proportional to the volume or mass of fluid. A pressure force is proportional to area. Let P, Q and R represent the x-, *y*- and *z*-components, respectively, of the body force per unit mass. Then the total force acting on the element in the positive *x*-direction is

$$\left[P\rho + \frac{\partial p}{\partial x}\right]dxdydz$$

Since force equals mass times acceleration, the dynamic relation for the x-direction becomes

$$\left[P\rho - \frac{\partial p}{\partial x}\right]dxdydz = \rho dxdydz\frac{du}{dt}$$
$$P\rho - \frac{\partial p}{\partial x} = \rho\frac{du}{dt} \qquad (23)$$

where du/dt is the x-component of the total acceleration. Equations for the y- and *z*-directions can be derived in a similar fashion. The final set of dynamic equations for the three directions is thus

$$P\rho - \frac{\partial p}{\partial x} = \rho\frac{du}{dt}$$
$$Q\rho - \frac{\partial p}{\partial y} = \rho\frac{dv}{dt} \qquad (24)$$
$$R\rho - \frac{\partial p}{\partial z} = \rho\frac{dw}{dt}$$

The above equations are sometimes called Euler's hydrodynamic equations. The total acceleration in equation *(24)* can be expressed in the form given by equation *(20)*.

Steady Flow of a Frictionless Fluid. — A general objective in fluid mechanics is to map out the velocity and pressure distribution in the field or region of a flowing fluid. Knowledge of the pressure distribution around a body is helpful in determining the total force of the fluid on the body. For example, in investigations of pumps, fans, compressors and turbines, the force acting between a fluid and a blade may be determined with the help of a pressure-distribution study. The velocity and pressure distributions around a body or along a channel are useful in studies of energy transfer.

Various means are used in determining the pressure distribution around a body or along a channel. One direct method is to make measurements on the actual body or channel, or the prototype. Sometimes it is more convenient to make measurements on a geometrically similar model of the body or channel. A body may be tested in a wind tunnel or a water tunnel. In each case pressure openings along a surface can be connected to suitable manometers or pressure gauges to find the pressure distribution.

In some cases it may be difficult and expensive to make an experimental investigation. The expense and difficulty of a test may not be warranted. Then there is this question: Can the velocity and pressure distribution be calculated analytically?

The general problem of fluid flow around a body or through a channel is divided into two parts. In one part is the study of the field or region of flow close to the surface (of the body or channel) in which there is a marked velocity change from zero at the surface to a velocity greater than zero at some distance from the surface; this is the region of the boundary layer. Viscosity plays a major role in boundary layer flow. In the other part is the stud; of the flow outsidd the boundary layer, in a region where the fluid is regarded as having no viscosity or internal friction. Some treatment of boundary layer flow has been given in the previous paragraphs. The following will give some treatment of frictionless flow.

Consider frictionless flow of an incompressible fluid without any body forces. Assume two-dimensional flow in the *x-y* plane; this means that the flow is identical in parallel planes. The basic equations available for studying this flow are the equation of continuity and the dynamic equations. For the case under consideration, equation *(21)* and equation *(24)* reduce to

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \qquad (25)$$

$$-\frac{\partial p}{\partial x} = \rho\frac{du}{dt} \qquad (26)$$

$$-\frac{\partial p}{\partial y} = \rho\frac{du}{dt} \qquad (27)$$

The resultant velocity V at any point in the fluid has the components u and *v*. Multiplying both sides of equation *(26)* by dx, multiplying both sides of equation *(27)* by *dy*, adding the resulting equations and integrating gives the result

$$p + \tfrac{1}{2}\rho V^2 = \text{constant} \qquad (28)$$

This equation is sometimes called Bernoulli's equation. Equation *(28)* brings out an important feature. If the velocity at each point in the field is known, an application of equation *(28)* gives the pressure at each point. Thus attention is frequently focused on determining the velocity distribution in the field of flow.

Velocity Potential and Stream Function. — Potential functions have been established for expediting the analytical study of velocity fields. One type of function is called a velocity potential. Let ϕ represent velocity potential; ϕ is a scalar quantity which is some function of x and y, and is defined by the relations

$$u = \frac{\partial\phi}{\partial x} \qquad v = \frac{\partial\phi}{\partial y} \qquad (29)$$

where u is the x-component of the resultant velocity and v is the y-component of the resultant velocity.

The feet and second units will be employed to illustrate a few examples. If the velocity potential for a certain flow is $\phi_1 = 20x$ then u is 20 ft. per second ($u = \frac{\partial\phi}{\partial x}$). The velocity is *20* ft. per second in the x-direction for all points in the field of flow. If the velocity potential for another flow is $\phi_2 = 10y$, then v is 10 ft. per second; the velocity at all points is *10* ft. per second in the *y*-direction. These two flows can be superposed or combined mathematically by simply adding the two potential functions. An algebraic addition of two potential functions is equivalent to a vector addition of velocities. The potential function $\phi = \phi_1 + \phi_2$ represents the combined flow pattern. This simple example illustrates the convenience of potential functions.

Using the equation of continuity with the velocity potential gives the relation

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0 \qquad (30)$$

Equation *(30)* is commonly called the Laplace equation. This equation must be satisfied for all flows, in order to satisfy the equation of continuity.

The stream function ψ is a scalar quantity which is a function of x and y, and defined such that

$$u = \frac{\partial\psi}{\partial y} \qquad v = -\frac{\partial\psi}{\partial x} \qquad (31)$$

For the function ϕ the total derivative can be written as

$$d\phi = \frac{\partial\phi}{\partial x}dx + \frac{\partial\phi}{\partial y}dy = udx + vdy \qquad (32)$$

An equipotential line is defined as a line along which the function ϕ is constant. Along this line $d\phi = 0$, and equation (32) gives

$$\frac{dy}{dx} = -\frac{u}{v} \qquad (33)$$

Equation (33) gives the slope of the equipotential line.

For the function ψ the total derivative can be written as

$$d\psi = \frac{\partial\psi}{\partial x}dx + \frac{\partial\psi}{\partial y}dy = -vdx + udy \qquad (34)$$

For a line along which the stream function is constant, $d\psi = 0$, and equation *(34)* gives

$$\frac{dy}{dx} = \frac{v}{u} \qquad (35)$$

Equation (35) gives the slope of a curve which is tangent to the resultant velocity at a point. A line of constant ψ is thus a

streamline. A comparison of equations (33) and (35) shows that, at each point in the field, the equipotential line is perpendicular to the streamline.

The general problem is to map out the velocity or pressure distribution in the field or region of a flowing fluid. If the velocity at each point in the field is known, then an application of the dynamic or energy equation yields the pressure at each point. Thus, the first problem is to determine the velocity field. In order to determine the velocity field, we can start with certain elementary types of flows, as (1) a rectilinear flow in which all the streamlines are parallel; (2) a radial flow, a source or sink, in which all the streamlines are radial; and (3) a circular or vortex flow. in which all the streamlines are concentric circles. Basic relations for each of these elementary types of flow can be established. Then, using these elementary types as building blocks, various combination flows can be formed.

The velocity potential and the stream function can be determined for these types of elementary flow. Once these basic flows are established, then various combinations of flow can be determined analytically in a simple manner. For example, a source flow, a sink flom and a rectilinear flow can be combined to give the flow around a circular cylinder. This is a case of a practically important flow.

APPLICATIONS

Flow in a Curved Path. — Imagine the flow between two concentric streamlines as indicated in fig. 12. The tangential linear velocity is V, the radius of curvature is R. The element has a height dR, and an average area dA along the curved surface. The mass of the element is $\rho dRdA$; the radial acceleration is V^2/R. The pressure on the element varies from p to $p + dp$ as the radius varies from R to R + dR. Since force equals mass times acceleration,

$$dpdA = \rho \frac{V^2}{R} dRdA$$

$$dp = \rho \frac{V^2}{R} dR \qquad (36)$$

In curved flow the pressure increases with radius.

A vortex is a flom in which the streamlines are concentric circles. There are two types of vortex motions: the forced vortex (one with a torque acting) and the free vortex (one with no torque acting).

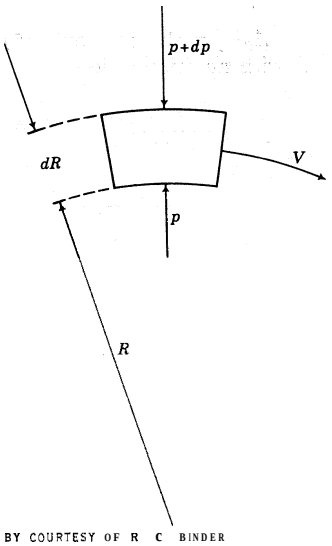

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FIG. 12.— FLOWIN A CURVED PATH

Picture a vertical cylinder containing liquid rotating about a central vertical axis. The liquid rotates like a solid body if there is no motion relative to the container: this motion can be realized with vanes in the cylinder. Such a flom is called a forced vortex: there is an external torque acting on the fluid. Let ω represent the angular speed of the vessel (in radians per unit time), and R the radial distance to any point. The linear velocity V at any point is given by the relation $V = R\omega$. Application of equation (36) to this type of flow shows a parabolic pressure distribution with respect to radius.

As brought out by equation (5) the force F acting on a body equals the time rate of change in linear momentum

$$F = \frac{d}{dt}(mV)$$

Picture a body of mass m moving at a radius R about an axis of rotation. with V the tangential linear velocity of the body. The foregoing momentum equation can be extended by the multiplication of each side of the equation by R to give the torque T

$$T = FR = \frac{d}{dt}(mRV) \qquad (37)$$

The product mRV is called the moment of momentum or angular momentum. In words, torque equals the time rate of change in angular momentum.

Picture a frictionless fluid moving in a circular path with no torque applied. For this free vortex,

$$\frac{d}{dt}(mRV) = 0$$

Integration gives the relation RV = K, or

$$V = K/R \qquad (38)$$

where K is some constant. In a free vortex the velocity decreases as the radius increases.

A forced vortex might be found in the runner portion of a centrifugal pump. A free vortex might be found in the casing, or volute, outside the rotating impeller of a centrifugal pump.

Incompressible Flow in Pipes.—A wide variety of applications involves the flow of some fluid through a pipe. There are almost as many miles of pipe as there are of railroads.

For pipe flow a Reynolds-number is defined as

$$N = \rho \frac{VD}{\mu} \qquad (39)$$

where p is the density of the fluid, D is the inside diameter of the pipe, μ is the dynamic viscosity of the fluid and V is the average velocity. Experiments show that the stable form of motion for pipe flow is normally laminar for N less than 2,000. Below N = 2,000 an initially turbulent flom, with its irregular mixing motion, cannot be maintained indefinitely. For the usual conditions, the pipe flow is turbulent for values of N above about 3.000. In the transition range N = 2,000 to N = 3,000 there are various possible conditions, depending upon the initial disturbances, the pipe entrance and the pipe roughness.

Let h represent the head loss in the pipe length l; h has the dimensions of energy loss per unit weight, or the net dimension of a length; h might be expressed in such units as foot-pounds energy loss per pound of fluid flowing, or h might be expressed in feet of fluid flowing. It is customary to express the lost head h in the form

$$h = f \frac{l}{D} \frac{V^2}{2g} \qquad (40)$$

where V is average velocity, g is gravitational acceleration and f is a dimensionless friction coefficient. The ratio l/D is dimensionless. The factor $V^2/2g$ is sometimes called a velocity head; it can be expressed as foot-pounds per pound of fluid, or it can be expressed as feet of fluid.

For usual velocities, many measurements have established the fact that the friction coefficient depends only on the Reynolds number of the flow and the geometry of the inner pipe surface. For circular pipes the geometry of the conduit can be expressed in

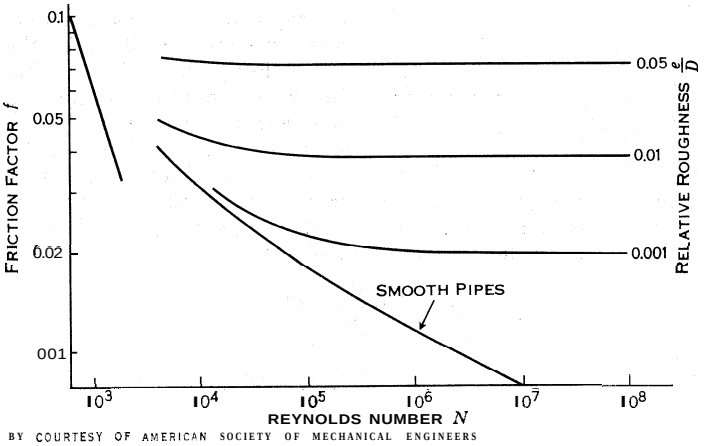

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FIG. 13.— FRICTION FACTORS FOR FLOW IN CIRCULAR PIPES

terms of a factor called the relative roughness of the pipe. Thus for circular pipes the friction factor f is a function of the relative roughness and the Reynolds number.

Fig. 13 shows a plot of friction factor as a function of Reynolds number using logarithmic scales. For N below 2.000, for laminar flow, there is a single curve. For turbulent flow there are various curves depending on the roughness. Each curve is for a certain relative roughness e/D, where e is the absolute roughness (a length dimension) and D is the inside pipe diameter; e/D is a dimensionless ratio; any set of consistent units could be used. Table II gives typical roughness values.

TABLE **11.**—*Absolute Roughness Values for Pipes*

Pipe	Absolute roughness e feet
Commercial steel	0.00015
Asphalted cast iron	0.0004
Galvanized iron	0.0005
Cast iron	0.00085
Concrete	0.001 to 0.01
Riveted steel	0.003 to 0.03

One common type of problem is to determine the pressure drop for a given pipe length, pipe diameter, dynamic viscosity. density and velocity. For this type of problem, the Reynolds number can be calculated, and then the friction factor determined from fig 13 The head loss h can be calculated by equation (40) The pressure drop can be found by using the energy equation (8). This equation gives, for the head loss,

$$h = \frac{p_1 - p_2}{w} + z_1 - z_2 \tag{41}$$

If the pipe is horizontal, then the pressure drop is

$$p_1 - p_2 = wh \tag{42}$$

Laminar Flow in Circular Pipes.—For fully developed laminar flow in circular pipes. many experiments have shown that $f = 64/N$. For this type of flow the pressure drop in a horizontal pipe of length l becomes

$$p_1 - p_2 = w\frac{64}{N}\frac{l}{D}\frac{V^2}{2g} = \frac{32\mu l V}{D^2} \tag{43}$$

Equation (43) is sometimes called the Hagen-Poiseuille law.

Fluid Meters.—Force, time and length are quantities which can be measured very accurately. It is good technique to refer all derived measurements, as velocity, volume rate of flow and pressure, as directly as possible to the established and easily available standards of force, length and time. For example, in order to determine the rate of flow of a liquid from a pipe or pump, high accuracy can be obtained by weighing the discharge during a measured time interval. In some cases, convenience and economy, however, may require the use of secondary instruments whose accuracy depends solely on a calibration or assumed coefficients.

The Pitot tube is a device far measuring linear velocity. As illustrated in fig. 14, V_0 is the velocity and p_0 is the static pressure some distance ahead of the simple Pitot tube. The flowing fluid is brought to rest at the nose or stagnation point of the instrument. The static fluid inside the Pitot tube can be connected to some pressure gauge, to give a measurement of the total or stagnation pressure p_s. Applying the energy equation for incompressible frictionless flow, equation (10), gives

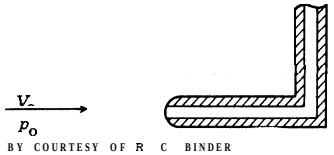

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FIG. 14.— PITOT TUBE

$$\frac{p_0}{w} + \frac{V_0^2}{2g} = \frac{p_s}{w}$$

$$V_0 = \sqrt{\frac{2g(p_s - p_0)}{w}} \tag{44}$$

Thus, if we know p_s, p_0 and w, the velocity V_0 can be calculated by equation (44). Various special shapes of Pitot tubes can be constructed. Equation (44), however, is the basic relation involved.

The Venturi meter, the flow nozzle and the orifice meter are instruments used for measuring and controlling the volume rate of flow. As shown in fig. 15, the Venturi meter (named after G. B. Venturi) consists of a venturi tube (the flow channel) and some form of pressure gauge or gauges for measuring differential pressure. The flow channel has a converging portion, a throat (section of smallest area) and a diverging portion. The converging portion serves to increase the velocity of the fluid and to reduce the static pressure. Thus a pressure difference between inlet and throat is developed; this pressure difference is correlated with the rate of flow through the meter. The diverging portion serves to lower the velocity and increase the pressure. Different proportions and different arrangements of pressure gauges are used in practice. The term flow nozzle usually refers to a nozzle placed in or at the end of a pipe for purposes of measuring rate of flow. Fig. 16 illustrates the flow nozzle. The flow nozzle resembles a Venturi meter without a diverging portion.

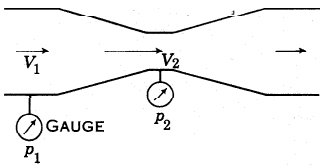

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FIG. 15.—VENTURI METER

The orifice is probably one of the oldest and most common devices for controlling and measuring the flow of fluids. Fig. 17 illustrates an orifice meter. A thin plate, with a hole in it, is mounted in a pipe. The orifice plate may be clamped between flanges Pressure connections or pressure taps are made at holes on both sides of the plate. The inlet edge of the orifice opening may be sharp. Different sizes of holes, different locations of pressure taps and different types of pressure gauges are used.

The form of the basic flow equation is the same for the Venturi meter. the flow nozzle and the orifice meter. *See* fig. 15 for the notation The area at section 1 is A_1, the velocity at each point over section 1 is V_1, p_1 is the pressure at section 1, and w is the specific neight. Similar terms apply for section 2. For incompressible steady flow with no friction, the energy equation becomes

$$\frac{p_1}{w} + \frac{V_1^2}{2g} = \frac{p_2}{w} + \frac{V_2^2}{2g} \tag{45}$$

Using the continuity equation $A_1V_1 = A_2V_2$ with equation (45) gives the ideal volume rate of flow Q with no friction loss

$$\text{ideal } Q = A_2V_2 = \frac{A_2}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}}\sqrt{\frac{2g(p_1 - p_2)}{w}} \tag{46}$$

A measurement of the pressure difference along with the areas provides a measurement of volume rate of flow. The actual volume rate Q is expressed as $Q = CA_2V_2$, where C is a dimensionless discharge coefficient. The best technique is to determine C experimentally for each meter installation. Sometimes this is not possible, and then discharge coefficients must be assumed.

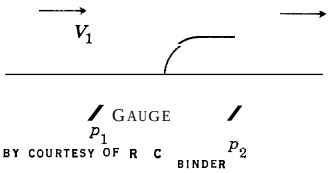

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FIG. 16.—FLOW NOZZLE

Sometimes the volume rate is expressed in the form

$$\text{actual } Q = KA_2\sqrt{\frac{2g(p_1 - p_2)}{w}} \tag{47}$$

where K is a flow coefficient

$$K = \frac{C}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}} \tag{48}$$

Discharge and flow coefficients are usually correlated with Reynolds number for the meter installation.

A weir is sometimes used for the measurement and control of

the flow of water in an open channel, that is, a channel with the water surface open to atmospheric pressure. As indicated in fig. 18, there is a distance H of the undisturbed water level above the upper edge or crest of the weir. This height H is correlated with the volume rate of flow. The measurement of H should be made accurately. In one method, a sharp conical point or hook is moved by a micrometer screw. The hook is first entirely submerged in the water, screwed up until it touches the surface, and then the height H observed. The opening in the weir plate through which water flows may be rectangular, triangular or semicircular. The best plan is to calibrate the weir in place, under the same conditions for which it is to be used.

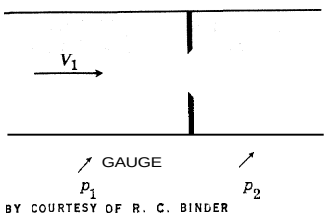

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FIG. 17.—ORIFICE METER

There are various mechanical devices which consist primarily of a rotating element whose angular speed of rotation is correlated with the linear velocity of flow. Such devices can be calibrated by insertion in a stream of known velocity or by moving the device at a known speed through a body of stationary fluid. When used in air such devices are frequently called anemometers; when used in water, current meters. The rotating member may consist of a series of vanes (as in a windmill) or a series of cups mounted on a shaft held in bearings. The rotating shaft is connected to some sort of revolution counter; an observation is made of the number of revolutions during a measured time interval.

Different hot-wire anemometers have been devised for measuring linear velocity and velocity fluctuations. In the hot-wire anemometer there is a wire (such as platinum) of very small diameter mounted on a probe. This probe is held in the fluid stream to be studied. An electric current is passed through the wire. The heated wire cools when exposed to the fluid flow, and its electrical resistance changes. The linear velocity of flow is correlated with electrical measurements. Since rapidly changing electrical signals can be measured, fluid velocity fluctuations can be measured.

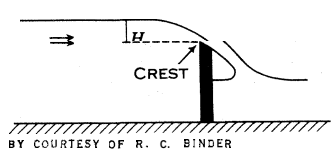

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FIG. 18.— WEIR

The salt-velocity method of measuring water flow in a conduit depends on the fact that salt in solution increases the electrical conductivity of the water. Salt is introduced into the conduit at some point. Various electrodes are arranged along the conduit. The flow of the salt solution is recorded by electrical instruments. The time for the salt solution to travel a certain distance is measured. The velocity of flow and the volume rate of flow are calculated from these data and dimensions of the conduit.

A viscometer is an instrument for measuring the dynamic viscosity of a fluid. Probably the best method for measuring the dynamic viscosity of a fluid is the capillary-tube method. A measurement is made of the flow through a capillary or a tube of very small inside bore. If the flow is laminar, the Hagen-Poiseuille law, equation (43), can be arranged in the form

$$\mu = \frac{(p_1 - p_2)\, D^2}{32\, l\, V} \tag{49}$$

If measurements are made of the pressure drop, the inside diameter D, the length 1 and the average velocity V, then the dynamic viscosity can be calculated by equation (49).

Resistance or Drag. — In various cases it is necessary to study the forces acting on a body completely immersed in a relatively large expanse of fluid. Examples are airplanes. automobiles and submarines. As illustrated in fig. 19, let V be the uniform, undisturbed velocity some distance ahead of the body at rest. The flowing fluid exerts a certain resultant dynamic force on the body. This force of the fluid on the body depends only on the relative velocity between body and fluid. It is customary to resolve this resultant force into two components. One component along the line of the upstream velocity V is called the resistance or drag. The other component at right angles to the upstream velocity V is called the lift. This section discusses drag; the next will discuss lift. The total resistance or drag may be divided into separate contributions, as skin-friction drag and pressure drag.

Fig. 7 indicates a surface parallel to the flowing fluid. If the fluid had no viscosity or internal friction, the fluid would slip over the surface with the uniform velocity U; no drag would result. With real viscous fluids, on the other hand, there is a boundary layer as indicated by the velocity variation in fig. 7. Shear stresses are developed in the boundary layer because adjacent layers of fluid move with different velocities. A force is necessary to hold the surface in the stream, to overcome the skin-friction drag. Pressure drag is the contribution resulting from pressure differences over the surface of the body. The flow in front of a blunt body is different from the flow behind the body. Behind the body there may be an eddying wake with a low pressure. In front of the body the pressure may be high; this pressure difference contributes to the drag.

It is customary to express the total drag force D as

$$D = C_D \frac{\rho V^2}{2} \text{ (area)} \tag{50}$$

where C_D is a dimensionless ratio called the drag coefficient and p is the density of the fluid. The product $\rho V^2/2$ is a pressure. The area in the drag relation depends on the body under consideration. For spheres .and cylinders the area may be the projected area normal to the upstream flow. In organizing data. it is customary to express the drag coefficient as a function of Reynolds number $\rho Vl/\mu$ where l is some characteristic length of the body. Drag coefficients can be measured by means of models in air streams and water streams.

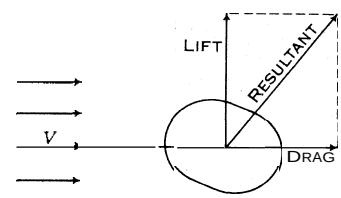

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FIG. 19.—DRAG AND LIFT FORCES

Dynamic Lift. — The lift force illustrated in fig. 19 is a dynamic lift due to the flow of the fluid. Dynamic lift is different from buoyant lift. Buoyant lift is a force which can act vertically upward on a body in a stationary or static fluid; this buoyant lift equals the weight of the fluid displaced by the volume of the body.

Dynamic lift is obtained by making the flow unsymmetrical about a line parallel to the approach velocity V (see fig. 19). An unsymmetrical flow pattern can be obtained by making the body unsymmetrical, or by tilting a plate with respect to the upstream flow. Twirling a ball causes an unsymmetrical flow because of boundary layer effects. The curve of a tennis ball, a baseball or a golf ball is a familiar example of a dynamic lift action; the spinning of the ball around an axis through the ball is necessary in order to produce the curve.

Fig. 20 shows certain conventions employed in discussing lifting vanes or sections. The geometric chord c is the length of an arbitrary reference line usually established by the designer of the section. The angle A between the chord and the direction of the upstream flow is called the angle of attack.

It is customary to express the lift force L in the form

$$L = C_L \frac{\rho V^2}{2} \text{ (area)} \tag{51}$$

where C_L is a dimensionless lift coefficient. The area in equation (51) is usually taken as the projected chord area.

In many cases of lifting vanes, the lift coefficient increases, reaches a maximum and then drops as the angle of attack increases from a low value. The stall of a lifting vane is reached when the angle of attack is greater than that of the maximum lift coefficient. At the stall condition the fluid separates from the vane and forms an eddying wake.

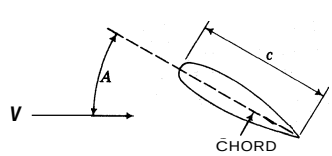

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FIG. 20.—NOTATION FOR LIFTING VANE

Flow of Liquids in Open Channels. — An open channel is one in which the liquid stream is not completely enclosed by solid

boundaries and thus has a free surface subjected only to atmospheric pressure. The flow in an open channel depends on the slope of the liquid surface and the slope of the channel bottom. Natural streams. rivers, sewers and tunnels are examples of open channels. It is difficult to obtain reliable experimental data on the flow in open channels. Thus the treatment of open channel flow is somewhat more empirical than that of other aspects of fluid mechanics, such as that of pipe flow.

The word stage is sometimes used in place of depth; either word refers to the vertical height of liquid in a channel. Steady flow refers to flow in which the characteristics at a point do not change with time. Flow in an open channel is uniform when the depth, velocity, slope and other such features remain constant from section to section. Uniform flow should not be confused with steady flow.

The term hydraulic radius or hydraulic mean depth R is defined

$$R = \frac{\text{cross-sectional area}}{\text{wetted perimeter}}$$

The cross-sectional area is the area normal to the flowing fluid. The wetted perimeter is the length of solid boundary in contact with the fluid; the wetted perimeter does not include the distance across the free surface.

Consider steady uniform flow. Let S represent the slope or the change in elevation h (of either the bottom of the channel or the free liquid surface) divided by the length l of the channel; $S = h/l$. Let V represent fluid velocity. Then the following relation is commonly used

$$V = C\sqrt{RS} \tag{52}$$

where C is a coefficient given by the relation

$$C = \frac{1.49}{n} R^{1/6} \tag{53}$$

where n is a roughness factor. Some average values of n are given in Table III.

TABLE III.—*Some Values of* n

Nature of surface	n
Planed wood	0.012
Brick	0.016
Gravel	0.028
Cast iron	0.014

The term specific energy is used in different studies of open channel flow. Specific energy E is defined as the energy per unit weight of the flowing fluid with respect to a line passing through the bottom of the channel,

$$E = y + \frac{V^2}{2g} \tag{54}$$

where y is depth. The specific energy equals the sum of the depth and the velocity head.

Consider liquid at rest at a depth y in a relatively shallow channel. Let c_w represent the velocity of propagation of a small surface wave. This velocity is given by the relation

$$c_w = \sqrt{gy} \tag{55}$$

where g is gravitational acceleration.

Sext, consider flow in an open channel. So-called critical flow refers to a flow in which the liquid velocity V equals the wave velocity c. If a wave were started it could not progress upstream because the two velocities are equal. In tranquil or subcritical flow, the liquid velocity is less than c_w. In subcritical flow the small surface waves would travel upstream. In rapid or supercritical flow the liquid velocity is greater than c. In supercritical flow small surface waves would be swept downstream. If a body, such as a boat, moves through water with a velocity greater than c_w, a bow wave is formed in front of the body.

Under certain circumstances the flow at a depth less than the critical may suddenly change to a flow at a certain depth greater than the critical. With this depth increase there is a corresponding velocity decrease. This phenomenon, which may take place in a relatively short distance. in which flow passes abruptly from the rapid to the tranquil state, is called the hydraulic jump. This jump may be found in the flow over rocks and other objects in streams. and in storm drains. The hydraulic jump is similar to the sudden expansion in a pipe, or a rapid increase in flow area, with a corresponding decrease in velocity.

Cavitation. — If a liquid flows through a stationary passage or a machine, there may be an unfavourable change in performance as operating conditions vary. There may be a dangerous erosion or pitting of metal parts. and a loss in energy. In many cases these effects have been attributed to a phenomenon called cavitation.

Cavitation refers to an alternate formation and collapse of vapour bubbles. If, at some point in the normal water flow, the fluid pressure equals the vapour pressure at the temperature of the fluid, the liquid will vaporize; a cavity or void will form. If the fluid pressure fluctuates slightly above and below the vapour pressure, there will be an alternate formation and collapse of vapour bubbles; this can pit metal parts and result in a loss in energy of the flowing fluid.

Compressible Flow. — Density variations may have an appreciable effect on the flow. The flow of gas through various machines. the motion of some craft at high velocities and the motion of projectiles are some examples of many in which the compressibility of the fluid exerts an influence. The specific heat of a substance is the amount of heat required to change the temperature of unit weight of the substance one degree. A parameter of importance is the ratio

$$k = \frac{\text{specific heat at constant pressure}}{\text{specific heat at constant volume}}$$

For air, carbon monoxide, hydrogen and oxygen, k is about 1.4. For carbon dioxide k is 1.3. If a volume of fluid v under a pressure p were decreased in volume by dv, the increase in pressure would be dp. The bulk modulus E is defined as the ratio

$$E = -\frac{dp}{dv/v} \tag{56}$$

The negative sign in equation (56) indicates a decrease in volume for a positive increase in pressure. E is about 300,000 lb. per square inch for water at ordinary conditions. For a gas following a constant-temperature or isothermal process. $E = p$, where p is the particular gas pressure. For a gas following a frictionless adiabatic process, E = kp. In a perfectly rigid and incompressible substance an impulse is transmitted instantaneously from one element to another. In an elastic or compressible substance. honever, the transmission of an impulse is retarded by the inertia of the displaced elements. In some cases the time of travel of an impulse may be short or difficult to observe if the distance of travel is short. In other cases the time of travel may be noticeable if the distance is large. Thunder, for example, is heard some time after the lightning is seen if the observer is some distance away from the storm.

The velocity of propagation of a small pressure wave or small pressure disturbance is variously called the velocity of sound, sonic velocity or acoustic velocity. This velocity c is given by the expression

$$c = \sqrt{\frac{E}{\rho}} \tag{57}$$

where E is the bulk modulus of the fluid. and p is the density of the fluid. For gases, the relation becomes

$$c = \sqrt{\frac{kp}{\rho}} \tag{58}$$

For air at 14.7 lb. per square inch absolute and 59° F., c is about 1,120 ft. per second. Consider the flow of some compressible fluid in which the predominating forces are inertia. pressure and elastic. A significant pair is inertia force and elastic force. The inertia force is proportional to $\rho l^2 V^2$ where V is some characteristic velocity, 1 is some characteristic length and p is density. The

elastic force is proportional to El^2, where E is the bulk modulus. Then the ratio (inertia force)/(elastic force) is proportional to

$$\frac{\rho l^2 V^2}{El^2} = \frac{V^2}{c^2}$$

The ratio $M = V/c$ is commonly called Mach number, after E. Mach. If inertia, elastic and pressure forces determine the flow for a prototype, then the model flow is similar to the prototype flow if the model Mach number is equal to the prototype Mach number. Compressible flow data are frequently correlated as a function of Mach number.

Flow at a Mach number less than 1 is subsonic; flow at a Mach number greater than 1 is supersonic. Subsonic flow differs from supersonic flow in various respects.

Imagine a converging channel, that is, one in which the area decreases in the direction of flow. For continuous subsonic flow the velocity increases in the direction of flow, the pressure decreases in the direction of flow; the channel is called a nozzle. For continuous supersonic flow the velocity decreases in the direction of flow, the pressure rises in the direction of flow; the channel is called a diffuser.

Imagine a diverging channel, that is, one in which the area increases in the direction of flow. For continuous subsonic flow, the velocity decreases in the direction of flow, the pressure rises in the direction of flow; the channel is a diffuser. For continuous supersonic flow the velocity increases in the direction of flow, the pressure decreases in the direction of flow; the channel is a nozzle.

In compressible flow there are some cases of sharp or abrupt changes in pressure. In a sound wave, for example, across the wave (in a very short distance) there is a very small change in pressure. In some cases: in a very short distance (a small fraction of an inch) there may be a very large pressure change; this pressure change may be called a compression shock or a shock wave.

Picture a craft moving steadily through air at a subsonic speed. A sound wave or a pressure signal travels ahead at sound velocity minus craft velocity with respect to the craft. A sound or pressure signal travels backward at a speed equal to the sum of craft velocity and sound velocity with respect to the craft. The distribution of sound signals is not symmetrical. Each point in the immediate vicinity of the body, however. is reached by a signal.

Picture next a craft moving through air at supersonic speed. It travels faster than the pressure signal. Thus at the nose of the craft there is a bow wave, across which there is a pressure change.

There are features associated with the propagation of a pressure wave through a compressible fluid that are similar to those involved in the travel of a slight disturbance at the free surface of a liquid. Critical flow in an open channel is analogous to sonic flow in a compressible fluid. Supercritical flow in an open channel is analogous to supersonic flow in a compressible fluid. A similar analogy holds for subcritical and subsonic flows.

The hydraulic jump in open channel flow is analogous to the compression shock in compressible flow. Before the jump the liquid moves with a high velocity at a low depth; behind the hydraulic jump the liquid moves with a low velocity at a high depth. Before the compression shock the gas moves with a high velocity at a low density (low pressure); behind the shock the gas moves with a low velocity at a high density (high pressure).

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MECHANISM is the general name for the view that natural phenomena can and should be explained by reference to matter and motion and their laws. Historically. the term has acquired somewhat different senses in different contexts, according to the other view which it is intended to contradict. In the 17th century the "mechanical philosophy" was revived, partly under the influence of Greek atomism, as an alternative to Aristotle's qualitative physics in keeping with the newly developing science of mechanics. "Give me extension and motion and I will remake the world," Descartes wrote; "the universe is a machine in which everything happens by figure and motion"; and Robert Boyle expressed the "tenets of mechanical philosophy" as consisting in explaining physical phenomena by means of "little bodies variously figured and moved." The upholders of this philosophy were mainly concerned with the elimination from science of such notions as "substantial forms," "occult qualities," "hypostatical principles," etc., which could not be related to the new mathematical methods in use and which, so far from being explanations, were declared merely to put a stop to all further inquiry. Among the important problems to which 17th-century mechanism gave rise are those involved in the distinction made by Galileo (and by Locke) between primary and secondary qualities, in the Cartesian dualism of mind and a purely mechanical body and in the question, discussed by Boyle, whether "mechanical" could be combined with teleological explanations or with the assumption that Nature has "designs." Descartes' view of the body as a machine—and of animals as nothing but machines—had a profound effect upon the history of physiology. It was advanced in opposition to the alternative Aristotelian view of animals as organisms, and it stimulated the tendency to look for explanations of living processes in terms of physics and chemistry. Later developments in biology led to the view, taken for instance by Kant, that, while physicochemical modes of explanation must be pursued as far as possible, these were inadequate to account for the whole of the facts of life. The methods of physiology have perforce led to the pursuit of mechanical explanations in this sense, but biologists since the 18th century have differedsharply in their conceptions of the ultimate nature of living things: at one extreme is the view, held for instance by Lamettrie, by Theodor Schwann, by Jacques Loeb and by some 20th-century students of biochemistry and of cybernetics that there is no aspect of living organisms that cannot be explained by the laws of inorganic nature; at the other extreme is the form of vitalism which asserts that there is in each living thing a kind of entelechy or directive vital principle. See also EMERGENCE.

(A. C. CE.)

MECHITHARISTS, a congregation of Armenian monks in communion with the Church of Rome. The founder, Mechithar, was born at Sebaste in Armenia, 1676. He formally joined the Latin Church, and in 1701, with 16 companions, he formed a definitely religious institute of which he became the superior. Their Uniat propaganda encountered the opposition of the Armenians and they were compelled to move to the Morea, at that time Venetian territory, and there built a monastery. 1706. On the outbreak of hostilities between the Turks and Venetians they migrated to Venice, and the island of St. Lazzaro was bestowed on them, 1717. This has since been the headquarters of the congregation, and there Mechithar died in 1749, leaving his institute firmly established. (E. C. B.)

MECKLENBURG, a *Land* in northern Germany, dissolved in 1952, on the Baltic sea, formerly divided into two—Mecklenburg-Schwerin and Mecklenberg-Strelitz; these were reunited in Jan. 1934. Area 8,856 sq.mi. Pop. (1950) 2,027,124.

Mecklenburg-Schwerin was bounded north by the Baltic sea, west by Ratzeburg and Schleswig-Holstein, south by Brandenburg and Hanover and east by Pomerania and Mecklenburg-Strelitz, and possessed three small exclaves. It became a republic in 1918 and by the constitution of 1920 was governed by a *Landtag* of 64 members until 1933. For administrative purposes it was divided into 17 divisions, in addition to the four cities of Rostock, Schwerin, Wismar (the capital) and Giistrow. Area 5,068 sq.mi. Pop. (1933) 693.775.

Mecklenburg-Strelitz comprised two detached parts, the former duchy of Strelitz on the east of Mecklenburg-Schwerin, and the former principality of Ratzeburg on the west. The first is bounded by Mecklenburg-Schwerin, Pomerania and Brandenburg, the second by Mecklenburg-Schwerin, Lauenburg and the territory

of the free town of Lubeck. Their joint area was 1,131 sq.mi. Pop. (1933) 110,514. The state was declared a republic in *1918* and by the constitution of 1923 it was governed by the 35 members of the *Landtag* who chose an executive of two. It was represented in the *Reichsrat* by one member until 1933. The capital was Neu-Strelitz.

Industries.—Agriculture is by far the most important industry of the region, and the chief crops are rye, wheat, potatoes and hay. The pastures support herds of sheep, cattle and horses. The industrial establishments include a few iron foundries, wool-spinning mills, machine factories, dye works, tanneries, brickfields, soap works, breweries, limekilns and tar-boiling works, tobacco factories and mills of various kinds. Rostock, Warnemiinde and Wismar are the principal commercial centres. The chief exports are grain and other agricultural produce, live stock and wood; the chief imports are colonial produce, iron and coal. Fishing is carried on extensively in the numerous inland lakes.

History.—The Teutonic peoples, who in the time of Tacitus occupied the Mecklenburg region, were sutceeded in the 6th century by some Slavonic tribes, one of these being the Obotrites, whose chief fortress was Michilenburg, the modern Mecklenburg, near Wismar; hence the name of the country. Though partly subdued by Charlemagne toward the close of the 8th century, they soon regained their independence, and the effective subjugation of Mecklenburg was made by Henry the Lion, duke of Saxony. The Obotrite prince Niklot was killed in battle in *1160* while resisting the Saxons, but his son Pribislaus (d. 1178) submitted to Henry the Lion, married his daughter to the son of the duke, embraced Christianity and was permitted to retain his office.

His descendants and successors, the later grand dukes of Mecklenburg, were the only ruling princes of Slavonic origin in Germany. In 1170 the emperor Frederick I made Pribislaus a prince of the empire. In 1348 the emperor Charles IV raised Mecklenburg to the rank of a duchy, and in *1418* the University of Rostock was founded.

In 1549 Lutheranism was recognized as the state religion; a little later the churches and schools were reformed and most of the monasteries were suppressed. In 1611, by a partition, Duke Adolphus Frederick I (d. 1658) received Schwerin, and John Albert II (d. *1636)* received Giistrow. The town of Rostock, "with its university and high court of justice," was declared to be common property, while the diet or *Landtag* also retained its joint character, its meetings being held alternately at Sternberg and at Malchin.

In *1701*, by the treaty of Hamburg, a new division of the country was made. Mecklenburg was divided into two parts, which were later represented by the duchies of Mecklenburg-Schwerin and Mecklenburg-Strelitz. At the same time the principle of primogeniture was again asserted, and the right of summoning the joint *Landtag* was reserved to the ruler of Mecklenburg-Schwerin.

Under Duke Christian Louis of Mecklenburg-Schwerin there was signed, in April 1755, the convention of Rostock by which a new constitution was framed for the duchy. By this instrument all power was in the hands of the duke, the nobles, and the upper classes generally, the lower classes being entirely unrepresented. In the early years of the French Revolutionary Wars Duke Frederick Francis I (1756–1837) remained neutral, but in *1806* his land was overrun by the French and in 1808 he joined the Confederation of the Rhine. He was the first member of the confederation to abandon Napoleon, to whose armies he had sent a contingent, and in 1813–14 he fought against France. In 1815 he joined the Germanic Confederation (*Bund*) and took the title of grand duke.

In 1810 serfdom was abolished in his dominions. During the movement of *1848* the duchy witnessed a considerable agitation in favour of a more liberal constitution, but in the subsequent reaction all the concessions which had been made to the democracy were withdrawn and further restrictive measures were introduced in *1851* and 1852.

Mecklenburg-Strelitz adopted the constitution of the sister duchy by an act of Sept. 1755. Having been a member of the alliance against Napoleon, its duke, Charles, joined the Germanic Confederation in *1815* and assumed the title of grand duke.

In *1866* both the grand dukes of Mecklenburg joined the North German Confederation and in 1871 the two grand duchies became states of the German empire.

MECKLENBURG DECLARATION OF INDEPENDENCE, a document containing five resolutions embodying a declaration of independence from England, adopted, it is claimed, at a meeting on May *20,* 1775, of the citizens of Mecklenburg county, N.C.

The declaration was first printed in the *Raleigh Register* for April *30. 1819,* from a draft written from memory in 1800 by John M. Alexander, recording clerk of the meeting. No contemporary draft has ever been discovered and the question of the document's authenticity has given rise to a large body of controversial literature. The best reasoned attack is W. H. Hoyt, *The Mecklenburg Declaration of Independence* (1907), and the best reasoned reply is J. H. Moore, *Defence of the Mecklenburg Declaration of Independence* (1908).

MECOPTERA, a small order of mostly winged insects best represented by the scorpion flies, the large family Panorpidae. Included also in the order are the tiny, blackish snow scorpion flies, family Boreidae, and the craneflylike hanging flies, family Bittacidae. *See* SCORPION FLY; INSECT: *Classification: Mecoptera.*

MEDALS AND DECORATIONS. Man has always wished to distinguish himself from his fellows by some outward sign. In Greek times and the Roman era the laurel wreath was used for this purpose; in the days of chivalry the coloured shield and plumed helmet were employed. Over the centuries the medal has become the universal mark by which services are rewarded and participation in certain events indicated. In monarchies most awards are made in the name of the sovereign; in other countries in the name of the government. Indiscriminate foundations and awards are frowned upon, although some countries find their suppression more difficult than others.

Orders of knighthood, of which the higher classes confer nobility or the accolade of knighthood and the lower ones designations such as commander, officer, member, etc., are dealt with in the article KNIGHTHOOD AND CHIVALRY. Their insignia are chiefly silver and enamel stars worn on the breast, enameled gold or silver badges attached to a broad ribbon over the shoulder or round the neck and smaller badges worn on the left breast with other decorations and medals.

Decorations awarded for gallantry include the British Victoria cross and George cross, the U.S. medal of honour and the French *médaille militaire;* and there are medals for long service, medals to commemorate coronations, jubilees, participation in wars, humane actions, the saving of life, services to the community and innumerable others.

The insignia vary considerably in size and value. The Victoria cross and the medal of honour are made of bronze, the *médaille militaire* has a gilt and enamel design, while others are of solid gold or silver.

Additional awards of the same decoration can be signified by the addition of bars of metal worn transversely across the ribbon, or by oak-leaf clusters. roses, palms, stars and other devices. Some countries (the U.S.S.R. for example) simply repeat the original award in full, thus enabling a holder to wear four or five replicas of the same badge.

Decorations in their entirety are worn only with full dress or on ceremonial occasions. At other times strips of the ribbons only are arranged on the left breast in a strictly regulated order with the highest decoration in the top row and nearest the centre of the coat. With evening dress, miniature (half-size) decorations are worn. In some countries full-size awards are allowed to be worn in two or more rows, the metal portions of the top row obscuring the ribbons of the second row; the more usual arrangement, however, is to have all the medals on the same bar but overlapped, the senior one being shown in full.

UNITED STATES

The foremost U.S. decoration, the medal of honour, instituted in *1861* for the navy and *1862* for the army, was at first confined to enlisted men, officers being admitted later. It is given only for "courage above and beyond the call of duty." The medal is worn round the neck and has a bronze badge, which for the army is in the form of a five-pointed star resting on a wreath suspended from a bar bearing the word "Valor," on which sits an eagle with outspread wings. The centre of the medal shows the head of Minerva and the ribbon is pale blue and decorated with a pattern of 13 white stars just above the eagle. The naval design is a five-pointed star suspended from an anchor. Its centre device is an allegory representing Minerva repulsing Discord. The ribbon is the same as for the army. The undress ribbons show only five stars and second awards are represented by an oak-leaf cluster for

the army and a gold star for the navy.

In succession follow the distinguished service cross and the distinguished service medal for the army, the navy cross and the distinguished service medal for the navy and the distinguished flying cross for the air force. The silver star, the bronze star and the air medal are lesser awards for gallantry, while the soldier's medal and the navy and marine corps medal reward services in peacetime or "heroism not involving actual conflict with the enemy."

The legion of merit is the only U.S. decoration which has distinct ranks. Members of the armed forces of other countries can be admitted in the grades of chief commander, commander, officer and legionnaire but U.S. citizens receive only the lowest grade. The basic badge is a five-armed, ball-tipped. double-pointed white cross resting on a green wreath, the arms having red edges and the centre being blue with 13 white stars.

The purple heart was originally founded by George Washington in 1782 for bravery. The device consisted of a purple heart-shaped piece of cloth edged with silver braid and two specimens still exist. Only three were actually awarded. The 200th anniversary of Washington's birth was chosen for the revival of this award and on Feb. 22, 1932, a new purple heart was instituted. Its principal purpose now is to award recognition to those who have been wounded or killed in the service of their country. The decoration consists of a purple, heart-shaped badge with light bronze edges. Between the top of the heart and the ribbon are Washington's arms (two bars below three stars) and the ribbon is purple with narrow white edges.

The medal for merit was established in 1942 for award to civilians of the United States and its allies for exceptionally meritorious service or courageous acts in the furtherance of the war effort. The device is an eagle with upspread wings on a blue white-starred ring and the ribbon is claret with two central white stripes. In what might be called a lower category is the medal of freedom, which is more widely distributed (ribbon, red with four white central stripes).

An entirely new award is the national security medal, a blue 16-pointed compass rose surrounded by a red oval bearing the words "United States of America National Security," the whole aithin a gold wreath. It hangs from its ribbon by an eagle with upstretched wings and the ribbon is yellow with blue edges and transverse blue "stepped" stripes.

The equivalent of the British system of "mentioned in dispatches" in the United States is the award of medals called "commendations" and there are separate ones for the army (from the ribbon of which hangs a hexagonal pendant showing an eagle), the navy, coast guard and air force.

Campaign medals (then called badges) were first issued about 1904, although one or two medals commemorating specific events had come out earlier. They ranged from the Civil War medal to awards for the Indian campaigns and the Spanish-American War. Later there were medals for service in Mexico, Nicaragua, Haiti and Dominica. World War I was commemorated solely by the victory medal to which bars could be added. Two naval medals signifying service in China and on the Yangtze river in the 1930s bring the history of U.S. medals up to World War II.

For service during the period before the actual declaration of hostilities in 1941, the American defense service medal was instituted, to the ribbon of which could be added a letter A in bronze for service in the Atlantic. The women's army corps service medal was given to all women who had served in the corps during 1917–18 and who rejoined in World War II.

For the purpose of the award of campaign medals the world was divided into three areas: the American, the Asiatic-Pacific, and the European, African and middle eastern. Medals were given to all who served specified periods in the different parts. with bronze stars to mark engagements and an arrowhead to indicate a landing on an open beach or by parachute. Subsequently a victory medal was added and the armies of occupation in Germany and Japan received the army of occupation medal (as they had done during the occupation of Germany after World War I).

After the end of World War II, the Berlin air lift of 1948–49 was commemorated by the humane action medal, another medal was issued for service in Korea while a general medal under the title of the national defense service medal appeared in 1953.

All the states and territories issue their own crosses and medals, principally to reward long service in their national guard contingents, but sometimes in connection with floods, riots, etc., and occasionally to supplement the valour and campaign medals given by the federal government.

Numerous private societies and contingents of the reserve officers training corps have their own awards. many being merely membership badges such as those of the Veterans of Foreign Wars and the Daughters of the American Revolution. The Society of the Cincinnati, which is composed entirely of direct descendants of officers of the Continental army, has as its badge an eagle suspended from a pale blue, white-edged ribbon and can be worn with uniform, when it takes precedence over all awards except the medal of honour.

Two ancillary services of the U.S. armed forces issued their own decorations — the merchant marine and the coast and geodetic survey. The former had a distinguished service medal, a meritorious service medal, a defense bar and American, Asiatic and European bars, together with "gallant ship" and combat bars. the one bearing a small silver sea horse emblem for a second award and the other a silver star to indicate an "abandon ship" operation. The ribbon of the defense bar is very distinctive. having a black centre shading to red, pink and white each side, bounded by narrow green edges.

The coast and geodetic survey uses its own distinguished service medal, meritorious service medal, long service, defense, Atlantic and Pacific war zone bars.

For civilians in the war department an elaborate system of bars numbering 24 was created to indicate 1, 10 or 25 years service in a particular division or periods in the various war theatres. Gold or silver wreaths on the ribbon indicated exceptional or meritorious service.

UNITED KINGDOM AND COMMONWEALTH

Great Britain.—The pre-eminent decoration for valour is the Victoria cross, founded by Queen Victoria in 1856 as an award open to all ranks of the army and navy without distinction who distinguished themselves by gallantry of an outstanding nature. The conditions of warfare changed so considerably in the succeeding 100 years that, whereas in 1856 the saving of a comrade's life under fire or the capture of a standard was sufficient to earn the Victoria cross, during World War II a much higher degree of self-sacrifice was required, as was shown by the number of Victoria crosses posthumously awarded. In all by 1957, 1,343 crosses had been awarded, to which must be added three bars for second awards, making a total of 1,346 in all. The decoration is in the form of a cross pattée bearing the royal crest (a lion standing on a crown) above a scroll inscribed "For Valour." The 13-in.-wide ribbon is described in the statutes as red. but is actually a dull crimson. The crosses are individually forged and are made from guns captured from the Russians in the Crimean War.

The second highest British award, the George cross. which was instituted in 1940 by King George VI, may be given only for "acts of the greatest heroism or of the most conspicuous courage in circumstances of extreme danger." The cross is silver, plain, bearing in the centre a representation of St. George slaying the dragon, surrounded by the words "For Gallantry." The ribbon is 1½ in. wide and of garter blue.

For the Distinguished Service Order see KNIGHTHOOD AND CHIVALRY. The distinguished service cross and the military cross are lower decorations for army and navy officers. while the distinguished flying cross and the air force cross are reserved for R.A.F. officers.

For other ranks there is a series of medals roughly comparable aith the above, including the conspicuous gallantry medal and the distinguished service medal for the navy, the distinguished conduct medal and the military medal for the army and the distinguished flying medal and the air force medal for the air force. The George medal is analogous to the George cross, but the stand-

ard required is not so high (both incidentally may be awarded to civilians).

A medal frequently given for gallantry and for numerous other services is the British empire medal, which is allied to the Order of the British Empire. Its ribbon is pink with gray edges, with an additional stripe of gray in the centre for the military division. The Edward medal is rarely awarded now, but at one time it was used to reward lifesaving in mines and industrial plants. a high degree of gallantry being required. The Albert medal, the queen's police medal and the queen's fire service medal are awarded for gallantry or distinguished service. The Royal Humane society's silver and bronze medals are well known; its Stanhope gold medal is awarded annually for the bravest deed of lifesaving of the year.

Great Britain and the United States easily lead the field in the number of types of award for gallantry and war service. Britain was probably the first country to produce war decorations which could be worn. Some of the recipients of commemorative medals in the 16th and 17th centuries used a thin chain to suspend their medals round their necks. The "ark in flood" medal (so called from its design) issued by Queen Elizabeth I to commemorate the defeat of the Spanish Armada in 1588 and the medals proposed by Charles I in his royal warrant of 1643 may be quoted as examples of early decorations.

The first English campaign medal for both officers and men was the one issued by parliament in 1650 to mark the victory over the royalists at the battle of Dunbar. It bore the portrait of Cromwell (in spite of his protests) on one side and a representation of the house of commons on the other. It has no loop at the top for suspension. Few medals were issued until the end of the 18th century, when naval gold medals for admirals and captains appeared and with them one of the first references to a medal ribbon, appropriately enough in blue and white, the colours selected for the first naval uniforms. About the same time the Honourable East India company began to issue various awards for native soldiers. The early Indian medals were probably worn round the neck from a yellow cord. As there was no general award made to the rank and file after the battle of the Nile (1798), Alexander Davison, Nelson's prize agent, presented a medal to every man who took part. His example was followed by Matthew Boulton, of the Soho mint, Birmingham, who in 1805 gave a medal to all ranks present at the battle of Trafalgar.

During the Peninsular War an army order authorized gold medals to be awarded to officers not below the rank of lieutenant colonel or battalion commander who had taken part in the major operations of Roleia (Roliça), Vimiero, Corunna and Talavera, and the order was extended to cover other battles. As many officers became entitled to more than one medal it was decided in 1813 that only one medal would be awarded, with two clasps for second and third operations, while on the fourth operation a gold cross would be substituted, bearing the battle names on the arms. Clasps could be added to this and the duke of Wellington obtained the largest individual number of clasps (nine) awarded to anyone.

The first modern war medal awarded to all ranks alike was the Waterloo medal (1815). Although issued in the reign of George III, it bore the effigy of the prince regent and used the ribbon of the army gold cross. red with blue edges.

The East India company issued a series of campaign medals for service in India. After much agitation and against the wishes of the duke of if'ellington the British government instituted in 1848 a military general service medal for award to survivors of campaigns which took place during 1801–14. A similar medal for those who took part in naval operations from 1793 to 1840 appeared also. A medal for service in India covering the years 1799–1826 was struck by the East India company in 1851 in imitation.

After the Crimean War and the Indian mutiny, campaign medals multiplied and the device of general service medals was adopted to cover a series of campaigns, each marked by an appropriate bar.

World War I created problems of a new character — the large number of troops involved, the numerous fronts on which the war was waged and the periods of time spent on each. During the war a star was awarded to those who went to certain areas before the end of 191j, a separate issue, the 1914 star (commonly known as the Mons star), being given to those who landed in France before Nov. 23, 1914. A general issue of the British war medal covered the majority of men who served during 1914–18 and those who went overseas received also the victory medal, an award common to all the Allied nations.

World War II presented even greater difficulties. Two stars, the 1939–43 star and the Africa star were authorized as interim awards in 1943 and were later extended to cover the years 1939–45. The other stars issued at the end of the war. each covering a specific area, were the Pacific star, Atlantic star. Burma star, air crew Europe star, Italy star and France and Germany star. In addition there were the defense medal (for home defense and noncombatant areas) and the war medal, given to all who served at least one month.

The naval general service medal (1915) was awarded with appropriate bars for operations after World War II in Palestine, the far east, Malaya, Cyprus and Suez and also for mine sweeping. The general service medal (1918) was given to soldiers and airmen for postwar service in various places. The Mau Mau rising in Kenya occasioned the reissue of the Africa general service medal of 1902, with Queen Elizabeth II's head and the bar Kenya. The Korea medal bears the head of Queen Elizabeth II on the obverse and Hercules slaying the hydra on the reverse.

A large number of British medals are awarded for long service in the various regular, territorial and volunteer forces and the police and fire brigades now have official medals to replace those previously given by some individual forces., The Order of St. John of Jerusalem awards a lifesaving medal and a long service medal, while the British Red Cross society has the voluntary medical service medal. Among other decorations may be mentioned the various polar medals, having appropriately white ribbons, and given to members of polar expeditions.

The royal observer corps has a long service medal as do the officers and instructors of the cadet forces (sea, army and air), the ribbon of which is ingeniously constructed from the territorial efficiency medal with the addition of narrow stripes of dark blue, red and light blue placed between the green centre and yellow edges. The medal suitably bears the torch of education. Coronation and jubilee medals have been issued since the reign of Queen Victoria and the latest. Queen Elizabeth II's coronation medal, is silver, rimless and bears her crowned effigy on the obverse and her cipher and the date June 2, 1953, on the reverse.

The queen's medal for chiefs and the badge of honour are awarded to non-European dignitaries in the commonwealth and consist of circular or oval silver-gilt, silver or bronze medals bearing the queen's effigy and title on the obverse and a suitable design and territorial name on the reverse.

Canada. — The Canada medal was instituted in 1943 for award to Canadians and others for "meritorious service above and beyond the faithful performance of duties." The silver prototype bore the effigy of King George VI on the obverse and a crowned shield of the arms of Canada surrounded by a maple leaf wreath on the reverse. The ribbon is equal thirds of red-white-red. The Canadian forces decoration (19jo). awarded to all members of the Canadian forces after 12 years' service, is a silver-gilt decagonal medal. For service during World War II the Canadian volunteer service medal was issued.

Australia. — The Australia service medal was created for those who served during World War II. The obverse bears the sovereign's effigy. while the reverse shows the Australian coat of arms.

New Zealand. — The New Zealand government issued a war service medal for service during if'orld War II and also presented to the widows and mothers of those who died on active service the silver memorial cross.

Union of South Africa. — A silver medal was instituted in 1920 by the Cnion government for award to officers and men who served against Britain during the South African War. After issuing the Africa service medal for World War II, South Africa created in 1952 an entirely new set of decorations to replace in future all British decorations. They are named after people and places with South African associations and include the Castle of Good

Hope decoration (the equivalent of the Victoria cross), the Van Riebeeck decoration, the star of South Africa, the Louw Wepener decoration, etc.

India. — The principal decorations are military: the Param Vir Chakra is awarded for outstanding bravery in the face of the enemy, the Maha Vir Chakra for acts of gallantry in the face of the enemy and the Vir Chakra for gallantry. All these awards were instituted in 1950. The Indian independence medal was founded by the Indian government to commemorate the attainment of sovereignty by India.

Pakistan. — The government authorized the founding of a set of orders and decorations following the British style, which were in course of production in the late 1950s. In commemoration of independence, the Pakistan medal was created.

Ceylon. — Ceylon marked the establishment of its armed forces by the institution of the Ceylon armed forces inauguration medal.

FRANCE

The *mkdaille militaire,* instituted in 1852, is conferred upon high-ranking officers in the army and navy and other ranks in the services for distinguished conduct in action.

For the Legion d'Honneur, *see* KNIGHTHOOD AND CHIVALRY. The *croix de guerre,* established in 1915, is awarded to all ranks for individual feats of arms mentioned in dispatches, and may also be won by officers and men of allied armies. A new ribbon was issued to commemorate service in World War II. In 1940 Gen. Charles de Gaulle created the *ordre de la libération* to reward distinguished service in the cause of the liberation of France. It could be awarded to civilians as well as to servicemen. The decoration has a sword on a shield, surmounted by a black Lorraine cross (ribbon, green with black edges and two narrow black stripes). Other decorations issued during and after World War II include a medal for those who took part in the resistance movement and another for those who were interned or deported during the resistance.

An interesting feature of World War II was the creation of decorations by the Vichy government. These included the *francisque gallique,* a small badge consisting of a double-headed ax protruding from a marshal's baton. a *croix de guerre* (ribbon, green with seven black stripes), the *croix des combattants 1939–40* (ribbon, black with four pale blue stripes) and another *croix de guerre* for the volunteers who fought against the Soviet Union (ribbon, green with black edges and seven black lines).

There are numerous awards given to civilians for various services, among which may be named the following: the *ordre de me'rite agricole,* the *ordre de me'rite commercial,* the *ordre de palmes acadkmzques* and the *ordre de me'rite civil.* Numerous societies add their quota to the decorations worn in France and there are many medals for lifesaving, social work, etc.

The cross for military valour was issued in 1956 to cover military operations in peacetime. Medals were struck for the wars in Indochina and Korea. Another was awarded for service in north Africa, to which bars were added for Morocco, Algeria and Tunisia. The Suez operation of 1956 was marked by the reissue of the orient medal of 1919, with a suitable bar.

GERMANY

For the order *pour le mérite* see KNIGHTHOOD AND CHIVALRY.

The iron cross was instituted in 1813 as a reward for distinguished service in the War of Liberation. It was revived for the Franco-German War of 1870–71 and was again issued for service in World War I. The cross is a Maltese cross of cast iron edged with silver. On the upper arm is a crown, on the lower link is the date of the campaign. There are three classes of the order of the iron cross. The grand cross, double the size of the ordinary cross, is worn round the neck, and is awarded solely for the winning of an important battle or equivalent exploit. During World War I several nonwearable medals were issued in Germany, including one for the (proposed) march on Paris and another celebrating the victory over the Russians at Tannenberg. The battle of the Falkland Islands was commemorated by a bronze medal and the Zeppelin attack on London in Aug. 1917 by a medal cast in iron.

Before 1918 there were at least 20 separate states awarding decorations in Germany. Under the Weimar republic awards all over the country were forbidden and only gradually revived. and after a time the nearing of the old types of decoration was permitted. A Red Cross decoration was instituted and quite widely distributed. Under the Nazi regime the long service medal (the lowest class for only four years' service) was reinstituted, with its familiar cornflower blue ribbon. One of Hindenburg's last acts was to approve of commemoration crosses for World War I, making use of the same ribbons as were employed with the medals for the victorious campaign against France during 1870–71.

For the Olympic games in Berlin in 1936 both a cross and a medal were struck and to reward members of the Nazi party who took part in some of the incidents before his rise to power Hitler created the so-called blood order in 1934. The ribbon, red with narrow black and white edges, was used again in different proportions for the 1939 iron cross, which bore a swastika at its centre.

In World War II Germany created only one medal for a military campaign as such, that for the "winter war in the east," the invasion of Russia in 1941. For the other theatres of war there were "shields." small metal plaques worn on the arm, including the Crimea shield, the Lapland shield, the Kuban shield, etc. A different type of badge with oak leaves outstretched on either side of a centrepiece, worn on the breast, was awarded to participants in bombing raids, tank actions, close combat fighting. etc., while for the navy the badge consisted of various types of ship within an oval. Other decorations of the Nazi period include the order of merit of the German eagle. intended only for foreigners, and the *Deutsches Kreuz,* the highest German military order awarded by Hitler during World War II. The war merit cross was instituted as an inferior award to the iron cross.

Under the German Federal Republic a series of lifesaving and fire-brigade medals have been instituted, while the Red Cross decoration has been revived. The order of merit of the Federal German Republic has eight classes from grand cross to medal. the universal ribbon being red with black and gold edges. In 1957 the *bundesrat* (the Federal German parliament) passed a law approving the wearing of decorations gained in World War II providing that the swastika was removed.

U.S.S.R.

The order of Lenin (1930) may be awarded to individual citizens or collective bodies for special services rendered to the regime. The badge has a circular portrait of Lenin framed in a gold wreath of ears of rye. Numerous orders awarded during World War II for military and naval merit include those named after such national heroes as Kutuzov, Suvorov, Alexander Nevsky, etc. The order of glory is given for valour in battle and the gold star for outstanding feats contributing to the honour and material development of the U.S.S.R. The order of victory is the highest decoration for senior army officers and is given for an outstandingly successful military operation. It comprises an elaborate five-pointed star decorated with diamonds.

A series of medals was created to commemorate service in the various theatres of war including medals for partisans, for the defense of Leningrad, Moscow, Sevastopol, Stalingrad, the Soviet arctic, Odessa and the Caucasus. Decorations were awarded for the liberation of towns in adjacent countries (Warsaw, Prague, Belgrade), and for the capture of cities in enemy countries (Budapest, Vienna, Berlin, Konigsberg). There were general medals for the victories over Germany and Japan.

Later medals were awarded for: frontier defense (1951), distinguished service in the preservation of public order (1952), the restoration of the coal mines in the Don basin (1947), the restoration of the heavy industry of the south (1948). Medals are issued for 20, 30 and 40 years' service in the army (the equivalent of long service medals) and for civilians there are medals for valiant labour and for labour distinction. Widely distributed medals commemorate the 800th anniversary of the foundation of Moscow (1947) and the 250th anniversary of the creation of St. Petersburg (Leningrad) (1957).

OTHER COUNTRIES

Belgium. — The *décoration* militaire (1902) is awarded to ranks of the armed forces for acts of courage or distinguished service. The croix de guerre (1915) is an award given for acts of courage on the field of battle or for long service at the front. Various orders were founded to give recognition for services in the Congo. Several new decorations were created to commemorate the period of German occupation during World War II.

Italy. — Until World War I Italian medals were not numerous but since then a spate of more or less unofficial ones has made it difficult to assess their value adequately. The blue-ribboned medal for military valour, founded in 1833 in gold, silver and bronze, has always held a high place. the gold medal being very rarely awarded. World War I was commemorated by the general service medal. The Fascist regime produced numerous awards and there were decorations for those who took part in the Abyssinian mar and the Spanish civil war. During World War II there were medals for the campaigns in France, Africa. Greece, Yugoslavia and the Soviet Union. Recent orders include the order of merit of the Italian republic and the order of military merit of Italy, which replaces the military order of Savoy.

Netherlands. — Decorations established in World War II include the Bronzen *Kruis,* the Bronzen *Leeuw,* the *Kruis* voor Verdienste and the Vliegerkruis. A resistance cross, the *Verzetskruis,* was founded in 1946.

The Republic of the Philippines has created a series of decorations on U.S. lines with slightly different titles which speak for themselves — the medal for valour, distinguished service star, distinguished conduct star. legion of honour, gold cross. distinguished aviation cross, silver wing medal, medal of military merit, etc. The Philippines had their own medal for Korea (ribbon, yellow with red-white-blue centre) and the United Nations medal they use has the reverse inscription in the native language Tagalog.

Poland. — The *ordo virtuti militari,* originally established at the end of the 18th century, was revived in 1919. It has five classes and is awarded for services in the field. Other decorations include the Grunwald cross for outstanding service during World War II, the Warsaw medal, (awarded to those who took part in the fighting round Warsaw in 1944), the cross of merit and the cross of merit for bravery.

Portugal. — Portugal's last war medal commemorated World War I. Many awards are, however, made for services of various kinds, especially in Portuguese African dependencies, among which may be named the distinguished service medal and the distinguished service overseas medal.

Spain. — During the 19th century Spain issued more than 150 medals, the majority commemorating actions in the Peninsular and Carlist wars. Medals were issued for the Spanish-American War and for campaigns in Morocco. For the civil war of 1936–39 decorations issued included a general service medal and medals for the defense of Oviedo, volunteers of Bilbao and Majorca, etc.

UNITED NATIONS

The United Nations medal was instituted for award to those who took part in operations in Korea during 1950–53. It is of bronze with the UN device on the obverse side and an explanatory inscription on the reverse. The ribbon consists of 17 narrow stripes, nine blue and eight white, representing the 17 nations which participated in the Korean war.

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(L. F. GE.)

MEDAWAR, PETER BRIAN (1915–), British biologist, co-winner, with Sir Macfarlane Burnet (*q.v.*), of the 1960 Nobel prize for medicine for the discovery of acquired immunological tolerance. He was born in Brazil on Feb. 28, 1915, and was educated at Marlborough and at Magdalen college, Oxford. In 1947 he was appointed Mason professor of zoology in Birmingham university and in 1951 he became Jodrell professor of zoology and comparative anatomy at University college, London.

The concept behind the original and important immunological work was first formulated by Burnet in 1949. The theory put forward was that cells "learn" during embryonic life to distinguish between their own tissue substances and unwanted cells or materials introduced from without — bacteria, for example, or incompatible transfused blood or a skin graft. The idea was then suggested that if substances that would be antigenic to an adult were injected during embryonic life, they should inhibit the development of an antibody response. Medawar showed that this was correct and that the phenomenon of acquired immunological tolerance could be produced in the laboratory. He injected foreign living cells into mice embryos and found that mice so injected failed to react against skin grafts transplanted later in life. It was thought that this discovery might lead to the solution of the problem of grafting foreign tissues and that it would profoundly influence the study of immunity in general. Medawar was elected a fellow of the Royal society in 1949 and received its Royal medal in 1959. His publications include The Uniqueness of the Individual (1957) and Reith Lectures on the Future of Man (1960).

(W. J. BP.)

MEDEA, a famous sorceress, daughter of Aeetes, king of Colchis. She fell in love with Jason the Argonaut and exacted a terrible revenge for his faithlessness (see ARGONAUTS and JASON). After the murder of Jason's second wife and the death of her own children, she fled from Corinth in her car drawn by dragons, the gift of Helios, to Athens, where she married king Aegeus, by whom she had a son, Medus. But the discovery of an attempt on the life of Theseus, the son of Aegeus, forced her to leave Athens (Apollodorus i, 9, 28; Pausanias ii, 3, 6–11; Diod. Sic. iv, 45, 46, 54–56). Accompanied by her son, she returned to Colchis and restored her father to the throne, of which he had been deprived by his own brother Perses. Medus was regarded as the eponymous hero and progenitor of the Medes. Medea was honoured as a goddess at Corinth, and was said to have become the wife of Achilles in the Elysian fields. The chief seat of her cult, however, was Thessaly, which was always regarded as the home of magic. The popularity of the story of Jason and Medea in antiquity is shown by the large amount of literature on the subject. To name extant works only, she figures largely in Pindar (Fourth Pythian Ode), Euripides, Apollonius of Rhodes, Ovid (Heroides and Metamorphoses), Seneca (Medea), Valerius Flaccus and several prose authors; her story was already known to some at least of the Cyclic poets. She is also a common subject in ancient art. Beginning as a heroine of fairy tales, she acquires a more human and also more formidable character, especially in Euripides.

See the articles in Daremberg and Saglio's *Dictionnaire des antiquitds* and Roscher's *Lexikon der Mythologie.*

MEDELLÍN, a city of Colombia and capital of the department of Antioquia, 150 mi. N.W. of Bogotá, on a plateau of the Central cordillera, 4.823 ft. above sea level. Pop. (1951) 328,294. Medellín, the foundation of which dates from 1674, stands in the valley of the Porce, a tributary of the Cauca, and is considered one of the most healthful and one of the most attractive cities of the republic. It has a university, national college, school of mines and other educational institutions, assaying and refining laboratories, a public library and a mint. The principal industry of the surrounding country is mining, and gold and silver are exported in considerable quantities. Coffee and hides are also exported. Medellín has direct connections by rail with Puerto Berrio on the Magdalena river, but for many years the high mountain of La Quiebra divided the railroad into two sections: one running from Puerto Berrio to Limón and the other from Santiago to Medellin. The two sections, however, were united through a tunnel.

MEDENINE, a small town in southern Tunisia, 46 mi. S.E. of Gabès. The military camp is the most important French post on the frontier of Tripoli, and Médenine is the chief place of the southern territories of Tunisia. The Ksàr (a fortified village), consists of an agglomeration of rhorfas — long, low-vaulted chambers. piled one above the other four or five stories high, and reached from the interior by steps, while on the external side

they form a continuous defensive wall, pierced only by the small windows. The commune population in 1956 was 5,350.

MEDFORD, a city of Middlesex county, Mass., U.S., on the Mystic river 5 mi. N. of Boston (*q.v.*); primarily a middle-class, residential suburb of Boston and an important trading area for the surrounding communities. Medford's history dates back to 1630 when Gov. Mathew Cradock sent a group of men from the Massachusetts Bay colony to settle a promising location on the banks of the river. Its early economy was based on farming and fishing. Shipbuilding began in 1631 with the "Blessing of the Bay," the first ocean-going ship to be built in America. Merchants grew prosperous from both foreign and domestic trade; Medford rum became world famous; and the city served as a supply depot for New Hampshire and Vermont. Medford-built ships continued to bring prosperity to the town until the last sailing ship was built in 1873.

Medford was incorporated as a city in 1892. It has a council-manager form of government, in effect since 1950, and is the home of Tufts university, a private university founded in 1852. Pop. (1960) 64,971; for comparative population figures see table in MASSACHUSETTS: *Population.* (L. G. BA.)

MEDFORD, a city and the seat of Jackson county in southwestern Oregon, U.S., is located on Bear creek 10 mi. from its confluence with the Rogue river. Medford was founded in Dec. 1883 as a depot on the Oregon and California railroad and was named for the city in Massachusetts. It was incorporated as a town in 1884 and grew rapidly as a freight centre. It was the centre of the Rogue river pear boom of 1900–10; incorporated as a city in 1905, it grew steadily, becoming the county seat in 1927. The period 1921–34 was marked by political turbulence and violence as the Ku Klux Klan and, later, the Good Government league attempted to control city and county government. After that the city was characterized by steady growth based on a sound, expanding economy.

Medford is the residence of many retired persons. The principal industries are agriculture, with pears as the chief crop; forest products, suppgrted by 1,500,000 ac. of commercial timber; and tourist trade, attracted by Crater Lake National park, 80 mi. N.E. of Medford, and the historic mining camp of Jacksonville. The city has a council-manager form of government, in effect since 1954. For comparative population figures see table in OREGON: *Population.* (F. D. H.)

MEDHURST, WALTER HENRY (1796–1857), English Congregationalist missionary to China, was born in London and educated at St. Paul's school. He was a missionary for the London hlissionary society at Shanghai from 1842 to 1856. He was a member of a committee of delegates for the revision of existing Chinese versions of the Bible. The result was a version in High Wen-li. With John Stronach he also translated the New Testament into the Mandarin dialect of Nanking. Medhurst died in London on Jan. 24, 1857.

MEDIA, the ancient name of the northwestern part of Iran, the country of the Medes, corresponding to the provinces of Azerbaijan, Xrdelan (former province), and parts of Kurdistan. It is separated from Armenia and the lowlands on the Tigris (Assyria) by the mighty ranges of the Zagrus (mountains of Kurdistan; in the northern parts probably called Choatras. Plin.. v, 98), and in the north by the valley of the Xraxes (Aras). In the east it extends toward the Caspian sea; but the high chains of mountains which surround the Caspian sea (the Parachoathras of the ancients and the Elbrus) separate it from the coast, and the narrow plains on the border of the sea (Gilan, the country of the Gelae and Amardi, and Mazandaran, in ancient times inhabited by the Tapuri) cannot be reckoned as part of Media proper. The greater part of Media is a mountainous plateau, about 3,000–5,000 ft. above the sea; but it contains some fertile plains. The climate is temperate, with cold winters, in strong contrast to the damp and unwholesome air of the shores of the Caspian, where the mountains are covered with a rich vegetation. Media contains only one river which reaches the sea, the Sefid Rud (Amardus), which flows into the Caspian; but a great many streams are exhausted alter a short course: and in the northwest is a large lake, the lake of Urumiah or Urmia.[1] From the mountains in the west spring some great tributaries of the Tigris, viz., the Diyala (Gyndes) and the Karkheh (Choaspes). Toward the southeast Media passes into the great central desert of Iran, which, eastward of Rhagae (mod. Rai, near Teheran), in the region of the "Caspian gates," reaches to the foot of the Elbrus chain. On a tract of about 150 mi. the western part oi Iran is connected with the east (Khurasan, Parthyaea) only by a narrow district (Choarene and Comisene), where human dwellings and small villages can exist.

The people of the Mada, Medes, appear in history first in 836 B.C., when the Assyrian conqueror Shalmaneser II in his wars against the tribes of the Zagrus received the tribute of the Amadai (this form, with prosthetic a-, which occurs only here, has many analogies in the names of Iranian tribes). His successors undertook many expeditions against the Medes (Madai). Sargon in 715 B.C. subjected them "to the far mountain Bikni," *i.e.,* the Elbrus (Demavend) and the borders of the desert, and received the tribute of 28, and in 713 of 46 chieitains; from their names we learn that they were an Iranian tribe and that they had already adopted the religion of Zoroaster. In spite oi different attempts of some chieftains to shake off the Assyrian yoke, in connection with the northern barbarism, the Cimmerians and the Ashguza (perhaps the Scythians), who had invaded Armenia and Asia Minor, Media remained tributary to Assyria under Sargon's successors, Sennacherib, Esarhaddon and Assur-bani-pal.

Herodotus, i, 101, gives a list of six Median tribes, among them the Paraetaceni, the inhabitants of the mountainous highland of Paraetacene, the district oi Isiahan, and the Magi; *i.e.,* the Magians, the hereditary caste of the priests, who in Media took the place of the "fire-kindlers" (athravan) of the Zoroastrian religion, and who spread from Media to Persia and to the west. But the Iranian Medes were not the only inhabitants of the country. The names in the Assyrian inscriptions prove that the tribes in the Zagrus and the northern parts of Media were not Iranians or Indo-Europeans, but an aboriginal. population, like the early inhabitants of Armenia, perhaps connected with the numerous tribes of the Caucasus. We can see how the Iranian element gradually became dominant: princes with Iranian names occasionally occur as rulers of these tribes. But the Gelae, Tapuri, Cadusii, Amardi, Utii and other tribes in northern Media and on the shores of the Caspian were not Iranians.

In the second half of the 7th century the Medians gained their independence and were united by a dynasty, which, if we may trust Herodotus, derived its origin from Deioces (*q.v.*) a Median chieftain in the Zagrus, who was, with his kinsmen, transported by Sargon to Hamath (Hamah) in Syria in 715 B.C. The origin and history of the Median empire is quite obscure, as we possess only very scanty contemporary information, and not a single inscription irom Media itseli. Our principal source is Herodotus, who wrongly makes Deioces the first king and uniter of the whole nation, and dates their independence from *c.* 710; *i.e.,* from the time when the Assyrian supremacy was at its height. But his account contains real historical elements, whereas the story which Ctesias gave (a list of nine kings, beginning with Arbaces, who is said to have destroyed Nineveh about 880 B.C., preserved in Diod., ii, 32 et *seq.,* and copied by many later authors) has no historical value whatever, although some of his names may be derived from local traditions. According to Herodotus, Phraortes, the son of Deioces, was the first who attacked Nineveh, but was defeated and slain; and when his son Cyaxares renewed the attack, his progress was interrupted by an invasion of the Scythians, who founded an empire in western Asia which lasted 28 years. This invasion of Asia by the Scythians appears to have greatly shaken the Assyrian empire; from Jeremiah and Zephaniah we know that a great invasion of Syria and Palestine by northern barbarians really took place in 626 B.C. Some stories in Herodotus show the Scythian warriors in connection with Cyaxares and the Medes; so the probable explanation is that the Babylonian annals generally give the title "king of the hosts of the Manda" to the Median kings; Manda is an old word for the nomadic tribes of the north, which is also applied to the Cimmerian chieftains.

Until 1923 practically nothing was known about the fall of the Assyrian empire. But in that year a chronicle was discovered by Gadd (the "Fall of Nineveh") in the British Museum, which gives the exact dates. From it was learned that Nabopolassar oi Babylon and Cyaxares (Uvakishtar) of Media began the war against the Assyrians (who were supported by the Egyptians) in 616 B.C. In 612 the allies began the siege of Nineveh, which was stormed and destroyed. The last king, Siusharishkun, the Saracus of Berossus, probably sought his death in the flames of his palace; but an offspring of this dynasty, Assur-yuballidh, still maintained the fragments of his kingdom for several years in Harran (Carrhae), until this town also was taken by the Medes.

The victors divided the provinces between themselves. Syria with Palestine and the south of Mesopotamia fell to the Chaldaean empire of Babylon; the Median king ruled over the greatest part of Iran, Assyria and northern Mesopotamia. Armenia and Cappadocia His power was very dangerous to their neighbours, and the exiled Jews expected the destruction of Babylonia by the Medes (Isa. xiii, xiv, xxi; Jcrem. 1, li), and Nebuchadrezzar tried to secure his kingdom by great

[1] Anc. Mantiane, Straho, xi, jzg; Martiane, Ptol., vi, *2,* **j.**

fortifications, canals and walls against the menace from the north. He succeeded in establishing a state of equilibrium for half a century, further secured by an intermarriage between the dynasties. When Cyaxares attacked Lydia, the kings of Cilicia and Babylon intervened and negotiated a peace in 585, by which the Halys was established as the boundary.

About the internal organization of the Median empire it is known only that the Greeks derived a great part of the ceremonial of the Persian court, the costume of the king, etc., irom Media. But it is certain that the national union of the Median clans was the work of their kings, and probably the capital, Echatana (*q.v.*), was created by them.

By the rebellion of Cyrus, king of Persia, against his suzerain Astyages, the son of Cyaxares, in 553, and his victory in 550, the Medes were subjected to the Persians. In the new empire they retained a prominent position; in honour and war they stood next to the Persians; the ceremonial of their court was adopted by the new sovereigns who in the summer months resided in Ecbatana, and many noble Medes were employed as officials, satraps and generals. After the assassination of the usurper Smerdis, a Mede, Fravartish (Phraortes), who pretended to be of the race of Cyaxares, tried to restore the Median kingdom, but was deieated by the Persian generals and executed in Ecbatana (Darius in the Behistun inscription). Another rebellion, in 409, against Darius II (Xenophon, *Hellen.*, i, 2, 19) was of short duration. But the non-Aryan tribes of the north, especially the Cadusians, were always troublesome; many abortive expeditions of the later kings against them are mentioned.

Under the Persian rule the country was divided into two satrapies. The south, with Ecbatana and Rhagae (Rai), Media proper, or "Great Media," as it is often called, formed in Darius' organization the 11th satrapy (Herodotus, iii, 92), together with the Paricanians and Orthocorybantians; the north, the district of Matiane (see above), together with the mountainous districts of the Zagros, and Assyria proper (east of the Tigris) was united with the Alarodians and Saspirians in eastern Armenia and formed the 18th satrapy (Herod., iii, 94; *cf.* v, 49, 52; vii, 72). When the empire decayed and the Carduchi and other mountainous tribes made themselves independent, eastern Armenia became a special satrapy, while Assyria seems to have been united with Media; therefore Xenophon in the Anabasis (ii, 4, 27; iii, 5, 15; vii, 8, 25; cf. iii, 4, 8 et *seq.*) always designates Assyria by the name of Media.

Alexander occupied Media in the summer of 330; in 328 he appointed as satrap Atropates, a former general of Darius (Arrian, iii, 8, 4; iv, 18, 3; vi, 29, 3), whose daughter was married to Perdiccas in 324 (Arrian, vii, 4, 5). In the partition of his empire southern Media was given to the Macedonian Peithon; but the north, which lay far off and was of little importance for the generals who fought for the inheritance of Alexander, was left to Atropates. While southern Media with Ecbatana passed to the rule of Antigonus, and afterward (about 310) to Seleucus I, Atropates maintained himself in his satrapy and succeeded in founding an independent kingdom. Thus the partition of the country, which the Persian had introduced, became lasting; the north was named Atropatene after the founder of the dynasty, a name which is preserved in the modern Azerbaijan. The capital was Gazaca in the central plain, and the strong castle Phraaspa (Dio Cass., xlix, 26; Plut., Anton., 38; Ptol., vi, 2, 10) or Vera (Strabo, xi, 523), probably identical with the great ruin Takhti Suleiman, with remains of Sassanid fire altars and of a later palace. The kings had a strong and warlike army, especially cavalry (Polyb., v, 55; Strabo, xi, 253). Nevertheless, King Artabazanes was forced by Antiochus the Great in 220 to conclude a disadvantageous treaty (Polyb., v, 55), and in later times the rulers became in turn dependent on the Parthians, on Tigranes of Armenia and then Rome. Pompey defeated their King Darius (Appian, *Mithr.*, 108), Antonius invaded Atropatene, and Augustus received the homage of their kings. In the time of Strabo (A.D. 17) the dynasty existed still (p. 523); in later times the country seems to have become a Parthian province.

Southern Media remained a province of the Seleucid empire for a century and a half, and Hellenism was introduced everywhere. "Media is surrounded everywhere by Greek towns, in pursuance of the plan of Alexander, which protect it against the neighbouring barbarians," says Polybius (x, 27). Only Ecbatana retained its old character. But Rhagae became a Greek town, Europus; and with it Strabo (xi, 524) names Laodicea, Apamea, Heraclea or Achais (cf. Plin., vi, 48). Most of them were founded by Seleucus I and his son Antiochus I. In 221 the satrap Molon tried to make himself independent (there exist bronze coins with his name and the royal title), together with his brother Alexander, satrap of Persis, but they were deieated and killed by Antiochus the Great. In the same way, in 161, the Median satrap Timarchus took the diadem and conquered Babylonia; on his coins he calls himself "the great King Timarchus"; but this time again the legitimate king, Demetrius I, succeeded in subduing the rebellion, and Timarchus mas slain. But with Demetrius I the dissolution of the Seleucid empire begins, which was brought on chiefly by the intrigues of the Romans, and shortly afterward, about 150, the Parthian king, Mithradates 1 (*q.v.*), conquered Media (Justin, xli, 6). From this time Media remained subject to the Arsacids, who changed the name of Rhagae, or Europus, into Arsacia (Strabo, xi, 524), and divided the country into five small provinces (Isidorus Charac.). From the Arsacids or Parthians it passed in A.D. 226 to the Sassanids, together with Atropatene. By this time the old tribes of Aryan Iran had lost their character and had been amalgamated into the one nation of the Iranians. The revival of Zoroastrianism, which was enforced everywhere by the Sassanids, completed this development. It was only then that Atropatene became a principal seat of fire worship, with many fire altars. Rhagae now became the most sacred city of the empire and the seat of the head of the Zoroastrian hierarchy; the Sassanid *Avesta* and the tradition of the Parsees therefore consider Rhagae as the home of the family of the Prophet. Henceforth the name of Media is used only as a geographical term and begins to disappear irom the living language; in Persian traditions it occurs under the modern form *Māh* (Armen. *Maī;* in Syriac the old name Madai is preserved; cf. Marquart, Eranshahr, 18, *seq.*). For Mohammedan history see CALIPHATE; for later history SELJUKS and PERSIA. (ED M.)

MEDIAN, the point on a statistical scale of the distribution of cases, above which and below which lie exactly 50% of the cases. The median is thus a measure of "central tendency." It has the advantage over the arithmetical mean or "average" that it is not affected by unusually high or low values of the variable. For instance, given the values 3, 4, 5, 6, 7, 8, 100, the median is 6, and the arithmetic mean is 19. For some purposes the median value better describes the central tendency of such a series.

In a triangle, it is a line drawn from any vertex to the mid-point of the opposite side. The three medians of a triangle meet in a point which is two-thirds of the distance from each vertex to the mid-point of the opposite side. This point is the centroid of the triangle. and is its centre of gravity.

MEDIANT, a term in music signifying the note occupying the third degree of the diatonic scale (*e.g.*, E in the key of C), the name being derived from the fact that the note in question stands midway between the tonic (the first note) and the dominant (the fifth). (See HARMONY.)

MEDIATION, the practice under which, in a conflict, the services of a third party are utilized as a means of reducing differences or of seeking a solution. Mediation differs from "good offices" in that the mediator usually takes more initiative in prosposing forms of settlement. It differs from arbitration (*q.v.*) in that the opposing parties are not bound by prior agreement to accept the suggestions made.

Mediation of Industrial Disputes. — In labour disputes, if the conflict does not fall within a labour-management agreement, or if it exceeds the capacity of such machinery to settle, the government usually provides a mediator. The U.S. government and the majority of the governments of western Europe maintain labour mediation or conciliation services. In the United States several states and some cities have developed mediation services available to regional or local industry. In the great majority of situations in which labour mediation agencies have been created by a governmental unit, these agencies have the power to intervene in a dispute when in their judgment the public interest is threatened. Such public bodies do not have the power to compel an acceptance of the terms they propose, but their freedom to publicize their recommendations and their power to report to a superior body capable of recommending legislative action usually serve as an important stimulus to agreement. (See also INDUSTRIAL RELATIONS.)

International Mediation. — While mediation procedures are less fully developed in international conflicts, important moves forward were made in the Hague treaties of 1899 and 1907, in the League of Nations covenant, and in the United Nations charter.

There were several instances of successful mediation in the 19th century: of Great Britain in 1825 between Portugal and Brazil; of the great powers in 1868–69 between Greece and Turkey when relations were strained over Crete; and of Pope Leo XIII in 1885 between Germany and Spain in the matter of the Caroline Islands. In these cases mediation probably averted war. In the Xustro-Prussian war of 1866, the war between Chile and Peru in 1882 and that between Greece and Turkey in 1897, the mediation of neutral powers was instrumental in bringing hostilities to a close. Despite the successful outcome of these efforts, however, the conviction persisted throughout much of the 19th century that the mediatory intervention of a third state constituted an unfriendly act. In the Hague treaties it was specified that an

offer of mediation was not to be so considered.

While the Hague treaties provided certain procedures for mediation, it was not until the League of Nations was established that states assumed an obligation to submit disputes "likely to lead to a rupture" to the procedures of peaceful settlement (League covenant, article 12). The secretary-general of the League was authorized on request of a member of the League to summon a meeting of the council. (Article 11.) He was also authorized to take certain initiatives in arranging for a full investigation and consideration of disputes. (Article 15.) Once the dispute had been submitted to the council, or to the League assembly if it was so referred, the body could proceed on the basis of (1) good offices; (2) mediation; (3) seeking a judicial opinion on some aspect of the case; or (4) some general but less distinct form of conciliation. (*See* also ARBITRATION, INTERNATIONAL.)

United Nations. — Under the United Nations system members assumed an even more precise obligation to settle their disputes in a peaceful manner. Article II, paragraph 3, states *inter alia* that all members "shall settle their international disputes by peaceful means." Under article 33 the parties to any dispute likely to endanger the maintenance of international peace and security are enjoined first to "seek a solution by negotiation, inquiry, mediation, conciliation, arbitration, judicial settlement, resort to regional agencies or arrangements or other peaceful means of their own choice." Should they fail to settle it by these means they are obliged under article 37 to refer it to the security council. The council, or the general assembly if the dispute is referred to it, then undertakes the form of settlement which it believes suited to the particular case.

Following discussion in the council or in the assembly, the dispute is frequently submitted to mediation. In May 1948, for instance, the general assembly appointed Count Folke Bernadotte of Sweden as mediator in Palestine. After his assassination, Ralph Bunche of the United Nations secretariat was appointed acting mediator. In the winter and spring of 1949 he was able to conclude armistice agreements between Israel and the four neighbouring Arab states. Sir Owen Dixon of Australia was under similar appointment of the security council for mediation of the Kashmir dispute between India and Pakistan. He was succeeded in 1951 by Dr. Frank P. Graham of the Gnited States.

Several commissions appointed by the security council and by the general assembly had mediatory functions, *e.g.,* the commission on Indonesia, the India-Pakistan commission, the Palestine Conciliation commission and the commission on Korea.

With the growth of international political organization such clear lines as formerly existed between fact finding, good offices, mediation, arbitration and judicial settlement tended to become somewhat blurred. Disputing states and the United Nations may use different procedures in sequence, or they may separate out certain parts of a dispute for a judicial opinion. The initial discussion in the security council or in the general assembly usually assists in clarifying the issues. In connection with these considerations conciliatory influences are brought to bear. This process has been referred to as "parliamentary diplomacy." The term mediation has usually been reserved for the work of the subsidiary bodies set up by the security council or the general assembly to conduct the more intimate and detailed negotiations with the countries in dispute.

The secretary-general of the United Nations, in article 99 of the charter, was given power "to bring to the attention of the security council any matter which in his opinion may threaten the maintenance of international peace and security." This is considerably more power than the secretary-general of the League of Nations was given. The rules of procedure of the general assembly permit the secretary-general to place any item on the provisional agenda of the assembly. While Trygve Lie, the first secretary-general of the United Nations, and Dag Hammarskjold, the second secretary-general, were cautious about exercising these powers, both men interpreted their role as a broad one. Hammarskjold was asked by the general assembly in December 1954 to seek the release of United Nations airmen imprisoned in China. He was asked by the security council in April 1956 to undertake to get compliance with the armistice agreements in the middle east. In the Suez and Hungarian crises in 1956 and 1957, he again undertook difficult mediatory missions.

See Elmore Jackson, *Meeting of Minds, a Way to Peace Through Mediation* (1952); Philip C. Jessup, *Parliamentary Diplomacy,* Academie de Droit International, 181 (1957). (EE. JN.)

MEDLATIZATION, the process by which at the beginning of the 19th century, a number of German princes, hitherto sovereign as holding *immediately* of the emperor, were deprived of their sovereignty and *mediatized* by being placed under that of other sovereigns.

MEDICAL AND SURGICAL SOCIETIES. Many early scientific societies included medicine within their scope, and several were founded by medical men. The history of the older societies is obscure, and many societies disappeared without trace. Medical societies have fostered the development of experimental science by discussion among members, by the formation of libraries and by the publication of proceedings and monographs.

Europe.—Following the schools, lyceums and museums, the forerunners of societies as now defined, the earliest scientific societies are encountered in Italy. The Academia Secretorum Naturae, founded at Naples in 1560; the Accademia del Cimento (1657–67) of Florence; and the Accademia dei Lincei, founded at Rome in 1603 by Prince Federigo Cesi, were probably the three earliest scientific societies in that country. Joachim Jung (1587–1657), founded the Societas Ereunetica at Rostock, Ger., but it did not survive beyond 1625. Another physician, Johann Lorenz Bausch (1605–55), founded the Academia Naturae Curiosorum at Schweinfurt, Ger., in 1652, and from 1670 this society published a periodical entitled *Miscellanea curiosa Medico-Physica.* Following other changes in title, the society became the Academia Caesaraea Leopoldino-Carolina Germanica Naturae Curiosorum in 1859. Two other early German societies of note were the Collegium Curiosorum sive Experimentale (1672), and the Königliche Preussische Societat (Akademie) der Wissenschaften zu Berlin (1700), founded by Gottfried W. Leibniz.

The College of Physicians of London was founded in 1518 by Henry VIII, and was housed in its premises in Pall Mall East in 1825. Renamed the Royal College of Physicians, this body, in conjunction with the Royal College of Surgeons, grants qualifying degrees in medicine and surgery. The latter college was founded in 1800, succeeding the Company of Surgeons of London (1745), itself an offshoot of the Barber Surgeons company, founded in 1540. The Royal College of Physicians of Ireland (1667) and the Royal College of Physicians of Edinburgh, Scot., (1681) also demand mention.

The weekly meetings of a few scientists at Gresham college, London, begun about 1645 and continued at Oxford (1648–49), led to the formation of the Royal Society of London in 1660, a royal charter being granted on July 15, 1662. Fourteen medical men were elected fellows at its inception, and the early numbers of the *Philosophical Transactions,* first published by the society on March 6, 1664–65, contain much of medical and surgical interest. The society also published monographs, and since 1832 has issued its *Proceedings* of *the Royal Society,* both this and the *Philosophical Transactions* being still current. Yet another 17th century medical society, the Society of Apothecaries, incorporated by a charter from James I in 1606, is still in existence and functions as an examining body.

In France the Académie de Chirurgie, Paris, was founded in 1731 and, although suppressed during the French Revolution, was afterward revived as the Société nationale de Chirurgie. The Académie royale de Chirurgie et Société royale de Médecine was succeeded by the Académie de Médecine, this being divided into sections devoted to medicine, surgery and pharmacy. The académie published its proceedings as *Mémoires.*

Medical societies founded by students fostered an early interest in the development of medicine. The Royal Medical Society of Edinburgh, founded as a student body in 1737, was incorporated by royal charter in 1779. Guy's Hospital Physical society was founded in 1771, and a branch of the society intended solely for students was formed in 1830 as Guy's Hospital Pupils' Physical

society, and the latter continues to function. The Middlesex Hospital Medical society, formed in 1774, represents another student society, while the Edinburgh Harveian society, founded in 1782, meets once a year on the anniversary of William Harvey's birth. At St. Bartholomew's hospital, London, the Medical and Philosophical society was founded by John Abernethy in 1795, and in 1832 was revived as the Abernethian society. It flourishes as a student body. Two medical societies were founded by John Hunter and George Fordyce: the Society for the Improvement of Medical and Chirurgical Knowledge (1783–1818), meeting monthly at a coffeehouse and publishing three volumes of *Transactions* between 1793 and 1812; and the Lyceum Medicum Londinense which met every Friday evening in Hunter's lecture room, commencing in Jan. 1785, and had a large membership.

Apart from student bodies, the Medical Society of London is the oldest existing medical society in the metropolis. Founded by John Coakley Lettsom (1744–1815) in 1773, the society quickly became prosperous, housing an extensive library. In 1871 the Medical society took over its headquarters in Chandos street and began publishing the proceedings of its meetings as *Memoirs* or *Proceedings* and, from 1872, as *Transactions*, issued annually. In 1805, however, many members left the Medical society to found the Medico-Chirurgical society, later incorporated in the Royal Society of Medicine. Many other British medical societies were founded in the 19th century, and the trend toward specialization became noteworthy. For example, the Edinburgh Obstetrical society, the Royal Microscopical society and the Pathological Society of London were all founded in 1846; the Epidemiological society, London (1850), the Odontological Society of Great Britain (1856), the Physiological society (1876), the Glasgow Obstetrical and Gynaecological society (1885), the Anatomical Society of Great Britain and Ireland (1887) and the North of England Obstetrical and Gynaecological society (1890) also appeared during that period. The Hunterian society, established in 1819, has published its *Transactions* since 1885 and awards the Hunterian society medal annually for an essay. In 1831 the Harveian Society of London was founded as the Western London Medical society, and institutes the Harveian lectures.

The British Association for the Advancement of Science held its first meeting in 1831, and although devoted to general science, includes sections covering medicine and allied subjects. The Provincial Medical and Surgical society also dates from this period, having been founded in 1832 by Charles Hastings. The society published its *Transactions* until 1853, when these were succeeded by the *Association Medical Journal*, which in 1857 became the *British Medical Journal*, one of the foremost medical periodicals. The society had become the British Medical association in 1856, and by mid-20th century had more than 100 branches in various parts of the world. It also publishes several specialist periodicals, including an abstracting journal, and achieved prominence in furthering the aims of the medical profession in general. The association possesses an extensive library at its headquarters in London.

The oldest existing society in Great Britain devoted to pathology, the Reading Pathological society, was founded in 1841, while in 1862 the Ulster Medical society was formed by the amalgamation of the Belfast Medical society (1806) and the Belfast Clinical and Pathological society (1853). The society printed its *Transactions* from 1892 to 1931, when it founded the *Ulster Medical Journal*. Sir William Bowman founded the Ophthalmological Society of the United Kingdom in 1830, and two years later appeared the West London Medico-Chirurgical society, the proceedings of which are published in the *West London Medical Journal*.

A society having as its primary objective the publication of important classic writings on medicine was founded in 1843. This was the Sydenham society, which issued 29 publications before it was discontinued in 1858. It was succeeded by the New Sydenham society, which continued the policy of its predecessor, publishing 195 items, excluding periodicals, before it ceased to exist in 1907.

In 1882 the Royal Academy of Medicine in Ireland was formed by the amalgamation of the Association of Fellows and Licentiates of the King and Queen's College of Physicians in Ireland (1816), which later became the Medical Society of the College of Physicians; the Surgical Society of Ireland (1831); The Pathological society (1838); and the Obstetrical society. The Royal academy published *Transactions* from 1893 to 1920, followed by the *Dublin Journal of Medical Science*, which in 1922 became the *Irish Journal of Medical Science*.

The Royal Society of Medicine, the largest medical society in London, was formed in 1907 by the amalgamation of 18 societies. This mas effected largely through the efforts of Sir John **Y.** W. Macalister (1856–1925), the larger societies involved being the Royal Medical and Chirurgical Society of London (1805), the Pathological Society of London (1846), the Epidemiological society (1850), the Odontological Society of Great Britain (1856) and the Obstetrical Society of London (1858). These brought funds and books with them, and the library of the Royal Society of Medicine became the largest medical library in the British Commonwealth. The Royal society publishes its *Proceedings* monthly.

The growth of medical societies in the first half of the 20th century progressed rapidly. specialist and local societies springing up to render difficult the recording of individual names. In 1913 there were 132 medical societies in Great Britain, the total in Europe at mid-century running into several thousands. Taking the year 1935 as representative of the development of medical societies before World War II, we find the following inaugurated: Association of Industrial Medical Officers; Clinical institute, Kiev, U.S.S.R.; Deutsche Gesellschaft für Ernahrungsforschung, Berlin. Ger.; Gesellschaft Deutscher Neurologen und Psychiater, Munich, Ger.; Perm State Medical institute; Society of Radiotherapists of Great Britain and Ireland; and the State Institute for Pediatric Medicine, Leningrad, U.S.S.R. Many societies ceased to function during hostilities, some suffered considerable damage and few new ones were founded.

See Sir D'Arcy Power (ed.), *British Medical Societies* (London, 1939); John L. Thornton, "The Rise of Medical Societies," chap. vii, pp. 130–144, "A Chronological List of Medical Societies and Institutions," appendix 1, pp. 218–243, *Medical Books, Libraries and Collectors* (London, 1949). (J. L. T.)

Australia, Canada. — In Australia the Medical Society of Victoria was established in Melbourne and began publication of its medical journal in 1856.

In Canada the Canadian Medical association at Toronto, Ont., was established and began publishing transactions in 1877. In addition, the Canadian Public Health association, also at Toronto, and the Canadian Tuberculosis association, Ottawa, Ont., were established to perform the special functions designated by their titles.

United States. — The first medical society in the American colonies was mentioned in a letter by William Douglass to Cadwallader Colden, dated Feb. 17, 1735, in which he states: "We have lately in Boston formed a medical society. . . ." The society lasted about six years, and an operation was performed before it by Silvester Gardiner in 1741.

The fundamental organization of physicians for scientific, economic and representational purposes is the county medical society, which elects representatives to the state medical societies. The latter in turn elect their representatives to the house of delegates of the American Medical association, the number of delegates being determined by the number of the membership. The house of delegates makes the policies that guide the American Medical association.

For scientific purposes the American Medical association is organized into scientific sections representing each of the medical specialties. Examples are the sections on surgery, obstetrics, urology, orthopaedic surgery and laryngology, otology and rhinology. Whereas these sections are largely surgical, other sections, such as nervous and mental diseases, dermatology and syphilology, pathology and physiology, radiology, gastroenterology and proctology and anaesthesiology, are largely medical.

There are also many societies devoted to the advancement of knowledge in specialized medical fields — more in surgery than in

almost any other specialty. If a surgeon is a resident in a large city or lives near a large city, he has a local surgical society like those of Chicago, Ill., New York city or Washington, D.C. In a few of the larger states there are state surgical societies, and many of the state medical societies have special sections devoted to surgery. Then come the regional surgical societies. with the western, the Pacific coast. the north Pacific, the southern, the southeast, the New England and similar groups. On a national scale there are the American Surgical association, American College of Surgeons and International College of Surgeons. In addition. there are clinical groups and smaller units of surgeons for studying such surgical specialties as orthopaedics, urology, surgery of the chest. plastic surgery and similar branches. There are also special societies for practically every other field of medicine as well as county, state and regional organizations of such specialties.

In addition to societies organized primarily for the advancement of medicine and surgery, there are also organizations concerned primarily with public health. The outstanding organization in this field is the American Public Health association, but special groups include the National Tuberculosis association. American Child Health association, American Social Hygiene association American Cancer society. American Heart association and similar groups.

Later agencies and societies were formed particularly for the distribution of medical care, such as the various Blue Cross hospital associations, state medical society insurance plans. Associated Medical Care Plans, Inc., etc (For a complete listing of U S medical societies, see the latest edition of the American Medical *Directory.)*

International. — The great need for dissemination of medical information throughout the world for the benefit of mankind has been reflected in the formation of a great many international medical societies, including among the oldest those devoted to surgery, physiology, tropical diseases and bacteriology.

For consideration of social and economic problems. later groups include the World Health organization of the United Nations. the World Medical association and the Federation Medica Panamericana. (M. FI.)

MEDICAL EDUCATION is devoted to teaching the knowledge and skills used in the prevention and treatment of disease and to developing the methods and objectives appropriate to the study of the still unknown factors that produce disease or favour well-being.

History. — The Greeks' spirit of rational inquiry may be considered the starting point of medical education because it introduced the practice of observation and reasoning regarding disease. Rational interpretation and discussion lend themselves to teaching and thus to the formation of schools such as that at Cos where Hippocrates (*q.v.*) taught. Later the Christian religion greatly contributed to both learning and teaching medicine because it favoured as acts of Christian piety not only the protection and care of the sick but the establishment of institutions where collections of sick people encouraged observation, analysis and discussion among physicians by furnishing excellent opportunities for comparison. With the rise of the universities in Italy and later in Cracow, Prague. Paris, Oxford and elsewhere in western Europe, the teachers of medicine were in some measure drawn away from the life of the hospitals and were offered the attractions and prestige of university professorships and lectureships (see also UNIVERSITY). As a result, the study of medicine led more often to a familiarity with theories about disease than with actual sick persons. This emphasis upon theory, doctrine and systems lasted well into the 18th century. Little by little the value of hospital experience and the training of the students' sight, hearing and touch in studying disease were reasserted, though to rather indifferent contemporaries, in London by Thomas Sydenham and later in Leiden by Hermann Boerhaave (*qq.v.*) and more effectively in Vienna by Gerhard van Swieten. In the 18th century in Europe medical education began slowly to assume its modern character in the application of a gradually increasing knowledge of natural science to the actual care of patients. This return to the bedside aided the hospitals in their long evolution from dwelling places of the poor, the diseased and the infirm, maintained by charity and staffed usually by religious orders, to the well-equipped. efficient places of today used by every part of the community, maintained by charity or at public expense and staffed by trained nurses, physicians, surgeons and lay assistants.

The 19th-century discoveries of Louis Pasteur, which showed the relation of micro-organisms to certain diseases, Joseph Lister's application of Pasteur's concepts to surgery and the studies of Rudolf Virchow and Robert Koch brought immense stimulus to the practice of medicine and surgery. In the U.S., medical education was greatly influenced by the example set in 1893 by the Johns Hopkins Medical school. Baltimore, Md. It admitted only college graduates with a year's training in the natural sciences. Its clinical work was superior because the school was supplemented by the Johns Hopkins hospital, created expressly for teaching and research carried on by members of the medical faculty. A reduction in the number of entirely inadequate medical schools in the United States followed the publication in 1910 by the Carnegie Foundation for the Advancement of Teaching, of a report by Abraham Flexner. The report attracted attention to the need of medical schools for better laboratory facilities! better access to patients in hospitals, and larger, better-trained teaching staffs. Aided by the General Education board, the Rockefeller foundation and a large number of private donors. U.S. and Canadian medical education was characterized by substantial improvements from 1913 to 1929, in point of endowments, buildings, laboratories, clinical facilities, teaching staffs and methods of instruction.

Valuable supervision and control of medical education in the United States was provided by the Council on Medical Education and Hospitals of the American Medical association.

General Characteristics. — The distinctive feature of medical education is the thoroughness with which theoretical and scientific knowledge are fused with what experience teaches in the practical responsibility of taking care of human beings. It must be remembered that the clinical teacher has an immediate and absolute responsibility to his patients as well as to his students. This double burden of theory and practice is all the heavier when great advances are being made in medical science. The curriculum is already overcrowded, and no one now expects a practitioner of any branch of medicine to complete a fully adequate training in less than four years after receiving the minimum of the four- or five-year medical education necessary in most countries to secure the licence to practise.

The premedical courses required in most countries are in the subjects of physics, chemistry and biology. Graduation from a recognized secondary school is required. The courses in physics, chemistry and biology are required in order to make it possible to present subsequently the subjects of anatomy, physiology, biochemistry and pharmacology with precision and economy of time to minds prepared in scientific method and content. Each of the courses required should include laboratory periods of from two hours to six hours a week for a full academic year. However, the extent of the student's familiarity with the use of instruments and laboratory procedures varies widely from country to country since premedical instruction is expensive and is often of inferior quality.

The medical schools begin their work with the study of the structure of the body and its formation: anatomy, histology and embryology. Concurrently, or soon thereafter, come the studies related to function; *i.e.*, physiology, biochemistry, pharmacology and in most schools, biophysics. Usually after the microscopical study of normal tissues (histology) has begun: the student is introduced to pathological anatomy. bacteriology, immunology, parasitology — in short, to the agents of disease and the changes they cause in structure and function of the tissues. Courses in medical psychology, biostatistics and public health may be found in the first two or two and one-half years of the medical course, but this was not common before 1935. Wide differences are observed from country to country and from decade to decade in the sequence and emphasis given the courses in the above-named medical sciences, and in the balance between laboratory work,

lectures and seminars. The essentials to be desired, however, remain: superior quality of the teaching staff, a high ratio of teaching staff to students, adequate funds for laboratory work and research and a high quality character, mind and training in the students.

The two or more clinical years of an effective curriculum are characterized by active student participation in small group conferences and discussions, a decrease in the number of formal lectures and increased contact with patients in teaching hospitals and clinics. Through work with patients under the supervision and guidance of experienced teachers, students learn methods of obtaining comprehensive, accurate and meaningful accounts of illness. how to conduct physical examinations and develop judgment in the selection and utilization of laboratory diagnostic aids. During this period they learn to apply the knowledge gained in their pursuit of the basic medical sciences to the study of general medicine and the medical and surgical specialties.

This first phase of clinical indoctrination can only develop a foundation through offering the opportunity to learn certain essentials; to this the student physician must add expertness and competence through special and advanced education and training. Such advanced education and training in medicine is of two general types. (1) On completion of medical school, the physician usually seeks graduate training and experience in a hospital under the supervision of competent clinicians and other teachers. In North America the first year of such training is known as an internship. Persons seeking further graduate education and training to qualify themselves as specialists or to fulfill requirements for a higher academic degree, subsequently become hospital residents or fellows for periods of from one to four or five years. (2) The second type of advanced training is known as postgraduate education. It consists of courses and training opportunities of from a few days to several months in duration, designed to enable physicians to learn of new developments within their special areas of concern. Such courses, fostering the continuing education of physicians, are offered by medical schools, hospitals and medical societies in many parts of the world.

Pedagogical Aspects.—Abraham Flexner rightly insisted that medical education is a form of education and not a mysterious process of professional initiation or apprenticeship. In terms of educational methods the following points deserve mention:

In the United States and Great Britain and its dominions, medical schools are inclined to limit the number of students admitted so that each student may have a reasonably good opportunity. In western Europe, South America and most other countries. no exact limitation of numbers of students has been effected. though there is a trend toward such limitation in some of the western European schools. Some medical schools in North America are able to show ratios of teaching staff to students as high as 1 to 1 or 1 to 2. in contrast nith 1 teacher to 20 or even 100 students in certain European universities.

Where the laboratory or the clinical facilities are inadequate for a large number of students, or where the teaching force is small, the relative importance of the examination increases. When the examination is the sole control on the student's industry, knowledge and capacity, emphasis usually comes to be placed on memory rather than on powers of observation and reasoning.

The Association of American Medical Colleges established annual institutes on various aspects of medical education. These institutes have played a significant role in stimulating a widespread experimentation characterizing undergraduate medical education in the United States today.

As applied to clinical teachers the term "full time" originally implied an educational ideal: that a clinician's salary from the university should be large enough to relieve him of any reason for seeing private patients for the sake of supplementing his salary by professional fees. "Full time" has come to be applied, however, to a variety of modifications; it may mean that a clinical professor may supplement his salary as a teacher up to a defined maximum, or may see private patients only at his hospital office, or may see such patients only a certain number of hours per week. The intent of "full time" has always been to place the' professor's capacities and strength entirely at the service of his students and the patients entrusted to his care as a teacher and investigator.

Courses in the medical sciences commonly follow the formula of three hours of lectures and six to nine hours' laboratory work per week for a three-, six- or nine-months' course. Instruction in the clinical subjects, though retaining the formal lecture, tends to diminish the time and emphasis allowed to lectures in favour of experience with and attendance on patients. Nonetheless, the level of lecturing and formal presentation in continental Europe remains high. Formality and a considerable measure of emphasis on status also characterize the relationship between professor and student in European schools.

In the United States the fifth, or intern. year is of special importance and value, though it is not usually directly controlled by the medical school and ordinarily follows the award of the M D degree. The intern usually lives in an approved hospital and in any case devotes his entire time to the work of the hospital. Often the intern year leads to a second year called assistant residency or residency, a continuation of this extremely valuable practical experience. In the United States approximately three-fourths of graduate physicians enter residency training for a period of two to five years following the internship.

The clinicopathological conference is a distinctive feature of medical education in North America. As a public exercise, a clinician comments upon the record of a case of fatal illness in a patient he has not seen and discusses from this record the probable cause and nature of the illness. The pathological anatomist who examined the organs of the deceased then reports upon the actual findings. The lessons are vivid and the effect upon the fullness and accuracy of hospital records is excellent.

In Great Britain, Canada. Australia, New Zealand. South Africa and Ireland the academic degrees given at the end of five years of study are the M.B. and B.Ch. (bachelor of surgery). Only after considerable further study is the M.D. given, and only to a few persons.

In some countries of western Europe, in South America, North America. China and the Philippines, the M.D. is given at the end of four to six years of study and is not, therefore, an advanced degree.

The quality of medical education is supervised in the English-speaking countries by councils appointed by the profession as a whole—the General Medical council in Great Britain, the Council on Medical Education and Hospitals of the American Medical association in the U.S. In other countries this is a function of the ministry of public instruction with, in some cases, the help of special councils to represent professional knowledge and experience.

Social Factors.—In the United States, licensure to practise medicine is controlled by boards of licensure in each of the states. These boards set and conduct examinations of applicants to practise within the state and examine the credentials of applicants who wish licences obtained in other states to be accepted in lieu of examination. In 1915 the National Board of Examiners was created as a voluntary organization with two representatives each from the army, navy and public health service, three representatives from state licensing boards and seven other physicians to hold examinations leading to a diploma that would be acceptable to all the state boards.

National laws regulating professional practice cannot be enacted in the United States.

In Canada the Medical Council of Canada conducts examinations and enrolls successful candidates on the Canadian medical register. The provincial governments accept this certificate of registration as the main requirement for licensure In Great Britain, the medical register is kept by the General Medical council, which in effect controls the licensing bodies. In most European countries, graduation, on conditions set by law, from the state-controlled university in effect serves as a licence to practise; and the same is true for the U.S.S.R., China, Japan and India.

After 1920 there was a steady growth and improvement of preventive medicine and public health in the U.S., both in terms

of the number and qualifications of professional personnel employed by cities, counties, states and the U.S. public health service and in terms of its importance in the medical curriculum. A similar development characterized many other countries, especially the U S.S.R.

It is becoming apparent that it is of special advantage to a patient to obtain care in a teaching hospital, since, if his case is to be used for discussion or teaching, there is every likelihood that the examination, diagnosis and treatment will receive particular care and repeated attention; hence, a hospital's affiliation with a medical school for research and teaching purposes is very desirable. This was realized by the U.S. Veterans administration in 1945 when the Deans' committee assured collaboration between the medical schools and the hospitals of the Veterans administration. Collaboration between school and hospital has given rise to the so-called medical centres.

Economic Aspects.—The income of a medical school is derived from four principal sources: (1) tuition and fees; (2) endowment income or appropriation from the government (taxation); (3) gifts from private sources; (4) donation of teachers' services. Tuition or student fees are large in the English-speaking countries, except in U.S. state universities, and small throughout the rest of the world. Only rarely does income from tuition exceed 50% of a school's total income. The total cost of maintaining a medical school, if prorated among the students, would give a figure from 3 times to 50 times the tuition or other charges paid by the student.

The expenses of medical education fall into two groups: those of the instruction given in the medical sciences and those connected with hospital teaching. The cost of building maintenance, laboratory equipment and supplies, research expenses. salaries of teachers, wages of employees, etc., in the medical sciences, though heavy, are comparable to those in other departments of the university. In the clinical subjects all expenses in connection with the care of patients usually are considered as hospital expenses and not carried from the medical school budget nhich should be reserved for expenses of teaching and research. Here the heavy expenses are salaries of clinical teachers, especially the full-time teachers, and the cost of studying cases of illness with a thoroughness appropriate to their use as teaching material

To a considerable degree in all countries outside the U S.S R., the cost of securing an adequate medical education has tended to exclude the student whose family cannot contribute a large share of his living expenses and tuition for a period of four to ten years. This difficulty is offset in several medical schools by loan funds and scholarships. but these aids are commonly offered only in the second or subsequent years.

Scientific Aspects.—Medical education has the double task of passing on to students nhat is known and attacking what is still unknown. The cost of research is borne by a few; the benefits are shared by many. There are countries whose inhabitants are too poor to support physicians or use them: countries nhich can support a few physicians but are too poor to maintain a good medical school; countries which can maintain medical schools where nhat is known can be taught but no research can be carried out; and a few countries where teaching and research in medicine can be carried on to the great advantage of the world at large.

A medical school having close geographical as well as administrative relationships with the rest of the university of which it forms a part usually profits by this intimate and easy contact. From the biological sciences medicine cannot wisely be separated. From chemistry. physics, mathematics and psychology, medicine has already gained immensely and continues to profit The social sciences have a contribution to make in helping physicians provide a better distribution of medical care. Contact, therefore, with teachers and the advancing knonledge in other faculties of the university would extend and improve the chances of progress in medicine.

International Aspects.—With the development of the World Health organization and the World Medical organization following World War II there has been increasing international interest in medical education. World War II shoned the advantages and economy derived from satisfactory systems of medical education. Defects and diseaies were more widely and accurately detected among recruits than ever before, health and morale were effectively maintained among combatants, and disease and battle injuries were effectively treated in the armed forces of those nations whose medical schools had been of high quality. and only in those nations. However, as a result of the war, the medical schools of Norway, Finland. western U.S S.R.. Poland, Czechoslovakia, Germany. Austria, the Balkan states. Italy. France, Belgium, the Netherlands and London, as well as those of China, Japan, the Philippines Java and Siam, suffered either physical destruction of laboratories, hospitals and libraries or serious losses of teaching personnel and students.

In Aug. 1953 over 600 registrants from 59 nations attended the first World Conference on Medical Education in London. That conference was centred around undergraduate medical education and concerned itself with the requirements for entry into the medical schools, the aims and content of the medical curriculum, the techniques and methods of medical education and preventive and social medicine.

The second World Conference on Medical Education, dealing with the problems of education beyond the medical school, was held in Chicago, Ill., during 1959, with representatives of 63 countries in attendance.

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(AL. G.; E. L. TR.)

MEDICAL JURISPRUDENCE deals with the relationships of law and medicine. A registered medical practitioner is one mhose name appears on the register kept by the General Medical council established under the Medical acts of 1858 to 1886 to set up standards of professional knowledge. to keep a register of men and women who reach this standard and to deprive of their qualifications those whom the council finds guilty of "infamous conduct in a professional respect." This body is not to be confounded with the British Medical association, a voluntary association comprising 64% of the medical men and women on the register.

The elements of medical jurisprudence form part of the curriculum of every examining body approved by the General Medical council. The introductory part of this study treats of the doctor as witness, a medical man being in the nature of things often asked in a court of law to give his opinion as well as to testify as to facts. (See EVIDENCE.)

At the threshold of this subject stands the question of so-called medical privilege. (See PRIVILEGE.) Is a doctor bound to disclose in a court of law communications made to him by his patient? The law recognizes no such thing as medical privilege in the sense that there is legal privilege, nor is the reason far to seek. A medical man is consulted about questions which are or ought to be unconnected with the law; a patient does not ask a doctor to undertake his defense in a case before the courts. A medical witness appearing as such should never in any sense be an advocate and must not take sides, whether he be called for the plaintiff or for the defendant.

hledical writers themselves hold this ideal up to the profession although in practice it is not always adhered to. Many medical men on graduation take, and all reputable medical men consider themselves bound by, the Hippocratic oath, the relevant part of which is as follows: "Whatsoever in connection with my professional practice or even outside of it I see or hear in the life of men which *ought not to* be spoken of I will not divulge." The italics are important.

It is clear' that it is required of medical men, as it is required of bankers, that they shall not gossip. When, however. the law requires it, it is clearly proper to divulge such matters; indeed it will be contempt of court to refuse to do so. On the other hand,

it will not be proper to divulge certain matters under any other circumstances, for example, to the executive, who have not the authority, though they often assume it, of the judiciary. (See CONSTITUTION AND CONSTITUTIONAL LAW.)

The Notification of Infectious Diseases act of 1889 and many others show that medical privilege is no more recognized by statute law than it is by the common law. The list of acts of parliament which affect medical men is a long and formidable one. Not all of these, however, are considered as forming the subject matter of medical jurisprudence. the majority of them are considered to belong rather to the domain of public health (*q.v.*).

The precision required for elucidation of medicolegal problems will sometimes exceed and sometimes fall short of that required by science; that is to say, the law will at times be content with what may seem rough and ready methods while at others it is necessary to decide between the diametrically opposed views of medical experts of equal eminence Obviously the law, by its very nature conservative. must lag a little behind contemporary science, for the interests of justice require not theories nor even hypotheses but facts.

The law's routine relations are rather with medicine as an art than medicine as a science. This fact is apt to be lost sight of when the so-called expert is extolled at the expense of the general practitioner whose very name denotes that he deals mith the realities of life rather than with theories. For this reason medical practitioners enjoy a certain equality in the eyes of the law (nor have we any system as obtains in France where a panel of experts, called *médecins légistes* and consisting of pathologists, toxicologists. gynaecologists and alienists, is drawn up every year by the court). The certificate under the Lunacy acts may be signed by any registered medical practitioner, although one of the two medical certificates required by s. 5(3) of the Mental Treatment act of 1930 in cases of "temporary treatment without certification" ***(sic)*** may be signed only by a practitioner of five years' standing approved by the Board of Control.

The coroner (*q.v.*) will in difficult cases of course prefer to have the services of a pathologist or of a toxicologist, that is, of men whose reading and practice specially qualify them for the determination of the causes of death, but no such persons are known to the law.

It is difficult to arrange in logical order the subjects falling within the purview of forensic medicine; but a more or less orderly arrangement may be made according to the nature of the court and the case before it.

First in date and interest, if not in importance, is the institution, peculiar to the English-speaking peoples (under the common law). of the court of the coroner (q v.) whose duty it is to enquire into all deaths of nhich the cause is unknown, deaths from violence (accidental or criminal) or in circumstances of suspicion in prisons. lunatic asylums, etc., or from certain notifiable diseases. It is strictly an enquiry and not a trial: there is no suit and there are no parties. The question is—hom and by what manner X came by his death.

In the great majority of cases death will be found to be due to natural causes, and the investigation of those cases in which the physician in attendance is unwilling or unable to give a death certificate forms the routine work of the pathologist. Some diseases, such as acute haemorrhagic pancreatitis. are almost never diagnosed *ante mortem* Then again, in cases of sudden death, the physician will be chary of giving a certificate in a case that he has not been attending regularly. Although the coroner enquires into all cases of sudden death, he is not alnays bound to have an autopsy.

Some writers. Taylor among them, urge that there should always be an autopsy. Some go further and say that all autopsies should be done by pathologists and not by an ordinary medical man. Before 1927 where a certificate was refused and there were no circumstances of suspicion, the publicity of an inquest seemed unnecessarily painful to relatives and not perhaps required by the interests of justice. A useful compromise is found in s. 21 the Coroners Amendment act of 1926 rnhereby, if there are no circumstances of suspicion and he is not otherwise bound to hold an inquest the coroner may, upon the report of a medical man whom he has instructed to make an autopsy, dispense with an inquest if he thinks fit.

Next in order of frequency will be fatal vehicle accidents which since 1927 must be taken with a jury. It might be thought that in some of these the actual physical cause of death was obvious. as where a man is decapitated by a train. But suppose a man had a stroke and fell under a train: only an autopsy could reveal this and avoid, say, a wrong verdict of suicide, the next commonest case before the coroner.

Last in order of frequency, but of great interest for forensic medicine, will be deaths in respect of which a crime (murder, infanticide, abortion, manslaughter) will be imputed to someone. The duplication of procedure which existed before 1927 has been wisely done away mith by the act of 1926 and the coroner, when he learns that someone has been charged with a crime in respect of a body lying within his jurisdiction, adjourns his inquest until after the finding of the criminal court. It is upon the criminal courts that the weapons of forensic medicine have been whetted.

The study of murder (q v.) has a peculiar fascination for many (not necessarily morbid) minds and a vast quantity of material has been collected on this subject. A medical man will usually be one of the first persons on the scene in such cases and it is his duty to note, not only the condition of the body. but also any surrounding circumstances that may be of use in elucidating the crime.

Although it is no part of a doctor's business to play the detective. society expects him to take at least as much interest as any other of its members in the suppression of crime. Is an apparent case of suicide, for instance, really one of murder? Did a man found hanging in reality hang himself or was he in fact strangled and then hanged by his assailant? Antoine Louis, a French medical jurist of the 18th century, taught us how to distinguish such cases. A man is found shot or with his throat cut, and a razor or revolver is found by him or actually in his hand; was it murder or suicide?

These and a host of similar questions are answered in any standard work on forensic medicine. Reading. however, does not make the medicolegal expert. Most of the serious contributions to legal medicine have been made by men who have combined knowledge and experience with the ability to apply both of these to an emergency.

Some methods, however, have been worked out in the quiet of the laboratory. Of these the most striking is the precipitin test for blood. Blood may be detected by chemical, spectroscopic, microscopic and immunological methods. The first three detect blood but not necessarily human blood. nor was the chemical test (since improved) free from fallacies. The second has no biological specificity while the third enables one to distinguish the blood of the mammalia. The fourth. a veritable triumph of science, enables one to say definitely that the extract of bloodstains examined contains human blood. The stain is extracted with salt solution and added to the serum of a rabbit which has been injected at intervals uith human blood: a precipitate will form if the blood is human but not otherwise. The test is done after it has been established by one of the other methods that the stain is blood. In the strictly biological sense the test is generic rather than specific and is given (in a less marked degree) by the anthropoid apes

The time that has elapsed since death in any given case is an important question to nhich, in the absence of evidence, the answer cannot in the present state of our knowledge be given nith scientific precision. Yet the careful observation of generations has worked out certain rules which allow of an approximation of a fair degree of accuracy. The average rate of cooling of the body is about one degree per hour, depending, however, somewhat on surrounding temperature and moisture and even, at times. on the mode of death. Post-mortem rigidity comes on 3 to 6 hr. after death. and lasts. on an average, 16 to 24 hr., while decomposition usually begins on the third day. These are

some of the data that are relied on, but they are interpreted in practice with great caution.

If poisoning is suspected, the examiner, under direction of the coroner, sends the stomach and contents and pieces of the solid viscera in sealed jars to the analyst. The study of poisons and their detection is called toxicology. Needless to say the methods have been elaborated with great care, as they must be susceptible of the closest scrutiny.

The crime of infanticide (*q.v.*) is not very old in English law. Wilful killing of an infant as of any other human being was murder, but the unwillingness of juries to convict led to the Infanticide act of 1922, whereby the killing of a newly born child by its mother is made equivalent to manslaughter.

Inquiries into the death of infants who were born alive are not infrequent. The questions for the opinion of the police surgeon, who usually performs the autopsy, will be: Was the child born alive? How long did it live? Was death due to violence, neglect or natural causes? The answers to these questions can be given with precision only by those who have experience with such cases and are acquainted with the fairly comprehensive body of knowledge already acquired—a body of knowledge elaborated, it must be remembered, under the jealous scrutiny of the courts of law when infanticide was murder.

Abortion in law means unlawful abortion, a criminal act, the penalty for which is provided by ss. 55, 58 and 59 of the Offences Against the Person act of 1861. Abortion, however, means to medical men any artificial termination of pregnancy. There are several indications for the lawful termination of pregnancy and their common factor is the danger to the mother's life through the continuance of pregnancy; if the foetus is viable its life will, if possible, be preserved. In criminal abortion on the other hand, it is the mother's convenience that is studied and the act is aimed against and is intended to destroy the ovum or foetus. Lawful abortion will be marked by deliberation, consultation with professional brethren and the asepsis of the operating theatre. Criminal abortion will be hurried, secret and often septic and unskilful.

Space does not allow the consideration of the numerous other offenses against the person which are comprised in legal medicine. The various kinds of manslaughter need not detain us, but mention must be made of the increase in the number of convictions in recent years, due to the enormous development of motor transport; *e.g.*, where the driver was "drunk in charge" of a vehicle, criminal negligence will be hard to rebut. The criteria of drunkenness are a subject which is not purely medical. In this condition akin to insanity the factor of conduct looms so large that others besides medical men claim to be able to give an opinion; *e.g.*, in the navy the criterion is: "Is the man fit for duty?" The officer of the watch applies it, unless the man asks to see the surgeon. (See INEBRIETY, LAW OF.)

Turning now to civil causes, medical evidence will be required in inquisitions upon lunacy, sometimes in actions upon wills, in actions under Lord Campbell's act, under the Workmen's Compensation acts and in matrimonial causes. In connection with workmen's compensation the question of malingering has sometimes to be considered, a subject more familiar to medical men in countries which have adopted conscription. In divorce and in legitimacy cases the period of gestation will sometimes be an issue. After much learned argument there is now pretty general agreement that the period can, in exceptional cases, be as much as 300 days, which happens to be the figure fixed by the XII Tables. (*See* ROMAN LAW.)

The fact that a medical man may be compelled to disclose in a court of law information obtained from a patient who has consulted him on the faith of the secrecy promised by the Venereal Diseases act would seem to make it desirable that medical privilege should be accorded, not indeed with regard to this particular matter alone but in all cases which concern neither fraud nor crime nor otherwise the public interest. (F. T. G.)

UNITED STATES

Medical jurisprudence deals with the reciprocal relations of law and medicine, using the latter term in its broadest sense. The application of medical knowledge in legal trials is designated forensic medicine. In the United States, the practice of medicine is restricted to licensed physicians, the issuing of licences, as also the regulation of practice, being in the main the function of the individual states.

In presenting evidence of service to a patient, the elements to be established are: the employment, the performance of the service and the value of the service. An original entry of the actual transactions is generally receivable in evidence and is a valuable record. The calling on or of a physician is generally accepted as evidence of employment. Unless there are definite circumstances indicating a contrary relation, the person treated and not the person calling the physician is liable.

By statutes differing in the various states, workmen receive compensation from employers when injured in the pursuit of their employment. The Workmen's Compensation law of the state of New York provides that the employer must furnish the medical, surgical or other treatment which "the nature of the injury or the process of recovery may require." The employee is not entitled to recover from the employer for expenditures for such services unless, after request, the employer has refused or failed to provide promptly such treatment; nor is a claim of any attending physician valid unless within 20 days from the first treatment he furnish to the employer and to the industrial commissioner, on a prescribed form, a report of the injuries and treatment. The delay may be excused by the board. All fees are subject to regulation by the board and are limited to such charges as prevail in the community for similar treatment of injured persons of a like standard of living. Under this law a large portion of the cases treated is by physicians specializing in compensation work and in clinics of the insurance carriers. Physicians not on the preferred lists of the insurance companies continually experience difficulties over their bills.

The treatment of a patient obliges the physician to possess the ordinary knowledge of his profession and to exercise the ordinary skill. Failure to do so, including wilful neglect, renders him liable for malpractice. A mistake in judgment does not render him liable. Failure to take an X-ray, where the usual practice is to do so, has been construed by the courts as negligence. Wilful unlawful acts towards a patient constitute a second division of malpractice. A third includes acts forbidden by statute, such as the production of criminal abortion or the treatment of a patient while the physician is intoxicated.

Under the Hippocratic oath, physicians regard communications from patients as privileged. Under the English rule of law, the courts do not so recognize them, but in the United States communications are made privileged by statutes in the following states: group i, in which the patient's consent is necessary for a disclosure: California, Colorado, Idaho, Iowa, Minnesota, Montana, Nebraska, Nevada, New York. North Dakota, Ohio, Oregon, South Dakota, Utah, Washington. Wyoming; group ii, in which the patient waives privilege, if he offers himself or his physician as a witness: Colorado, Kansas, Oklahoma, Oregon; group iii, in which the presiding judge of a superior court may compel disclosure if he deems it necessary to a proper administration of justice: North Carolina; group iv, in which the statutes are silent on the subject of waiver: Indiana, Kansas, Michigan, Wisconsin. In the federal courts, in trials at common law the laws of the respective states apply, except where otherwise provided; in a criminal prosecution the privilege secured by state statutes does not avail.

When a physician is called upon as a witness in court merely to relate facts which he has observed, including inferences and deductions which all men are accustomed to make, he is governed by the rules applicable to an ordinary witness. When called upon to explain or interpret facts by reason of his special knowledge, he becomes an expert witness. As an ordinary witness he is subject to subpoena. If the issue concerns a charity patient, the subpoena must be issued by the judge of the court, in some jurisdictions. It is optional with the physician whether he act as an expert witness. In the latter capacity, by reason of his employ-

ment by a particular litigant, he is confronted with the possibility of bias which should be avoided.

There is criticism of the choice of experts by litigants and resulting conflicting views. To an extent such conflict is due to the relative stability of law with its consequent lagging behind contemporary medical knowledge; experts, especially alienists, thus frequently testifying from different points of view. General medicine, surgery, pathology and toxicology afford less basis for intelligent difference of opinion.

There is no right of property in a dead human body, but duties are imposed upon public officers and next of kin to protect the body from violation and to see that it is properly disposed of and subsequently protected. They may authorize a necropsy to the extent of ascertaining the cause of death. The coroner or other officer is authorized by statutory enactments, varying in detail in the different states, to order a necropsy and such further examination as may be required when, in the discharge of his official duties, it is deemed necessary in cases of sudden death or where there is suspicion that a crime has been committed. If a person dies in one locality and the body is transported to another, the officers where the body is located have jurisdiction.

(E. E. SM.)

MEDICAL LEGISLATION. Medical legislation is of great antiquity, the earliest example being the Babylonian code of Hammurabi. about 2080 B.C., which prescribed the fees patients were to pay and the punishments for negligent treatment. The next great code, with the force, if not the form. of legislation, was the Mosaic law, formulated between 1400 and 1250 B.C. and later amplified in the Talmud. The laws of Greece and Rome by the 5th century provided for public medical officers to treat the poor and to control epidemics, and for many communal sanitary services. In A.D. 1140 the first edict penalizing those practising medicine without state permission and proof of their ability was enacted in Salerno, Italy. (J. A. Sc.)

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I. UNITED STATES

1. U.S. Public Health Service. — This federal agency is specifically charged with carrying on federal activities relating to the protection and improvement of public health. The activity was originated in 1798, as the U.S. marine hospital service, by an act providing medical relief to merchant seamen. Legislation reorganizing the service and authorizing the appointment of a surgeon general was passed in 1870. In 1889, 1893 and in 1902 laws were passed effecting further reorganization, and, in 1902 the service was given the responsibility for licensing and regulating the interstate sale of biologics; the hygenic laboratory. established in 1887, was placed on a more effective basis; and the name of the service changed to the U.S. public health and marine hospital service. The service was further enlarged in 1912 and the name changed to the Cnited States public health service. In 1930, the regular corps was expanded to include engineers and dentists; the name of the hygenic laboratory was changed to the National Institutes of Health: and the name of the advisory board to that laboratory to the National Advisory Health council. Initially an integral part of the treasury department. the service was transferred to the federal security agency in 1939 which in turn became a part of the department of health, education and welfare in 1953. In 1944 the Public Health Service act was passed codifying substantially all of the federal public health legislation, providing for greater assistance to the states in establishing and maintaining adequate public health services and effecting the developing of co-ordinated research in the causes and prevention of disease. The commissioned corps was expanded to include research scientists, nurses and other health specialists.

Prior to World War II, the major emphases in public health work were the development of full-time local health services, the strengthening of state health agencies, the promotion of maternal and child health and the control of communicable diseases. After 1946 legislation was enacted affecting chronic disease, mental illness. the construction of hospital facilities and medical research and training. The research activities of the service were broadened by the creation of the National Institute of Mental Health in 1946. the National Microbiological institute in 1948 (renamed the National Institute of Allergy and Infectious Diseases in 1956), the Xational Heart institute and the National Institute of Dental Research in 1948 and the National Institutes of Arthritis and Metabolic Diseases and of Neurological Diseases and Blindness in 1950. In 1953 the clinical centre of the National Institutes of Health was opened, permitting combined laboratory and clinical research into the major diseases.

2. Cancer. — In 1937 the National Cancer act was passed which created the National Cancer institute as a part of the National Institutes of Health. The act authorized federal grants to scientists and institutions for cancer research, as well as fellowships for the training of scientists and clinicians. Annual appropriations under the act for the National Cancer institute reached approximately $25,000,000 by the late 1950s.

Every state had established a cancer control by mid-century. Services are provided by state health departments and departments in the District of Columbia and in the Virgin Islands and Puerto Rico. There were 2 state cancer commissions (Arkansas and New Hampshire), 27 state universities or medical colleges, 9 departments of welfare and 3 agencies of other types. A large share of the state-wide cancer program is carried on by private agencies such as state chapters of the American Cancer society and by state medical societies. In almost every state funds are provided for personnel. equipment or supplies to local health departments. medical societies, cancer societies and other voluntary organizations and state universities.

In about 80% of jurisdictions state health agencies give supervision or consultation and interpretation regarding cancer problems to interested groups and private physicians. Nearly one-half of the states promote local programs, while all states offer a varying amount of direct service. Medical schools of the state universities furnish a vast share of the actual clinic, hospital and laboratory services and conduct cancer research, while the role of welfare boards is that of furnishing medical social service, including financial assistance in some instances. The common objective is the reduction of deaths and illness from cancer through promotion of a program leading to early detection and treatment. (See also CANCER RESEARCH.)

3. Mental Health. — In 1946, congress enacted the National Mental Health act and created the National Institute of Mental Health as part of the U.S. public health service. The institute's program is designed to provide more knowledge about the causes, treatment and prevention of mental illness and to insure the effective use of existing knowledge in treatment and prevention. Research is provided through grants for training of mental health personnel and by grants-in-aid and technical assistance to the states for community mental health programs. In 1955 congress enacted the Mental Health Study act which provided for a review and evaluation of current knowledge concerning resources, methods and practices for dealing with mental illness.

As of 1950 every state had a mental health program and with the exception of the territories of Alaska and the Virgin Islands and the District of Columbia every state operated one or more

hospitals for the care of the mentally ill. In general, state programs involve two areas of mental health services: (1) the community services program; (2) treatment and custodial care of patients in mental institutions. Among the functions of the community service program are the ,maintenance of rosters in connection with mental health activities; development of lay and professional educational programs; operation of mental health clinics; promulgation of rules and regulations; financial assistance to local agencies; promotional, supervisory and consultative services to local and voluntary agencies; and special surveys and research studies.

4. Water and Air Pollution Control. — A federal law passed in 1948 authorized the public health service to undertake a comprehensive program for the abatement and control of water pollution and for the conduct and support of technical research relating to improved methods of treatment of industrial wastes. Congress authorized $22,600,000 a year for five years for loans to states for the construction of sewage treatment works and grants of $1.000.-ooo a year to state and interstate agencies for research in uater pollution control. In 1956 congress authorized expanded research and training programs and, for the first time, made federal aid available to communities for the construction of sewage treatment facilities.

In 1956 congress also authorized the public health service to assist the states in developing and strengthening community programs to control the harmful effects of atmospheric pollution. A national network of air sampling stations was established to measure and analyze pollution in various parts of the country and under varying climatic conditians.

5. Venereal Diseases.--Federal activities to promote better control of syphilis, gonorrhea and chancroid stem principally from an act passed by congress in 1918. It created a division of venereal disease control in the public health service and made available federal funds for the states to assist them in establishing and maintaining adequate measures for the prevention, treatment and control of these diseases. A 1938 amendment provided for an expanded program and authorized larger appropriations (as high as approximately $4,000,000 annually) for allotments. The 1918 act, as amended, was further amended and embodied in the Public Health Service act of 1944.

These diseases are reportable in every state. Various other types of state control legislation have been enacted, such as laws against prostitution, forbidding advertising of cures and the selling of cures and proscribing the sale of cures except on the prescription of a physician. The compulsory examination and quarantine of suspects under certain conditions may be resorted to in many states. Two types of state laws deserve prominent mention

Prenatal examinations for syphilis were mandatory or required under specified conditions in all states by 1954 except Alabama, Maryland, Minnesota, Mississippi, Tennessee, Wisconsin, the District of Columbia and in Puerto Rico.

Premarital examinations, to prevent the spread of venereal disease through marriage, were required in all states by 1954 except Arizona, Maryland, Minnesota, Mississippi, Nevada, New Mexico, South Carolina, Washington, the District of Columbia, Puerto Rico and the Virgin Islands.

6. Hospital and Medical Facilities. — The Hospital Survey and Construction act of 1946 provided for assistance to the states in inventorying existing health facilities, determining needs for additional facilities and providing for their construction. The amount of $3,000,000 was appropriated for survey and planning grants and $75,000,000 annually for five years for allotments to the states to aid in the construction of public and other nonprofit hospitals. The term hospital includes laboratory outpatient departments, nurses' homes and training facilities and central service facilities operated in connection with hospitals.

In 1949 the annual appropriation for construction grants was increased and the formula for federal participation was altered from the original uniform rate of one-third to a variable rate ranging from one-third to two-thirds, based upon the per capita income of the state. Also authorized was research relating to the effective development and use of hospitals.

In 1954 the original act was extended until July 1959 and increased in scope to include additional types of facilities with separate construction authorizations for each type. Included was $20,000,000 annually for construction of diagnostic or treatment centres; the same amount for hospitals for the chronically ill and impaired; and $10,000,000 annually for construction of rehabilitation facilities and for nonproprietory nursing homes.

By the end of 1957, nearly 3,700 projects had been approved for federal assistance, to make more than 157,000 hospital beds and 974 health units for outpatient care available. The total cost of all facilities approved amounted to about $3,000,000,000, of which the federal share represented $932,000,000.

7. Food, Drugs, Cosmetics and Devices. — The federal Pure Food and Drugs act was passed in 1906 and completely rewritten and modified in 1938 to enlarge the scope of coverage and to provide more effective procedures for enforcement. The laws as amended included the following provisions: extended coverage to cosmetics and devices, required predistribution clearance of safety on new drugs; prohibited additions of poisonous or deleterious substances to foods, except where required or unavoidable; provided for tolerances for unavoidable or required poisonous substances; authorized standards of identity and quality of containers for food; authorized factory inspections; and added the remedy of court injunction to previous remedies of seizure and prosecution.

Significant amendments to this law were enacted in 1941 to provide for the free distribution, testing and certification of the safety and efficacy of penicillin; in 1947 to provide testing and certification of drugs containing streptomycin; in 1948 to affirm U S. jurisdiction over products adulterated or misbranded after interstate shipment; in 1951 to require that drugs which cannot be safely used without medical supervision bear the prescription legend on the label and be dispensed only upon prescription; in 1953 to clarify previous provision regarding mandatory factory inspection and to require the issuing to manufacturers of written reports on inspections and analysis of factory samples; in 1954 to simplify method of promulgating food standards where no controversy was involved; and also in 1954 to authorize prompt establishment of safe tolerances for pesticide residues on raw agricuiturai commodities.

In 1940 the food and drug administration was transferred from the department of agriculture to the federal security agency which in turn became the department of health, education and welfare in 1953.

Legislation to regulate interstate sales, patterned after the revised federal law, has been enacted by the several states.

8. Narcotics. — The first federal narcotic control law was enacted in 1909. It prohibited the import and use of opium for other than medicinal purposes. The act was amended in 1914 to prohibit the export of opium or cocaine except to a country which regulated the entry of drugs; and in 1922 to regulate the imports and exports of opium. coca leaves, cocaine or any salt derivative or preparation of such drugs. In 1914 the Harrison Narcotic act was passed to direct the manufacture and distribution of narcotic drugs through medical channels for medical or scientific purposes only. In 1929 an act was passed which provided for two public health service hospitals for the confinement and treatment of certain narcotic drug addicts. In 1937 congress enacted the Marihuana Tax act to regulate the distribution and use of marijuana.

Forty-four states have enacted the Uniform State Narcotic Drug act formulated by the National Conference of Commissioners on Uniform State Laws. Every state, except Wyoming, as of 1957 had some statutory regulation of barbiturates.

9. Veterans. — In 1851 congress first authorized support for invalid and disabled soldiers of the army. In 1888 congress provided that Civil War veterans disabled by age. disease or otherwise, incapable of earning a living by reason of such disability, could be admitted to the House for Disabled Volunteer Soldiers. In 1919 the secretary of the treasury was authorized to provide hospital and sanatorium facilities for discharged sick and disabled servicemen.

In 1930 the Veterans administration was established, after which a succession of laws were passed authorizing extensive inpatient and outpatient as well as rehabilitation medical care for veterans of all wars with service or nonservice connected disabilities and diseases. In 1946 the department of medicine and surgery in the Veterans administration was created. In 1957 congress codified all veterans' benefits. including those providing for hospital and medical care.

10. State Health Services. — Approximately 100 state agencies with various designations are actively engaged in health-related activities. although the state health department is the most active. By the mid-20th century, the governments of the states, the District of Columbia and the territories were spending about $1,000,000,000 a year for health programs, including both preventative services and hospital and other medical care.

(C. J. SR.)

II. OTHER COUNTRIES

Early medical legislation in England and other European countries was mainly concerned with measures to control epidemics— notably plague. cholera and smallpox — of which isolation and quarantine were the chief. The Industrial Revolution and the humanitarian impulses of the 19th-century philanthropists led to laws providing better medical services for the poor. to the beginnings of an industrial medical service, including notification and compensation for certain industrial diseases and accidents. to vastly improved sanitary and environmental services supervised by medical officers of health. and finally to an insurance medical service for workers. In the last field Germany led. The 20th century has given legislative sanction to personal services designed to promote health and prevent disease: maternity and child welfare. school health. tuberculosis and active inoculation against certain diseases in practically every civilized country. In some, including Great Britain and New Zealand. Sweden and the Communist countries, a more or less complete medical service was available at mid-century. In others. notably the United States, extensive schemes of voluntary insurance against the costs of medical care supplemented the services officially available for the indigent and for war veterans. The volume of health legislation is now so vast that the World Health organization (W.H.O.) publishes a quarterly *International* Digest *of Health* Legislation. (*See* also PUBLIC HEALTH; SOCIAL SECURITY.)

1. International Health Legislation. — Such legislation is mainly concerned in preventing the spread of communicable diseases. whether by land. sea or air. It is embodied in International Sanitary conventions dating back to 1892 which are regularly revised and brought up to date through the World Health organization. (*See* also PREVENTIVE MEDICINE.)

2. Medical Registration. — Registration in England was first enacted in 1511, its object being to minimize the harmful activities of quacks. Its administration was entrusted to the bishops. each in his own diocese, advised by four medical men. The Medical act of 1858 brought into existence the General Medical council to supervise medical education, to inspect examinations, to keep a medical register of qualified practitioners and to maintain high standards of professional conduct, it being "expedient that persons requiring medical aid should be able to distinguish qualified from unqualified practitioners." The act did not, as in other countries and in most parts of the British commonwealth, give registered practitioners any monopoly or proscribe unqualified practice.

3. Nurses and Midwives. — The first country to introduce an act solely concerned with the registration of nurses was New Zealand (1901). Other countries, 'notably Cuba. Canada. Australia, Austria, Belgium and Germany, soon followed and after World War I most countries in Europe passed acts recognizing the legal status of nurses and arranged state training schemes. In Great Britain the movement was delayed by the opposition of Florence Nightingale (*see* NURSING), but in 1919 the Nurses Registration act was passed. This set up a general nursing council. with power to enforce training standards, inspect and recognize training schools and keep a register of nurses. to which after 1925 admission was by examination. Further acts in 1943 and 1949 extended the council's powers over assistant nurses. There is a separate council for Scotland.

The movement for the licensing of midwives was begun in England in the 17th century by Peter Chamberlen (*see* CHAMBERLEN), but it was only in 1902 that the Midwives act made it illegal for anyone other than a doctor. registered midwife, medical student or pupil midwife to attend a woman in childbirth. It set up a central midwives' board to maintain a register, conduct examinations and enforce rules of practice. In 1936 a further act prohibited untrained women from receiving pay for attending women during lying-in.

Standards of training in midwifery differ widely in different countries: New Zealand. Scotland and Ireland have systems recognized by the central midwives' board. Other countries with state control are Scandinavia and the U.S.S.R.

4. Lunacy and Mental Deficiency. — Legislation concerning persons suffering from insanity (*i.e.,* derangement of a normal mind) or mental deficiency (*i.e.,* incomplete or arrested development of mind at an early age) can be traced back in England to the 14th century when the king was empowered to protect the property of lunatics and idiots. Various acts were passed from the end of the 18th to the middle of the 19th century, dealing with the provision, control and inspection of asylums, which previously had been privately conducted with little or no supervision. and the care and treatment of persons maintained therein.

The Lunacy act. 1890, provides the basis of the legislative code for the care and treatment of persons of unsound mind in Great Britain, although extensive changes were suggested by the royal commission on mental health which reported in 1957. The act lays down the procedure for the admission of persons of unsound mind to asylums (now called mental hospitals) by orders made by justices of the peace. gives power to detain such persons against their will and provides safeguards against improper detention. The Mental Treatment act. 1930, enables persons to submit themselves voluntarily for treatment in mental hospitals, thus providing opportunity for early treatment. The Mental Deficiency act, 1913, deals with the care and supervision of persons suffering from mental deficiency. gross and antisocial manifestations of which had previously been dealt with under the Lunacy act or the criminal code. The National Health Service act, 1946, amended the Lunacy and Mental Deficiency acts to fit them into the pattern of the national health service.

5. Notifiable Diseases. — Such diseases in Great Britain fall into two main groups: (1) infectious, under the Public Health acts. Food and Drugs acts, and various ministerial orders; and (2) industrial diseases under the Factory acts. The purpose of notification is both preventive (*e.g.,* isolation of dangerous infections, safety devices in industrial processes) and curative (hospital treatment, etc.), but it also enables the machinery for compensation payments to begin to function. For entirely different reasons, births are both registrable and notifiable and deaths, with their causes, registrable. (*See* the articles DEATH; LEGITIMACY AND LEGITIMATION.) All these conditions entail statutory notification duties for the medical profession.

6. Vaccination and Immunization. — In the 18th century in Great Britain one child in every six died of smallpox, which attacked nearly everyone. Scars and other disabilities marked the survivors, and experience in the rest of Europe was hardly less severe. Inoculation with the virus produced a milder but no less infectious attack than disease arising from natural infection and was widely practised. The modern method of vaccination evolved by Edward Jenner (*q.v.*) in 1796 was made officially available free of charge in Great Britain in 1840 and compulsory in 1853. The "conscience clause" allowing exemption on conscientious grounds was introduced in 1898 and, with the introduction of the national health service, vaccination was made completely voluntary. As knowledge increased, cognate methods of active protection against other infectious diseases, notably diphtheria, typhoid, tetanus, cholera. yellow fever, typhus, whooping cough, tuberculosis and infantile paralysis were introduced. Some countries require immigrants and visitors to produce proofs of vaccination against smallpox and certain other diseases.

7. Tuberculosis. — Under the British Public Health act, 1936, sufferers from pulmonary tuberculosis in an infectious stage could under certain circumstances be compulsorily removed to a hospital; Denmark had similar compulsory powers. Several countries prohibited the employment of sufferers from tuberculosis in the milk and food industries.

The disease was not notifiable in all European countries, but national schemes for treatment, based on the tuberculosis dispensary and the sanatorium. were general. Great Britain, under the National Insurance acts and the National Assistance acts, provided treatment allowances on a more generous scale than the usual sick benefits.

The tuberculin testing of all school children became compulsory in the Scandinavian countries; in Norway immunization of negative reactors was made compulsory in 1946. although a declaration of conscientious objection was provided for, Many countries, including Britain, had official schemes of immunization by the mid-1950s, and W.H.O. teams had immunized millions of children in the less advanced countries.

Under the tuberculosis (attested herds) scheme, 1938, of the British ministry of agriculture and fisheries, designed to encourage the establishment of herds officially certified as free from tuberculosis, 58% of the cattle in England and Wales were by Dec. 1955 in attested herds.

The slaughter of cattle with advanced or open tuberculosis on a compensation basis had been compulsory in England and Wales after 1914.

8. Venereal Diseases. — These diseases are also the subject of legislation. In the 19th century emphasis lay on their spread by prostitutes, and in Great Britain the Contagious Diseases acts, 1864–69, made these women subject to compulsory medical examination in 18 garrison towns. These acts were repealed, owing to feminist opposition, by 1886. Legislation in 1916 and 1917 made provision among other things for free and confidential treatment at special clinics.

The notification of these diseases has always been rejected in Great Britain, but in the interests of the war effort limited powers to notify and treat contacts were given by Regulation 33B and were operative during the years 1942–47. (See also PROSTITUTION.)

9. Patent Medicines. — Patent medicines, with which it is so easy to exploit ignorance and credulity, must in Great Britain, by virtue of the Pharmacy and Medicines act, 1941, display on the label of the container details of the active constituents or of each of the ingredients used, together with the quantities thereof. Similar provisions apply to patent foods under the Food and Drugs act. See also ADULTERATION. (J. A. Sc.)

MEDICAL OPTICS: see EYEGLASSES; OPTICS.

MEDICAL RESEARCH is the fundamental investigation, medical, biological and behavioural, of problems encountered in medical and public health practice. Its content and organization are extremely broad and complex. Annually throughout the world. about 180.000 research reports appear in approximately 5,000 journals. and an estimated 10.000 books are published on medical-science subjects. Research workers also are employed by a wide variety of institutions — academic, philanthropic. industrial and governmental. Such diversity of activity and structure precludes a detailed review in this article. The topic will be treated generally, in historical and socioeconomic perspective.

History. — Medical research is as old as the practice of medicine. No two cases of a disease are exactly alike. and the physician may have to change the treatment and even the diagnosis as facts about the patient's illness come to light. In the course of practice, he observes disease processes and the effects of therapy. learning through experience and communicating his findings. The modern medical scientist may treat many subjects — patients or experimental animals—with identical procedures, in order to take into account the variation in individual reactions. Such methods accelerate the process of observation and discovery, but the ancients, though less systematic, also amassed medical knowledge.

Prior to the 18th century, medical research was predominantly descriptive rather than experimental. Hippocrates, in the 5th–4th centuries B.C., wrote on epidemics. fevers, epilepsy, fractures, health in general and medical ethics. Avicenna, the most illustrious physician in Arabian medicine, in the 11th century A.D. codified the whole of medical knowledge up to his time, producing a medical text that proved to be the most influential in Europe and Asia for several centuries. Andreas Vesalius issued at Basel in 1543 his masterpiece of anatomy, De *humani corporis* fahrica, illustrated in Titian's workshop; together with its companion Epitome, this volume remains one of the paramount descriptive anatomies of all time.

Classic descriptions of diseases include the writings of Johann Lange on nutritional anemias (1554), William Harvey on the circulation (1628), Gaspar Casal on pellagra (1735) and Percivall Pott on soot-induced cancer (1775). A pioneer of this early descriptive period was the Dutch microscopist Anton van Leeuwenhoek, the first to see single-cell organisms such as bacteria.

Among early experimenters was Lazzaro Spallanzani, who studied digestion, circulation, fertilization in animals, the senses of bats and regeneration of the limbs in salamanders. Experimental pathology was introduced in the 18th century by John Hunter. who described inflammation, compensatory circulation and fetal development. Well-preserved specimens of diseased organs prepared by Hunter may be seen in London today. In 1796 Edward Jenner vaccinated a small boy with cowpox and demonstrated protection against smallpox, anticipating the development of other vaccines by more than 80 years.

During the 19th century, medical research was continued and broadened by many dedicated workers. Major events of this period include the introduction of the cell theory by Theodor Schwann, a German anatomist (1839); the use of ether as an anesthetic by a U.S. dentist, William Morton (1846); the recognition by Ignaz Semmelweis, a Viennese obstetrician, that deaths from puerperal fever among women hospitalized for childbirth were due to infection by the hands of attending physicians (1847); the explanation of the function of nerves by the French physiologist Claude Bernard (1851); and the publication of a text on cellular pathology by the German Rudolf Virchow (1858). The theory of evolution propounded by Charles Darwin in The Origin of Species (1859) has many implications in medical science, casting light on variation. the forerunner of natural selection in the evolutionary process, through the science of genetics. The last, founded by the Austrian monk Gregor Johann Mendel in 1865, went unrecognized for 3j years.

The later 19th century saw the development of basic principles that led eventually to the control of many infectious diseases. Earlier progress in physiology, pathology, chemistry, physics and other disciplines provided the foundation for such new sciences as microbiology and radiation. Louis Pasteur, French chemist and bacteriologist, set out to learn why wines soured. In studying wine and beer, he discovered that living microorganisms caused fermentation and putrefaction. His answer to the question of how to prevent this was heat — pasteurization (c. 1860). The work led to the concept that germs can cause disease: "When we see beer and wine subjected to deep alterations introduced and now swarming within them. it is impossible not to be pursued by the thought that similar facts may, must take place in animals and man!" Pasteur also discovered the technique of vaccination with attenuated microbes, developed a treatment for rabies (1885) and made many other basic contributions.

Lord Lister, in England. applied Pasteur's ideas to surgery, performing operations in a spray of carbolic acid to prevent infection (186j). Modern aseptic techniques evolved from these experiments.

Robert Koch, a German, made bacteriology an exact science. As a physician in Silesia, he tracked down the microbial agent in the blood of animals dead in an epidemic of anthrax, bred the bacillus in pure culture and found that it would infect other animals (1876). The discovery that specific microbes cause specific diseases, one of the most epoch-making in the history of medicine, soon led to identification of the causal agents of gonorrhea, diphtheria, typhoid fever and many other diseases. Koch himself

isolated the microorganisms of tuberculosis and cholera.

The theory of immunity is attributable to the Russian Élie Metchnikoff, who, while studying the origin of the digestive organs, observed that certain cells not involved in digestion can nonetheless engulf foreign bodies. He showed that these agents—white blood cells—destroy bacteria, and called them the body's first line of defense against disease. This observation and its relation to antibodies is the foundation of immunology.

Another pioneer of this era was Paul Ehrlich, a German, who applied stains to cells and tissues in order to reveal their function, founded the science of hematology and developed the side-chain theory of immunity (1897). This theory held that unstable side chains on protein molecules can combine with harmful materials to neutralize them. Variants of the theory serve modern chemotherapy, a field launched by Ehrlich with the introduction in 1910 of Salvarsan for the treatment of syphilis.

Although microbiology predominated during this period, other sciences also flourished. The foundations for the science of radiation were laid by two discoveries made almost simultaneously—X-rays and radium. Wilhelm Conrad Rontgen, a German, discovered X-rays in 1895; and Marie Curie. a Pole working in France with her husband, Pierre Curie, and A. H. Becquerel, discovered radium in 1898.

The turn of the century saw the beginnings of a precise understanding of body chemistry. Svante Arrhenius of Sweden developed the theory of electrolytic dissociation (1887), which underlies modern fluid- and salt-balance therapy. In 1900 the Viennese pathologist Karl Landsteiner discovered blood groups, making possible the accurate typing of blood and safe transfusions. Frederick Gowland Hopkins of England isolated growth-promoting substances and in 1906 predicted the isolation of vitamins.

Progress against infectious diseases, begun with discoveries of the later 19th century, was rapidly accelerated through the introduction of sulfa drugs in 1935 and the antibiotics during World War II. Basic agents were Prontosil, discovered by Gerhard Domagk (Germany); penicillin, by Sir Alexander Fleming (England. 1928); and streptomycin, by Selman A. Waksman (U.S., 1944).

Organization of Medical Research.—Biological science is traditionally organized along disciplinary lines. In attacking health problems, the individual research worker generally applies his particular discipline—pathology, endocrinology, genetics—to a specific disease, retaining orientation to his field. Thus, in universities and medical schools, a given health problem such as cancer is studied in several departments. Disciplinary orientation generally prevails in scientific teaching, societies and journals.

Medical research institutions, on the other hand, are often organized to attack a single disease or group of related health problems. Mental and neurological disorders, tuberculosis and other infectious diseases were among the first health problems to be approached categorically. Early examples of disease-oriented institutions are those founded by Henry Phipps for the study of tuberculosis (1903) and the U.S. National Cancer institute (1937). This principle, much extended after World War II as a result of public interest, influenced but did not transform the medical schools, societies and communication.

Cardiovascular Disease *Research.*—Heart disease, a general term for disease of the heart and blood vessels, causes half the deaths in the United States. The problem of heart disease is greatest in countries where control of infectious diseases and good economic conditions have lengthened the life span. Indeed, the trend toward longer life—and a higher incidence of diseases affecting older persons—accounts for most of the tremendous increase in cardiovascular (and cancer) deaths. The mechanism of the cardiovascular system was first clarified by Harvey, who, working for over 20 years on animals, prepared the ground for modern physiology and experimental medicine.

Early clinical discoveries (c. 1700) included Théophile Bonet's association of shortness of breath with cardiac enlargement; Raymond Vieussens' explanation of the coronary circulation, the blood system serving the heart muscle; and G. M. Lancisi's correlation of sudden death with autopsy findings. In 1749 Jean Senac gave advice about diagnosis and treatment in the first clinical text on heart disease. A few years later, Louis Jenner related angina pectoris and disease of the coronary artery.

The first great step in treatment of heart disease was the introduction of digitalis by William Withering in 1785. Early diagnostic advances included Stephen Hales's technique for measuring blood pressure in animals (1733); Leopold Xuenbrugger's method for detecting cardiac enlargement and edema by percussion (1761); and R. T. H. Läennec's invention of the stethoscope (1819). Thus the physicians of the early 19th century were equipped to begin precise identification and treatment of diseases of the heart.

In 1827 Richard Bright. an Englishman whose name was given to the kidney disease now called nephritis, described a part of the kidney's role in circulation and related this to dropsy (edema) in impaired heart action. This mechanism, together with the fact that much kidney disease is vascular (arteriosclerotic), accounts for the modern disease grouping "cardiovascular-renal."

Two invaluable tools in heart disease diagnosis, X-rays and the electrocardiograph, were discovered around the turn of the century. In 1903 Willem Einthoven of the Netherlands introduced the principle of the electrocardiograph in adapting a galvanometer to record the heart's electrical impulses. Four years later A. Keith and M. Flack of England discovered the pacemaker, a tiny mass of tissue in the right auricle which sends out impulses—normally about 70 a minute—to the heart muscle.

The 20th century saw three revolutionary advances in cardiovascular pharmacology. The first was the introduction by Paul Saxl (Austria. 1920) of mercurial diuretic injections in the treatment of cardiac edema and congestive heart failure. The second was Karl Link's discovery of Dicumarol (U.S., 1940), an anticoagulant, used in surgery and in coronary thrombosis. The third was the introduction of blood-pressure-lowering drugs, such as reserpine (1952). These led to an impressive array of agents for treating the cardiovascular patient.

Even more dramatic than the pharmacologic advances were the 20th-century developments in heart surgery. Robert E. Gross (U.S., 1939) was the first to correct a congenital heart defect, patent ductus arteriosus. Alfred Blalock and Helen Taussig (U.S., 1945) devised the "blue baby" operation for alleviating pulmonary stenosis, one of a combination of defects which deprive the body of oxygen and nourishment. Also in 1945, in Sweden, C. Crafoord corrected a coarctation of the aorta, an abnormal narrowing of the body's main artery. Surgery within the human heart (rather than on the blood vessels outside it) was developed by Charles Bailey (U.S., 1948), though actually such surgery was first performed by E. C. Cutler (U.S.) and P. W. Souttar (England) in the early 1920s. Bailey, by means of a finger knife, opened a valve scarred by rheumatic fever. After 1952 several surgeons attacked other defects, particularly intraseptal, through open-heart surgery. This utilizes complicated heart-lung apparatus for bypass circulation, anticoagulants, advanced anesthesiology, sometimes hypothermia (reduction of body temperature) or stop-heart techniques, electronic controls and other aids, as well as the ultimate skills of a clinical team.

Heart research in surgery, physiology, pharmacology and biochemistry is advancing rapidly. Emphasis is placed on studies of hypertension (high blood pressure) and of atherosclerosis. These problems are being attacked on a vast front, but firm conclusions as to cause, prevention or treatment cannot be drawn. These will be a product of the new era in medical research, an era in which exploration of metabolism, or body chemistry, promises to be particularly important.

Cancer *Research.*—The most effective cancer treatment known today—surgery—was practised in India 4.000 years ago. The early Egyptians treated tumours with an ointment of arsenic and vinegar, and caustic salves have been used since ancient times. A distinction between benign and malignant tumours was made by Hippocrates in the 5th century B.C. Cntil modern times the attitude toward cancer causation tended to be fatalistic. For example, Galen (2nd century A.D.), whose influence prevailed for several centuries, attributed it to the individual's constitution, rec-

ognizing, however. the danger of secondary tumours and the importance of early diagnosis.

The nature of cancer became better understood with the gradual progress of pathology. In the 7th century AD. Paul of Aegina stated correctly that cancer can arise in any external or internal part of the body. Eleven centuries were to pass, however. before M F. X Bichat deduced and Johannes Müller established (1838) the fact that tumours represent a proliferation of cells Virchow, a pupil of Müller's, showed the may to the accurate diagnosis of cancer by microscopic examination.

Modern cancer research may be said to date from 1775, when Pott related scrota1 cancer in chimney sneeps to prolonged exposure to soot. Over the years a variety of environmental agents —ionizing radiations. coal-tar products. azo dyes and chromate dust, to name a few—have been recognized as carcinogenic. First to demonstrate chemical carcinogenesis experimentally were two Japanese scientists, K. Yamagiwa and K. Ichikawa. who in 1915 induced tumours on the ears of rabbits with coal tar. In 1926 E. L Kennauay and others at the University of London extracted from coal tar the potent carcinogen 3.4-benzpyrene, first of the hundreds of cancer-causing chemicals known today.

Viruses were shown to be a cause of cancer in chickens by Peyton Rous (U S , 1911), who succeeded in transmitting a sarcoma by means of a cell-free extract. Interest in viruses as a cause of cancer grew through recognition of three properties: the genelike composition of viruses (nucleic acid); their capacity for long, inert survival; and their ability to induce a variety of tumours in animals. During the 1930s virus cancers were identified in rabbits (Richard E. Shope), mice (John J. Bittner) and frogs (Balduin Lucké). Virus transmission of leukemia in chickens was established by V. Ellerman (1918) and in mice by Ludwik Gross (1951). A characteristic of all these viruses is high specificity—ability to cause cancer only in animals of the same or closely related species In 1957. however, Bernice Eddy and Sarah Stewart (U.S.)incubated filtrates of mouse leukemia in tissue culture and extracted the polyoma virus, nhich induces a variety of cancers in hamsters and other species as well as mice. These many studies ranging over half a century suggest strongly that methods may be found for discovering a cancer virus in human beings.

Discovery of the mammary tumour agent by Bittner in 1936 was a result of studies in genetics. Through inbreeding with selection over many years, geneticists had developed strains of mice with high, predictable rates of cancer and others in which tumours were uncommon. Bittner found that mice of a strain in which mammary cancer ordinarily occurs frequently develop few tumours if nursed by mice of a low-tumour strain, indicating that a tumour agent in mice is transmitted by the milk. Hereditary factors are undoubtedly involved in human cancer, but they are probably multiple. thus precluding eugenic control. Further genetic studies, however, may establish environmental and hereditary factors in man as they have in animals.

Genetically pure strains of mice, tumour-transplantation techniques and dependable means of inducing experimental cancers have made possible productive biochemistry in cancer research. After the 1930s, biochemical analysis contributed greatly to an understanding of the properties of tumours and the tumour-bearing host. Whereas earlier investigation was concerned largely nith describing tissues in terms of composition, modern biochemical studies are elucidating tissue function.

Emphasis is placed on those aspects of metabolism that are likely to be instrumental in the origin or maintenance of cancer; enzyme activity, which underlies and effects the metabolic processes; the role of nucleic acid, associated nith cellular reproduction; protein synthesis. which in tumours is obviously excessive; and carbohydrate utilization, which suggests impaired respiration in the cancer cell.

As in other areas of medical research, many valuable tools are available. One is the Warburg apparatus, uhich enables the scientist to measure the activity of enzymes, natural accelerators of chemical reactions in the tissues. By means of chromatography. substances such as the components of protein may be separated. Tracer studies with radioisotopes constitute an invaluable approach to the mapping of body chemistry. Biophysical developments include the electron microscope; the ultracentrifuge, a high-speed separator; and electrophoresis apparatus for tissue analysis.

The research attack upon cancer has two major aims: the gaining of basic knowledge, with a long view to practical application; and the development of improved methods of prevention. diagnosis and treatment in the absence of an adequate explanation of the cancer process. Attempts to treat cancer with drugs were reported as early as 1865. Effective chemotherapy, however, began in 1941. when Charles Huggins in the United States succeeded in arresting prostatic cancer with female hormone. During World War II nitrogen mustards, closely related to mustard gas. were observed to damage cell nuclei and soon proved to be useful against cancers of the blood-forming organs. In 1948 Sidney Farber in the United States found that chemical antagonists to folic acid, a B vitamin, could alleviate acute leukemia in children.

Contemporary approaches to and techniques in this important area of medical research are discussed more fully in a separate article. CANCER RESEARCH.

Medical Research in the United States.—Until the late 19th century. medical research in the United States was sporadic, poorly financed and little recognized. Many physicians went abroad for their education, and most applied their knowledge to therapy and prevention. Historians attribute the delayed development to two factors—the struggle to settle a new country and the lack of a tradition of learning.

Early landmarks were the founding of the Philadelphia hospital (1751), the Medical society in Boston (1735) and the American Philosophical society (1743) and the publication of a pharmacopoeia (1778) Individual contributions included Benjamin Rush's description of dengue (1780), William Beaumont's studies on digestion (1833) and several surgical advances.

Organized research efforts were a result of public clamour over the medical problems of the Civil War. With the reorganization of the army medical department, the Army Medical museum was founded in 1862, and eight years later a massive work. *The Medical and Surgical History of the War of the Rebellion,* was completed. The museum acquired a laboratory for microscopy, anatomy and pathology, and contact was maintained with European scientists. Over the years, such famous researchers as John Shaw Billings, Walter Reed and James Carroll helped make the museum—now the Armed Forces Institute of Pathology—a centre of medical investigation.

The U.S. public health service (formerly the marine hospital service) has conducted medical research since 1887, when a laboratory of bacteriology was established on Staten Island, N.Y. Its director, Joseph J. Kinyoun, was the first to detect the cholera organism among immigrants to America. From this early laboratory, later transferred to Washington, D.C., evolved the National Institutes of Health, the world's largest centre for the conduct and support of medical science.

Research by pharmaceutical manufacturers probably had its start in the 1860s when A. C. Abbott of Chicago, finding plant extracts unreliable, studied Belgian techniques and isolated pure alkaloids. The drug industry, also stimulated by the Civil War, began to expand rapidly. Biologics against smallpox, tetanus and diphtheria were on the market by the end of the 19th century, and World War I gave a ponerful impetus to applied research in biological products and chemotherapy.

Private organized health research in the United States began with the founding in 1893 of the Johns Hopkins medical school, for which support was provided through private endowment, inaugurating an important trend. The turn of the century brought into being the Rockefeller Institute for. Medical Research. the McCormick Institute for Infectious Diseases and the Carnegie Institution of Washington. Generous annual contributions to medical research were made by the Milbank Memorial fund, Julius Rosenwald fund, Commonwealth fund, Rockefeller foundation (independent of the institute) and other organizations.

A peculiarly American approach to the support of health services and. to a substantial extent, of medical research is seen in the large voluntary health agencies, beginning with the National

Tuberculosis association in 1904. Other outstanding examples are the National foundation (formerly the National Foundation for Infantile Paralysis), the American Cancer society and the American Heart association. Nearly every major health problem is represented by a private national agency that raises funds for services and research.

Total U S. expenditure for medical research rose from $75,000,000 in 1945 to about $480,000,000 in 1958. During that period each of the major contributors — philanthropy, endowment. industry and government — increased its support, the federal government most rapidly In 1958 government supported about half the medical research in the United States and industry about a third Most of industry's investment in medical research is spent in its own laboratories. Thus it has fallen largely to government and voluntary health agencies to support most of the research effort in medical schools. universities and other private institutions.

The principal government contributors are the public health service, department of defense, Atomic Energy commission. Veterans administration and National Science foundation. Among these the public health service represents by far the principal investor in the biological sciences related to medicine. The National Institutes of Health conducts its research and support programs at Bethesda, Md., where laboratories, offices and a research hospital are located on a 305-ac. tract. The seven institutes comprising the NIH are concerned primarily with major killing and crippling diseases. In addition. a division supports studies in general medical science, and one of three service divisions regulates the commercial production of biological products. (Js. A S)

Medical Research in the United Kingdom. — The organization with the main governmental responsibility for medical research in the United Kingdom is the Medical Research council, the successor of the Medical Research committee, nhich was incorporated under its present title by royal charter in 1920. The council, nhich is financed largely by an annual parliamentary grant-in-aid, is responsible to the Committee of the Privy Council for Medical Research, of which the minister for science is chairman. Of the 12 members of the council, normally appointed by the committee for four years, nine are scientifically qualified and, of the three lay members, one must be a member of the house of lords and one a member of the house of commons. The council's chief function is the promotion of research on all aspects of health and disease, in which they are assisted by special committees appointed to advise on particular subjects In the field of clinical research the council is advised by its Clinical Research board, to which appointments are made in consultation nith the ministry of health and the department of health for Scotland.

The council supports research in three main ways: by appointing its onn staff for work in the National Institute for Medical Research and in research units, which in 1960 numbered 72; by awarding grants for research projects to the staffs of universities and hospitals; and through its schemes of fellowships and scholarships for training in research methods. In addition to its work in the United Kingdom the council undertakes research overseas, maintaining establishments in Gambia, Uganda and Jamaica and acting jointly with the colonial office in assisting work supported from colonial development and welfare funds in tropical countries

Medical research is also undertaken in the medical faculties of universities and in the medical schools. This is supported primarily out of the block grant made to the universities by the University Grants committee on a five-year basis in aid of their teaching and research programs.

Further support for medical research is provided by the ministry of health and the department of health for Scotland, which also initiate and maintain particular projects and services. A considerable amount of research is, of course, undertaken in the national health service in the normal course of hospital treatment of patients. Other government departments, such as the ministry of labour and the ministry of pensions, and bodies such as the Atomic Energy authority request and authorize special investigations and health surveys.

An important contribution to medical research is also made by private organizations such as the British Empire Cancer campaign, the Imperial Cancer Research fund, the National Fund for Research into Poliomyelitis and Other Crippling Diseases, the Nuffield foundation and the Wellcome trust. Close co-operation is maintained between these organizations and the Medical Research council to ensure the best allocation of resources. (H. P. HH.)

Medical Research in the Commonwealth. — The activities in medical research of members of the British Commonwealth are not co-ordinated.

In India medical research on modern lines dates from the 1840s, when T E. Dempster began to measure malarial endemicity by estimating the spleen rate In the early days, most research activities were undertaken as individual enterprises and there was no organized medical research until the Central Research institute was mooted in 1894. Among the earlier independent workers were T Lewis on trypanosomes and filaria, H. Vandyke Carter on spirilla and mycetoma, C. N. Macnamara on cholera and J. Fayrer on snakes and snake venoms. In the first 40 years of the 20th century much research, now regarded as classical, was carried out at the research institutes at Kasauli, Bombay. Madras and Calcutta. Malaria received a large measure of attention from R. Ross, S R. Christophers, H. E. Shortt and S. P. James, and their work was continued by R. N Chopra, M. K. Afridi. S. S Sokhey and Jaswant Singh. W. Haffkine's work on plague and that of R. McCarrison on nutrition in the tropics were seminal The contributions of Leonard Rogers to knowledge of cholera, kala azar and leprosy are commemorated in the Calcutta School of Tropical Medicine, one of the great commonwealth research institutions.

In Australia, the work of the Walter and Eliza Hall Institute for Medical Research at Melbourne has won world repute, especially in the fields of virology and the rickettsioses.

W. G. Penfield's nork in Montreal on the cellular pathology of the nervous system is outstanding. while in Toronto C. H. Best, in the university department of medical research, carried on the distinguished pioneer work in biochemistry which, with F. G. Banting, was so fruitful in the early days of research on the internal secretions of the pancreas.

There are many other medical research institutes throughout the commonwealth, including the South African Institute for Medical Research, Johannesburg; the Medical Research institute, Colombo, Ceylon; the Institute for Medical Research, Kuala Lumpur, Federation of Malaya; and the Medical Research institute, Accra, Ghana. (G. R. McR.)

In colonial territories money and men for research projects are provided peripherally by the individual territorial governments and centrally in Britain by the colonial office. The latter made a notable contribution when, in 1945, it made an allocation for colonial medical research from the funds provided by parliament under the Colonial Development and Welfare acts. These reinforced the existing medical research organizations in the territories by providing research units or individuals. by seeding with grants the colonial universities and by aiding in the universities in Britain much basic research relevant to colonial health problems. These centrally held funds are administered by a Colonial Medical Research committee of 16 members drawn from the colonial office, the Medical Research council and the universities and schools of tropical medicine in Britain. It is assisted by specialist subcommittees and by three overseas regional medical research organizations, in British East Africa, West Africa and the Caribbean respectively, which co-ordinate medical research effort in each region and develop an increasing degree of autonomy.

Further impetus is given by contributions by organizations such. as the Medical Research council. the Nuffield foundation. the Wellcome trust. the Rockefeller foundation, the Walter Reed Army Research and Graduate school and the World Health organization.

Many notable advances found effective application in colonial territories in the years folloning World War II; *e.g.,* in malaria, the discriminative use of residual insecticides and chemoprophylactic and chemotherapeutic drugs; in yellow fever. the 17D vaccine and antimosquito measures; in leprosy, the sulfone drugs; in rickettsia1 and typhoid fevers, chloramphenicol; in plague, streptomycin; and in the pyrexias of unknown origin, the identification

of several distinct causal viruses. (RD. L.)

Medical Research in Europe. — After World War II medical research became of primary interest in all European countries and research work proceeded in all fields of medicine, chiefly in university laboratories and university hospitals. Special institutes for medical research exist but are usually of a small order and closely affiliated to the universities. Exceptions to this are such large institutes as the French Institut Pasteur in Paris, devoted to the study of microorganisms and their importance in disease; the Spanish Instituto Cajal de Investigaciones Biológicas in Madrid. devoted to the study of the microscopical structure of the human body and the brain; and the Italian Istituto Superiore di Sanità in Rome, devoted to the study of parasitology, microbiology and biochemistry. Many of the European universities are state owned and supported, but some are governed by private foundations and in all cases heavy support from public funds is necessary for large-scale research. Another financial source for medical research projects is the medical research councils. They may be part of a larger organization, supporting all kinds of research; *e.g.,* the Deutsche Forschungsgemeinschaft in Germany. the Consiglio Nazionale delle Ricerche in Italy, the Consejo Superior de Investigaciones Cientificas in Spain and the Norges Almenvitenskapelige Forskningsrdd in Norway. Councils devoted to medical research exclusively include the French Institut National d'Hygiène, the Dutch Gezondheidsorganisatie T.S.O. and the Swedish Statens Medicinska Forskningsråd. Private foundations and increasing support from U.S. funds, such as the Rockefeller foundation and various U S. federal agencies, also play an important part. Much medical research is promoted by the pharmaceutical and chemical industry in its own or in university laboratories, especially in, for instance, S itzerland.

In the C.S.S.R. the organization of medical research follows a somewhat different pattern. There the medical faculties of the universities are chiefly devoted to the training of doctors, and medical research is largely directed by the central Academy of Medical Sciences with its seat in Moscow. This academy, appointed and financed by the government, consists of medical scientists, and under it about 40 larger or smaller research institutes function, devoted to all branches of medical sciences. The personnel of these institutes are thus wholly devoted to medical research, though the qualified research workers are in some instances also attached to the universities as teachers. These institutes present their work plans to the academy, with which the ultimate decision on the scientific policy rests and which thus is ultimately responsible for the planning and direction of all medical research in the union. The same general organization of medical research seems to prevail also in Poland, Czechoslovakia, Hungary, Rumania and Yugoslavia. (B. RD.)

International Research **Activities.**—As even this brief review shows, medical progress is international, and with improved communications it can be made more so. Great economic advantage results from dissemination of research results, since duplication of experiment is a much costlier process than is translating a report. The growing appreciation of this fact is evidenced in the increase in interchange of scientific personnel among countries. Congresses and conferences also are held by the approximately 150 international societies in sciences related to medicine. Still another international activity is the research project itself. The U.S. public health service, among other agencies, conducts some research in foreign countries and does studies in the U.S. that are particularly significant to peoples abroad. An example of the former activity is the Middle America Research unit, a field station in Panama to further research on diseases of the tropical Americas. Other PHS laboratories study diseases common in Africa, the Pacific islands, the near east and other areas. In addition, PHS awards a limited number of research grants to foreign scientists. Programs for translating scientific literature and for international exchange of publications also are in existence. (JS. A. S.)

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MEDICAL SERVICES, MILITARY. Recruitment to the medical services of the armed forces is a problem in almost every. country. As wars increase in extent and magnitude. provision for the sick and wounded has to be made on a correspondingly larger scale. The atomic age presents problems of unprecedented nature and extent. calling for close co-operation between the medical services of the armed forces and those of the civilian population.

Up to the middle of the 19th century the army or navy surgeon was mainly concerned with the care of the sick and wounded in battle; the organization of the medical departments was extremely deficient; and the status and conditions of service of the medical officers were deplorably low. By the middle of the 20th century a complete revolution had taken place in all these respects. The most striking change was seen in the way in which the functions of the medical officer were regarded. Emphasis had shifted to achieving the highest physical efficiency in all servicemen. The modern soldier is fed on a precisely balanced diet and is immunized against most of the communicable diseases which formerly decimated armies. His personal equipment is designed with the help of physiologists and psychologists and, when he is actually in battle, the whole organization—with everything that relates to first-aid treatment, surgery and evacuation to hospital—follows him into the fighting line. In early wars at least three-quarters of those wounded died, but in World War II the recovery rate among the Allies for nearly all types of wounds was over 90%.

(W. J. BP.)

UNITED STATES

Except for certain joint activities such as the supply system, the medical services of the U.S. army, navy and air force are independent of one another. Because each service has its o n peculiar medical support obligations to its operating forces, the organization. administration and techniques are separately adapted to the particular character of the forces served.

The three military departments are subordinate to the department of defense, which has an assistant secretary of defense (health and medical). He formulates broad medical policies applicable to all three military departments and co-ordinates their medical activities to avoid unnecessary duplication. He is aided by an advisory council composed of leading figures in the civilian medical field.

Medical co-ordination began before the establishment of the department of defense in 1947, after which time a number of joint agencies were created, usually with representation from the three military departments. Among them are the Armed Forces Institute of Pathology; Epidemiological board; Regulating office, which governs the flow of patients to military hospitals; Military Medical Supply agency, which is mainly concerned with procurement; Publishing agency for producing the *United States Armed Forces Medical Journal* and the *Medical Technicians Bulletin;* and an office for dependents' medical care. The last-named agency contracts with civilian medical agencies for the care of persons dependent on members of the army, navy, air force and certain other governmental services when medical treatment facilities of the services are not available for their care.

Army. — The army medical service is a partly centralized, partly decentralized organization. The surgeon general of the army, who

bears the rank of major general in the medical corps (see below), is appointed by the president of the United States for a statutory four-year term, subject to approval by the senate. In the establishment of army policies concerning the health and medical care of troops and the utilization of professional medical personnel he is subordinate only to the secretary of the army and the army chief of staff, having direct access to both in these matters. For policy making in other fields, such as medical supply and finance, he operates under the direction of the army's deputy chief of staff for logistics. His office has "technical supervision" over all medical operations of the army—that is, it develops and promulgates the techniques for carrying out general policies. The surgeon general exercises the power of command over certain medical facilities, including the widely known Walter Reed army medical centre in Washington, D.C., and the Brooke army medical centre at Ft. Sam Houston. Tex.

Each subordinate command of the army normally has a medical officer known as the chief surgeon, or surgeon, who is responsible to the commander for the operation of all medical services within the latter's jurisdiction, and who has technical supervision of all medical troops of the command.

The army medical service is composed of officers: both male and female, and enlisted personnel, together with a large force of civilian employees most of whom assist with ordinary administrative work, although a considerable number occupy high posts as consultants or serve in other professional capacities. The officer group comprises a medical corps (physicians), a dental corps, a veterinary corps (mostly concerned with the sanitary inspection of meat and dairy products consumed by the armed forces), a nurse corps, a medical specialist corps (dietitians, physical and occupational therapists) and a medical service corps (trained in administration or in fields of science or technology allied to medicine).

The army medical service possesses reserves, both commissioned and enlisted, and large numbers of reserve officers are constantly on active duty.

The training of officers is accomplished partly before and partly after their appointment. A candidate for the medical corps in the regular army, for example, must be a graduate of an approved civilian medical school and must have served an internship or have had equivalent experience in the practice of medicine; after appointment he receives instruction in military subjects and may continue his medical education in army, other governmental or civilian institutions. The opportunities for advanced education open to officers are extensive; internships, residencies and fellowships in the various professional specialties and other types of postgraduate training are available in the field of medicine; in nursing, courses in special techniques have a prominent place in the program. For enlisted personnel the army, besides providing basic medical training, offers courses of study which produce technicians in various medical fields.

For the care of its sick and injured the army employs numerous types of units, ranging in capability from the regimental medical company—whose "aid men" individually accompany combat platoons into battle—to completely equipped hospitals. Thus means are at hand to establish series of treatment stations extending from the front line to the extreme rear in any military operation. The echelonment of medical units in this fashion. called the chain of evacuation. enables lightly equipped medical troops near the front to keep pace with the foremost combat elements, to care promptly for their casualties and quickly to restore to duty those suffering from minor ailments.

Patients needing lengthy or specialized treatment are passed farther along the chain to more fully equipped and therefore less mobile establishments. For the care of patients whose condition does not permit them to be transported any great distance, small mobile surgical hospitals are sent well forward to supplement the facilities of less completely equipped medical units and enable them to retain their mobility. In conditions of peace, the pattern of evacuation is apt to be less complex and more stabilized; when troops are concentrated on posts or camps they are served by static dispensaries and hospitals. In both war and peace certain hospital facilities are set aside for highly specialized care of various types of cases.

In the prevention of disease the army medical service employs a full range of measures, including physical examinations, control of communicable diseases and the establishment of standards for sanitation and proper nutrition. It also conducts an extensive occupational health program for all military and civilian personnel of the army.

As auxiliaries to its system of preventive and restorative medicine the army medical service possesses a complement of laboratories and supply depots. To improve the quality of army medicine it also carries on extensive programs of training and research, and keeps comprehensive statistics on the incidence of death, sickness and injury in the army. After World War II it became concerned with the medical aspects of nuclear warfare, including the medical use of radioisotopes, management of mass casualties and training in nuclear-weapons effects.

(S. B. Hs.; D. O. Wr.)

Navy.—The personnel and facilities devoted to maintaining the health of members of the navy and marine corps and to treating them when they are injured or ill are collectively termed the medical department. This comprises a central administrative and management agency, the bureau of medicine and surgery, and a multitude of activities ashore and afloat, at home and abroad. These activities vary greatly in character, and range in size from large. fully equipped general hospitals to small medical departments on ships or at advanced bases. Some are specialized for medical research or as epidemiology or sanitation units. All are concerned nith various aspects of the mission to promote physical fitness, prevent disease and injury and provide the best possible professional care for the sick and injured.

The medical, dental, nursing and allied activities of the navy are supervised by a senior naval medical officer who is appointed by the president of the United States, subject to approval by the senate, for a statutory four-year term with the rank of rear admiral and the title of surgeon general of the navy. This officer is directly responsible to the secretary of the navy, and acts as chief of the bureau of medicine and surgery, through which he directs and co-ordinates the activities of the medical department.

The bureau formulates policy; develops plans to meet service needs; procures. trains and assigns personnel; assembles and codes statistical data; procures and allocates funds and matériel; and assembles and reviews medical records. Medical and dental officers are detailed to the staffs of commandants of naval districts and commanders of certain fleet forces and supervise medical and dental care in the district or command and assist in the administration of medical and dental services through recommendations to their commanders and reports to the bureau. The bureau has both command and technical control of naval hospitals, schools, research units and similar activities that are commanded or supervised by medical department officers. Over medical and dental departments of other activities ashore and afloat, it has technical supervision only.

The military personnel are technically trained for their particular duties, and have prerogatives and responsibilities common to all naval officers or men of comparable rank or rating. There are five separate corps, of which the medical, dental, nurse and medical service corps are composed entirely of officer personnel. The hospital corps consists of medical service warrant officers and enlisted men, the latter constituting the largest group in the medical department.

To qualify for appointment, medical officers must be graduates of accredited civilian professional schools and have completed approved internships. Dental and nurse officers have corresponding qualifications. Candidates for appointment in the pharmacy, optometry, and medical allied sciences section of the medical service corps must hold degrees in their chosen fields, whereas officers of the administration and supply section are appointed from the enlisted ranks.

Throughout a career in the navy, medical department personnel have repeated opportunities for advanced training and specializa-

tion. Newly appointed medical officers are given indoctrination in the special features of military medicine. Subsequently they may choose one of many planned careers. In addition to the clinical subspecialties of medicine and surgery, possible career patterns include specialization in research, aviation medicine. submarine medicine, atomic medicine, preventive medicine. field medicine and amphibious medicine. The latter two concern medical care of marine corps troops in the field and medical support of units engaged in amphibious assault.

New members of the hospital corps are given elementary professional education in an extensive basic course. They later may enter an advanced course preparing them for duty independent of a medical officer, as on board a destroyer or mine sweeper, or they may take one of many specialized courses that train administrators and technicians for supporting the medical-dental service.

A large reservoir of trained officers and enlisted personnel on inactive duty is available in case of national emergency. Training and refresher courses at reserve training centres are supplemented by short tours of active duty for training purposes.

Each naval activity has its own medical unit for (1) sanitary inspections of crew, provisions and living quarters; (2) instruction of crew in hygiene and first aid; (3) immunization of crew against disease; and (4) treatment of the sick and injured. Ordinarily, patients requiring prolonged or specialized treatment are transferred to an adjacent hospital or hospital ship that has more equipment and a larger staff. The medical and dental departments on an aircraft carrier may include medical, dental, medical service corps and medical service warrant officers and perhaps 20 corpsmen. This unit would be prepared to treat bed patients and perform major surgery. At shore stations the medical department may be a small dispensary with one corpsman, a 20-bed station hospital or a general hospital with well over 1,000 beds that is equipped and staffed to provide every type of specialized medical care. (B. W. HN.; B. F. AY.)

Air Force. — The surgeon general, traditionally a major general, heads the air force medical service, which is composed of the several groups of health specialists in various fields: medicine, aviation medicine, dentistry, nursing, preventive. occupational and environmental medicine, public health, physical medicine, nutrition and medical administration.

As senior medical adviser, the surgeon general reports directly to the chief of staff and the secretary of the air force. Like other air staff offices, the office of the surgeon general is organized under the directorate system with responsibility and authority delegated to three directors — those of professional services. medical staffing and education, and plans and hospitalization — and to special assistants for dental and veterinary services. All report directly to the surgeon general.

The surgeon general's staff determines air force medical policies and offers technical guidance to the major commands into which the air force is organized.

In procuring and retaining career officers, the air force sponsors programs for active commissioning in the senior years of medicine and dentistry; internships; residency training; and the reserve officers training corps (ROTC). It offers direct commissions to trained professional men and women for both career service and reserve duty. Opportunities for advanced study in aviation medicine are offered at the school of aviation medicine. Randolph air force base. Tex.

Leaders in the principal medical specialties are retained as consultants, some being assigned to individual bases and a small group of nationally recognized professional men and women acting as advisers to the surgeon general. The consultants provide a source of training and supervision, ensuring adequate standardizatior, of medical practices and rendering advice and assistance in determination of policies.

To provide the information. techniques and equipment required for protection, escape and survival of air crews, an extensive aeromedical research and development program is carried out at several air force research centres and at several leading universities throughout the Cnited States. The results of this effort make it possible to bridge the gap between conditions and requirements imposed by rapid technological advances in aviation and man's limited capabilities. For example, aeromedical science has developed a pressure suit which will protect the flyer against the virtual vacuum of the highest altitudes attainable. This pressure suit has already saved many valuable lives and expensive aircraft. Many other developments in this field are daily responsible for support of the human element so critical in manned flight and make it possible to maintain the air supremacy upon which national security depends. Aeromedical endeavour also is directed toward the solution of the physiological and psychological problems of space flight, involving sealed cabin existence and protection against the hazards of cosmic radiation, temperature extremes, meteorites and the gravity-free state.

The military air transport service provides rapid transportation for the army. navy and air force and also emergency evacuation of the sick and mounded in time of catastrophe among civilian communities. (D. C. O.; M. M. LK.)

GREAT BRITAIN

The medical services of the navy, army and air force in Great Britain are each headed by a director-general. A chain of medical liaison and control is maintained by the director-general and his staff right down to the medical officers of units. All newly qualified doctors liable for military service are required to serve for two years in the medical branch of one of the armed services.

The medical branches of the armed forces provide for their personnel a health service similar to that available to the civilian population; *i.e.*, a general practitioner service, a specialist service and a hospital service. The medical officer in charge of a unit corresponds to the general practitioner. The specialist service covers all branches of medicine and surgery. and military specialists carry out the same duties as those performed by civilian specialists and consultants. All three services maintain hospitals, medical reception stations, convalescent depots and rehabilitation centres. Medical care extends to the families of servicemen and includes antenatal and maternity services. A forces medical and dental services committee, the Waverley committee, was set up in 1953 and reported in 19j6.

British Army Medical Service. — The only medical men engaged in early narfare were the personal attendants of the king and the nobility. but by the time of the Hundred Years' War they were also recruited to look after the rank and file. More than a score of medical men were attached to the English army at the battle of Agincourt in 1415. The status of the army surgeons was generally very low: in the time of Elizabeth I they were ranked with drummers and received the same basic pay. Doctors were first offered a permanent career by the purchase of a commission when a standing army was founded by Charles II. Following the scandals of the Crimean War, some reforms were made but the royal army medical corps (R.A.M.C.) was not founded until June 23, 1898.

Two-thirds of medical officers in the R A M.C. are employed on general practitioner duties. After attending the junior officers' course at the R.A M.C. college Millbank, London. they start their career as regimental medical officers. They later serve overseas. On their return they attend a senior course at Millbank and at various London hospitals, and they may then choose to remain at general medical duties or take up field training or junior staff appointments.

Specialists are employed on specialist duties up to the rank of colonel. Thereafter they may serve in this rank up to the retiring age of 57 or may be selected for promotion to brigadier in either a specialist or nonspecialist capacity.

At the end of World War II the establishment of the R.A.M.C. was 11,421 officers and 78,171 other ranks. The designation "other ranks" comprises dispensers. clerks. radiographers. nursing orderlies, laboratory assistants, masseurs and sanitary assistants. All ranks are trained as stretcher bearers.

Though there nere over 800 dental surgeons in the British army by the end of World War I. the army dental corps was not founded until 1921. During World War II the corps reached a maximum of 2,300 officers and 3,500 other ranks. The army dental

corps was given the prefix "royal" in 1947.

Royal Navy Medical Service.—A graphic picture of the life of a surgeon's mate in an 18th-century man-of-war is given in Tobias Smollett's Roderick Random. It was not until 1855 that assistant surgeons won the right to be considered as wardroom officers. Naval medicine includes the physical aspects of service afloat and ashore, tropical diseases, industrial hygiene, aviation medicine, the physiology of diving and a variety of other subjects. Entry to the service is by short commission in the first instance. Short service consists of either three or four years, during which a medical officer becomes a surgeon lieutenant. R.N., and is eligible to apply for a transfer to the permanent list. Promotion to the full rank of surgeon lieutenant normally follows after one year's service and to surgeon lieutenant commander after a further seven years' service. Further promotion is by selection. Service on the active list is up to the age of jj for all officers, 57 for surgeon captains and 60 for surgeon rear admirals. Officers on the permanent list are encouraged to specialize and are given full facilities for obtaining higher qualifications.

Medical Branch of the **R.A.F.**—On the formation of the Royal Air Force (R A.F.) in April 1918 medical officers who had served with the Royal Naval Air service and the Royal Flying Corps were transferred or attached to the new air force. They were granted R.A.F. rank in November of the following year. Appointment is usually to short service commissions for three, four or five years, but permanent commissions can be applied for at any time during short service. The normal rank on appointment is flying officer, with promotion to flight lieutenant after one year's service. to squadron leader after eight years' service and to higher ranks by selection. Since the safety and efficiency of the air force depend to a large degree on its medical service, great importance is attached to recruitment of the right type of medical officer. The air force medical officer is concerned with problems of high-altitude flying, flying at supersonic speeds, parachuting. mountain rescue, air evacuation of sick and wounded and the special type of injuries associated with flying accidents, as well as with the clinical specialties and the treatment of service families. See also SANITATION, MILITARY. (W. J. BP.)

MEDICAL TECHNOLOGY is the branch of medicine concerned with laboratory and instrumental procedures that are of aid in the diagnosis and treatment of illness. The term is usually applied to the actual performance of these procedures, but in a broader sense it also includes their professional supervision and the medical interpretation of the results obtained by their use. The procedures constituting medical technology are derived chiefly from biochemistry, physiology, hematology, microbiology, immunology, histology, physics and radiology.

Mounting knowledge of disease processes and the introduction of new forms of therapy have increased greatly the use of laboratory techniques in following the course of illness, and the increase is paralleled by development of instrumentation that enables rapid and precise performance. For example, in the late 1940s the flame photometer. based on the measurement of intensity of the characteristic spectra of vaporized sodium or potassium, was introduced for the analysis of these elements in blood and urine; it replaced older methods and greatly increased the rate of performance of these determinations.

In the late 1950s the process of automation began to be reflected in the field of medical technology, and machines requiring little attention were devised for preparing tissues for microscopic study or for analyzing certain components directly from the blood. Such advances tend to increase the scope and sophistication of medical technology and to raise its importance to clinical medicine.

Content of Medical Technology.— The biochemical aspects consist in the quantitative and occasionally qualitative determination of the approximately 100 chemical components in body fluids. secretions and excretions that may show abnormal concentrations in disease. Among the analyses most commonly performed are those for protein and glucose in urine; urea, glucose, carbon dioxide, sodium, potassium, chloride, calcium, phosphate, cholesterol. bilirubin and various enzymes in blood; protein and glucose in spinal fluid.

Among the physiological procedures that are important in medical technology is the measurement of rate of oxygen consumption under resting and other basal conditions, which permits calculation of the basal metabolic rate, a value of particular use in the diagnosis of thyroid disease. The electrocardiogram is a pattern of the electrical potential differences and the resulting currents produced in the body by the mechanical action of various parts of the heart; many types of heart disease show characteristic deviations from the normal pattern. The electroencephalogram is a record of electrical waves of varying amplitudes and frequencies that appear to arise spontaneously in the central gray matter of the brain; it is of value in the diagnosis and treatment of various brain disorders.

Medical technology in hematology consists of a wide variety of methods for studying the blood, such as the determination of the number of red and white blood cells and the microscopic examination of the structure of the blood cells. Blood cells from bone marrow may be obtained by special puncture and examined in a similar fashion. Of considerable importance is the collection and classification of blood in blood banks for use in transfusions.

Microbiological techniques include the examination and study of the presence and nature of bacteria and other microorganisms in the blood, urine, cerebrospinal fluid, stools, sputum and infected areas of the body. The examination may be made by direct smear and stain of the material on a slide or by growing the organism in special media (see ANIMAL CELL [TISSUE] CULTURE). Closely associated with microbiological techniques are immunological methods, for immunological reactions are the processes by which the living body protects itself against the attacks of microorganisms (see IMMUNITY).

Technology in histology is concerned with the preparation of various body tissues for microscopic examination by the pathologist. Small blocks of fresh tissue are immersed in fixative solutions to stop natural decay. They are then washed and dehydrated, embedded in paraffin or similar material and cut into very thin sections, which are stained with dyes that bring out various details of the cellular and tissue structure.

The field of physics has contributed much to medical technology. X-ray technicians assist the radiologist in therapy and diagnosis. With the rapid advances in radiation and nuclear physics, persons with varying degrees of training in physics have been utilized in such activities as calculation of tissue dosage, personnel and area monitoring and maintenance of equipment.

Training of Medical Technicians.— This varies widely. The physician in private practice frequently teaches his office assistant a few office procedures for which he has frequent use, such as urine analysis. red and white blood cell counts or the taking of electrocardiograms or X-rays. In this situation, the physician can supervise his assistant closely.

In the small or moderately sized hospital, a need exists for medical technologists who are capable of performing a greater variety and number of procedures. In 1936 the Board of Registry of Medical Technology of the American Society of Clinical Pathology, in association with the Council on Medical Education and Hospitals of the American Medical association, instituted standards of training for medical technologists, and such standards have been periodically revised. The duration of the training program in approved schools, which are located in hospitals and often affiliated with universities, was 12 months in most institutions and ranged up to 36 months in some. The usual fields of medical technology, exclusive of X-ray, were included in these programs. In Great Britain applicants who are at least 16 years of age and have a general school certificate or the equivalent, with completion of specified science courses, are accepted for training in laboratories approved by the Institute of Medical Laboratory Technology. At the end of three years' training, these student technicians are eligible to take the examination for the intermediate diploma of the Institute of Medical Laboratory Technology and, if they pass it successfully, attain the rank of junior technician. Further training and higher ranks also are available.

Because of the large load of work and the complexity of certain procedures, many large hospitals, particularly those affiliated with medical schools or research institutes, have special laboratories in

biochemistry, bacteriology or hematology. In these the medical technologists are usually college graduates who, instead of performing a varied array of clinical pathological procedures, are trained in one special field.

Professional Supervision. — As the result of advances in medicine during the 20th century, the growing dependence of clinical medicine upon laboratory procedures and the increase in the number and size of hospitals and medical centres, the role of professional personnel in supervision of technological procedures and medical interpretation of results has been much expanded. In general, the function of supervision and interpretation is fulfilled by a physician who, in addition to some postdoctoral clinical experience, has had several years of training in a laboratory specialty. In the United States the American Board of Pathology designates competence by granting of certification in clinical pathology. clinical chemistry, clinical bacteriology, clinical microbiology or hematology. Similarly, the American Board of Radiology grants certification in such special fields as radiological physics and medical nuclear physics. In Great Britain similar professional competence is denoted by .diplomas from various graduate schools of medicine or from the royal colleges. *See* also DIAGNOSIS; PATHOLOGY.

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MEDICI, the name of a famous Italian family. Legend declared that the house was founded by Perseus, and that Benvenuto Cellini's bronze Perseus holding on high the head of Medusa was executed and placed in the Loggia dei Lanzi at Florence to symbolize the victory of the Medici over the republic. The name appears in Florentine chronicles as early as the late 12th century.

Early Bearers of the Name. — The first of the family to be a distinct figure in history was Salvestro dei Medici, who, in 1378, was the real leader in the revolt of the Ciompi (wool-carders). The lesser gilds had gained some ground by this riot, and Salvestro dei Medici the great popularity at which he had aimed.

Giovanni.—Giovanni, son of Averardo Bicci dei Medici (1360–1429), may be considered the actual founder of Medicean greatness. He realized an immense fortune by trade — establishing banks in Italy and abroad, which in his successors' hands became the most efficient engines of political power. The Council of Constance (1414–18) enabled Giovanni dei Medici to realize enormous profits. Like his ancestor Salvestro, he was a constant supporter of the lesser gilds in Florence. Historians record his frequent resistance to the Albizzi when they sought to oppress the people with heavier taxation, and his endeavours to cause the chief weight to fall upon the rich. For this he gained a great reputation. Giovanni dei Medici died in 1429 leaving two sons, Cosimo (1389–1464) and Lorenzo (1395–1440). From the former proceeded the branch that ruled for many generations over the nominal republic of Florence and gave to Italy the popes Leo X and Clement VII. On the extinction of this elder line in the 16th century, the younger branch derived from Lorenzo, Cosimo's brother, for two centuries supplied grand-dukes to Tuscany.

Cosimo.—Cosimo, surnamed Cosimo the Elder, and honoured after his death by the title of *pater patriae,* first succeeded in solving the problem of becoming absolute ruler of a republic keenly jealous of its liberty, without holding any fixed office, without suppressing any previous form of government, and always preserving the appearance and demeanour of a private citizen. Born in 1389, he was forty when his father died. He showed much taste and an earnest love both for letters and art. But he was devoted to business to the day of his death, and like his forefathers gained wealth through his friendly relations with the papal court. He inherited the leadership of the opposition to the then dominant party of the greater gilds headed by Rinaldo degli Albizzi, Palla Strozzi and Niccolb da Uzzano.

Cosimo was generous in lending and even giving money when it suited his political ends. He is said to have fomented the war with Lucca, and to have made money out of it. When the fortune of war turned against Florence, Cosimo turned on the Albizzi and their friends who were mainly responsible for its conduct. The Albizzi vowed revenge. A general assembly of the people was convoked and a *balia* chosen, which changed the government and sent Cosimo into exile at Padua.

Finally, on Sept. 1, 1434, a signory was elected in Florence composed of his friends, and his recall was decreed. Rinaldo degli Albizzi determined to oppose it by force, but his attempt failed, and he left Florence never to return. For three centuries, dating from that moment, the whole history of Florence was connected with that of the house of Medici.

Cosimo secured himself by exiling the most powerful citizens to all parts of Italy. It was impossible for Cosimo openly to assume the position of tyrant of Florence, nor was it worth his while to become gonfalonier, since the term of office lasted only two months. He attained his object by securing the control of the magistracy, whose members were appointed for a five year term.

Cosimo's Patronage of Art. — Without the title of prince, this merchant showed royal generosity in his expenditure for the promotion of letters and the fine arts. Besides his palace in the city, he constructed noble villas at Careggi, Fiesole and other places. He built the Badia of Fiesole, and the St. Lorenzo church in Florence, and enlarged the church and monastery of St. Mark. Even in distant Jerusalem he endowed a hospice for the use of pilgrims. He was the patron of Donatello, Brunelleschi, Ghiberti, Luca della Robbia, and many others. Cosimo purchased many Greek and Latin manuscripts; he opened the first public library at St. Mark's at his own expense, and founded another in the abbey of Fiesole. The Greek refugees from Constantinople found a constant welcome in his palace. During the Council of Florence (1439–1442), Gemistus Pletho spoke to him with enthusiasm of the Platonic philosophy. Cosimo was so deeply attracted by the theme that he decided to have the young Marsilio Ficino (*q.v.*) trained in philosophy and Greek learning in order to make a Latin translation of the complete works of Plato. Through Ficino he founded that Platonic academy which led to such important results in the history of Italian philosophy and letters. On Aug. 1, 1464, Cosimo died at the age of seventy-five, while engaged in listening to one of Plato's dialogues.

Cosimo was succeeded by his son Piero "the Gouty," who quelled a plot against his leadership, and maintained his authority for five years, mainly through the prestige inherited from Cosimo. He died on Dec. 3, 1469, leaving two sons, Lorenzo (1449–1492) and Giuliano (1453–1478).

Lorenzo.—The younger, the gentler and less ambitious of the two, was quickly removed from the world. Lorenzo seized the reins of state with a firm grasp. In literary talent he was superior to Cosimo, but as a financier was inferior. In politics he had nobler conceptions and higher ambitions, but he was more easily carried away by his passions, less prudent in his revenge, and more disposed to tyranny. Lorenzo's policy, although prosecuted with less caution, was still the old astute policy initiated by Cosimo.

Among his worst enemies were the powerful clan of the Pazzi. They were on the point of inheriting the large property of Giovanni Borromeo when Lorenzo hurriedly caused a law to be passed that altered the right of succession. The hatred of the Pazzi was thereby exasperated to fury. There ensued a desperate quarrel with Pope Sixtus IV. Consequently the Pazzi and Archbishop Salviati, another enemy of Lorenzo, aided by the nephews of the pontiff, determined to destroy the Medici. On April 26, 1478, while Giuliano and Lorenzo were attending high mass in the cathedral of Florence, the former was mortally stabbed by conspirators, but the latter was able to beat back his assailants and escape into the sacristy. Lorenzo wreaked cruel vengeance upon his foes. Several of the Pazzi and their followers were hanged from the palace windows; others were hacked to pieces, dragged through the streets, and cast into the Amo, while others were condemned to death or sent into exile. The pope had excommunicated Lorenzo, put Florence under an interdict, and, with

the help of the Neapolitan king, made war against the republic. Lorenzo went to Naples, to the court of King Ferdinand of Aragon, and secured an honourable peace, which soon led to a reconciliation with Sixtus.

Thus at last Lorenzo found himself complete master of Florence. But, as the *balia* changed every five years, it was always requisite to secure a new magistracy favourable to his aims. In 1480 Lorenzo compassed the institution of a new council of seventy, which was practically a permanent *balia* with extended powers, which not only elected the chief magistrates, but had also the administration of numerous state affairs. This permanent council of devoted adherents once formed, his security was firmly established. By this means, the chroniclers tell us, "liberty was buried," but the chief affairs of the state were always conducted by intelligent and experienced men, who promoted the public prosperity. Florence was still called a republic; the old institutions were still preserved, if only in name. Lorenzo was absolute lord of all, and virtually a tyrant.

His immorality was scandalous; he kept an army of spies; he frequently meddled in the citizens' most private affairs, and exalted men of the lowest condition to important offices of the state. Yet, as Guicciardini remarks, "If Florence was to have a tyrant, she could never have found a better or more pleasant one." In fact all industry, commerce and public works made enormous progress. The civil equality of modern states, which was quite unknown to the middle ages, was more developed in Florence than in any other city of the world. Even the condition of the peasantry was far more prosperous than elsewhere. Lorenzo's authority was very great throughout the whole of Italy. He was on the friendliest terms with Pope Innocent VIII., from whom he obtained the exaltation of his son Giovanni to the cardinalate at the age of fourteen. This boy-cardinal was afterwards Pope Leo X. From the moment of the decease of Sixtus IV., the union of Florence and Rome became the basis of Lorenzo's foreign policy.

The palace of Lorenzo was the school and resort of illustrious men. Within its walls were trained the two young Medici afterwards known to the world as Leo X. and Clement VII. Ficino, Poliziano, Pico della Mirandola and all members of the Platonic academy were its constant habitués. It was here that Pulci gave readings of his Morgante, and Michelangelo essayed the first strokes of his chisel. Lorenzo's intellectual powers were of exceptional strength and versatility. He could speak with equal fluency on painting, sculpture, music, philosophy and poetry.

But his crowning superiority over every other Maecenas known to history lay in his active participation in the intellectual labours that he promoted. He was an elegant prose writer, and a poet of real originality. It is Lorenzo's lasting glory to have been the initiator of the movement for the revival of the national literature in the mother tongue. He died on April 8, 1492.

Pietro.—Lorenzo left three sons—Pietro (1471–1503), Giovanni (1475–1521) and Giuliano (1479–1516). He was succeeded by Pietro, whose rule lasted but for two years. He fomented the hatred between Lodovico Sforza and Ferdinand of Naples, which hastened the coming of the French under Charles VIII., and the renewal of foreign invasions. When the French approached the frontiers of Tuscany, Pietro, crazed with fear, accepted terms equally humiliating to himself and the state. The enraged citizens decreed his deposition, and he fled to Venice. He was drowned at Garigliano in 1503.

Cardinal **Giovanni** (Leo **X.**), **Giuliano, Lorenzo.**—A republican government was maintained in Florence from 1494 to 1512, and the city remained faithful to its alliance with the French, who were all-powerfill in Italy Cardinal Giovanni, the head of the family, resided in Rome, playing the patron to a circle of litterati, artists and friends, and waiting for better days. The battle of Ravenna wrought the downfall of the fortunes of France in Italy, and led to the rise of those of Spain, whose troops entered Florence to destroy the republic and reinstate the Medici. Pietro had left a young son, Lorenzo (1492–1519), who was afterwards duke of Urbino. In 1513 Cardinal Giovanni was elected pope, and assumed the name of Leo X. ***(qv.).*** Meanwhile his kinsmen continued to govern Florence by means of a *balia.* And thus, being masters of the whole of central Italy, the Medici enjoyed great authority throughout the country. This was the moment when Niccolò Machiavelli (*q.v.*), in his treatise The Prince, counselled them to accomplish the unity of Italy

Giuliano dei Medici had died during Leo's reign, in 1516, without having ever done anything worthy of record. He was the husband of Philiberta of Savoy, was duke of Nemours, and left a natural son, Ippolito dei Medici (1511–1535), who afterwards became a cardinal. Lorenzo was invested by his kinsman, Leo X., with the duchy of Urbino, after expelling on false pretences its legitimate lord, Francesco Maria della Rovere. This prince, however, soon returned to Urbino, where he was joyously welcomed by his subjects, and Lorenzo regained possession only by a war of several months, in which he was wounded. In 1519 he also died, worn out by disease and excess, By his marriage with Madeleine de la Tour d'Auvergne, he had one daughter, Caterina dei Medici (1519–1589) (see CATHERINE DE' MEDICI), married in 1533 to Henry, duke of Orleans, afterwards king of France. Lorenzo also left a natural son named Alessandro. Thus the only three surviving representatives of the chief branch of the Medici, Cardinal Giulio, Ippolito and Alessandro were all of illegitimate birth, and left no legitimate heirs.

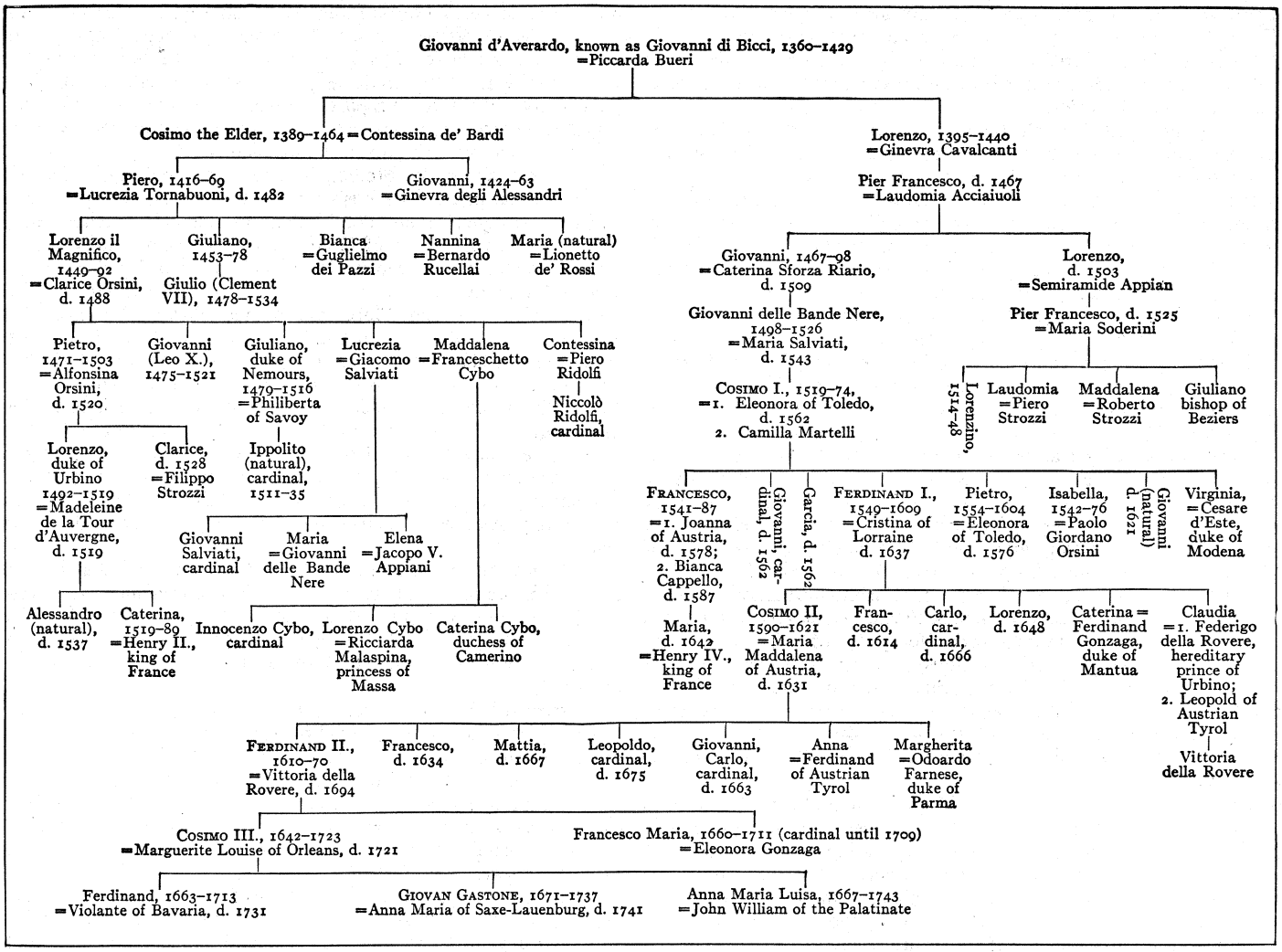
Cardinal Giulio (Clement **VII.**).—Cardinal Giulio (see CLEMENT VII.), who had laboured successfully for the reinstatement of his family in Florence in 1512, had been long attached to the person of Leo X. as his trusted factotum and companion. When Giuliano and Lorenzo died, the pope appointed the cardinal to the government of Flcrence. When, after the death of Leo X. and the very brief pontificate of Adrian VI., he was elected pope (1523) under the name of Clement VII., he entrusted the government of Florence to Cardinal Silvio Passerini conjointly with Alessandro and Ippolito, who were still young.

Giovanni delle Bande **Nere.**—The younger branch of the Medici, descended from Lorenzo, brother to Cosimo the elder, now emerged from obscurity. In fact the most valiant captain of the papal forces was Giovanni dei Medici, afterwards known by the name of Giovanni delle Bande Nere. His father was Giovanni, son of Pier Francesco, who was the son of Lorenzo, the brother of Cosimo dei Medici The youthful Giovanni was the only leader who opposed a determined resistance to the imperial forces. He was seriously wounded at Pavia when fighting on the French side. On his recovery he joined the army of the League. When the imperial troops were struggling through the marshes of Mantua, surrounded on every side, and without stores or ammunition, Giovanni attacked them with a small body of men. One of the first shots fired by the enemy injured him so fatally that he died a few days after. He was married to Maria Salviati, by whom he had one son, Cosimo (1519–1574), who became the first grand duke of Tuscany, and indeed the founder of the grand duchy and the new dynasty.

Duke **Alessandro.**—Meanwhile the imperial army had sacked Rome, and Clement VII. had signed a treaty of alliance with the emperor (1529), who sent an army to besiege Florence and restore the Medici, whom the people had expelled in 1527 on the re-establishment of the republic. After an heroic defence, the city was forced to surrender (1530). Ippolito being a cardinal, Alessandro was chosen as the new ruler of Florence.

By imperial patent Duke Alessandro (he was duke of Citth di Penna) was nominated head of the republic. No previous ruler of the city had enjoyed hereditary power confirmed by imperial patent, and such power was incompatible with the existence of a republic. A new council was formed of two hundred citizens elected for life, forty-eight of which number were to constitute a senate. Alessandro, as duke of the republic, filled the post of gonfalonier, and carried on the government with the assistance of three senators, changed every three months, who took the place of the suppressed signory. The duke's chief advisers and the contrivers of all these arrangements were Baccio Valori, Francesco Vettori and above all Francesco Guicciardini—men, especially the latter two, of lofty political gifts and extensive influence. When the leading Florentine families realized not only that the republic

GENEALOGICAL TABLE OF THE MEDICI



was destroyed, but that they were reduced to equality with those whom they had hitherto regarded as their inferiors and subjects, their rage was indescribable, and hardly a day passed without the departure of influential citizens who were resolved to overthrow their new ruler. They found a leader in Cardinal Ippolito dei Medici, who was then in Rome.

Cardinal Ippolito.—In 1534 the principal Florentine exiles were despatched to Charles V. with complaints of Alessandro's tyranny. Ippolito represented his own willingness to carry on the government of Florence in a more equitable manner, and promised the emperor a large sum of money. He set out to meet Charles in Tunis, but on Aug. 10, 1535, died suddenly at Itri, poisoned, it is supposed, by order of Alessandro. On the emperor's return from Africa, the exiles presented themselves to him in Naples. Duke Alessandro, being cited to appear, came to Naples accompanied by Francesco Guicciardini, who by speaking in his defence, tarnished his illustrious name. Alessandro rose higher than before in the imperial favour, married Margaret of Austria, the natural daughter of Charles, and returned to Florence with increased power. Alessandro now indulged unchecked in the lowest excesses of tyranny, and gave way to increased libertinism.

Lorenzino.—His constant associate in this disgraceful routine was his distant kinsman Lorenzo, generally known as Lorenzino dei Medici. On Jan. 5, 1537, Lorenzino led the duke to his own lodging, and left him there, promising shortly to return with the wife of Leonardo Ginori. Alessandro fell asleep on the couch while awaiting Lorenzino's return. Before long the latter came accompanied by a desperado known as the Scoronconcolo, who aided him in murdering the sleeper. They placed the body in a bed, hid it beneath the clothes, and, Lorenzino having attached a paper to it bearing the words, *Vincit amor patriae, laudumque immensa cupido,* they both fled to Venice. In that city Lorenzino was assassinated some ten years later, in 1548, at the age of thirty-two, by order of Alessandro's successor He wrote an *Apologia,* in which he defended himself with great skill and eloquence, saying that he had been urged to the deed solely by love of liberty. By Alessandro's death the elder branch of the Medici became extinct.

Cosimo I.—Cardinal Cybo convoked the council of forty-eight to decide upon a successor. Guicciardini and other leading citizens favoured the choice of Cosimo, the son of Giovanni delle Bande Nere He was already in Florence, was aged seventeen, was keen-witted and aspiring, strong and handsome in person, heir to the enormous wealth of the Medici, and, by the terms of the imperial patent, was Alessandro's lawful successor. Charles V. approved the nomination of Cosimo, who without delay seized the reins of government with a firm grasp.

Meanwhile the exiles assembled their forces at Mirandola. They had about four thousand infantry and three hundred horse; among them were members of all the principal Florentine families, and their leaders were Bernardo Salviati and Piero Strozzi. They entered Tuscany towards the end of July 1537 Cosimo ordered Alessandro Vitelli to collect the best German, Spanish and Italian infantry at his disposal, and attack the enemy. Alessandro Vitelli re-entered Florence with his victorious army and his fettered captives. Cosimo had achieved his first triumph.

On four mornings in succession four of the prisoners, all members of great families, were beheaded. Then the duke saw fit to

stay the executions. Baccio Valori, however, and his son and nephew were beheaded on Aug. 20 in the courtyard of the Bargello. Filippo Strozzi still survived, but, later, on Dec. 18, he was found dead in his prison, with a blood-stained sword by his side, and a slip of paper bearing these words: *Exoriare aliquis nostris ex ossibus ultor.*

The young prince's cold-blooded massacre of his captives cast an enduring shadow upon his reign and dynasty. But it was henceforward plain to all that he was a man of stern resolve, who went straight to his end without scruples. He was regarded by many as the incarnation of Machiavelli's *Prince.* Guicciardini, who still pretended to act as mentor, withdrew from public life and when he died in 1540, it was immediately rumoured that the duke had caused him to be poisoned. This shows the estimation in which Cosimo was now held. He punished with death all who dared to resist his will. By 1540 sentence of death had been pronounced against 430 contumacious fugitives, and during his reign 140 men and six women actually ascended the scaffold, without counting those who perished in foreign lands by the daggers of his assassins.

Cosimo bore a special grudge against the neighbouring republics of Siena and Lucca. Siena was an old and formidable foe to Florence, and had always given protection to the Florentine exiles. It was now very reluctantly submitting to the presence of a Spanish garrison, and, being stimulated by promises of prompt and efficacious assistance from France, rose in rebellion and expelled the Spaniards in 1552. Cosimo instantly wrote to the emperor, asking leave to attack Siena, and begged for troops. He then began negotiations with Henry II. of France, and, by thus arousing the imperial jealousy, obtained a contingent of German and Spanish infantry. Siena was besieged for fifteen months, and its inhabitants made a most heroic resistance, even women and children helping on the walls. But finally the Sienese were obliged to capitulate on honourable terms that were shamelessly violated.

In 1559 Cosimo also captured Montalcino, and thus formed the grand-duchy of Tuscany, but he continued to govern the new state—*i.e.* Siena and its territories—separately from the old. His rule was intelligent, skilful and despotic; but his enormous expenses drove him to excessive exactions in money. Hence, notwithstanding the genius of its founder, the grand-duchy held from the first the elements of its future decay. Cosimo preferred to confer office upon men of humble origin in order to have pliable tools, but he also liked to be surrounded by a courtier aristocracy on the Spanish and French pattern. Cosimo was no Maecenas; nevertheless he restored the Pisan university, enlarged that of Siena, had the public records classified, and executed public works like the Santa Trinità bridge. During the great inundations of 1557 he turned his whole energy to the relief of the sufferers.

In 1539 he had married Eleonora of Toledo, daughter of the viceroy of Naples, by whom he had several children. Two died in 1562, and their mother died shortly afterwards. It was said that one of these boys, Don Garcia, had murdered the other, and then been killed by the enraged father. Indeed, Cosimo was further accused of having put his own wife to death but neither rumour had any foundation. Worn by the cares of state and self-indulgence, Cosimo, in 1564, resigned the government to his eldest son, who was to act as his lieutenant, since he wished to have power to resume the sceptre on any emergency. In 1570, by the advice of Pope Pius V., he married Camilla Martelli, a young lady of whom he had been long enamoured. In 1574 he died, at the age of 54 years and ten months, after a reign of 37 years, leaving three sons and one daughter besides natural children. These sons were Francesco, his successor, who was already at the head of the government, Cardinal Ferdinand, and Piero.

Francesco I.—Francesco I., born in 1541, began to govern as his father's lieutenant in 1564, and was married in 1565 to the archduchess Giovanna of Austria. He was suspicious, false and despotic. Holding every one aloof, he carried on the government with the assistance of a few devoted ministers. He cast himself like a vassal at Austria's feet. He reaped his reward by obtaining from Maximilian II. the title of grand-duke, for which Cosimo had never been able to win the imperial sanction, but he forfeited all independence. Towards Philip II. he showed even greater submissiveness, supplying him with large sums of money wrung from his overtaxed people. His love of science and letters was the only Medicean virtue that he possessed. He had an absolute passion for chemistry, and passed much of his time in his laboratory. Francesco was a slave to his passions, and was led by them to scandalous excesses and deeds of bloodshed.

In 1576 Isabella dei Medici, Francesco's sister, was strangled in her nuptial bed by her husband, Paolo Giordano Orsini, whom she had betrayed. Piero dei Medici, Francesco's brother, murdered his wife Eleonora of Toledo from the same motive. Still louder scandal was caused by the duke's passion for the famous Bianca Cappello, a Venetian of noble birth, who had eloped with and married a young Florentine named Pietro Buonaventuri. Francesco nominated her husband to a post at court. Upon this Buonaventuri behaved with so much insolence, even to the nobility, that one evening he was found murdered in the street. After the death of the grand-duchess in 1578 he married Bianca. The grand-duke died at his villa of Poggio a Caiano on Oct. 18, 1587, and the next day Bianca also expired. Rumour asserted that she had prepared a poisoned tart for the cardinal, and that, when he suspiciously insisted on the grand-duke tasting it first, Bianca desperately swallowed a slice and followed her husband to the tomb.

Such was the life of Francesco dei Medici, and all that can be said in his praise is that he gave liberal encouragement to a few artists, including Giovanni Bologna (*q.v.*). He was the founder of the Uffizi gallery, of the Medici theatre, and the villa of Pratolino; and during his reign the Della Cruscan academy was instituted.

Ferdinand I.—Ferdinand I. was thirty-eight years of age when, in 1587, he succeeded his brother on the throne. A cardinal from the age of fourteen, he had never taken holy orders. He was the founder of the Villa Medici at Rome, and the purchaser of many priceless works of art, such as the Niobe group and many other statues afterwards transported by him to Florence. After his accession he retained the cardinal's purple until the time of his marriage.

He re-established the administration of justice, and sedulously attended to the business of the state. Tuscany revived under his rule, and regained the independence and political dignity that his brother had sacrificed to love of ease and personal indulgence. He ensured the prosperity of Leghorn, by an edict enjoining toleration towards Jews and heretics, which led to the settlement of many foreigners in that city. He improved the harbour and established canal communication with Pisa, and carried out many works of public utility in the duchy. He retained the reprehensible custom of trading on his own account, keeping banks in many cities of Europe. In foreign policy he sought emancipation from Spain.

During this grand-duke's reign the Tuscan navy was notably increased, and did itself much honour on the Mediterranean. The war-galleys of the knights of St. Stephen were despatched to the coast of Barbary to attack Bona, the headquarters of the corsairs, and they captured the town with much dash and bravery. In the following year (1608) the same galleys achieved their most brilliant victory in the archipelago over the stronger fleet of the Turks, by taking nine of their vessels, seven hundred prisoners, and jewels of the value of 2,000,000 ducats.

Cosimo II.—Ferdinand I. died in 1609, leaving four sons, of whom the eldest, Cosimo II., succeeded to the throne at the age of nineteen. Like his predecessors, Cosimo II. studied to promote the prosperity of Leghorn, and he deserves honour for abandoning all commerce on his own account. He was fond of luxury, spent freely on public festivities and detested trouble. Tuscany was apparently tranquil and prosperous; but the decay of which the seeds were sown under Cosimo I. and Ferdinand I. became before long beyond all hope of remedy. Cosimo II. protected Galileo Galilei. He recalled him to Florence in 1610, and nominated him court mathematician and philosopher. Cosimo died in February 1621. His mother, Cristina of Lorraine, and his wife, Maddalena

of Austria, had been nominated regents and guardians to his eldest son Ferdinand II, a boy of ten.

Ferdinand 11.—In 1627 Ferdinand II, then aged seventeen, chose to assume the government; but he decided on sharing his power with the regents and his brothers. When Florence and Tuscany were ravaged by the plague in 1630, he showed admirable courage and carried out many useful measures. But he was entirely subservient to Rome. On the death in 1631 of the last duke of Urbino, the pope was allowed to seize the duchy without the slightest opposition on the part of Tuscany. Ecclesiastics usurped the functions of the state; and the ancient laws of the republic, together with the regulations decreed by Cosimo I as a check upon similar abuses, were allowed to become obsolete. On the extinction of the line of the Gonzagas at Mantua in 1627, war broke out between France on the one side and Spain, Germany and Savoy on the other. The grand duke, uncertain of his policy, trimmed his sails according to events. Fortunately peace was re-established in 1631. Mantua and Monferrato fell to the duke of Nevers, as France had always desired. But Europe was again in arms for the Thirty Years' War. Urban VIII wished to aggrandize his nephews, the Barberini, by wresting Castro and Ronciglione from Odoardo Farnese, duke of Parma and brother-in-law to Ferdinand. Farnese marched his army through Tuscany into the territories of the pope. The grand-duke was drawn into the war to defend his own state and his kinsman. By means of the French intervention, peace was made in 1644. But the pope resigned none of his ecclesiastical pretensions in Tuscany. The septuagenarian Galileo was obliged to appear before the Inquisition in Rome, which treated him with infamous cruelty.

Like his predecessors, Ferdinand II gave liberal patronage to science and letters. His brother Leopold, who had been trained by Galileo Galilei was one of the founders of the celebrated accademia del Cimento, which took for its motto the words *Provando e riprovando,* and followed the experimental method of Galileo. Formed in 1657, it was dissolved in 1667.

Cosimo III.—Cosimo III succeeded his father in 1670. He was weak, vain, bigoted and hypocritical. His wife, Louise of Orléans, niece.of Louis XIV, being enamoured of duke Charles of Lorraine, was very reluctant to come to Italy. After the birth of her third child, Giovan Gastone, her hatred for her husband increased almost to madness and she returned to France.

In Cosimo's reign the wretchedness of the people increased, and the insufficient revenues of the state were spent on clerical endowments.

Cosimo's eldest son Ferdinand died childless in 1713. The pleasure-loving Giovan Gastone was married to Anna Maria of Saxe-Lauenburg, widow of a German prince, a wealthy, coarse woman wholly immersed in domestic occupations. After living with her for some time in a Bohemian village, Giovan Gastone withdrew to France, and ruined his health by his excesses. After a brief return to Bohemia he finally separated from his wife, by whom he had no family. Thus the dynasty was doomed to extinction. Cosimo had a passing idea of reconstituting the Florentine republic, but, this design being discountenanced by the European powers, he determined to transfer the succession, after the death of Giovan Gastone, to his sister Anna Maria Louisa, who in fact survived him. For this purpose he proposed to annul the patent of Charles V, but the powers objected to this arrangement also: and by the treaty of 1718 the quadruple alliance of Germany, France, England and the Netherlands decided that Parma and Tuscany should descend to the Spanish Infante Don Carlos. The grand-duke made energetic but fruitless protests.

Giovan Gastone.—Cosimo III had passed his 80th year at the time of his decease in Oct. 1723, and was succeeded by his son Giovan Gastone, then aged 53. The new sovereign was in bad health, worn out by dissipation, and had neither ambition nor aptitude for rule. His throne was already at the disposal of foreign powers, and his only thought on ascending it was to regain strength enough to pass the remainder of his days in enjoyment. And when, after prolonged opposition, he had resigned himself to accept Don Carlos as his successor, the latter led a Spanish army to the conquest of Naples, an event afterward leading to the peace of 1735, by which the Tuscan succession was transferred to Francis I, duke of Lorraine and husband of Maria Theresa. Giovan Gastone was obliged to submit. Spain withdrew its garrisons from Tuscany, and Austrian soldiers took their place and swore fealty to the grand-duke on Feb. 5, 1737. He died on July 9 of the same year. Such was the end of the younger branch of the Medici, which had found Tuscany a prosperous country, where art, letters, commerce, industry and agriculture flourished, and left it poor and decayed in all ways, drained by taxation and oppressed by laws contrary to every principle of sound economy, downtrodden by the clergy and burdened by a weak and vicious aristocracv.

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MEDICI, GIACOMO (1817–1882), Italian soldier, was born at Milan in Jan. 1817. Exiled in 1836. he fought in Spain against the Carlists between 1836 and 1840, and in 1846 he joined Giuseppe Garibaldi at Montevideo.

Returning to Italy with Garibaldi in 1848, he raised a company of volunteers to fight against Austria, and commanded the volunteer vanguard in Lombardy, proceeding thence to Rome, where he gained distinction by defending the "Vascello," a position near the Porta San Pancrazio, against the French. During the siege of Rome he was wounded.

In the war of 1859 he commanded a volunteer regiment, and was sent by Camillo Benso di Cavour into Tirol. In 1860 he tried in vain to dissuade Garibaldi from the Marsala expedition; but. after his chief's departure, he sailed for Sicily with the second expedition, taking part in the whole campaign, during which he forced Messina to capitulate after an eight-day siege. Joining the regular army, he was appointed military commandant of Palermo, in which capacity he facilitated the abortive campaign of Garibaldi in 1862. In 1866 he commanded the division which invaded Tirol, but the effect of his victories was neutralized by the conclusion of peace. Returning to Palermo, he did good work in restoring order in Sicily. He became a senator in 1870, and marquis of the "Vascello" and first aide-de-camp to the king in 1876. He died on March 9. 1882.

MEDICINE is the department of knowledge and practice dealing with disease and its treatment. The present article does not attempt to discuss the broad subject of medicine since its beginnings *(see* MEDICINE, HISTORY OF); rather, it places emphasis on developments from approximately the last quarter of the 19th century. No attempt is made to discuss in detail the contributions of pure science to medicine except for certain important applications of such research.

FUNDAMENTAL KNOWLEDGE

Bacteriology and Immunity.— For centuries man had vaguely appreciated that cleanliness is an important factor in the healing of wounds, but he had not accepted this fact as a fundamental law. In fact, the so-called "laudable pus" was considered a desirable condition. Louis Pasteur (1822–95) was the first to put to experimental proof the theory that bacteria are the cause of some diseases in man and animals. Despite violent opposition, the laws which Pasteur laid down are still the basis of the whole concept of the prevention and cure of many communicable diseases. He enunciated the philosophy of vaccination against bacterial and even virus infections. It is true that Edward Jenner (1796) had preached the prevention of smallpox by the inocula-

tion of humans with cowpox. thus producing a mild reaction sufficient to build up an immunity to the more serious epidemic disease (viruses were not conceived of for more than 120 years later). It was Pasteur. however, who successfully added another preventive principle in the case of hydrophobia. He infected rabbits with the "virus" and after death dried their spinal cords over lime. The longer these were dried the more attentuated the "virus" became. By experiment in animals he found that after about 16 days of drying, the "virus" was innocuous but produced some protection. By inoculating a human with such a product and each day using material from a spinal cord dried for a progressively decreasing number of days, protection was obtained.

Pasteur's concept that many diseases were caused by microorganisms, visible and invisible, created a revolution in medical thought. It was received by the conservative with skepticism and even hostility. But time proved the validity of his philosophy.

In 1867 Joseph Lister published an article in which he contended that so-called "hospital fever" following surgical operations was due to contamination from unclean instruments and environment. Influenced by Pasteur, he advocated thorough cleanliness and sterilization of articles with carbolic acid and the surrounding atmosphere with a carbolic spray. In its beginnings, antiseptic surgery was crude and dangerous, and carbolic acid poisoning was not unusual. There gradually developed the concept of "aseptic surgery." Whereas Lister accepted bacteria as being always present, aseptic surgery was based on the thesis that infecting agents should not be present. Therefore, all articles, including the hands of the surgeon and all assistants, should be aseptic before use. This developed to the point that even the air of operating rooms is sterilized by filtration and ultra-violet rays, and dust is removed by air conditioning and treatment of floors, walls and other surfaces of the operating suite.

Prevention of Communicable Diseases.—Proof of the bacterial cause of disease opened a new horizon in the problems of public health. The manner in which bacteria or other infectious agents are communicated to man became a study of first importance. It was soon demonstrated that communication might be by water. milk, food, air, insects or direct contact of man to man; as a natural sequence these agents received careful study from an epidemiological vie point. This research was of particular importance for the air-borne and the insect-transmitted agents; these were the most elusive and could cause epidemics or world-wide pandemics. Diseases transmitted by water, milk or food were more easily controlled, by rigid requirement that the physician report all communicable diseases. The last communicable diseases to come under control were those directly transmitted from man to man, such as syphilis and gonorrhoea. (See also PREVENTIVE MEDICINE.)

Applied Physiology and Biochemistry.—Whereas the bacterial concept of infectious diseases was a revolution and continued to hold a dominant place in medical thought, there gradually developed after 1900 a more intensive study of the normal physiological processes, primarily by the experimental method. Fundamental research was first conducted on lower animals, but soon was transferred to man. Particular attention was devoted to the nervous system, respiration, circulation, gastrointestinal function, renal function, etc., and finally to the group of glands with internal secretion—the endocrine system.

During the development of this fundamental knowledge in physiology it soon became apparent that chemistry played such a prominent role as to justify its being classed as a separate biological science, and so was born biochemistry, or biological chemistry. New techniques made possible the study of chemical processes in man. The range of biochemistry is extremely broad, including inorganic, organic, sterol, physical, colloid chemistry, etc., as well as enzymology. The sister science to chemistry, physics, likewise developed many applications to medicine, and the new science of biophysics resulted.

Although physiology and biochemistry are considered separate divisions of the medical sciences, the same distinctions cannot be made for man himself. Function often influences chemical processes and vice versa, especially in abnormal conditions. Impairment of cardiac function leads to widespread disturbance of tissue metabolism and hepatic, renal, respiratory and nervous functions. On the other hand, impaired storage and utilization of carbohydrates in diabetes mellitus caused by deficiency of insulin leads to biochemical, functional and structural changes.

As long as physiology and biochemistry dealt with normal processes it had a rather restricted influence on medicine. The knowledge gleaned by these sciences, however, formed the foundation for the study of abnormal or perverted processes, called disease, in man. The experimental method was extended to these studies, changing medicine from a static to an intensely dynamic concept. This applied not only to the understanding of disease processes during life but also to their correction and treatment. If they were not completely reversible to normal at least many could be controlled, as, for example, with the use of insulin in diabetes mellitus, liver extract in pernicious anaemia, thyroid extract in myxoedema, thiourocil compounds in hyperthyroidism, and adrenal cortical extract in Addison's disease.

For more than a decade it has been known that the pituitary produced an adrenal corticotrophic substance (ACTH) which apparently stimulates an increased supply of the corticosterones. These substances are not specific for any particular disease but rather influence the physiology and histology of many tissues and the biochemical equilibrium of the body. Their therapeutic effects are, therefore, many and diverse but are still in the experimental stage.

The discovery of vitamins revolutionized nutrition, which once had been concerned mainly with calories.

The influence of these sciences on the study of physical disease in man intrigued those who were most interested in the cause and effect of abnormal processes. So the experimental method was reintroduced into the study of pathological anatomy and histopathology.

Applied Psychology and Psychiatry.—The fixed abhorrence or idolatry of mental abnormalities is written in history. But until relatively modern times the concept of "bedlam" has been a dominating blight on the medical profession. A fresher concept began in the early years of the 20th century. Men of original thought like Sigmund Freud, Pierre Jonet, Alfred Adler, William A. White, Adolph Meyer and many others introduced a more realistic and optimistic scientific approach. The old idea of heredity and predestination was shown to be invalid in many instances; emotional instability was shown to be as epidemic, infectious and familial as tuberculosis. The seeds were sown in infancy and childhood and the full harvest reaped in adult life. Psychoanalysis revealed the emotional trauma upon which future aberrations were built. But this was not the sole concept of modern psychiatry; family relations, the impact of the parent or adult upon the infant or adolescent, also required careful exploration. Experimental psychology laid the basis for much of this progress, until psychiatry became one of the most dynamic of all the experimental medical sciences.

World War II revealed the enormous influence of emotional disturbances upon manpower efficiency in the combat forces of all nations. There seemed, however, to be more hope for victims of emotional conflicts—not only for those suffering from the severer psychoses but also for the large group representing their conflicts as physical complaints. Medicine came to realize that many physical conditions are made more poignant by fears and frustrations, and many psychological disturbances have somatic patterns which may eventually lead to definite physiological, biochemical and even anatomical changes. The psyche and the soma are interrelated and interdependent. (See also PSYCHIATRY.)

Economic and Industrial Medicine.—I11 health as the cause of the greatest waste of manpower and: consequently economic loss received increasing attention after 1900. The physical aspects were chiefly concerned with industrial hazards such as lead and other chemical poisoning, silicosis and asbestosis, dust explosions and machinery hazards. In addition, medicine became concerned with such physiological disturbances in industry as the variation in human efficiency under high and low barometric pressures, high and low temperatures in relation to humidity and wind

velocity and other meteorological conditions. Aviation opened up a special field of medicine wherein these conditions and the strain on the special senses received concentrated attention.

The release of atomic energy in warfare raised new problems in medicine. The effects of the intense heat generated and those of radioactivity must not be confused. The former is no new problem, while the latter depends upon its dispersion and concentration. The toxic results are not so severe as at first supposed, while the impetus to technical and therapeutic uses of radioactive isotopes is infinite.

It has been estimated that psychological disturbances account for more than 50% of industrial maladjustment and absenteeism; in this sphere the psychiatrist, psychologist, industrial physician and labour relations departments of industry began to contribute much to social welfare.

MEDICAL EDUCATION AND RESEARCH

Educational Standards.—In Great Britain and western Europe medical education has been controlled for centuries by the universities and other authorized teaching bodies conducted under rigid governmental charter. In the United States this was not necessarily the case. In 1910 Abraham Flexner published a report on medical education in the United States and Canada which revealed that there were 155 institutions granting medical degrees. Many had inadequate equipment and hospital facilities and granted degrees after the most superficial training for a relatively exorbitant fee. Through the prompt action of the American Medical association, the standards required of medical schools were raised and maintained. All schools were graded on a factual basis. The American College of Surgeons undertook a parallel task of grading hospitals, particularly for standards of undergraduate teaching and for postgraduate training. The quality of general medical education was improved further by raising examination standards of the various state medical boards and by creation of the National Board of Medical Licensure.

A parallel movement occurred in Canada although control of the standards of medical education through the various provincial medical acts had been more specific than in the United States.

In Great Britain, the General Medical council, created by parliament, was vested with control of the standards of medical education. Except in Canada, this body had a dominating influence throughout the Commonwealth of Nations.

University Departments of Medicine.—After 1910 an increasing number of medical schools became affiliated with colleges or universities. By mid-20th century, only a few of the grade A medical institutions in the United States and Canada were not under the control of a university or college.

In Great Britain the situation was somewhat different. Creation of the Royal Colleges of Physicians and Surgeons (London, England, Edinburgh and Ireland) and the Faculty of Physicians and Surgeons of Glasgow had a profound effect upon medical education. Medical faculties of universities were comparatively few except in Scotland, until the latter half of the 19th century. The Royal colleges were affiliated for teaching purposes with the large metropolitan hospital medical schools and acted as their examining bodies, over-all standards being determined eventually by the General Medical council. They exercised a somewhat similar role in postgraduate training, although there again they were principally examining bodies for membership or fellowship to the respective colleges. It would be difficult for a young practitioner to obtain an appointment upon the staff of a large hospital without such an advanced diploma. The universities exercised an increasingly important role in medical education on both undergraduate and graduate levels and the Royal colleges played an important part in maintaining the general uniformity of postgraduate training.

The National Health act and the Goodenough Report on Medical Education in Great Britain have had far-reaching influences. These have been chiefly because of increased subsidies to the medical colleges, improved and enlarged laboratories and clinical facilities, the creation of many more positions for full-time teachers and scholarships and fellowships for undergraduates and postgraduate students. What the effect of the British socialization of medicine will be upon the eventual standards of medical education and practice only the future can reveal.

Research Foundations.—Medical research up to the end of the 19th century in North America and Great Britain was almost wholely individual effort in clinical medicine and pathology. Governments. however. were becoming conscious of the importance of research in parasitology and bacterial epidemic diseases, and supported investigations of cholera, plague, dysentery, malaria, yellow fever, etc., in India, Africa and the Panama Canal Zone. These studies led to fundamental discoveries but were carried out under discouraging bureaucratic restrictions. Industry, particularly shipping, supported similar studies, but research in a wide sense had to await endowment of universities for this purpose and the creation of foundations by private gifts and government support. Typical private foundations were the Beit foundation in Great Britain, the Rockefeller foundation in the United States and the Banting foundation in Canada and their many prototypes. Government-supported institutions included the Medical Research committee of Great Britain and the National Research councils of the United States and Canada. In western European countries publicly sponsored projects were generously supported, particularly through the universities in Germany, France, Denmark, Sweden and Austria.

Postgraduate Study and Training.—There has always been criticism of undergraduate medical education in that it did not completely prepare a student for the practice of his profession. Although in the best medical schools the clinical. or bedside, method of teaching was paramount, responsibility and authority for the care of the patient could not be vested in the undergraduate. Postgraduate training in hospitals was therefore introduced, first in Great Britain and western Europe and later in North America; by mid-20th century, this method of teaching was almost universal in the British Commonwealth, Scandinavia and the Americas. The period of such training was gradually extended, lasting from two to six years after graduation.

Prior to World War I, the mecca for postgraduate study was Europe. particularly Austria and Germany, although Great Britain excelled in certain branches. The reformation in U.S. medical education was gathering momentum, however, and the war gave it a rare opportunity for pre-eminence, particularly in the medical specialties. From 1920 to 1930 there was a steady rise in the level of North American medicine. Austria thereafter lost its eminence, and German medicine under the intellectual shackles of Hitlerism rapidly declined to a place of little importance. Spain under the Republican regime began a renaissance which however was short-lived. Italy showed an improvement in equipment rather than independent thought. The British Commonwealth, the United States and Scandinavia became the recognized leaders in medical education, postgraduate training and research—a leadership which was strengthened during and after World War II.

MEDICAL PRACTICE

Complexity and Specialization.—The advances of medical knowledge and the introduction of physiological, biochemical and bacteriological techniques heightened the complexity of medical practice. In addition to the general laboratory techniques there was a rapid development of technical professional skills. New diagnostic instruments were perfected, such as the ophthalmoscope and the slit lamp in ophthalmology, the laryngoscope and bronchoscope in laryngology, the otoscope, oesophagoscope. gastroscope, proctoscope, sigmoidoscope and cystoscope. Various opaque techniques were adapted to the X-ray, such as the bronchogram, gastrointestinal visualization by barium sulphate, visualization of the gall-bladder. the genito-urinary tract, the vessels of the brain, the meningeal spaces of the spinal cord and brain and the angiocardiogram. The sphygmomanometer (blood-pressure machine), the electrocardiograph, the basal metabolism apparatus (based on fundamental caloric research) and many other physiological, biochemical and bacteriological determinations brought medicine to a factual rather than a speculative diagnosis

and determined the specific method of treatment.

After 1900 these new techniques led to specialization in diagnosis and treatment — gradually in the British Commonwealth and in western Europe and more intensively in North America. "Croup practice'! arose in companies and hospitals and among professional individual specialists who share the high cost of equipment. Some specialists restrict their practice to one field, such as cardiology, haematology, tuberculosis or gastroenterology. Others continue their interest in general or internal medicine and become particularly expert in one of the, divisions.

At least three specialties grew to the point where they could rank with medicine and surgery: (1) obstetrics and gynaecology; (2) pediatrics; and (3) psychiatry. Obstetricians and pediatricians made rapid progress in the knowledge of diseases of the newborn and childhood and brought a spectacular reduction in infant mortality. Psychiatry extended beyond the field of insanity and pushed its frontiers much farther back. (See DIAGNOSIS.)

The Family Physician. — The mainstay of the medical profession, however, m s still the family physician! in spite of the complexity of his practice. Modern transportation widened the area of professional service, but facilities to meet the complexity of medical knowledge did not keep pace with the requirements. The young man entering practice found it difficult to carry on his work without the aids to which he had been accustomed in a teaching hospital. Furthermore, the rapid progress of medicine in all its branches required intellectual contact with his fellows which was not often possible in the isolation of rural or semi-rural areas. For these and other reasons many young physicians chose to settle in the larger towns and cities where hospital and consultant assistance were at hand. Unfortunately little or no attempt had been made in medical education by the middle of the 20th century to train the "family doctor," nor had adequate professional facilities been made available to him.

Cost of Medical Care. — The cost of medical treatment rose continually after 1872, with greater momentum after 1910. The causes were manifold. but most important were the increasing complexity of medical practice, the rise of specialization, the more common use of hospitalization and the demand for more adequate medical service. Increasing concentration of doctors in the cities and larger towns also added to medical costs in rural areas, By the 1950s the financial burden of illness had become so great that there was increasing demand for some form of protection against it. To meet the hazard of illness and the increased cost of medical care numerous plans for health insurance were devised. (See INSURANCE: MISCELLANEOUS.)

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MEDICINE, HISTORY OF. This article covers the history of western medicine from its beginnings. and oriental medicine. For developments in western medicine from approximately the last quarter of the 19th century, see also MEDICINE. Many of the principal articles on medical specialties. for example OBSTETRICS and ORTHOPAEDIC SURGERY, also include historical information (see MEDICAL ARTICLES).

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I. PRESCIENTIFIC MEDICINE

1. Primitive Peoples. — The medicine of primitive people has only the simplest theoretical foundation and since it exhibits no development it cannot strictly be said to have a history. Among savage and barbarous peoples knowledge accumulates with extreme slowness; yet even the lowest savage knows well that he can sustain injury at his own hands or those of others. He therefore thinks that his symptoms are the result of injuries inflicted by beings like himself and that his sufferings are produced by weapons or agents comparable to those that he employs. Thus, he comes to regard sickness as having such origins as: (1) projections of objects into his body by magical or demonic action; (2) poisoning either by accident or, purposely, by some malign creature; (3) affection of a part by substances in contact with it or by events in its neighbourhood (contagious magic); (4) sympathy of an organ for things that resemble it or even bear similar names (sympathetic magic); and (jj powers inherent in certain actions, objects and persons (the "mana" of anthropologists).

These ideas are common to all primitive peoples. The reason for this is differently explained by different schools. The two extremes are represented by Sir James G. Frazer (1854–1941), author of *The* Golden Bough (1890), who regarded the resemblances as the result of similarity of mental processes, and Sir Grafton Elliot Smith (1871–1937), who regarded them as always the result of cultural diffusion. The truth probably lies between the two.

Treatment among primitive peoples is either magical or purely empirical. It includes application of heat and cold, bloodletting, counterirritation, baths, suction, etc. Manipulative procedures, notably massage, are sometimes brought to a remarkable efficiency. Surgery includes the astonishing operation of trephining, successfully and widely practised from at least Neolithic times. The pharmacopoeia includes purgatives and emetics, but consists mostly of herbal substances without physiological action. It also includes substances of a disgusting character. The basis for the use of the latter is doubtless belief in possession — the desire to discomfort the possession spirit so that it vacates the body of its victim.

Much so-called primitive medicine is the medicine of some more ancient civilization corrupted and misunderstood. Thus, the medicine of barbarian and medieval Europe and folk medicine among modern European peoples consist mostly of very debased forms of ancient scientific Greek medicine. But a system of medicine is produced by every culture.

2. Egyptian medicine is the best known of the prescientific systems. It was chiefly magical and included many traditional practices of very great antiquity. The practitioners were, in part at least, temple priests and organized under a sort of physician in chief. They concentrated on hygiene and diet. Emetics. or clysters, were to be taken on 3 days in every 30 — the so-called "Egyptian days," later held to be unlucky. Ointments, potions

and poultices were in use. Among drugs were honey. salt, cedar oil. sycamore bark, sulfate of copper, alum, brains, liver, heart and blood of various animals, stag's horn and oil of camomile.

An interesting development was the tendency to deify actual practitioners. Thus, Imhotep, a historical personage, physician to King Zoser of the 3rd dynasty (*c.* 3000 B.C.), came to be regarded as a god to whom temples were erected to a late date in Egyptian history. Of the medical papyri best known are those associated with the names of Georg Ebers and of Edwin Smith. The contents of the latter suggest some skill in surgery and a very little knowledge of anatomy. There seem to be points of contact between the contents of this papyrus and the earliest Greek scientific medicine. Traces of ancient systems survived in Coptic documents into the Christian centuries.

3. Mesopotamian medicine was early highly developed. The liver was used for divination. It was regarded as the central organ, an idea that has left traces in the Old Testament. Disease was thought to be caused by demons that enter the body and must be expelled — the basis of the pathology of the Sew Testament. Therapy was mainly by exorcism and incantation. The surgical procedures in the Code of Hammurabi imply not only a high medical organization but also an elementary knowledge of anatomy. The names of hundreds of mineral and animal drugs that were in use are known. Among those most frequently encountered are turpentine, cedar, asafetida, mustard, henbane. myrrh, castor oil, mint, poppy. fig and mandrake. The last word is ultimately of Assyrian origin. The mandrake entered the medical magic of Greece from Babylon.

For prescientific medicine in the orient, see *Oriental Medicine* below.

II. ANCIENT MEDICINE

1. Greek Medicine. — The first rational or scientific medical system is Greek. In its pure form Greek scientific medicine was exhibited from about 500 B.C. till the rise of the Roman empire. Its chief development was on the Mediterranean littoral of Asia Minor. Other important centres were Athens and the Greek colonies in Sicily and Italy. This Greek system had various roots.

1. The submerged Minoan civilization. The cult of the serpent constantly associated with Aesculapius and certain ideas of the Greeks on sanitation were probably of Minoan origin.

2. From Mesopotamia the Greeks drew some superstitious beliefs, as well as some rational practices. The Mesopotamian peoples had for ages laid up a great treasury of observation of astronomical data, often applied to astrological ends, and of anatomy derived from the entrails of animals used in divination. On these records, the Greeks erected a scientific method which appears as a prominent feature in their intellectual life. There was also in Mesonotamia a standardization of medical procedure which the Greeks were quick to adopt. From Mesopotamia, too, came the demoniac theories important in later Greek medicine, as is seen in the New Testament.

3. From Egypt came many drugs used by the Greek physicians. The basis of Greek medical ethics can be traced to Egypt. Some practical devices of Greek medicine, such as the forms of certain surgical instruments, were Egyptian. The Egyptians deified a historic physician Imhotep exactly as the Greeks deified the historic Asklepios; *i.e.,* Aesculapius.

4. Persian and Indian sources contributed something to Greek medicine. As to the amount and the character of these contributions, it is not yet possible to speak with definiteness.

2. The Hippocratic Collection. — The Greeks of western Asia Minor, thus drawing material from many sources, developed near the end of the 7th century B.C. a philosophical system out of which the whole of their science was a natural growth. Factors in this development were the medical schools of Cos, where Hippocrates was born. and of the opposite peninsula, Cnidus. These were in active operation by the 6th century B.C. By the mid-5th century they were important elements in Greek life. Much of the *Hippocratic Collection,* which contains the earliest as well as the best Greek medical writings, was put together in the 4th century B.C. (*See* HIPPOCRATES AND *THE* HIPPOCRATIC COLLECTION.)

The Hippocratic Oath. — *No* part of the *Hippocratic Collection* is more impressive than the famous passage known as the "Hippocratic Oath." There is perhaps some suggestion of it in Egyptian papyri of the 2nd millennium B.C. and there is evidence that it was prepared under strong Pythagorean influence. Severtheless, no passage better reflects the spirit of the Hippocratic physicians:

I will look upon him who shall have taught me this Art even as one of my parents. I will share my substance with him, and I will supply his necessities, if he be in need. I mill regard his offspring even as my own brethren, and I will teach them this Art, if they would learn it, without iee or covenant I will impart this Art by precept, by lecture and by every mode of teaching, not only to my own sons but to the sons of him who has taught me, and to disciples bound by covenant and oath, according to the Law of Medicine.

The regimen I adopt shall be for the benefit of my patients according to my ability and judgment, and not for their hurt or for any wrong I will give no deadly drug to any, though it be asked of me, nor will I counsel such, and especially I will not aid a woman to procure abortion. Whatsoever house I enter, there will I go ior the benefit of the sick, refraining from all wrongdoing or corruption, and especially from any act of seduction, of male or female, of bond or free. Whatsoever things I see or hear concerning the liie of men, in my attendance on the sick or even apart therefrom, which ought not to be noised abroad, I will keep silence thereon, counting such things to be as sacred secrets.

Surgery in the Collection. — *The* treatise of the *Hippocratic Collection, On Wounds of the Head* has always drawn attention as bespeaking especial ingenuity and experience. The description of trephining is of peculiar interest, because the practice was known in prehistoric times. The process recommended for cases of fracture of the skull and injury to the underlying structures resembles, in many details, the modem surgical procedure. Another important surgical treatise of the *Collection* is *On Fractures and Dislocations.* A very remarkable work is that *On the Surgery.* It consists of notes for the conduct of operations and is surprisingly modern in tone.

Internal Medicine in the Collection. — *The* Hippocratic physician attends cases of every type. He is no "specialist." But the mass of his practice lay with cases to which instrumental treatment was inapplicable. In these he tended to adopt "expectant" treatment. Realizing that the tendency of the body is to recover, he "waited on nature." This does not imply that he was helpless, for much could be done by nursing, regimen and diet to aid the patient in that conflict which he alone must fight. But believing in "the healing power of nature" — the phrase is characteristically Hippocratic — the physician was not eager to administer drugs.

The *Aphorisms* is the most famous book with which the name of Hippocrates is linked. It is a series of very brief generalizations. Many have been confirmed by the experience of later ages. Some have become popular proverbs. The style suggests an aged physician reflecting on the experience of a lifetime. A few extracts will give a good idea of the book.

Life is short and Art is long; the Crisis is fleeting, Experiment risky, Decision difficult. Not only must the physician be ready to do his duty, but the patient, the attendants, and external circumstances must conduce to the cure.

Old persons bear fasting most easily, next adults, and young people yet less; least of all children, and of these least again those who are particularly lively.

When sleep puts an end to delirium, it is a good sign.

Weariness without cause indicates disease.

To eat heartily after a long illness without putting on flesh is a bad portent.

Food or drink slightly inferior in itself, but more pleasant, should be preferred to that better in itseli, but less pleasant.

The old have fewer illnesses than the young, but if any becomes chronic with them, they generally carry it with them to the grave.

Convulsions supervening on a wound are deadly.

Phthisis comes on mostly from 18 to 35 years of age.

Apoplexy is commonest between the ages of 40 and 60.

If you give the same nutrient to a patient in a fever and to a person in health, the patient's disease is aggravated by what adds strength to the healthy man.

The chief clinical achievement of the *Hippocratic Collection* lies in the descriptions of actual cases. These are not only without parallel during nearly 2,000 years, but are models of what succinct clinical records should be. They are clear and short. give all the leading features and yet show no attempt to prejudge the importance of any particular feature. It is a reflex of the spirit of

honesty in which the Hippocratic physicians worked that in the majority of the cases they record that death ensued.

Immense importance is attached by the Hippocratic writings to the art of "prognosis"; that is, of predicting the course which the disease will take. The work to which the title *Prognostics* is attached represents a very lofty standard of practice. Very famous is the description in it of the signs of impending death to which the name of *Hippocratic facies* has become commonly attached. It is imitated by William Shakespeare in his description of the death of Falstaff in *Henry* V:

You should observe thus in acute diseases: first the countenance of the patient, if it be like those of persons in health, and especially if it be like itself, for this is best of all. But the opposite are the worst; such as these—a sharp nose; hollow eyes; collapsed temples; the ears cold, contracted, and their lobes turned out; the skin about the forehead rough, stretched and parched; the colour of the face greenish, dusky livid or leaden. If the countenance be such at the beginning of the disease, and if this cannot be accounted for by the symptoms, and if the symptoms do not subside in a day and a night, be it known for certain that the end is at hand.

3. Aristotle.—In the 4th century B.C. medicine emerges as a definite part of the scientific consciousness. There then worked one whose thought has stamped itself on the whole subsequent course of medical science. Aristotle (384–322 B.C.) (*q.v.*) was the great codifier of ancient science. Without some knowledge of the biological verdicts ascribed to him it is impossible to understand the course subsequently taken by rational medicine. To one aspect of his science we must especially refer. Aristotle, following more ancient writers, held that there were four primary and opposite fundamental qualities—the hot and the cold, the wet and the dry. These met in binary combination to constitute the four essences of existences which enter in varying proportions into the constitution of all matter. The four essences, or to give them their usual name, "elements," were earth, air, fire and water. Thus, water was wet and cold, fire hot and dry, and so forth. With this theory later writers combined the somewhat similar Hippocratic doctrine, which held that the body was composed of the four "humours," or liquids: blood, phlegm, black bile (melancholy) and yellow bile (choler). Excess or defect of one or other humour gave rise to disease. Hence the so-called "humoral pathology" and the doctrine of the "temperaments," or proportional mixing of the humours which has its analogues in modern medicine.

4. The Alexandrian School.—Soon after the death of Aristotle in 322 B.C., a great medical school was founded at Alexandria. Its two earliest teachers were also the greatest—Herophilus of Chalcedon. who flourished about 300 B.C., and his slightly younger contemporary, Erasistratus of Chios. Herophilus may be regarded as the father of anatomy; Erasistratus, of physiology

Herophilus was the first to dissect the human body in public. He recognized the brain as the central organ of the nervous system and the seat of the intelligence. He extended the knowledge of the parts of the brain, certain of which still bear titles translated from those given by him. He was the first to grasp the nature of the nerves. which he distinguished as motor and sensory, though he did not separate them clearly from tendons. He also made the first clear distinction between arteries and veins.

In the Alexandrian period there flourished that view of the structure of the world known as "atomic" It was associated with the Epicurean philosophy. (See EPICURUS.) Atomism had reactions on medicine at Alexandria, where its leading exponent was Erasistratus of Chios.

Erasistratus professed himself a "rationalist," but had nevertheless to invoke the idea of "Nature" as an external power. shaping the ends to which the body acts in order to explain its workings. This contrasts with Aristotle's view of "soul" as entelechy, an innate and inherent factor. (See ARISTOTLE.) To make physiology intelligible, he added a conception, pneumatism, found also among older thinkers. Pneumatism is the belief that life is associated with a subtle vapour, a pneuma, or spirit, which permeates the organism and causes its movements. This vapour is held to have some affinities with the air we breathe. Pneumatism is, in fact, primarily an attempt to explain the phenomena of respiration; it passes on to attempt the explanation of the nature of life and, indeed, of all existence. It is a theory of great historical importance.

Erasistratus observed that every organ is formed of a threefold system of "vessels": veins, arteries and nerves, dividing indefinitely. These, plaited together, he believed, make up the tissues. Blood and two kinds of pneuma are the essential sources of nourishment and movement. The blood is carried by veins. Air is taken in by the lungs and passes to the heart. where it becomes changed into a peculiar pneuma, the vital spirit, which is sent to the various parts of the body by the arteries. It is carried to the brain, and there further changed to a second kind of pneuma, the animal spirit. This in turn is conveyed to the parts of the body by the nerves. It is the prime cause of movement.

In the brain Erasistratus observed convolutions, noted that they were more elaborate in man than in animals and associated this with higher intelligence. He distinguished between cerebrum and cerebellum, described the cerebral ventricles and regarded them as filled with "animal spirit." He regarded excess of blood (plethora) as the chief cause of diseases such as coughing of blood, epilepsy, pneumonia, tonsillitis, etc. Most of these could be treated by diminishing the supply of blood by limiting diet. Among his contemporaries bloodletting was habitually applied to almost every condition. Erasistratus employed it rarely, and his successors banned it altogether. He was opposed to violent remedies and his favourite therapeutic measures were regulated exercise, diet and the vapour bath.

5. Medicine under the Roman Empire.—The original native Roman medical system was that of a people of low culture. Its aspect was changed by the advent of Greek science. Yet, notwithstanding the large field that the western empire provided, and the wide acceptance of Greek medicine by the upper classes, it is remarkable that the Latin-speaking peoples produced no eminent physician. At first, medical education at Rome was a private matter. The earliest scientific teacher was the Greek Asclepiades of Bithynia (d. *c.* 40 B.C.) a contemporary of Lucretius and like him an Epicurean. Asclepiades ridiculed the Hippocratic expectant attitude as a mere "meditation on death," and urged active measures that the cure might be "seemly, swift and sure."

His school at Rome continued after him. At first it was the mere personal following of the physician, who took pupils and apprentices on his visits. Later such groups combined to form colleges, where problems of the art were debated. Subsidiary educational centres were established in other towns, first in Italy, then in the provinces. These secondary schools produced few whose writings have survived. They were largely training places for the army surgeons. That class seldom had scientific interests, though one of the most prominent physicians of antiquity, Dioscorides, who has influenced the modern pharmacopoeia, served in the army of Nero. (See DIOSCORIDES, PEDANIOS.)

The earliest scientific medical work in Latin is the *De* re *medica* of Celsus, prepared about A.D. 30, and in many ways the most readable and well-arranged ancient medical work. It is, however, not original but a compilation from the Greek. The ethical tone is high and the general line of treatment sensible and humane. An idea of the surgical instruments in use in his time can be obtained from those recovered from Pompeii.

Latin writers on architecture give much attention to the orientation, position and drainage of buildings. Sanitation was from an early date a feature of Roman life. Rome was already provided with *cloacae*, or subterranean sewers, in the age of the Tarquins (6th century B.C.). The Cloaca Maxima itself. still the main drain of Rome, dates back to that period. The finest monuments to the Roman care for the public health are the 14 great aqueducts which supplied the city with 300,000,000 gal. of water daily.

6. Public Medical Service.—Under the early empire a definite public medical service was constituted. Physicians were appointed to the various towns and institutions. The Roman medical system was at its best in connection with the army where there was an adequate supply of military medical attendants who were well organized.

A great contribution of Rome to medicine is the hospital system. Its organization is connected with the military system. It had

become the custom to expose sick and worn-out slaves in a temple to Aesculapius on an island of the Tiber. The emperor Claudius (A.D. 41–54) decreed that if such slaves recovered, they need not return to the control of their masters. Thus, the island became a form of hospital for the sick poor. Later there were established *valetudinaria,* "infirmaries," for such persons. This development early affected military life. At first, sick soldiers on service were sent home for treatment. As the frontiers expanded, military hospitals were founded at strategic points. From this the foundation of similar institutions for the imperial officials and their families in the provincial towns was no great step, The idea passed to Christian times, and the pious foundations of the middle ages are traceable to the Roman *valetudinaria.* These medieval hospitals for the sick must be distinguished from the even more numerous "spitals" for travelers and pilgrims, which may be traced to the resthouses along the strategic roads of the empire.

7. Galen. — Galen of Pergamum (A.D. 130–200) (*q.v.*) provided the final medical synthesis of antiquity and the effective medical standard for 13 centuries. He developed a characteristic physiological scheme which remained in vogue until the 17th century. It supposes three types of so-called spirits associated with three types of the activity of living things. These were the "natural spirits" formed in the liver and distributed by the veins; the "vital spirits" formed in the heart and distributed by the arteries; and the "animal spirits" formed in the brain and distributed by the nerves. The animal spirits were associated with the higher functions of sensation and motion. The scheme presupposed pores in the septum of the heart, through which venous blood, charged with natural spirits, passed from right ventricle into left, where it became charged with vital spirits. Arterial blood charged with vital spirits became converted to animal spirits in the brain in a hypothetical structure called the rete *mirabile.* Thence it was distributed by the nerves. Galen's system was an admirable working hypothesis, based on much experimental evidence.

Galen had no effective successor. Medieval medicine may be summed up as a corrupted version of Galenism A somewhat less corrupt tradition was revived for the west by translations of Arabic works. From the point of view of cultural contacts, the history of medieval medicine is of great interest but of little value for the history of scientific medicine. Practical anatomy was revived in the later 13th century and had an able exponent in the early 14th in Mondino da Luzzi (d. 1328). The true scientific tradition does not reappear till the 16th century.

III. MODERN MEDICINE

1. The Dawn of Modern Medicine. — The factors that produced the progressive medicine of the 16th century were excessively complex. Among them were certainly the invention of printing, the enlargement of the world by exploration, the revived knowledge of Greek, the questioning that arose through religious differences. All affected medicine along with other studies of the day. There are. however, two factors which affected medicine in a manner different from all other subjects. One of these mas the devastation caused by the epidemics of the time. The second was the advent of a school of art which studied the human body in detail and. therefore, demanded a knowledge of human anatomy. The main exponent of this method on the scientific as well as on the artistic side was Leonardo da Vinci (1452–1518) (*q.v.*). The modern father of anatomy, Andreas Vesalius (1514–64), was no unworthy successor of Leonardo.

The great anatomical work of Vesalius appeared in 1543. Vesalius initiated a period of exuberant scientific activity at Padua, which long remained the centre of scientific medicine in Europe. From him descends a dynasty of important teachers who carried on his tradition there. Even more important was the influence of his great book. This immediately transformed the practice of surgery. Of that art the leading exponent of the new school was the French surgeon Ambroise Paré (1517–90).

Internal medicine lagged behind surgery. The anatomical reforms of Vesalius had no counterpart in advance in physiological knowledge, without which there can be no science of internal medicine. The practice of the physicians remained largely medieval, and the ruling idea was still humoral.

2. Early Lines of Advance in Clinical Studies. — There are, however, a number of respects in which the physician's art improved during the 16th and first half of the 17th centuries.

There was some improvement in the ancient medical texts. More reliable translations, notably of the Hippocratic and Galenic works, became available. These were at least better than the old translations from the Arabic that had been the main source of the knowledge of these writers in the middle ages.

Exploration of new lands brought new drugs. These were often a mixed blessing, for some were useless, others dangerous. Nevertheless, several important drugs nere introduced, especially from America. Among them were ipecacuanha, quinine and, by no means least, tobacco. The last was for long used as a narcotic. Moreover, there was a corresponding advance in botany. The beautiful herbals of the time exercised, by the accuracy of their execution, an exemplary influence on the development of medical science.

There was advance in the knowledge of infectious disease. A rational theory of infection was set forth in 1546 by Girolamo Fracastoro (1483–1553) (*q.v.*) of Verona. He regarded infection as the passage from the infector to the infected of minute bodies, having the power of multiplication. The conception bears a superficial resemblance to the germ doctrine. A contribution to the conception of epidemics was made by the French physician Guillaume de Baillou (1538–1616), who reintroduced the Hippocratic idea of "epidemic constitution"; *i.e.,* that particular seasons and particular years are of their nature subject to particular diseases. The idea was developed by the English physician Thomas Sydenham (1624–89) (*q.v.*) and still has value.

Fracastoro, De Baillou and Sydenham all made additions to the knowledge of particular infectious conditions: Fracastoro to syphilis and typhus; De Baillou to whooping cough and rheumatism; Sydenham to gout and to measles and many other diseases. Thus arose an exact body of teaching concerning these conditions which was the necessary prelude to effective preventive measures.

The natural history of disease was a subject which Sydenham pursued with the greatest vigour and with life-long devotion. None before him had set himself to consider all the actual cases of disease that lay before him as a subject of scientific description and analysis. He set well on its way the conception of infectious conditions as specific entities, which has since been illuminated by the germ theory of disease.

During the middle ages there had smouldered in various districts an obscure disease known most frequently as lepra. Toward the end of the 15th century this disease broke out in epidemic form all over Europe, causing great destruction of life. It received various titles, such as "the pox," "the French disease," "the Spanish disorder." Only tardily was it recognized that it mas of venereal origin. In 1530, on the suggestion of Fracastoro, it received the cognomen syphilis. From the time of its recognition, syphilis has been pursued by a portentous mass of confused literature. Alarm. misunderstanding, religious feeling, false modesty, wilful misrepresentation and the change in type of the disease itself have all contributed their quota of obscurantism and fable to a naturally difficult subject. Fracastoro did something to bring order out of the confusion. Most writers on the history of medicine have treated syphilis as of native American origin.

3. The Rise of Physiology. — The later 16th and the earlier 17th centuries are marked by great activity in physical science. Physical phenomena were reduced to mathematical rules, based on measurement. This had a reaction on medicine. The first to apply these principles to medicine was Sanctorius (1561–1636), a professor at Padua. He described a thermometer — an extremely defective one — for comparing temperatures of different persons and an apparatus for comparing pulse rates. He also sought to estimate the body weight at different times and in different circumstances. In doing this he demonstrated that the body loses weight by mere exposure, which he ascribed to "insensible perspiration." He thus laid the foundations of the study of metabolism.

Jerome Fabricius (1537–1619) of Aquapendente, who taught

at Padua, was the founder of modem embryology and author of the first illustrated work on that subject. He investigated the valves of the veins and observed that their mouths are always directed toward the heart. He was a very great teacher and among his pupils was the discoverer of the circulation of the blood, William Harvey (1578–1657) (*q.v.*).

4. Harvey. — Knowledge of the circulation of the blood has been the basis of the whole of modern rational medicine. The blood, it mas seen, is a carrier always going round and round on the same beat. What it carries and why. how and where it takes up its loads and how, where and why it parts with them are questions the answering of which has been the main task of physiology in the centuries that have followed. As each question has obtained a more rational answer, so medicine has made a step toward becoming a true science. Thus, the work of Harvey lies at the back of every important medical advance.

In the second half of the 17th century there were two important scientific movements destined between them to develop yet further the conception of the workings of the body of which Harvey had made a beginning. These were the movement for the microscopical examination, or analysis, of the tissues (see BIOLOGY: History) and the movement from alchemy to chemistry. (See CHEMISTRY: History of Chemistry.)

5. Microscopy in the 17th Century. — The revelations of the early microscopists showed at once an unexpected complexity of all the parts and an unexpected resemblance of apparently diverse parts. Thus, the structure of the body came to be subjected to a process that we may call "microscopic analysis." After the 17th century the progress of microscopic analysis lay dormant. With the advance in the construction of the microscope in the 19th century, the method was taken up again with triumphant results. During the 16th and the first half of the 17th centuries anatomy and physiology had put on their modern dress.

6. Chemical **knowledge** remained peculiarly backward. Advances had been made in technical processes, but theoretical chemistry was in the hands of the class of dupes who, since the middle ages, had been seeking the philosophers' stone. The old theory of the four elements, earth, air, fire and water, formed an ill basis for experiment. The great defect of this ancient view of matter was that it contained no definite conception of the nature of a pure substance. The main agent in changing the alchemical to the chemical outlook was Robert Boyle (1627–91) (*q.v.*). Under him chemical study was freed from the mystic factor and, moreover, loosed from the chains which bound it to medicine, to the disadvantage of both.

7. Descartes and Other Theorists. — The great advances in the physical and biological sciences instituted during the 16th and 17th centuries left the old medical theories derelict. Numerous fresh theories arose. The more important can be classed under the headings iatrophysics, iatrochemistry and vitalism (see Borelli, Sylvius and *Stahl,* below).

The physical discoveries of the time and the demonstrations of Sanctorius, Harvey and others gave an impetus to the attempt to explain the animal body on mechanical grounds. One of the earliest exponents of physiological theory along these lines was the French philosopher René Descartes (1596–1650) (*q.v.*). His posthumous book De homine (1662) is the first modern textbook of physiology. Descartes had no extensive practical knowledge of the subject. On theoretical grounds he sets forth a very complicated model of animal structure. Subsequent investigation failed to confirm most of his views on physiology. For a time, however, they attracted many followers. A strong point in his theory is the stress on the nervous system and its power of co-ordinating bodily activities.

8. **Borelli,** Sylvius and **Stahl.**—More lasting was the achievement of the eminent Italian mathematician Giovanni Alphonso Borelli (1608–79). Stirred, like Descartes, by the success of the physicists in giving mathematical expression to mechanical events, Borelli attempted to do the same for the animal body. That department of physiology which treats of muscular movement on mechanical principles was effectively founded by him.

Just as some explained animal activity on a mechanical basis, so others resorted to chemical interpretation. Of these iatrochemists, the most prominent was Franciscus Sylvius (1614–72), noted professor of medicine at Leyden. The first university laboratory was built there at the instigation of Sylvius.

Sylvius devoted much attention to the study of salts and attained to the idea of chemical affinity. Well abreast of the anatomical knowledge of his day, and accepting the broader lines of mechanistic advance in biology, such as the circulation of the blood and muscular mechanics, Sylvius sought to interpret other activities in chemical terms. His abilities as a teacher gave his views wide currency and his pupils occupy a large part of the field of medical theory until well into the 18th century. By this school almost all forms of vital activity were expressed in terms of "acid and alkali" and of "fermentation." The latter process was assumed to be chemical. The school of Sylvius added considerably to the knowledge of physiological processes, notably by examining the digestive fluids, such as saliva, gastric juice and the secretion of the pancreas.

A third school of medical theorists arose under the German chemist and physician Georg Ernst Stahl (1660–1734) (*q.v.*). His was that view of the nature of the organism which goes under the term vitalism. Though expressed by him in obscure and mystical language, it is, in effect, a return to the Aristotelian position and a denial of the view of Descartes. To Descartes the animal body was a machine. To Stahl the word machine expressed exactly what the animal body was not. The phenomena characteristic of the living body are, he considered, not governed by physical and chemical laws, but by laws of a wholly different kind, those of the "sensitive soul." The sensitive soul of Stahl is, in its ultimate analysis, similar to the entelechy of Aristotle. Stahl held that the immediate instruments, the natural slaves of this sensitive soul, were chemical processes.

The language and the theories of the iatrophysicists, the iatrochemists and the vitalists of the 17th and 18th centuries have long been discarded; yet they represent three attitudes to the activities of living things which have current meaning. Each seems to present some aspect of truth. The philosophical foundations of modern rational medicine were laid by Borelli, Sylvius and Stahl.

9. **Boerhaave.**—The 18th century dawned with the refreshing breeze of Newtonian philosophy blowing through it. During the previous 200 years there had been much fruitful research along diverse lines. The new generation was bewildered with the mass and novelty of the material. Thus there is a period of pause and consolidation for the introduction of unitary conceptions into the mass of accumulated material. It was a consolidation not only of ideas but also of teaching. This task turned men's minds away from the accumulation of further knowledge. The first half of the 18th century exhibits something of a gap in the progress of research. The medical field is largely filled by two great figures, Boerhaave and Haller.

Hermann Boerhaave (1668–1738) (*q.v.*) was the first great clinical, or "bedside," teacher. Until the 17th century there was no systematic clinical teaching. The universities gave medical degrees on the basis of a spoken "disputation." No contact with the patient was usually demanded. The first effective attempt to change this was at Leyden, where clinical teaching was instituted about 1636. Boerhaave was first appointed as a teacher there in 1701. The medical school attained a reputation which rapidly surpassed even that of Padua. To Boerhaave more than to any other we owe the modern method of medical instruction, especially in English-speaking schools. Through his pupils he was the founder of the Edinburgh school and through it of the best medical teaching in English-speaking countries.

10. Albrecht von **Haller.**—The only figure in the 18th century whose influence is comparable to that of Boerhaave is his pupil, the Swiss Albrecht von Haller (1708–77) (*q.v.*). His great *Elements of the* Physiology of the *Human* Body (1757–66) marks the modernization of the subject. He did work on the mechanics of respiration, on the formation of bone, on the development of the embryo and on the action of the digestive juices. His most permanent contributions. however, are not so much contributions to knowledge as contributions to thought. Notable among

these are his conceptions of the nature of living substance and of the action of the nervous system, still integral parts of physiological doctrine.

During the 17th century the favourite doctrine of nervous action supposed the existence of a nervous fluid. This, it was held, passed down the nerves to inflate or extend the muscle fibres. Inflation was supposed to shorten the fibres and so the muscle came to "contract." An exquisite experiment made by Jan Swammerdam, about 1665 with a nerve-muscle preparation, had, in fact, disproved this, but the experiment remained unpublished till 1736. So the matter stood till Haller's time.

Haller concentrated on an investigation of the muscle fibres. A muscle fibre, he pointed out, had in itself a tendency to shorten with any stimulus, and afterward to expand again to its normal length. This capacity for contraction Haller, following a predecessor, called "irritability." He recognized the existence of irritability as an element in the movement of the viscera, and notably of the heart and of the intestines. The feature of irritability is that a very slight stimulus produces a movement altogether out of proportion to itself, and continues to do this repeatedly as long as the fibre remains alive.

But besides the force inherent in a muscle fibre, Haller showed that there was another force which comes to it from without, is carried from the central nervous system by the nerves and is the agent by which muscles are normally called into action. This force, like that of irritability, is, or at least can be, independent of will and can be called into action after the death of the animal. Haller thus distinguished the inherent muscular force from the extrinsic nerve force.

Haller next turned to consider sensation. He showed that the tissues are not, in themselves, capable of sensation but that the nerves are the sole channels or instruments of this process. He showed how all the nerves are gathered together into the brain, and believed that they tended to its central part. Throughout his discussion Haller never falters in his display of the rational spirit. He develops no mystical themes and. though his view of the nature of soul may lack clarity, he separates such conceptions sharply from those which he deduces from experience.

One of the ablest physiologists of the 18th century was an English country parson, the Rev. Stephen Hales (1677–1761) (*q.v.*), who investigated the dynamics of the circulation. He applied the principle of the pressure gauge, or manometer, to living things. By tying tubes into the arteries and veins of animals, he measured blood pressure and founded an important mode of studying disease. He computed the circulation rate and estimated the actual velocity of the blood in veins, arteries and capillary vessels. He made a very important contribution by showing that the capillary vessels are liable to constriction and dilatation, a knowledge that has become of primary importance to the practising physician. He began to explore that wonderful mechanism of the heart by which the organ adjusts itself to its needs of output. He exhibited his versatility by contributions to many other departments as, for example, discoveries on respiration, improvements in ventilation and a campaign for temperance.

11. Réaumur, Spallanzani and **Prout.**—Following up the work of Sylvius and his school, later researchers made some progress in the knowledge of the digestive processes. The French naturalist René Antoine de Réaumur (1683–1757), remembered for his thermometer (1731), made experiments on gastric digestion in birds (1752). He obtained gastric juice in a pure state and demonstrated its power to dissolve food substance in a test tube at body temperature. He thus destroyed the iatrophysical conception of digestion for it had been believed that the process was induced mechanically by muscles of the stomach wall.

The versatile Italian the abbé Lazaro Spallanzani (1729–99) showed that the churning action is an aid, but not an essential, to digestion (1782). He proved that digestion was not of the nature of putrefaction and differed essentially from the fermentation of wine. Spallanzani thus improved on the view of Sylvius and took a step toward that solution of the natures of putrefaction, fermentation and digestion which was clarified by Pasteur. He showed that the gastric juice was secreted by the stomach itself and not introduced into it from other organs. He observed that it curdled milk and so began our knowledge of the ferment, contained in rennet.

This phase of digestive physiology was closed by the English physician William Prout (1785–1850), who demonstrated in 1823 the existence of free hydrochloric acid in the stomach. He showed that the presence of this acid was necessary for gastric digestion, but that the actual process of solution of food was the work of another agent. The matter was at last brought into the range of medical practice by a U.S. army surgeon, William Beaumont (1785–1853), who, in the ten years ending 1833, had the opportunity to investigate gastric juice in a man who, having been shot in the stomach, had a permanent gastric fistula, through which the gastric juice could be obtained and the living gastric membrane examined at will.

12. Galvani, Black and **Priestley.**—A new department of physiology was opened by the extension of the knowledge of electric phenomena to the living body. Luigi Galvani (1737–98) of Bologna, while investigating the susceptibility of nerves to irritation, showed that nervous action could be induced by metallic contacts (1791). He was, in fact, producing an electrical current. Many thought that a new kind of electricity of specially animal origin had been produced and they called it "galvanism." Alessandro Volta (1745–1827) of Pavia, deviser of the Voltaic pile, was able to demonstrate (1800) that galvanism has no essential animal relationship and that a muscle can be thrown into continuous contraction by repeating electric stimulations. Humbug and misunderstanding in connection with the electrical relations of living tissues were rife, and electricity did not take a place in rational medicine till the time of E. du Bois Reymond (1818–96), from 1843.

During the second half of the 18th century, important advances were made in the knowledge of respiration on the basis of the work of the Scottish chemist Joseph Black (1728–99), the English Unitarian divine Joseph Priestley (1733–1804) (*q.v.*) and the French chemist Antoine Lavoisier (1743–94) (*q.v.*). Black showed that when chalk was heated, it lost a definite weight of "fixed air" (CO_2) and that under suitable conditions it regained it in an indefinitely continued reversible manner. He also showed that "fixed air" is a normal constituent of the atmosphere. Priestley showed that growing green plants would make respired air again respirable, and that they gave off a respirable gas. In 1774 he actually prepared oxygen by heating certain oxides, but was still hampered by the phlogiston theory. The real passage to the modern point of view was made by Lavoisier. By quantitative investigation of the changes during breathing, burning and calcination, he discovered the true composition of respired air and showed how both carbon dioxide and water are normal products of breathing. The modern physiological study of respiration dates from Lavoisier.

13. Morbid Anatomy and Clinical Medicine.—During the earlier 18th century there were published several accounts of groups of cases of post-mortem appearances connected with particular diseases. No general pathological principles were elicited. Theories of disease were still mainly speculative. This gap was bridged by Giovanni Battista Morgagni (1682–1771). He was professor of anatomy at Padua for 56 years and during this time performed an enormous number of post-mortem examinations. In his 79th year there emerged from his vast experience his work On *the Seats and Causes* of *Disease.* The life history of the patient, the history of his disease, the events in connection with his illness and death, are all recounted. The condition of the organs at post-mortem examination is minutely described and an attempt made to explain the symptoms as the result of the lesions. Morgagni introduced into the study of disease the "anatomical concept." the main element in modern diagnosis.

The work of Morgagni was worthily continued by the Scot Matthew Baillie (1761–1823), a successful London practitioner, who followed a convenient method in arranging his work by organs instead of symptoms. The task of naked eye pathological anatomy, effectively begun by Morgagni, was effectively completed by Karl Rokitansky of Vienna (1804–78).

The great teachers of the earlier 18th century, though they had more knowledge than their predecessors, had no better apparatus for diagnosis. The first efficient clinical instrument of precision was the "pulse watch." Sir John Floyer (1649–1734), an English provincial physician, introduced in 1707 an instrument constructed to go for just one minute. Attempts were also made to introduce a thermometer into practice, but the construction of suitable instruments proved impossible. Both these ideas gained final admission to practice in the 19th century. Two clinical advances of first-class importance. percussion and auscultation, were, however, introduced during the later 18th and early 19th centuries.

Percussion is of great value to the physician as a means of outlining the position of internal organs, especially those of the chest. It was introduced (1761) by Leopold Auenbrugger (1722–1809), a Viennese physician. Like the thermometer, it was slow in entering practice. Even more important than the introduction of percussion was the invention and adaptation of the stethoscope by the Breton physician R. T. H. Laënnec (1781–1826) (*q.v.*). He first described it in 1819. It was unitubular in type, and at first a mere roll of paper.

14. Surgery and Obstetrics. — During the 18th century few new principles were introduced into surgery. Nevertheless, the improvements in normal and pathological anatomy had their effects in surgical technique. Thus, operations could be performed that had seldom before been attempted. Even the greatest surgeon of the century, John Hunter (1728–93) (*q.v.*), introduced no fundamental new surgical principles. The main clinical improvements of the century, apart from operative technique, were probably those connected with the treatment of women in labour. Scientific obstetric works were produced, especially in France, in the second half of the 17th century. The obstetric forceps, for long a family secret. became widely known in the 18th century. For a long time there was great objection by pregnant women to treatment by medical men. The midwives were mostly ignorant, dirty and unskillful, and the resulting loss of life enormous. The objection to the "man midwife" was only gradually overcome, but his advent was attended by a great fall in maternal mortality. One of the ablest and most successful of the obstetric physicians was William Hunter (1718–83) (*q.v.*), the brother of John Hunter. Numerous lying-in hospitals were founded in England and elsewhere in his time.

15. John Hunter. — A new spirit was introduced into surgery by John Hunter. As an investigator his powers were superb, but he was handicapped by literary incoherence. Nevertheless. with him surgery begins at last to be a real science, and not as a mere applied art. Hunter brought to bear on it a mind stored with ideas drawn from comparative anatomy and pathology.

Technical advances are connected with Hunter's name, but his real scientific importance is as a pioneer in the making and ordering of museums. His monument is the Hunterian museum in London, based on his specimens of which a few somehow survived enemy bombing of World War II. Natural history museums, as now constituted in all civilized countries, have been influenced, if they have not been derived, from that which he literally gave his life to found.

16. Beginning of Vital Statistics. — The mathematical manner of the presenting of collective medical data was first appreciated by the versatile English physician and inventor Sir William Petty (1623–87) (*q.v.*), the "father of political economy." In 1662 and on many subsequent occasions he joined a friend, John Graunt, in issuing *Natural and Political Observations upon the Bills of Mortality* of London. He endeavoured to deduce population! death rates, disease prevalence and other matters of vital statistics from the crude figures of the day.

In 1741 a Prussian clergyman, J. P. Siissmilch (1707–67), produced a theological work, *The Divine Ordinance Manifested in the Human Race through Birth, Death and Propagation.* Its object was to exhibit God's design in the constant numerical relationships of vital statistics. The work is of great historic and scientific importance. It was based upon a vast mass of statistics and showed significant advance in method. From the time of its publication, statistical studies advanced rapidly.

Statistical science was placed on a firm foundation by the Belgian astronomer Lambert Quetelet (1796–1874). His principal work, *On Man and on the Development of His Faculties, an Essay on Social Physics,* contains his statistical researches on the development of the physical and intellectual qualities of man arid on the "average man." both physically and intellectually considered. In his treatise of 1848 *On the Social System and the Laws Which Govern It,* he shows how the numbers representing the individual qualities of man may be grouped round the numbers referring to the average man in a way corresponding to the principles of the theory of probabilities.

17. Military, Naval and Prison Medicine. — During the 18th century the only sick of whom statistics were available were soldiers, sailors and prisoners. Thus, the most important movements in preventive medicine, both in England and elsewhere, were initiated by naval and military surgeons.

The experience and position as chief medical officer of the British army of Sir John Pringle (1707–82) enabled him to get many of his reforms generally accepted. He was among the first to see the importance of ordinary putrefactive processes in the production of disease, and quite the first to apply these principles in hospitals and camps. He identified the deadly "'jail fever," or typhus, with "hospital fever," and laid down rules for the hygiene of camps.

The Scottish physician James Lind (1716–94) had a long naval experience. In an important work on scurvy (1754), then a very common and fatal disease at sea, he demonstrated how it might be prevented by fresh fruit or lemon juice. Fresh water had always been difficult to obtain on sea voyages. Lind arranged for sea water to be distilled for the purpose. He introduced rules for the prevention of typhus on ships: and made great improvements in naval hygiene. His essay of 1757, *On the Most Effectual Means of Preserving the Health of Seamen,* is very important. He also wrote an *Essay on Diseases of Europeans in Hot Climates,* which opened the campaign for the conquest of the tropics for the white man. Capt. James Cook (1728–79), the explorer, adopted Lind's principles and established a health record in a voyage to the South Seas.

18. Public Health Improvements. — The advent of the new system of labour in the 18th century had important reactions on public health. The industrial system began in England, but it has now spread to all civilized countries. With the growth of towns and increased population there was an increased demand for food. The country became better cultivated and better drained, and there were many improvements in agriculture. Certain diseases began to diminish, notably malaria, essentially a disease of undrained and ill-cultivated lands.

The improvement of hygienic conditions in the towns began in England soon after the middle of the 18th century. Westminster obtained an improvement act in 1762; Birmingham. in 1765; the City of London, in 1766; Manchester, in 1776; and most of the other provincial towns soon followed. As a result of such acts noisome streams, which were but open sewers, were covered in; streets were paved and lighted; and sewers improved. There were still many glaring defects of sanitation, including much which would horrify us now.

The improvement of such conditions as these could be made only by state action. This was clearly perceived by the social philosopher Jeremy Bentham (1748–1832) (*q.v.*). The efficient agents in convincing the public that factors which influence the health of the country must be the concern of the legislature were two disciples of Bentham, the 19th-century reformers Thomas Southwood Smith (1788–1861) and Edwin Chadwick (1800–90) (*q.v.*).

19. Rise of Hospitals. — An important hospital and dispensary movement arose about the middle of the 18th century. Many great hospitals, both in England and in continental countries, were then either founded or rebuilt. Between 1700 and 1825 no fewer than 154 hospitals and dispensaries were founded in the British Isles. Though defective from the modern point of view, yet under the influence of the sanitarians, such as Hales. Pringle and Lind, these were far better equipped and ventilated than those

constructed at the beginning of the 18th century. John Howard (1726–90) gives a very complete picture of them, and one more favourable than might be expected. The main defect was nursing. This was better in lying-in hospitals, where the services of a higher type of woman were available and ladies served on the management. The general state of the hospitals remained almost stationary from the mid-18th century until the changes in surgery and nursing in the second half of the 19th century.

20. Variolation and Vaccination. — During the 18th century smallpox was never absent from Britain, and from time to time the disease became epidemic. The outbreaks, often grave and fatal, varied greatly in virulence. Infection with a mild form would lead to protection from a graver. In the east direct inoculation of the disease from a patient suifering from a slight attack — variolation — was in vogue from an early date. The practice attracted little attention in Europe until Lady Mary M'ortley Montagu (1689–1762) studied it at Constantinople. It was then soon taken up in England, and on the continent.

The efforts of Lady Mary were reflected on the other side of the Atlantic. The Puritan leaders Increase Mather (1639–1723) and Cotton Mather (1663–1728) (*qq.v.*) ardently urged the operation. In England the learned Richard Mead (1673–1754) (*q.v.*), who greatly influenced the medical world in his day, strongly supported the practice. It spread widely and rapidly. The operation was largely in the hands of specialists who were not always medical men.

Such was the state of affairs when the country practitioner Edward Jenner (1749–1823) (*q.v.*) came upon the scene. In 1796 he de onstrated that the condition known as cowpox, or vaccinia, gave immunity to smallpox. From that time vaccination with cowpox has taken the place of variolation.

Even vaccination is a mere trifle compared to the train of new work and new thought that was ultimately opened by the study of immunity to disease of which that established by vaccination is a specia! instance. The work of Louis Pasteur, Lord Lister, Robert Koch, Emil von Behring, Paul Ehrlich and others and the main part of the modern therapeutical movement are based on the study of the type of phenomena to which Jenner drew attention.

21. Anatomy in the 19th and 20th Centuries. — By the beginning of the 19th century the knowledge of the naked-eye structure of the human body had been prosecuted almost as far as possible. Subsequent progress, in so far as it has taken the direction of morphology, the pure study of form, has been in the departments. first, of comparative anatomy, in which the leading figure was Georges Cuvier (1769–1832) (*q.v.*) in France, followed by Richard Owen (1804–92) (*q.v.*) and Thomas Henry Huxley (1825–95) (*q.v.*) in England, by Carl Gegenbaur (1826–1903) (*q.v.*) in Germany and by E. D. Cope (1840–97) in the U.S.; second, of development or embryology, a movement which was led by Karl Ernst von Baer (1792–1876) (*q.v.*) and Wilhelm His (1831–1904) in Germany, Francis Maitland Balfour (1851–82) (*q.v.*) in England and C. S. Minot (1852–1914) in the U.S. (See ANATOMY, COMPARATIVE; EMBRYOLOGY; MORPHOLOGY.)

In the 20th century new methods, notably those of frozen macroscopic sections and metallic injections, have made some advances possible; but the position of naked-eye anatomy cannot substantially change. On the other hand, the application of microscopic and experimental methods to embryology have largely altered our conception of the minute structure of the body.

22. Physiology in the 19th Century. — Far more important in its effect on medicine than this morphological movement has been the great impulse given to physiological progress by a series of very great teachers. hlost of the more prominent of these in the 19th century were Germans. France took a secondary place with the isolated but superb genius of Claude Bernard. The English-speaking world did not come to occupy an important position in the subject until the last quarter of the century, though at an earlier period it had produced Sir Charles Bell (1774–1842) and Marshall Hall (1790–1857) (Q.v.).

The foundations of 19th-century German physiology were laid by Johannes Miiller (1801–58) (*q.v.*), Justus von Liebig (1803–73) (*q.v.*) and Karl Ludwig (1816–95) (*q.v.*), typifying the application of the comparative, the chemical and the physical methods to physiological investigation. They were all great teachers, and physiology as a discipline has been largely their work through their numerous pupils. Claude Bernard (1813–78) (*q.v.*), perhaps more brilliant than any of them, has exerted his influence rather through his writings than personally.

Müller's textbook (from 1833) marks the starting point of physiology as a normal introduction to medicine. Not only did it sum up all the relevant knowledge of the day, but it brought before the reader many new points of view. Foremost of these was the "law of specific nerve energies," according to which each sense nerve, however stimulated, gives rise to the particular sensation associated with it and to no other. Conversely, the same stimulus, applied to different sense organs, produces a sensation which accords with the organ stimulated. Thus sensation is a specific attribute. This implies that the things of the external world are not, in themselves, discernible by us, but are known only by the way they act on the senses, acting in different ways on different senses. This conclusion is not only of physiological importance but is fundamental for our view of the validity of scientific method itself.

Von Liebig long remained the leader of the chemical view of life. He did more than any other to introduce laboratory teaching into medicine. Of the many scientific advances that he initiated, we note: (1) his method for detecting and measuring urea, a substance regularly formed in the course of the bodily processes; (2) his introduction, along with his colleague, Friedrich Wohler (1800–82), of the conception of the "radicle" as a chemical group capable of forming an unchanging constituent through a series of compounds; (3) his doctrine that animal heat is the result of combustion and is not "innate"!; and (4) his teaching that plants derive their carbon and nitrogen from the carbon dioxide and ammonia in the air or soil and that these compounds are returned by them to air or soil in the process of putrefaction, thus producing a sort of circulation in nature.

Claude Bernard did more than any other to create the view of the body as a machine in which all the parts are interdependent. In his researches on the action of the liver, he showed that the body could build up very complex chemical substances as well as break them down. He did pioneer work in elucidating the digestive functions, and in explaining the regulation of the blood supply.

Karl Ludwig had more pupils than any other of the great physiologists. He was very ingenious as a deviser of physical apparatus and was well equipped in physics and chemistry. He was responsible for introducing graphic methods into physiology. In doing this he was particularly fortunate in adapting the device of the kymograph, which had been originally introduced by Thomas Young in 1807. He was a mechanist and is important in this connection because of his success in showing that glandular activity can be brought under the law of conservation of energy.

23. Investigation of the Nervous System. — Important fundamental work in physiology was done by Charles Bell (1774–1842) (*q.v.*) and Marshall Hall (1790–1857) (*q.v.*). Bell demonstrated the specific sensory (afferent) character of the dorsal spinal roots and the motor (efferent) character of the ventral spinal roots: which form the basis of the physiology of the nervous system. Marshall Hall established (1833) the difference between volitional action and unconscious reflex and, indeed, effectively introduced the conception of a reflex to the scientific world. Since Hall's time there has been a great extension of the conception. The nervous system (*q.v.*) is integrated under higher and higher centres, till at last the highest centres of the brain are reached. A knowledge of this mechanism is essential for the theory and practice of medicine.

In connection with this process comes the question of the localization of functions of the brain. This idea was developed in the first third of the 19th century by the Viennese Franz Joseph Gall (1758–1828) and Johann Kaspar Spurzheim (1776–1832), who ultimately became phrenological quacks. Later many observers — Paul Broca (1824–80) (*q.v.*), John Hughlings Jackson (1834–1911) (*q.v.*) and David Ferrier (1843–1928) among them

—studied the parts of the cortex especially connected with movement. Many operations previously regarded as involving complex mental processes, as speech. reading, writing, drawing, etc., were represented as depending on simple nervous relationships. Centres for the initiation of these operations were described. In later years there was a reaction from this mechanical conception of the brain as an organ of the mind, under the leadership of Henry Head (1861–1940). The older school nevertheless achieved striking clinical successes, especially at the hands of Jean Martin Charcot (1825–93) (*q.v.*) and his school. (See BRAIN.)

24. Histology and Cellular Pathology.—The doctrine of the essential cellular nature of living things had been established by 1840. (See BIOLOGY: History.) Soon the conception of protoplasm as the "physical basis of life." and the general structure of the cell, including the nucleus as an essential structure. came into clear view. The study of tissues—histology—was raised to the status of an independent science by the Swiss Albrecht von Kölliker (1817–1905) (*q.v.*), a pupil of Johannes Miiller. Kolliker wrote the first textbook of histology in 1850.

A very important influence on medical thought was that of Rudolf Virchow (1821–1902) (*q.v.*). His achievement was the extension of the cell concept to diseased tissues. His Cellular Pathology (1858) analyzed such tissues from the point of view of cell formation and cell structure. Important sections of this science were explored so well by him that they have been little extended by his successors. He initiated the idea that the body may be regarded as a "cell state in which every cell is a citizen." Disease is often but civil war. The white blood corpuscles, which have the power of engulfing and rendering innocuous bacteria and other foreign bodies, have been compared to police or scavengers. Some of these ideas had been adumbrated by A. V. Waller (1816–70) and were further developed by the Russian biologist in Paris, Elie Metchnikoff (1845–1916) and by the English worker Almroth Wright (1861–1947).

Since Kolliker and Virchow, the study of the intimate structure and workings of the cells themselves, as distinct from the tissues, has become a separate science, cytology (*q.v.*), further extended to the study of cells in disease, cytopathology. A major development of cytopathology is the study of "new growths," among which cancer (*q.v.*) takes a leading place. There has also been extensive and intensive exploration of the microscopic appearances of diseased organs, illuminated by knowledge of the nature and action of microorganisms of disease and guided by experimental methods of producing disease in animals. which became of increasingly greater importance since Pasteur and Koch.

25. The Germ Doctrine of Disease.—This is, beyond doubt, the centre of the triumphs of medicine during the last hundred years. In the earlier decades of the 19th century it was shown that certain diseases are associated with microorganisms. Some believed them to be causative factors. Since the 18th century, too, many had strenuously denied that microorganisms are ever spontaneously generated. At the middle of the 19th century there rose the towering figure of Louis Pasteur (1822–95). In 1864, as a culminating experiment of centuries, he proved, as well as a universal negative can be proved, that the organisms of putrefaction and fermentation do not arise de novo but always and only from those of a kind like themselves. In 1863–69 he demonstrated the formation of highly resistant spores in several organisms.

At this time much essential work centred around the disease anthrax. A rodlike microscopic organism had long been known to be associated with it. In 1877 Pasteur proved it to have a causative relation to the disease. Anthrax bacilli were filtered off from the infected juices and the disease found not to be produced by the filtered juice but only by the bacilli.

In 1867 the technical genius Robert Koch (1843–1910) came on the scene. He introduced solid media for cultivating bacteria. By this means he obtained pure cultures of anthrax bacilli and demonstrated in 1876 that they contained spores highly resistant to heat and drying. The existence of these minute bodies explained many puzzling features in the recurrence of this and other diseases. By 1888 it was generally realized that the symptoms of disease were the result of the poisonous substances produced by the action of the organisms and that these substances were specific for many forms. The word "toxin" was introduced to describe them. All this work was contemporary with the rise of the new surgical technique, especially connected with the name of Lord Lister (1827–1912).

With the knowledge of the life history and disease-producing powers of the anthrax bacillus as their model, investigators turned to other diseases. The organisms of leprosy were detected in 1871 by the Norwegian Annauer Gerhard Hansen (1841–1912), of wound infection by Koch in 1877 and the following years, of gonorrhea by Albert Neisser (1855–1916) in 1879 and of glanders by Friedrich Loffler (1852–1915) in 1882. The great discovery of the organism of tuberculosis was made by Koch in 1882 with the assistance of methods invented by Paul Ehrlich (1854–1915).

Bacteriological technique had now reached a very high standard and had become an independent science, and a new phase of research was reached. An organism was demonstrated as having a causative relation to typhoid by Georg Gaffky (1850–1918) in 1884. Tetanus, cholera, diphtheria, cerebrospinal and Malta fever were all associated with their organisms at about the same time. The plague organism became known in 1894.

The last 20 years of the 19th century produced certain other bacteriological results in the laboratory that were destined to be extensively developed and widely applied during the subsequent period. Notably there then arose the scientific study of immunity.

"Active" immunity had been known for centuries. The concept became quite familiar with the development of variolation and vaccination at the beginning of the 18th century. The word "immunity" passed into general use about 1880 when there was much discussion of the specific infectious fevers, their incubation periods. their statistical incidence, their mode of spread, their probable microbic origin and the subsequent immunity conferred by their attacks. Methods of obtaining attenuated viruses for chicken cholera and anthrax and their use as preventive vaccines were attained by Pasteur at that time. A triumph of active immunization was the preventive vaccination against typhoid fever introduced tentatively in France in 1888. It later became practicable in England (1896–97) and was applied extensively to the army in India (1898–1900). It was a little too late for use in the South African War. No less important was the German discovery of very reliable tests for infection by the disease (1895).

The years 1890–94 were critical. New methods were being devised for attenuating toxins. It was demonstrated in 1890 by Emil von Behring (1854–1917) that the blood serum of animals immunized against attenuated diphtheria and tetanus toxins can be used for preventive inoculation against these diseases in other animals. In 1894 this method of inducing "passive" immunity was first used on a major scale on human beings for diphtheria. It was very successful and was soon widely adopted.

Investigation of the so-called tropical diseases has always stood a little apart and occupied a somewhat special place in medical thought. Because of colonial commitments it was naturally a peculiarly British interest. It is now recognized that some of the most important of these tropical diseases are caused by organisms other than bacteria. They are often caused by the unicellular organisms known as protozoa. The first protozoal disease to yield its secret was relapsing fever. The condition had been known in Europe since the 18th century and in 1847–48 and 1863–73 there had been outbreaks in London. The disease is world-wide. Its spirochete was described in 1873. In 1879 the disease was reproduced by direct inoculation of infected blood. The insectlike vectors. ticks, were not proved guilty until 1904 though they had been suggested as early as 1857. Similarly, the spirochete of syphilis was not adequately known till the 20th century though it had been figured in 1836.

Several naturalists in the 1860s and 1870s devoted themselves to the study of internal parasites. They showed that certain of these, filaria in particular, change their host during their life history. In 1877 the worm *Filaria* bancrofti was seen to go through some of its development in an anopheles mosquito and was traced into the blood of man by Sir Patrick Manson (1844–1922). This was the first direct conviction of an insect as a disease carrier. Soon

after, the malarial parasite was seen in human blood (1880) by Charles Laveran (1845–1922) and its significance grasped. Much research was done on human blood to elucidate the parasite's life cycle there. Its general character was clear by 1897, when other stages of the life history of the parasite were located by Ronald Ross (1857–1932) in the stomach wall of anopheles mosquitoes which had fed on the blood of malarial patients. Within a few months the spores of the parasites were shown to be concentrated in the salivary glands of the insect. The secret of malaria (*q.v.*), economically among the gravest diseases, was now revealed.

Demographically one of the most formidable parasites is the hookworm, *Ancylostoma,* the cause of tropical chlorosis, miner's anemia and such conditions under various other names. That it was pathogenic had been known since 1866. In 1898 it was shown that it can penetrate the skin and reach its final home, the intestine, by devious routes. The interest aroused by this led to the investigation of other worms parasitic in animals and men. Many are known to have extremely complex life histories involving several hosts. Thus, parasitology has arisen as an independent science. In 1892 there was a plague of field mice in Thessaly. It was eradicated by means of the *Bacillus typhimurium,* the first example of the deliberate use of a disease against a pest. In the same year it mas shown that the mosaic disease of tobacco mill pass the finest filters. In 1897–98 the same was found true of foot-and-mouth disease, the beginning of the study of filterable viruses in mammals and man. (*See* also DIAGNOSIS.)

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IV. ORIENTAL MEDICINE

1. Indian Medicine. — Indian medicine is very ancient, and its earliest concepts are set out in the *Vedas,* especially in the metrical passages of the *Atharva-Veda,* which may possibly date as far back as the and millennium B.C. According to a later writer the *Ayur-Veda* was received by Dhanvantari from Brahma, and Dhanvantari was deified as the physician of the gods. In later times his status was gradually reduced until he was credited with having been an earthly king who died of snakebite. There is a long legend which tells of Dhanvantari's relations with snakes and which illustrates the skill with which early Indian practitioners treated snakebite.

The period of Vedic medicine lasted until about 800 B.C. The *Vedas* are rich in magical practices for the treatment of diseases and in charms for the expulsion of the demons traditionally supposed to cause diseases. The chief conditions mentioned are fever (*Takman*), cough, consumption, diarrhea, dropsy, abscesses, seizures, tumours and skin diseases (including leprosy). The herbs recommended for treatment are numerous.

The golden age of Indian medicine lasted from 800 B.C. until about A.D. 1000 and may be termed the Brahmanistic period. It is marked especially by the works of Charaka and Susruta, known respectively as the *Charaka-samhita* and the *Susruta-samhzta* Both these works were formerly regarded as being of great antiquity, and hence arose claims for the priority of Indian scientific medicine over its Greek counterpart. Another school asserted that these norks were written many centuries after the beginning of the Christian era. The most recent estimates place the *Charaka* in its present form as dating from the 1st century A.D., though it was originally older. The *Susruta* probably originated in the last centuries of the pre-Christian era, and became fixed in its form in the 7th century A.D. at the latest. The Bower manuscript—the earliest-known manuscript—can be dated paleographically to a period between the 4th and 6th centuries A.D.; it mentions the *Susruta.* Other medical treatises of lesser importance are those attributed to Vagbhata (c. 8th century). All later treatises were based on these works.

As the Hindus were prohibited by their religion from cutting the dead body, their knowledge of anatomy was limited. Susruta recommended that a body should be placed in a basket and sunk in a river for seven days. On its removal the parts could be easily separated without cutting. As a result of these crude methods the emphasis in Hindu anatomy lay on the bones, and then on the muscles, ligaments and joints. The nerves. blood vessels and internal organs were imperfectly known. The texts state that the body has 360 bones, 210 joints and 500 muscles.

The Hindus conceived that the body contained three elementary substances. microcosmic representatives of the three divine universal forces, which they called spirit (air), phlegm and bile. These were comparable with the humours of the Greeks, and health depended on the normal balance of these three elementary substances. The spirit has its seat below the navel. the phlegm above the heart and the bile between the heart and the navel. The seven primary constituents of the body—blood, flesh, fat, bone, marrow, chyle and semen—are produced by the action of the elementary substances. Semen was supposed to be produced from all parts of the body and not from any individual part or organ.

Both Charaka and Susruta state the existence of a large number of diseases (Susruta says 1,120). Rough classifications of diseases are given. In all texts "fever," of which numerous types are described, is regarded as important. Pulmonary tuberculosis was apparently common and the Hindu physicians knem the symptoms of cases likely to terminate fatally. Smallpox was also common, and it is probable that smallpox inoculation was practised.

In diagnosis the Hindu physicians used all five senses. Hearing was used to distinguish the nature of the breathing, and alteration in voice and the grinding sound produced by the rubbing together of broken ends of bones. They appear to have had a good clinical sense, and their sections on prognosis contain acute references to symptoms which are of grave import. However. even until late in the classical period magical beliefs still persisted; the prognosis could be affected by such fortuitous factors as the cleanliness of the messenger sent to fetch the physician, the nature of his conveyance, or the type of persons whom the physician met on his journey to the patient.

Indian therapeutics was largely dietetic and medicinal. Dietetic treatment was important and it preceded any medicinal treatment. Fats were much used, internally and externally. The most important methods of active treatment were referred to as the "five procedures"; viz., emetics, purgatives, enemata, oil enemata and sneezing powders. Inhalations were frequently employed, as also were leeching, cupping and bleeding.

The Indian materia medica was extensive and consisted mainly of vegetable drugs. all of which were from indigenous plants. Charaka knew 500 medicinal plants and Susruta 760. However, animal remedies (such as the milk of various animals, bones, gallstones) and minerals (sulfur, arsenic, lead, copper sulfate and gold) were also employed. The physicians collected and prepared their own vegetable drugs. Among those which eventually appeared in western pharmacopoeias are cardamoms and cinnamon.

As a result of the strict religious beliefs of the Hindus, hygienic measures were very important in treatment. Two meals a day were prescribed, with indications of the nature of the diet, the amount of water to be drunk before and after the meal and the use of condiments. Bathing and care of the skin were carefully prescribed, as was also the cleansing of the teeth with twigs from certain trees, the anointing of the body with oil and the use of eye washes.

2. Indian Surgery. — In surgery ancient Hindu medicine reached its zenith. Detailed instructions on the choice of instruments and on the different operations are given in the classical texts. It has been said that the Hindus knew all ancient operations except the arrest of hemorrhage by the ligature. Their operations were grouped broadly as follows: excision of tumours and foreign bodies; incision of abscesses; punctures of collections

of fluid in the abdomen; extraction of foreign bodies; expression of the contents of abscesses; probing of fistulas; and stitching of wounds.

The surgical instruments used by the Hindus have received special attention in modern times. According to Susruta the surgeon's armamentarium should contain 20 sharp and 101 blunt instruments. The sharp instruments included knives of various patterns, scissors, trocars, saws and needles. The blunt instruments included forceps, specula, tubes, levers, hooks and probes. The *Susruta-samhita* does not mention the catheter, but it is referred to in later writings. The instruments were largely of steel. Alcohol seems to have been used as a narcotic during operations.

In two types of operations especially, the ancient Hindus were outstanding. Stone in the bladder (vesical calculus) was very common in ancient India and the surgeons frequently carried out the operation of lateral lithotomy for removal of the stones. Detailed instructions are given in the texts. They also introduced plastic surgery. Amputation of the nose was one of the prescribed punishments for adultery, and repair was carried out by cutting from the patient's cheek a piece of tissue of the required size and shape and applying it to the stump of the nose. The results appear to have been tolerably satisfactory and the modern operation is certainly derived indirectly from this ancient source. The Hindu surgeons also performed an operation for anal fistula, and in this they were in advance of the Greeks.

In the past there has been much speculation on the question as to whether the Greeks derived any of their medical knowledge from the Hindus. Works published at the middle of the 20th century appeared to demonstrate that there was certainly intercommunication between Greece and India before the time of Alexander the Great.

3. Chinese Medicine.— The Chinese system of medicine is of great antiquity and is independent of any recorded external influences. Legend has it that it commenced with Fu Hsi (c. 2953 B.C.), and was continued by the emperors Shên Nung (c. 2838–2698 B.C.) and Huang Ti (*c.* 2698–2598 B.C.). The latter, the Yellow Emperor, was always regarded as the author of the *Nei Ching* (the "Canon of Internal Medicine"). but recent research probably indicates that in its present form it does not date from earlier than the 3rd century B.C. Most of the Chinese medical literature is founded on the *Nei Ching* and it is still regarded as a great authority. Other famous works are the *Mo Ching* (the "Pulse Classic") composed *c.* A.D. 300; and the *Golden Mirror,* a compilation, made about A.D. 1 joo, of medical writings of the Han dynasty (206 B.C.–A.D. 220). Chinese medicine continued to progress to its zenith about A.D. 170, and until about A.D. 960 some progress was made, after which it was static and then degenerated, because progress was considered simply as the detailed elaboration of the ancient themes. European medicine began to obtain a footing in China early in the 19th century. but the native system is still widely practised. Modern Chinese workers, such as Wu Lien Teh who worked on plague and its prevention in the 1920s, had greatly increased in numbers by the 1950s.

The basis of traditional medicine is the dualistic philosophical cosmic theory of the Yang and the Yin. The Yang, the male principle, is active and light, and is represented by the heavens; the Yin. the iemale principle, is passive and dark, and is represented by the earth. Like matter in general, the human body is made up of five elements. wood, fire, earth. metal and water, and with these are associated the five planets, the five conditions of the atmosphere, the five colours, the five tones, etc. Health, character and the success of all political and private ventures are determined by the preponderance at the time of the Yang or the Yin. In the body their proportions can be controlled, and this is the great aim of ancient Chinese medicine.

The teachings of the religious sects forbid the mutilation of the dead human body and hence traditional anatomy rests on no sure scientific foundation. One of their most important writers on anatomy, Wang Ch'in Jen, gained his knowledge in A.D. 1798 from the casual inspection of dog-torn bodies of children who had died in a plague epidemic in that year. The anatomy of the Chinese is based on their cosmic system, which postulates the presence of such hypothetical structures as the 12 channels. Anatomical knowledge is therefore simply a corroboration of the system and, when there is a contradiction, the system is assumed to be right. The body contains five organs (heart, lungs, liver, spleen and kidneys) which store up but do not eliminate; and five viscera (such as the stomach, intestines, gall bladder and bladder) which eliminate but do not store up. Each organ is associated with a viscus, and also with one of the planets, and with one of the five colours, tones, smells and tastes. There are 36j bones and 365 articulations in the body. There are also three "burning spaces," concerning the form and position of which hypothetical structures there is little consensus of opinion.

According to the physiology of traditional Chinese medicine, the blood vessels are supposed to contain blood and air, in proportions varying with those of the Yang and the Yin. These two cosmic principles circulate in the 12 channels and control the blood vessels and hence the pulse. In the *Nei Ching* the statement is made that "the blood current flows continuously in a circle and never stops. It may be compared to a circle without beginning or end." (K. C. Wong and Wu Lien-Teh, *History of Chinese Medicine,* 2nd ed., p. 35, Shanghai, 1936.) On this flimsy evidence it has been claimed that the Chinese anticipated Harvey's discovery of the circulation of the blood. Tears are supposed to be secreted by the liver, and there are two kinds of salivary secretion, one arising from the heart and the other from the kidneys.

Traditional Chinese pathology is also dependent on the theory of the Yang and the Yin. and this had led to a detailed classification of diseases, in which most of the detailed types are without any scientific foundation.

In diagnosis detailed questions are asked about the history of the illness and the patient's taste, smell, dreams, etc. Attention is paid to the quality of the voice and far-reaching conclusions are drawn from it. Note is made of the colour of the face and the tongue. The most important part of the investigation, however, is the examination of the pulse.

The doctrine of the pulse is very ancient. Some say that it was introduced about 255 B.C., and the greatest authority on it lived about A.D. 280—Wang She-ho, who wrote the "Pulse Classic." This work, with innumerable commentaries, survives into modern times. The conception is that health depends upon the harmonious balance of the Yang and the Yin. If the flow of one of these principles is obstructed, disharmony and disease result. The state of the flow of the principles in the hypothetical channels has an effect upon the pulse, the state of the pulse indicating the point at which stagnation has occurred. Feeling the pulse is the most important aspect of diagnosis. Three fingers are used to feel the radial artery; and as there are six pulses, each of which must be felt three times, with strong, medium and weak pressure successively, the number of possible variations is very large. Several other qualities of the pulse at any point are also noted, and the pulses on the tno sides differ. The pulse also varies according to the time of the day and the season of the year in which it is taken. These comments refer only to the radial pulse at the wrist; but there are ten other places at which the pulse can be, and often is, felt. The minimum time necessary to feel the pulse is ten minutes, and the operation may take three hours. It is often the only examination which is made, and it is used not only for diagnosis but also for prognosis. Some say that from it the organs which are diseased can be ascertained and the time of death or recovery foretold.

From the point of view of the western observer Chinese medical treatment shows three points of interest: materia rnedica; the use of moxa; acupuncture.

The materia medica has always been very extensive, and consists of vegetable, animal (including human) and mineral remedies. There were famous herbals from ancient times; but all these, to the number of about 1,000, were collated. corrected and used by Li Shih-chen in the compilation of the *Pen-Ts'ao Kang Mu* (the "Great Herbal," A.D. 1552–78). This work, in 52 volumes, has been frequently revised and reprinted, and is still very authoritative. The use of drugs is mainly to restore the harmony of the Yang and the Yin. The drugs are also related to the five organs,

the five planets, the five colours, and so on. The art of prescribing is therefore complex. Almost every conceivable natural substance has at one time or other been used therapeutically. In addition, in prescribing there are often the elements of sympathetic magic, and the Doctrine of Signatures, long since abandoned by western medicine. For external application various plasters are often applied, sometimes far from the seat of the pain.

Among the drugs taken over by western medicine from the Chinese are rhubarb, iron (for anemia), castor oil, kaolin, aconite, camphor and Cannabis *indica* (Indian hemp). Chaulmoogra oil was used by the Chinese for leprosy from at least the 14th century and about a century ago it began to be used for this purpose by western physicians. The herb "Ma Huang" has been used in China for 4,000 years. Botanically it is Ephedra *vulgaris* and the isolation of the alkaloid ephedrine from it has greatly improved the western treatment of asthma and similar conditions. The most famous and expensive of Chinese remedies, ginseng, is used only by the very wealthy, much of it being imported from as far away as the U.S. Western methods have shown that it has diuretic and other properties.

Hydrotherapy is probably of Chinese origin, since cold baths were used for fevers in 180 B.C. The inoculation of smallpox matter, in order to produce a mild, but immunizing: attack of the disease. was practised in China from ancient times and came to Europe from Turkey about 1720.

Moxibustion consists in making a moxa, a small moistened cone of powdered leaves of mugwort (Artemisia *vulgaris*), applying it to the skin, igniting it and then crushing it into the blister so formed. Other substances are also used for the moxa. Dozens of moxas are sometimes applied at one sitting. The practice is often associated with acupuncture.

Acupuncture consists of the insertion into the skin and underlying tissues of a metal needle, either hot or cold. The theory is that the needle will affect the distribution of the Yang and the Yin in the "burning spaces" and in the hypothetical channels of the body. The organ which is most affected by the insertion depends on the site of the insertion. The practice of acupuncture dates from before 2500 B.C. and is peculiarly Chinese. Little of practical importance has been added since that date, although there have been many well-known treatises on the subject. About A.D. 860 the emperor ordered Wang Wei I to construct a bronze model showing the hundreds of specified points for the insertion of the needle and this was the forerunner of the innumerable models and diagrams which were later produced. The needles used are 1 in. to 10 in. in length. They are often inserted with considerable force and after insertion may be screwed to the left or the right. W. R. Morse gives a personal account of the carrying out of the operation. He saw unsterilized needles driven up to 15 cm. into solid organs such as the liver. The practice of acupuncture, often combined with moxibustion. is still widely used for many diseases, including fractures. Complications following the operation, such as sepsis, are very common.

4. Chinese Surgery.—The religious beliefs of the Chinese are against surgical interference with the body and practically the only operation which is ever performed is castration. Prior to the revolution in 1911 castration had been carried out from ancient times for the production of eunuchs for royal palaces. Two methods are employed. In the commoner method some degree of anesthesia is produced by hot water and the parts are removed by a single stroke of a curved knife. Hemorrhage is controlled mainly by pressure. Survivors are supposed to be recovered in 100 days. The mortality is variously stated to be between 2% and 50%. In the other method the parts are separated off spontaneously by a process of gangrene produced by a ligature.

5. Japanese Medicine.— In ancient times Japan had its own system of medicine, but about the 3rd century A.D. the country was infiltrated by Chinese principles of healing. Chinese medicine remained in favour until about the 16th century. Of the native physicians Tokuhon Nagata (1512–1630) is probably the best known. Western medicine was first introduced into Japan by Portuguese missionaries in the 16th century and was fully established by 1870. More recently Japan has produced brilliant laboratory workers, such as Shibasaburo Kitasato (1852–1931) and Hideyo Noguchi (1876–1928). See also MEDICINE AND SURGERY (ARTICLES ON).

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MEDICINE AND SURGERY (ARTICLES ON). The article MEDICINE, HISTORY OF discusses the evolution of knowledge of the nature of diseases and of methods for combating them; the relationship of medicine and surgery to other sciences and to society in various eras and regions; and the contemporary status of the medical profession. Developments that exemplify recent progress in many fields are cited in MEDICAL RESEARCH. Special aspects of the medical profession are surveyed in MEDICAL EDUCATION; MEDICAL JURISPRUDENCE; and MEDICAL LEGISLATION.

PATHOLOGY deals with the major causes of disease; the mechanisms of the human body for combating these; and the techniques employed for reinforcing resistance to injuries and bacterial invasions. Among the articles dealing with broad fields of pathology are ALLERGY AND ANAPHYLAXIS; ARTERIES, DISEASES OF; CONNECTIVE TISSUE, DISEASES OF; EYE, HUMAN: *Diseases of the* Eye; GASTROINTESTINAL TRACT, DISEASES OF; GALL BLADDER, BILIARY TRACT AND LIVER, DISEASES OF; KIDNEY, DISEASES OF; LUNG, DISEASES OF; PARASITIC DISEASES; RESPIRATORY SYSTEM, DISEASES OF; SKIN DISEASES; SPINE, DISEASES AND DISABILITIES OF; BLOOD, DISORDERS OF.

Pediatrics is discussed in CHILDREN, DISEASES OF. Articles on fields of specialization include ENDOCRINOLOGY; GYNECOLOGY; OPHTHALMOLOGY; PHARMACOLOGY; PSYCHIATRY; SKIN DISEASES; SURGERY; UROLOGY. Fields of medicine linked to environmental and occupational conditions are discussed in the articles AVIATION MEDICINE; DANGEROUS OCCUPATIONS; INDUSTRIAL MEDICINE; MEDICAL SERVICES, MILITARY; and TROPICAL MEDICINE.

Specific ailments are dealt with in such articles as ANEMIA; ARTHRITIS; ASTHMA; CANCER; CEREBRAL PALSY; COLD, COMMON; DIPHTHERIA; ENCEPHALITIS; EPILEPSY; GOUT; HAY FEVER; INFLUENZA; MENINGITIS; NEURITIS; PNEUMONIA; INFANTILE PARALYSIS; TUBERCULOSIS; ULCER; YELLOW FEVER; etc. The guiding principles employed in the identification of disease are described in DIAGNOSIS. Additional articles are devoted to individual factors of major importance—for example, CHOLESTEROL, dealing with one of the indications of disease of the arteries. Articles on major handicaps include BLINDNESS; DEAFNESS AND IMPAIRED HEARING; SPEECH DISORDERS; and REHABILITATION, MEDICAL AND VOCATIONAL.

THERAPEUTICS discusses the basic concepts of treatment and the various fields in which they find application. Among the articles on specialized branches of therapeutics are PHYSICAL THERAPY; RADIOLOGY; SERUM THERAPY; ULTRASONICS; and VACCINE THERAPY. The history of the use of drugs in the treatment of disease and the general principles accepted today in the study of the biological properties of drugs are outlined in PHARMACOLOGY. CHEMOTHERAPY discusses the theoretical basis of the selection of specific drugs to combat invading microorganisms.

Articles devoted to various groups of drugs include ANTIHISTAMINES; ANTIBIOTICS; BARBITURATES; SULFONAMIDES; TRANQUILIZING DRUGS: etc. Also, many articles are devoted to individual drugs—for example, AMPHETAMINE; ASPIRIN; ATROPINE; DIGITALIS; INSULIN; PENICILLIN; SALVARSAN; SCOPOLAMINE; etc. The establishment of standards of quality and strength for drugs is described in PHARMACOPOEIA.

Articles dealing in whole or in part with bacteriology, in addition to the article under that heading, include ANTISEPTICS; BACTERIAL AND INFECTIOUS DISEASES; EPIDEMIOLOGY; FOOD POISONING, BACTERIOLOGICAL; IMMUNITY; PARASITIC DISEASES; PARASITISM AND PARASITOLOGY; PHAGOCYTOSIS; RICKETTSIAE;

VACCINATION; and VIRUSES. The problem of transmittal of infectious disease by persons who have themselves become immune is discussed in CARRIER.

DIET AND DIETETICS discusses the physiological needs that must be taken into account in a well planned diet for the typical man and woman and for members of special population groups such as the aged. The functions of enzymes, carbohydrates, fats, proteins, salts, water and vitamins are discussed in NUTRITION and in MALNUTRITION. VITAMINS reviews the history of their role in counteracting deficiency diseases, and the chemical constituents and special functions of the various vitamins. References to additional material on individual vitamins and their applications will be found in the index (which should be consulted for a comprehensive view of the *Encyclopædia Britannica's* resources on any topic). VEGETARIANISM summarizes the hygienic and sociological benefits claimed by its advocates.

Articles on surgery include ABDOMEN, SURGERY OF; ANESTHESIA AND ANESTHETICS; BLOOD VESSELS, SURGERY OF; CAESARIAN SECTION; EYE, SURGERY OF; HEART AND LUNG, SURGERY OF; HERNIA; ORTHOPEDIC SURGERY; PLASTIC SURGERY; TRANSPLANTS, TISSUE AND ORGAN; etc. Among many articles in which surgical information is combined with discussions of medical problems in general are APPENDICITIS; BONE, DISEASES AND INJURIES OF; INTESTINAL OBSTRUCTIONS; VARICOSE VEINS; etc. Dental surgery is discussed in DENTISTRY and ORTHODONTICS.

CHILDREN, DISEASES OF is supplemented by ADOLESCENCE and INFANCY. Articles dealing with medical problems of women include CHILDBIRTH; MATERNAL AND CHILD HEALTH; MENOPAUSE; PREGNANCY; PUERPERAL FEVER; etc. Medical problems of old age are discussed in GERONTOLOGY AND GERIATRICS, and articles on related topics include DEATH (BIOLOGICAL) and LIFE SPAN, HUMAN.

The interconnection of physiological and psychological factors in all forms of life is exemplified by SEXUAL BEHAVIOUR. Articles discussing maladjustment of these two sets of factors include ALCOHOLISM; DEMENTIA; DRUG ADDICTION; HYPOCHONDRIASIS; NEUROPHARMACOLOGY AND PSYCHOPHARMACOLOGY; NEUROSES; PARANOID REACTIONS; PSYCHOANALYSIS; PSYCHOSES; PSYCHIATRY; etc. Additional listings will be found under PSYCHOLOGY (ARTICLES ON).

MEDICAL TECHNOLOGY summarizes the activities of technicians in bacteriology, clinical chemistry, hematology, serology, parasitology, etc., and the educational disciplines that are a prerequisite for these. Additional articles on occupations associated with medicine are APOTHECARY; OPTOMETRY; NURSING; PHARMACY; etc. CLINIC and HOSPITAL deal with the history and administrative procedures of these institutions. Articles on hygiene, in addition to the article under that title, include PREVENTIVE MEDICINE; REHABILITATION, MEDICAL AND VOCATIONAL; HEATING AND VENTILATION; WATER SUPPLY AND PURIFICATION.

Accidents and industrial diseases and measures to control their effects are treated in ANTIDOTES; ARTIFICIAL RESPIRATION; BLOOD TRANSFUSION; BURNS; DANGEROUS OCCUPATIONS; DROWNING AND LIFESAVING; DUST: *The Dust Problem In Industry;* FIRST AID TO THE INJURED; FRACTURES AND DISLOCATIONS; POISON; SHOCK AND COLLAPSE; SILICOSIS; SUNSTROKE AND HEATSTROKE; WOUND.

ANIMAL EXPERIMENTATION discusses advances in medicine and surgery that have accrued from this form of research, and the procedures by which it is legally regulated. Articles on medical topics of general interest include BLOOD PRESSURE; CANCER RESEARCH; EUGENICS; HAEMORRHAGE; INFLAMMATION; INSOMNIA; NIGHT BLINDNESS; OBESITY; PAIN; SLEEP; etc.

Much of the science of medicine is inseparable from the related fields of anatomy, physiology, biochemistry and biophysics. The articles under these headings should be consulted, as well as ANATOMY (ARTICLES ON); BIOLOGY (ARTICLES ON); and PHYSIOLOGY (ARTICLES ON).

Many biographical articles describe the work of great physicians, surgeons and exponents of medical research, from such classical figures as Galen and Hippocrates to recent Nobel prize recipients.

MEDICINE MAN: *see* SHAMANISM.

MEDILL, JOSEPH (1823–1899), U.S. newspaper editor and publisher, was born on April 6, 1823, in New Brunswick, Can. His Scotch-Irish father, whose family for many generations had been shipbuilders in Belfast, Ire., had emigrated to America in 1819. The area near St. John, where Joseph Medill was born, was thought to belong to the U.S., but the disputed land was later awarded to Canada by the Webster-Ashburton treaty of 1842.

In 1832 the family moved to Stark county, O. When Medill was 21 years of age, he began to study law, and in 1846 he was admitted to the bar. In 1849 he began his career in journalism by purchasing the *Coshocton* (O.) *Whig,* which he renamed the *Coshocton Republican.* Two years later he established in Cleveland a morning newspaper, the *Daily Forest City.* In 1852 the paper was merged with the *True Democrat,* a Free Soil journal, and called the *Cleveland Leader.*

The Whig party had suffered a great defeat in the elections of 1852, and Medill took a prominent part in the movement to organize a new party. A secret meeting, attended by men from the Whig, Democratic and Free Soil parties, was held in March 1854 at the office of the *Cleveland Leader.* Some participants, including Sen. Salmon P. Chase, favoured the name "Free Democracy," but the name Republican, advocated by Medill, was finally accepted.

In 1855 Medill purchased an interest in the *Chicago Tribune.* Although he did not at first gain full control of the paper, he became influential in setting the editorial policies. He supported Abraham Lincoln both in the editorial columns and in party circles, and he played an important part in securing the Republican presidential nomination for Lincoln.

As editor in chief of the *Tribune* from Nov. 1, 1863, until Aug. 1, 1866, Medill vigorously supported emancipation of the slaves, administration financial policy and measures to permit soldiers at the front to vote in the election of 1864.

On Oct. 9, 1871, the *Tribune* offices were destroyed in the great Chicago fire. Temporary offices were immediately established, and with makeshift equipment the newspaper resumed publication after missing only one issue. Medill was elected mayor of Chicago by a three-fourths majority on Nov. 7, 1871. The city was in a precarious financial condition when he took office, for the courts had held that many tax assessments were made illegally and the revenue could not be collected. Moreover, a number of public buildings had been destroyed in the fire. Medill requested an increase of the executive powers and responsibilities, and the council passed a "mayor's bill," which increased the mayor's control of administrative boards and gave him the power to veto individual items on appropriation bills. Rebuilding of the city began, and the fire department, which had been part of the political spoils system, was reorganized.

In Sept. 1873 Medill resigned as mayor and made a tour of several European countries. Upon his return from Europe in 1874, Medill purchased a controlling interest in the *Tribune* and again became editor in chief, a post he held until his death in San Antonio, Tex., on March 16, 1899.

MEDINA, JOSÉ TORIBIO (1852–1930), Chilean scholar, author and bibliographer, mas born in Santiago de Chile on Oct. 21, 1852. After an excellent education, he received his degree of advocate at the university in Santiago in 1873, but such time as he could spare from the practice of his profession he consistently gave to literature and the study of American history. In 1875 he was appointed first secretary of legation in Lima, Peru. He went to the United States in the following year and spent the next two years traveling in the United States and Europe, where he made a careful study of documents relating to the history of Chile. During the War of the Pacific Medina served as judge advocate of the reserve army and mas then made judge of several new provinces, chiefly Tarapacá.

Medina left this post to make a dangerous journey into Araucania at the end of 1880 to gather materials for a work on *Los Aborígenes de Chile,* to be the first volume of a complete history of Chile which he had projected. In 1884 he went to Spain as first secretary of the newly established legation in Madrid, where he was able to make extensive researches into the archives of the Indies in Seville and Simancas. When he returned to Chile in

1886, he set up his own printing press; from this and its successors he sent out a great number of books. In addition to his own works, Medina edited numerous others relating to the whole range of discovery, exploration, history and geography in all the Americas, particularly Chile.

His labours in the entire field of Hispanic-American bibliography were stupendous; a list of his works would exceed 300 titles, among them: *Historia de la literatura colonial de Chile* (1878); *Biblioteca americana* (1888); *Colección de documentos*, 30 vol. (1888–1902); *Historiadores de Chile*, 33 vol.; *Biblioteca hispano-americana* (1898–1907); *Los Tribunales del santo oficio en América; La Imprenta en Rio de la Plata* (1892), . . . *en Santiago de Chile* (1891), . . . *en Lima* (1904–07), . . . *en México* (1907–12); *La Araucana* (1910–18), a monumental edition in 5 folio vol.; El *descubrimiento del océano pacifico* (1913–20); *Cervantes en las letras chilenas* (1923). (W. B. P.; X.)

MEDINA (AL-MADĪNAH, "the city," or MADĪNAT RASŪL ALLĀH, "the city of the apostle of God"), a town of Saudi Arabia, 132 mi easterly from the Red sea port of Yanbu' and about 820 mi. by rail S.S E. of Damascus, the refuge of Mohammed on his emigration from Mecca, and a renowned place of Moslem pilgrimage, consecrated by the possession of his tomb. Pop. (1955 est.) 80,000.

The name Medina goes back to the Koran (*sur.* xxxiii, 60); the old name was Yathrib, the Iathrippa of Ptolemy and Stephanus Byzantinus.

Medina stands in a mountain basin on the uptilted western edge of the ancient plateau mass of Arabia. To the west the land falls abruptly to the Red sea coastlands, while southward the plain extends unbroken to the horizon. The most important mountain groups surrounding Medina are Jabal Uhud, the scene of the famous battle (*see* MOHAMMED), Jabal Thawr, Jabal 'Air and Jabal Sala'. A number of torrent courses descend from the mountains. and converge in the neighbourhood of the town. The convergence of torrent-courses in the neighbourhood of Medina makes it one of the best-watered spots in northern Arabia. The city lies close to one of the great volcanic centres of the peninsula, it was in violent eruption as late as AD. 1266. Volcanic activity has tended to confine the underground water, which can be reached at any point of the oasis by sinking deep wells

The volcanic soil, although impaired in some places by salt, has given a tradition of fertility to the city from the days of the Prophet. Thus situated. Medina was originally a city of agriculturists. unlike Mecca, nhich is a city of merchants The latter was a haram, or sanctuary, before the time of Mohammed, but Medina became a sanctuary only at the Prophet's command.

It was first heard of as an oasis held by Jews, among whom emigrants from Yemen afterwards settled. From the time of the emigration of Mohammed (A.D. 622) till the Omayyads removed the seat of empire from Medina to Damascus, the town became prominent as the capital of the new power that so rapidly changed the fate of the east. Its fall was not less rapid and complete, and since the battle of Harra and the sack of the city in 683 it has never regained political importance. (*See* CALIPHATE.) Mohammed invested the country round Medina with an inviolable character like that of the haram round Mecca; but this provision has never been observed with strictness. After the fall of the caliphs. who maintained a governor in Medina, the native amirs enjoyed a fluctuating measure of independence, interrupted by the aggressions of the sharifs of Mecca, or controlled by an intermittent Egyptian protectorate. The Turks, after the conquest of Egypt, held Medina for a time with a firmer hand; but their rule grew weak, and was almost nominal long before the Wahhabis first took the city in 1804. A Turko-Egyptian force re-took it in 1812, and the Turks remained in effective control until the revival of the Wahhabi movement under Ibn Sa'ud, from 1912 onwards, increased their difficulties. Turkish rule ceased during World War I, and Husain, the Hashimite king of Hejaz, revolted against them. He later came into conflict with Ibn Sa'ud. Medina was in the hands of the Hashimite government up to 1924, when it was besieged for 15 months and ultimately fell to Ibn Sa'ud (q *v.*).

The city proper is surrounded by a high, strong wall, with towers and nine gates forming an irregular oval running to a kind of angle at the northwest, where stands a fort built by the Turkish Sultan Selim in A.D. 1532. A second wall, less massive than the inner one, extends from near the Baqi' cemetery, where 10,000 of the Prophet's companions are said to be buried, to the fort at the northwest end. The space between the outer and inner walls is occupied by various suburbs of the city, and is also a resting place for the desert caravans. The oldest quarter of the city is at the eastern end, that is between the great mosque and Bab al-Baqi'. This is a region of small houses and tortuous streets. The glory of Medina, and the only important building, is the mosque of the Prophet, in the eastern part of the city, a spacious enclosed court between 400 and 500 ft. in length from north to south, and two-thirds as much in breadth. The minarets and the lofty dome above the sacred graves are imposing features; but the circuit is hemmed in by houses or narrow lanes, and is not remarkable, except for the principal gate (Bab al-Salām) at the southern end of the west front, facing the sacred graves, which is richly inlaid with marbles and fine tiles, and adorned with golden inscriptions. This gate leads into a deep portico, with ten rows of pillars, running along the southern wall. Near the farther end of the portico, but not adjoining the walls, is a sort of doorless house or chamber hung with rich curtains, which is supposed to contain the graves of Mohammed, Abu-Bekr and Omar. To the north of this is a smaller chamber of the same kind, draped in black, which is said to represent the tomb of Fatima. Both are enclosed with an iron railing, so closely interwoven with brass wirework that a glimpse of the so-called tombs can only be got through certain apertures, where intercessory prayer is addressed to the Prophet, and pious salutations are paid to the other saints. The portico in front of the railing is paved with marble, and in the eastern part with mosaic, laid with rich carpets; the southern wall is clothed with marble, pierced with windows of good stained glass, and the great railing has a striking aspect; but an air of tawdriness is imparted by the painting of the columns, especially in the space between the tomb and the pulpit, which has received, in accordance with a tradition of the Prophet, the name of the Garden (*rauḍa*), and is decorated with barbaric attempts to carry out this idea in colour. The throng of visitors passing along the south wall from the Bab al-Salām to salute the tombs is separated from the Garden by an iron railing. Within the court are the well of the Prophet, and some palm trees said to have been planted by Fatima.

The original mosque was a low building of brick, roofed with palm branches, and much smaller than the present structure. The wooden pulpit from which Mohammed preached appears to have stood on the same place with the present pulpit, in the middle of the south portico. The dwelling of the Prophet and the huts of his women adjoined the mosque. Mohammed died in the hut of Ayesha, and was buried where he died; Abu-Bekr and Omar were afterwards buried beside him. In A.D. 711 the mosque, which had previously been enlarged by Omar and Othman, was reconstructed on a grander scale, and in Byzantine style, by Greek and Coptic artificers by order of the caliph Walid (705–715), and under the direction of Omar Ibn-'Abd-al-'Aziz. The enlarged plan included the huts above named, which were pulled down. Thus the place of the Prophet's burial was brought within the mosque; but the recorded discontent of the city at this step shows that the feeling which regards the tomb as the great glory of the mosque, and the pilgrimage to it as the most meritorious that can be undertaken, except that to Mecca, was still quite unknown. It is not even certain what was done at this time to mark off the graves. Ibn-'Abd-Rabbihi, in the beginning of the 10th century (*'Iqd,* Cairo ed., iii, 366), describes the enclosure as a hexagonal wall, rising within three cubits of the ceiling of the portico, clothed in marble for more than a man's height, and above that height daubed with the unguent called *khalūq*. This may be supplemented from Iṣṭakhrī, who calls it a lofty house without a door. That there are no gravestones or visible tombs within is certain from what is recorded of occasions when the place was opened up for repairs. Ibn-Jubair (p. 193 *seq*) and Samhūdī speak of a small casket adorned with silver, fixed in the

eastern wall, which was supposed to be opposite the head of the Prophet, while a silver nail in the south wall indicated the point to which the corpse faced, and from which the salutation of the worshippers was to be addressed (Burton misquotes). The smaller chamber of Fatima is comparatively modern. In the time of Ibn-Jubair and of Ibn-Baṭūṭa (unless the latter, as is so often the case, is merely copying his predecessor) there was only a small marble trough north of the rauda (or grave) which "is said to be the house of Fatima or her grave, but God only knows." It is more probable that Fatima was buried in the Baqi', where her tomb was also shown in the 12th century (Ibn-Jubair, pp. 198 seq.).

The mosque was again extended by the caliph Mahdi (A.D. 781) and was burned down in 1256. Of its appearance before the fire there are two authentic accounts by Ibn-'Abd-Rabbihi early in the 10th century, and by Ibn-Jubair, who visited it in 1184. The old mosque had a much finer and more regular appearance than the modern one; the interior walls were richly adorned with marble and mosaic arabesques of trees and the like, and the outer walls with stone marquetry; the pillars of the south portico were in white plaster with gilt capitals, the other pillars were of marble. Ibn-'Abd-Rabbihi speaks of 18 gates, of which, in Ibn-Jubair's time, as at present, all but four were walled up. There were then three minarets. After the fire which took place just at the time of the fall of the caliphate, the mosque long lay in a miserable condition. Its repair was due chiefly to the Egyptian sultans, especially to Qa'it Bāy, whose restoration after a second fire in 1481 amounted almost to a complete reconstruction. Of the old building nothing seems to have remained but some of the columns and part of the walls. The minarets have also been rebuilt and two new ones added. The great dome above the tomb, the railing round it, and the pulpit, all date from Qā'it Bāy's restoration.

The principal street in the city is the one running from the Egyptian gate to the mosque entrance at Bab al-Salām. It is known as al-Siiq, and is the market street. The vegetable and cattle markets are held just outside the inner wall, near the Bab-al-Shiina, while the grain market is held lower down, near the Egyptian gate. In 1908 a railway line was completed from Damascus to Medina. This increased considerably the prosperity of the city, and many wealthy residents from Turkish lands came here to live. At the height of the Turkish rule the city had possibly some 70,000 or more inhabitants, but the unrest in the country after 1912, and particularly the 15-month siege of Medina, depleted this number to almost 6,000 by 1927; the population rose, however, to approximately 30,000 in 1943. Much of the cultivated land near the city was abandoned. In times of prosperity the volcanic soil among, the surrounding hills grew thousands of palms, and beneath their shade were grown cereals, particularly wheat and barley, and also fruits. Many fields show evidence of deep digging and removal of the surface soil, so as to utilize the richer soils beneath.

The date trade is important, and has links with Egypt, Iran and India. Medina was at one time a great centre for Moslem theological students. About 3 mi. from the Syrian gate, on the west of the city, is a large wireless telegraph station, placed beneath the old Turkish fort.

BIBLIOGRAPHY.—Medina has been described from personal observation by Burckhardt (1815) and Burton (1853), and by the Arab geographers, Bakrī and Yāqūt. Besides Ibn-'Abd-Rabbihi and Ibn-Jubair, Samhūdī wrote a history of the region. An extract is published by Wüstenfeld in the Göttingen *Abhandlungen,* vol. ix (1861). It deals with the period down to the 15th century. *See* also C. M. Doughty, *Travels in Arabia Deserta,* vol. ii; Eldon Rutter, *The Holy Cities of Arabia,* vol. ii (1928) and bibliography of article MECCA.

MEDINA SIDONIA, DON ALONSO PEREZ DE GUZMAN EL BUENO, 7TH DUKE OF (1550–1615), commander-in-chief of the Spanish Armada, was born Sept. 10, 1550. His father, Don Juan Claros de Guzman, died in 1555, and Don Alonso became duke, and on the death of his grandfather in 1559, master of one of the greatest fortunes in Europe. The family of Guzman first appears in the 10th century, and the branch to which the dukes of Medina Sidonia belonged was founded by Alonso Perez de Guzman (1256–1309), El *Bueno* "the stout-hearted," so called for allowing his son to be killed rather than surrender Tarifa (1296). The duchy of Medina Sidonia was conferred on his descendant, Juan Alonso de Guzman, count of Niebla in 1445.

The titles and grandeeship passed in accordance with Castilian law, by marriage of a daughter and heiress in 1777, to the marquess of Villafranca, and have since remained in that house. The 7th duke married Ana de Silva y Mendoza, daughter of the prince of Eboli. Though he bore the name of El *Bueno,* he was a man of mean spirit. Appointed to the command of the Armada on the death (Feb. 9, 1588) of the marquis de Santa Cruz (*q.v.*), he sought to move Philip II (who forced him to go out) by piteous declarations that he had neither experience nor capacity, and was always sick at sea. His conduct of the Armada justified his plea. He was even accused of cowardice, and was completely broken by the sufferings of the campaign.

He retained his posts of "admiral of the ocean" and captain-general of Andalusia in spite of the contempt openly expressed for him by the whole nation. In 1596 his sloth and timidity lost Cadiz to the English. He was held up to ridicule by Miguel de Cervantes Saavedra in a sonnet.

Yet the royal favour continued unmerited and unabated even under the successor of Philip II. In 1606 the duke's obstinacy and folly caused the loss of a squadron which was destroyed near Gibraltar by the Dutch. He died in 1615.

See C. Fernández Duro, *La Armada invéncible* (Madrid, *1884).*

MEDIOLANUM, the chief ancient city in Gallia Transpadana (mod. Milan, *q.v.*), Italy. The name is Celtic. The Romans defeated the Insubres in 225–222 B.C., and stormed Mediolanum itself in the latter year. Its inhabitants rebelled in the Hannibalic War, but were reduced to obedience in 196 B.C. In Strabo's time it was on an equality to Verona, but smaller than Patavium, but later increased.

At the end of the 3rd century it became the seat of the governor of Aemilia and Liguria (which then included Gallia Transpadana also, thus consisting of the 9th and 11th regions of Augustus), and at the end of the 4th, of the governor of Liguria only, Aemilia having one of its own thenceforth. From Diocletian's time onwards the *praefectus praetorio* and the imperial vicar of Italy also had their seat here: and it became one of the principal mints of the empire. The emperors of the west resided at Mediolanum during the 4th century, until Honorius in 402 transferred his court to Ravenna. Its many inscriptions indicate a strong Celtic character in the population. Procopius speaks of it as the first city of the west, after Rome, and says that when it was captured by the Goths in 539, 300,000 of the inhabitants were killed. Roads radiated to Comum, to the foot of Ticinum, to Laus Pompeia and thence to Placentia and Cremona, and to Bergomum. None of these roads had an individual name, so far as we know.

To its secular power corresponds the independent position which its church took in the time of St. Ambrose (*q.v.*), bishop of Milan in 374–397, who founded the church which bears his name, and here baptized St. Augustine in A.D. 384, and whose rite is still in use throughout the diocese. The Huns invaded it under Attila (452), the Heruli under Odoacer (476) and the Goths under Theodoric (493). When Belisarius was sent by Justinian to recover Italy, Datius, archbishop of Milan, joined him, and the Goths were expelled from the city.

Uraia, nephew of Vitigis the Goth, destroyed the whole of Milan in 539. Narses, in his campaigns against the Goths, had invited the Lombards to his aid; under Alboin, their king, they soon mastered north Italy, entering Milan in 569, but Pavia became the Lombard capital.

Of Roman remains little is seen above ground, but the plan of the city, which was rectangular, may be traced in the centre of the modern town and one of the round towers of its walls still exists. Close to the Torre del Carrobio remains of an ancient bridge and (possibly) of the walls of Maximian were found; and many remains of ancient buildings, including a theatre, have been discovered below ground level. The objects found are preserved in the archaeological museum in the Castello Sforzesco. (See MILAN.)

MEDITERRANEAN SEA. The Mediterranean is an intercontinental sea situated between Europe to the north, Africa on the south and Asia in the east. The maximum east-west extent, from the Straits of Gibraltar to the shores of the Gulf of Iskenderun, is more than 2,300 mi.. and the maximum longitudinal extent, between the coasts of Yugoslavia and Libya, is nearly 850 mi. Its area, including the Sea of Marmara but excluding the Black sea, is close to 970,000 sq.mi.

The hlediterranean is the main existing fragment of the Tethys sea, which before the Alpine mountain-building period girdled the eastern hemisphere. The structure and present form of the basin and its bordering mountain system have been determined by the convergence and recession of the relatively stable continental blocks of Eurasia and Africa. The main movement of early Tertiary times was one of convergence and led to the uplift of the ranges of the Alpine system, largely composed of sediments originally deposited on the floor of the Tethys. The corresponding troughs of the fold system and the later foundering of areas encircled by the folds created the major basins within the sea. Still more recently the Mediterranean was widened and changed in form by a drawing apart of the continental blocks. This last movement created the Adriatic sea between Italy and the Balkan mass, shattered the southern ranges between Greece and Asia Minor, thus forming the Aegean, and opened the connection between the Mediterranean and the Black sea. The existence of an earthquake and volcanic belt along the whole length of the area shows that these great crustal adjustments are still proceeding. Moreover, marine terraces appearing below and above the present sea level and encircling the Mediterranean indicate the fluctuations in sea level during glacial advances and interglacial periods of the Pleistocene.

Configuration.——A submarine ridge extending across the narrows between western Sicily and Cape Bon has a maximum depth of less than 1,148 ft. and divides the Mediterranean into an eastern and western basin, oriented along a northwest-southeast axis. The major subdivisions of the western Mediterranean are the Alboran basin east of Gibraltar. between the coasts of Spain and Morocco, the Algero-Ligurian basin in which the Balearic Islands are located, and the Tyrrhenian basin north of the Sicilian straits. The structure of the eastern Mediterranean is more complicated. and more fracturing has occurred. A submarine ridge from western Crete to Cyrenaica separates the Ionian basin in the west from the Levantian basin in the east. Several other smaller basins have been mapped, such as the Cypro-Syrian basin and sections of the Aegean sea. The Adriatic sea between Italy and Yugoslavia consists of a basin up to 3,937 ft. deep in the south, a middle basin with a depth of only 656 ft., and a shallo northern section.

TABLE I.—Per Cent of Area

Depth ft.	W. Medit.	E. Medit.	Adriatic	Aegean	Total to Dardanelles
0.0–656	15.3	16.3	78.2	25.2	19.9
656–3,280.8	21.2	21.2	14.8	59.7	23.6
3,280.8–6,561.6	15.1	19.4	7.0	11.6	16.8
6,561.6–9,842.4	43.6	27.0	—	3.5	29.3
9,842.4–13,123.2	4.8	15.4	—	—	10.1
more than 13,123.2	—	0.7	—	—	0.3

Except for the Adriatic and a shallow ramp extending some 200 mi. eastward from the Tunisian coast, the basins reach great depths and have steep continental slopes. Depths for various sections of the Mediterranean sea were calculated in relation to area by E. Kossinna in 1921 (Table I). While the western Mediterranean has more of its area at depths greater than 6,562 ft. the deepest soundings have been obtained in the Ionian basin south of Cape Matapan (Greece), where the basin floor is more than 15,092 ft. below sea level.

The bottoms of the basins are filled with brownish sediments varying in thickness from 328 to 8,858 ft. They are of sandy-clayey consistency with clay much in excess of sand, and they contain about 50% of carbonate of lime. The coarser calcareous constituents are chiefly pteropoda. while among the smaller shells foraminifera and coccoliths predominate. Fine riverine muds are deposited near the mouths of rivers emptying into the sea and are also carried considerable distances by offshore and submarine currents.

In general, coastal features are the direct result of the flooding of structural depressions and not of erosion. The shores are steep, and erosional cliffs and wave-cut platforms rare. In the northeastern Mediterranean deeply penetrating channels separated by high headlands recur along great stretches of coast, irrespective of the character of the rock of which they are composed. Coastal plains are small and scattered. Streams are heavily charged with sediments, but most of them have a small watershed because their headwaters are in highlands not far from the shore. The major exceptions are the large deltas of the Nile, Po and Rhbne rivers, all of uhich drain large land areas. The formation of deltaic lowlands is aided by the low tidal range nearly everywhere in the hlediterranean. Only at Gibraltar and on the east coast of Tunisia does the tidal range exceed three feet. Thus. the Po delta in the last two centuries has advanced 230 ft. per year. and the Rhbne delta 187 ft. per year since 1737. Deposits would be even more rapid, were it not for currents which carry them away and scatter them over a wide area.

Temperature and Salinity.— Temperatures of the surface water layers vary with the seasons. In February the lowest surface water temperature is 12° C. on the Provence coast in the western Mediterranean, and 10° C. in the northern Aegean in the east. In August the highest water temperatures occur along the coasts of Malaga and Israel, where they are 25° C. and 29° C. respectively. The average annual range in surface temperature for the Mediterranean as a whole is 12° C.; this range decreases with depth, and between 3,281 and 6,562 ft., temperature is remarkably uniform at all seasons—about 13° C. in the western basin and 13.7° C. in the eastern basin. Below 6,562 ft. there is a slight increase in temperature to the bottom, probably because of increased pressure.

Salinity is considerably higher than that of either the Atlantic ocean or the Black sea because of the heavy losses of water by evaporation. In general, it increases from west to east, from about 37 mills near Gibraltar and the Balearics to 39 mills in the Levant. However, salinity is loner everywhere toward the end of the rainy season, and it is considerably lower where fresh water is emptied into the sea. As a result of the Nile river floods. salinity as far north as the latitude of Mount Carmel decreases from 38.1 to 35.9 mills between August and September, and the discharge of the Vardar river into the Gulf of Salonika reduces salinity to 18 mills there. In depth there is a slight decrease from the surface to about 164 ft., then salinity increases to a depth of about 1,640 ft., and below that there is another slow decrease to 38.4 mills at the bottom in the nest, and to 38.7 mills in the east.

Water Balance.— The basic factors in the water balance of the Mediterranean sea are evaporation. precipitation, runoff, and flow through the Straits of Gibraltar and the Bosporus. Calculations made by Douglas B. Carter in 1956 established the balance of the Mediterranean sea and the Sea of Marmara (Table II). The contribution of water through the Suez canal is insignificant. It should be added that the total inflow of water exceeds considerably loss by evaporation, so that there is a great outflow into the Atlantic and some into the Black sea beneath the surface currents. There is a seasonal change in depth and velocity of the two flows, and although surface currents are always into the Mediterranean, the outflow underneath is greater in volume when water gains in the Mediterranean exceed evaporation (December to April).

TABLE 11.—Water Balance
(in 000,000 ac.ft.)

Addition of water through:	
Net flow, Gibraltar	972.0
Direct Precipitation	'838.4
Runoff	365.2
Net flow, Bosporus	164.4
Total	2,340.0
Loss through evaporation	2,340.0

The general pattern of surface currents is counterclockwise for the Mediterranean as a whole, as well as for individual sections. Locally, however, currents are complicated and modified by tides

and winds.

Climates. — The basic factors which influence types and distribution of climates in the Mediterranean are the latitudinal and longitudinal position and extent, the orientation of the axis of the sea from northwest to southeast, and the great variety of land areas in shape, size and mountain systems. which break up the continuity of the water surface. As a result of the interaction of these factors, the Mediterranean region has not one type of climate, as is commonly stated, but several, ranging from deserts to mountains with the highest precipitation in Europe. and from marine to continental.

The latitudinal position of the Mediterranean sea is such that in winter, when the relatively warm waters of the Mediterranean form a vast area of low pressure with several centres, colder air is drawn in from adjacent land masses and the Mediterranean is a part of the westerly wind system with its passage of cyclones and their associated frontal precipitation. In summer, honever, the waters remain relatively cooler than the land, so that the regional high pressure coincides with and strengthens the subtropical high which has expanded over the sea. Moreover, the eastern Mediterranean extends further south in latitude than the western, bringing the entire shore from Tunisia to Egypt into the great Sahara-Arabian dry belt.

Total annual precipitation generally decreases from north to south, and from west to east. Annual amounts range from more than 181 in. near the Dalmatian coast to less than 0.8 in. in the Sahara, and they are considerably higher on windward (west-facing) slopes than on leeward slopes. Precipitation maxima occur in winter in the southern portion of the Mediterranean. including southern Spain, southern Italy, and Greece, and the fringes of Turkey, at a time when the southern cyclonic tracks between Gibraltar and the Levant are significantly active. The northernmost section of Italy and the northern interior of Yugoslavia have distinct summer maxima indicating continentality and convectional precipitation. Between these two extremes is the transitional zone with two maxima, one in spring and the other in autumn. when storm tracks through the northern basins of the Mediterranean are most active.

Average winter temperatures in the Mediterranean do not fall below freezing except in the interior of Yugoslavia and Turkey, whrch are exposed to cold waves from eastern Europe. On the European coast there is a general decrease from west to east nith the increasing influence of the Eurasiatic high, interiors are colder than coasts, and east coasts are colder than west coasts. Along the north African shores, on the other hand. there is little change in average winter temperatures. so that isotherms follow parallels of latitude fairly closely. In summer, average temperatures are hot everywhere; they increase eastward on the African shore and they are higher in the interior of land masses than on the coasts.

The great diversity of land and water, and the peculiarity of pressure conditions give rise to many special wind systems. Among them the best known are the etesian winds which, belonging to the summer monsoon system of Asia, are steady, dry northwesterlies and northerlies blowing in the eastern Mediterranean; the sirocco, a dry and often hot mind originating in the dry lands south and east of the Mediterranean and blowing toward northern shores; the bora of the Yugoslav coast, the mistral of southern France, and others resulting from cold, dry air moving down slope from the mountains toward the sea.

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History. — The Mediterranean has been described as "a melting pot for the peoples and civilizations nhich have seeped into it from its continental hinterlands." (Ellen Churchill Semple. The *Geography of the Mediterranean Region,* Henry Holt and Co., New York, 1931.) The revolutionary development of higher civilizations based on agriculture evidently originated in the lands beyond the eastern Mediterranean, but. having "seeped" into the basin, the sea facilitated further diffusion westward. Thus, the Mediterranean sea has served throughout history principally as a vital medium for communication from shore to shore, although at certain periods in its history man has made the sea a barrier, slo ing down or paralyzing the interchange of people, goods and ideas.

The history of the Mediterranean sea can be divided into several major epochs. The first one encompassed the pre-Roman period during which a succession of maritime commercial states, such as Carthage, ancient Greece, and Phoenicia evolved on and near its coasts. Trading centres sprang up on all its shores and even in the Atlantic. many in competition with one another. Then, in the 3rd century B.C., the second major epoch began with the expansion of Rome. culminating in the political and economic unification of all lands bordering the Mediterranean sea as part of the empire.

The third epoch, extending roughly from A.D. 400 to the 11th century, saw the shattering of Roman unity by invasions of Germans and Slavs in the north, and by Moslem Arab conquests in the middle east, north Africa, Spain and Sicily. Saracen pirates endangered shipping and became a menace to coastal settlements. Commerce was greatly reduced and at times halted completely, and the centre of gravity shifted northward away from the Mediterranean toward the Atlantic, where by A.D. 800 Charlemagne had unified much of continental Europe under one empire.

In the 11th century the next great age began with a return to the sea. The Arab empire was lapsing into disorder and the crusades aided in the reopening of seaports in the Levant. Constantinople, Barcelona and Italian commercial states regained their positions in world trade; until the 15th century these and other cities assumed the role of intermediaries between the orient and northwestern Europe. In the 15th century, however. the rise of the Ottoman Turks brought a second period of eclipse as well as an era of severe rivalries. Turkish conquest of the Levant. the Balkans and north Africa. was followed by a rule of oppression and exploitation, and piracy once again made traffic on the sea hazardous. Moreover, the discovery of the route to Asia around the Cape of Good Hope at the end of the 15th century created a safer and easier sea route connecting northwestern Europe directly with the orient. Mediterranean lands lost their commercial function as intermediaries between Europe and Asia, and for more than two and a half centuries the Mediterranean sea remained a backwater of world ocean trade and traffic.

The opening of the Suez canal in 1869. together with the advent of the steamship, continued industrialization in northwestern and central Europe, and French colonization in north Africa made the Mediterranean again one of the busiest sea lanes of the world. Much of the traffic, however, passed through the sea en route between Asia and northwestern Europe. Countries in the Mediterranean basin had not been able to industrialize and had retained their agricultural and artisan economies, which limited their purchasing power and reduced their ability to trade. Nevertheless. a fierce competition ensued among ports in northwestern Europe and Mediterranean Europe for the capture of transit trade to and from the industrialized areas of western and central Europe, a rivalry which has continued to this day.

From the 18th century until World War II, the Mediterranean was dominated by Great Britain, which had gradually acquired control over several strategic points along the sea route so vital to its empire trade, among them Gibraltar (1704), Malta (1800), Aden (1839), Cyprus (1878), and finally Egypt (1882). The most recent stage in the development of the Mediterranean sea began with United States entry into north Africa during World War II in 1942. After that war it became apparent that only the United States was strong enough to oppose the Soviet Union which made repeated attempts to expand into the Mediterranean sphere economically and politically. Thus, with the view of keeping the Mediterranean under noncommunist control and to protect western. interests in the middle east and its oil fields. the United States took a leading role in the security of the Mediterranean and its borderlands, by initiation of the Marshall plan, the Truman doctrine, by

participation in the North Atlantic Treaty organization which it helped create and the enactment of the Eisenhower doctrine for the middle east.

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(G. G. WD.)

MEDIUM, the word originally used by spiritualists to denote a person acting as intermediary between the spirit world and ordinary humanity. It now means a person by or through whom "supernormal" phenomena are produced, whether the supposed ultimate cause of the phenomena is spiritistic or not. The word is often given a more restricted sense to include only those who habitually produce "physical" phenomena or give trance communications.

See PSYCHICAL RESEARCH; SPIRITUALISM.

BIBLIOGRAPHY.—For a general account of the earlier mediums *see* Podmore's *Modern Spiritualism:* those who find this too critical for their taste may prefer Sir A. Conan Doyle's *History of Spiritualism.* For D. *D.* Home, Crookes' *Researches in the Phenomena of Spiritualism,* and Lord Dunraven's *Experiences in Spiritualism with D. D. Home* (reprinted by the S.P.R. in 1924) are important: for Stainton Moses, A. W. Trethewy's *The Controls of Stainton Moses;* and for Eusapia Paladino, S.P.R. *Proceedings,* vol. xxiii. For favourable reports on modern mediums *see* numerous books *by* Schrenck-Notzing, Geley, Crawford, etc.: for the other side, *see* part I of *Der Okkultismus in Urkunden.* The *Proceedings* of the S.P.R. are indispensable.

MEDLAR, *Mespilus germanica,* a tree of the tribe Pomeae of the family Rosaceae, closely allied to the genus *Pyrus,* in which it is sometimes included; it is a native of Europe from Holland southwards, and of western Asia. It occurs in hedges, etc., in middle and south England, as a small, much-branched, deciduous, spinous tree, but is not indigenous. The medlar was well known to the ancients. The well-known fruit is globular, but depressed above, with leafy persistent sepals, and contains stones of a hemispherical shape. It is not fit to eat until it begins to decay and becomes "bletted," when it has an agreeable acid and somewhat astringent flavour. Several varieties are known in cultivation. The fruit should be gathered in November, on a dry day, and laid out upon shelves. It becomes "bletted" and fit for use in two or three weeks. The Japanese medlar is *Eriobotrya japonica (see* LOQUAT), a genus of the same tribe of Rosaceae.

MÉDOC, a district in France adjoining the left bank of the Gironde from Blanquefort (N. of Bordeaux) to the mouth of the Gironde. It is about 50 mi. long, and between 6 and 7 mi. broad. It is formed by a number of low hills, which separate the Landes from the Gironde, and is traversed only by small streams; the Gironde itself is muddy, and often wrapped in fog. Large areas of its soil are occupied by vineyards, the products of which give the finest vintages of Bordeaux. *(See* WINE.)

MÉDOC WINES. The MCdoc is the strip of land about 6 mi. wide and 50 mi. long on the left bank of the Gironde, which produces the finest red wines in the Bordeaux region of France and perhaps in the world.

There are 50 wine-producing communes in the Médoc, which together produce one-fifth of all the red wine of Bordeaux, an average of about 8,500,000 gal. annually. The highest quality comes from the 500 châteaux of the Haut MCdoc in the south. Two-thirds of the production of the Haut MCdoc is *cru bourgeois supérieur* (better quality), while 61 of the 62 châteaux chosen for classification in 1855 into five grades are situated there; these vineyards still retain this classification and justify it with few exceptions: they produce the greatest wines of all.

The best vineyards are to be found in the four plateaus of the principal communes: St. Estèphe, Pauillac, St. Julien and Margaux; each of these communes has its own strictly applied *appellation contrdle'e,* which is a hallmark of quality in itself. (There are two other communes with their own *appellation contrdle'e,* Listrac and Moulis, which rank midway between the label "Haut MCdoc" and the four superior communes.) If a red wine from any of the six communes reaches the required quality it may use its commune name; otherwise it will probably be sold as, simply, "Haut MCdoc" or "Médoc." (Very few white wines are produced; they are only entitled to the *appellation* "Bordeaux.")

The red wines are dry, perfectly balanced and very long-lived, and are easily distinguishable from the wines of other districts of Bordeaux by their flavour. *See* WINE. (C. C. H. F.)

MEDUSA, in mythology: *see* GORGON.

MEDUSA, a technical name for a jellyfish (*q.v.*); *see* also COELENTERATA.

MEDWALL, HENRY (fl. 1490), the earliest known writer of an English secular play, is said on good authority to have been wellborn. The date of his birth and the circumstances of his youth and education are unknown. The earliest reference to him is in Cardinal Morton's register at Lambeth in the year 1490. On Aug. 28, 1492, he was admitted to the rectory of Bulyngham in the English marches of Calais. It was not till Feb. 27, 1500–01 that he appears to have been granted letters of protection enabling him to go overseas, and a few months later he resigned. No later reference to him is known and it is surmised that he did not long survive his patron, Cardinal Morton, who died in 1500.

Morton had appointed him his chaplain and it was for the entertainment of the cardinal and his guests that Medwall exercised his remarkable dramatic gifts. His reputation as a playright has suffered from a story apparently invented by J. P. Collier, who stated that at Richmond in 1513 a moral interlude by Medwall, *The Fynding of Truth,* was performed but was not liked and that the king departed before the end to his chamber. There is no trace of the document on which the story is supposed to rest.

Medwall did, however, write a morality play called *Nature,* in two parts and containing 22 characters. It is preserved in a single copy (printed by William Rastell) in the British Museum, and is a favourable example of the allegorical play. In it Medwall displays his talent for realistic dialogue and his skill as a versifier.

It is, however, as the author of *Fulgens and Lucres,* the first known secular play in English, that Medwall has a distinctive place in the history of the drama. The play was supposed to have been lost, except for a fragment, but a copy printed by John Rastell was found in 1919 in Lord Mostyn's library and passed, at the sale of his books, to the late Henry E. Huntington of California. Its source is a neo-Latin *declamatio* by Bonaccorso of Pistoja, *de Vera Nobilitate,* telling how Fulgentius, a Roman senator, had a daughter Lucretia who had two suitors, Publius Cornelius, well-born, rich and idle, and Gaius Flaminius, of humble birth but virtuous. Each pleads his case, but there is no decision. In the play, Lucres decides in favour of Flaminius, as the more truly "noble" of the two. Medwall also adds a comic underplot, in which the servants of the suitors are rivals for the favours of her handmaid. By virtue of this play Medwall stands at the head of the long line of English playwrights.

See A. W. Reed, *Early Tudor Drama* (1926); *Fulgens and Lucres,* edit. by F. S. Boas and A. W. Reed (1926). (F. S. B.)

MEDWAY, a river in the southeast of England. It rises in the Forest ridges, in Sussex, and flows east to the county boundary, which it forms. Entering Kent near Ashurst, it continues northeast to its mouth. The river passes Tonbridge, receiving the Eden, and later the Teise and Beult, all these streams draining the Weald (*q.v.*) to the south of the North Downs, which the Medway breaches in a beautiful valley generally much narrower than the upper valley. Maidstone stands in this gap. Below Maidstone the valley forms a perfect basin. the hills descending upon it above Rochester. Below this city the river enters a broad, winding estuary, passing Chatham, and at Sheerness joining the Thames, so that the Medway may be considered a tributary, and its drainage area of 680 sq.mi. reckoned as part of that of the greater river. The length of the Medway is about 70 mi. including the estuary (about 12 mi.), which is navigable for sea-going vessels drawing 24 ft. up to Rochester bridge.

MEEK, FIELDING BRADFORD (1817–1876), American geologist and palaeontologist, the son of a lawyer, was born at Madison, Indiana, December 10, 1817. In early life he was in

business as a merchant! but his leisure hours were devoted to collecting fossils and studying the rocks of the neighbourhood of Madison. Being unsuccessful in business he turned his whole attention to science, and in 1848 he gained employment on the U.S. geological survey in Iowa! and subsequently in Wisconsin and Minnesota. In 1852 he became assistant to Professor James Hall at Albany, and worked at palaeontology with him until 1858. Meanwhile in 1853 he accompanied Dr. F. V. Hayden in an exploration of the "Bad Lands" of Dakota, and brought back valuable collections of fossils. In 1858 he went to Washington, where he devoted his time to the palaeontological work of the U.S. geological and geographical surveys, his work bearing "the stamp of the most faithful and conscientious research." and raising him to the highest rank as a palaeontologist. Besides many separate contributions to science. he prepared with W. M. Gabb (1839–78) two volumes on the palaeontology of California (1864–69), and also a *Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri. Country* (1876). He died at Washington Dec. 22, 1876.

MEERANE, a town in Karl-Marx-Stadt district. Ger.. 9 mi. N. of Zwickau and 37 mi. S. of Leipzig. Pop. (1959 est.) 24,710. It contains a medieval church. It is one of the most important industrial centres of Germany for the manufacture of woolen and mixed cloths, and in these products has a large export trade. There are also extensive dyeworks. tanneries and machine factories.

MEERSCHAUM, a German word designating a soft white mineral sometimes found floating on the Black sea and rather suggestive of sea foam (*Meerschaum*), whence also the French name for the same substance, *écume de mer*. It was termed by E. F. Glocker sepiolite. in allusion to its remote resemblance to the "bone" of the sepia or cuttlefish. bleerschaum is of an opaque white, gray or cream colour, breaking with a conchoidal or fine earthy fracture and occasionally fibrous in texture. Meerschaum has occasionally been used as a substitute for soap and fuller's earth, but its chief use is for tobacco pipes and cigar and cigarette holders.

Meerschaum can be readily scratched with the nail, its hardness being about 2 on Mohs' scale. The specific gravity varies from 0.988 to 1.279, but the porosity of the mineral may lead to error. Meerschaum is a hydrous magnesium silicate with the formula $H_4Mg_2Si_3O_{10}$, or $Mg_2Si_3O_8.2H_2O$.

Most of the meerschaum of commerce is obtained from Turkey, chiefly from the plain of Eski-Shehr where it occurs in irregular nodular masses in alluvial deposits, which are extensively worked for its extraction. The mineral is associated with magnesite (magnesium carbonate), the primitive source of both minerals being serpentine. When first extracted the meerschaum is soft, but it hardens on exposure to the sun or when dried in a warm room.

Meerschaum is found also, though less abundantly. in Greece, as at Thebes, and in the islands of Euboea and Samos; it occurs in serpentine in Moravia and it is found to a limited extent at certain localities in France, Spain and Morocco. In the United States, although not produced commercially after about 1914, it occurs in serpentine in Pennsylvania (as at Nottingham, Chester county) and in New Mexico, South Carolina and Ctah.

MEERUT, a city, *tehsil* (subdivision), district and division, in Uttar Pradesh, India. The city (pop. [1961] 283,878), 36 mi. N.E. of Delhi, consists of the municipal area and the cantonment to the north. Although dating back to the days of the Buddhist emperor Asoka (*c.* 250 B.C.) Meerut owes its modern importance to its selection by the British government as the site of a great military station. In 1805 it is mentioned as "a ruined. depopulated town." The cantonment was established in 1806. and the population rose to 29.014 by 1847. and 82.035 by 1853. It has accommodation for artillery, armour and infantry. It was here that the first outbreak of the Mutiny of 1857 took place. (*See* INDIAN MUTINY.) Glazed pottery and handloom weaving are the chief industries. MEERUT TEHSIL (286 sq.mi.) had a population in 1951 of 485.235.

MEERUT DISTRICT forms part of the upper Doab or tract between the Ganges and the Jumna. Area 2.322 sq.mi. Though well wooded in places and abundantly provided with mango groves, it has but few patches of jungle or wasteland, being almost one continuous expanse of careful and prosperous tillage. Its fertility is largely due to the system of irrigation canals. The Eastern Jumna canal runs through the whole length of the district. and supplies the rich tract between the Jumna and its tributary the Hindan. The main branch of the Ganges canal passes across the centre of the plateau in a sweeping curve and waters the midland tract. The Anupshahr branch supplies irrigation to the Ganges slope. and the Agra canal passes through the southern corner of Loni pargana from the Hindan to the Jumna. The Burh Ganga, or ancient bed of the Ganges, lies at some distance from the modern stream; and on its bank stood the abandoned city of Hastinapur, the legendary capital of the Pandavas at the period of the *Mahabharata*. The comparatively high latitude and elevated position of Meerut make it one of the healthiest districts in the plains of India. The average temperature varies from 57° F. in January to 87° F. in June. The rainfall is small, less than 30 in. annually. The population in 1961 was 2.717,153. The principal crops are wheat, pulses, millet, sugar cane and cotton.

The authentic history of the district begins with the Moslem invasions. The town was taken by Kutb ud-Din Xibak in 1191, and all the Hindu temples turned into mosques. In 1398 Timur captured the fort of Loni after a desperate resistance, and put all his Hindu prisoners to death. He then proceeded to Delhi and. after his memorable sack of that city. returned to hleerut. captured the town and put the male inhabitants to the sword. After the death of Aurangzeb the country was exposed to alternate Sikh and Maratha invasions. From 1 jo; till 1775 it was the scene of perpetual strife, and was only rescued from anarchy by the exertions of the military adventurer Walter Reinhardt, afterward the husband of the celebrated Begum Samru. who established himself at Sardhana in the north. and ruled a large estate. The southern tract, however, remained in its anarchic condition under Maratha exactions until the fall of Delhi in 1803. when the whole of the country between the Jumna and the Ganges was ceded by Sindhia to the British. It was formed into a separate district in 1818.

MEERUT DIVISION, the northern part of the Doab. consists of the districts of Dehra Dun, Saharanpur, Muzaffarnagar, Meerut and Bulandshahr. Area. 9,214 sq.mi.; pop. (1951) 6,718,510.

MEETING. Public meetings may be either those of statutory bodies or assemblies of persons called together for social, political or other purposes. In the case of statutory bodies, bylaws usually fix the quorum necessary to constitute a legal meeting. That of limited companies may be either by reference to the capital held or by a fixed quorum or one in proportion to the number of shareholders. It has been held that in the case of a company it takes at least two persons to constitute a meeting (*Sharp* v. *Daws*, 1886, 2 *Q.B* D. 26). In the case of public meetings for social. political or other purposes no quorum is necessary. They may be held. if they are for a lawful purpose, in any place, on any day and at any hour, provided they satisfy certain statutory provisions or bylaws made under the authority of a statute for the safety of persons attending such meetings. If, however, a meeting is held in the street and it causes an obstruction those convening the meeting may be proceeded against for obstructing the highway. The control of a meeting and the subjects to be discussed are entirely within the discretion of those convening it, and whether the meeting is open to the public without payment, or subject to a charge or to membership of a specified body or society, those present are there merely by virtue of a licence of the conveners. which may be revoked at any time. The person whose licence is revoked may be requested to withdraw from the meeting and on refusal may be ejected with such force as is necessary. If he employs violence to those removing him he commits a breach of the peace for which he may be given into custody.

The Public Meeting act, 1908, enacted that any person who acts in a disorderly manner for the purpose of preventing the transaction of the business for which a lawful public meeting was called together shall be guilty of an offense. Any person who incites another to commit the offense is equally guilty. A public meeting is usually controlled by a chairman, who may be appointed by

the conveners or elected by the meeting itself. On the chairman falls the duty of preserving order. of calling on persons to speak,. deciding points of order. of putting questions to the meeting for decision, and declaring the result and other incidental matters. (*See* PARLIAMENT : *Parliamentary Procedure.*)

In England it is illegal, by the Seditious Meetings Act 1817, to hold a public meeting in the open air within 1m. of Westminster Hall during the sitting of parliament.

See COMPANY; CORPORATION.

MEGACYCLE is a million cycles. This term is used in radio work as a contraction for "megacycle per second."

MEGALOPOLIS, an ancient city of Arcadia, Greece, in a plain about 20 m. S.W. of Tegea, on both banks of the Helisson, about 2½ m. above its junction with the Alpheus. It was founded by the Theban general Epaminondas in 370 B.C., as a bulwark for the southern Arcadians against Sparta, and as the seat of the Arcadian Federal Diet. The builders were protected by a Theban force, and directed by ten native oecists (official "founders"), who drew inhabitants from all parts of Arcadia, but especially from Maenalia and Parrhasia. Forty townships are mentioned by Pausanias (viii. 27, 3–5) as having been incorporated in it. It was 50 stadia in circumference, and was surrounded with strong walls. Its territory was the largest in Arcadia, extending northward 24 m. The city was adorned with many handsome buildings. Its temples contained ancient statues brought from the incorporated towns. After the departure of Epaminondas, Lycomedes of Mantineia succeeded in drawing the Arcadian federation away from its alliance with Thebes, and it was consequently obliged to make common cause with Athens. Its attempt to use the treasures of Olympia led to dissensions, and in the battle of Mantineia (362) one-half of the Arcadians fought on the side of the Spartans, the other on that of the Thebans. After this battle many inhabitants of Megalopolis sought to return to their former homes, and it was only by the assistance of three thousand Thebans under Pammenes that they were prevented. In 353, when Thebes was preoccupied with the Sacred War, the Spartans attacked Megalopolis; but with Theban help the city was rescued. It was at this crisis that a Megalopolitan appeal to Athens, occasioned the oration of Demosthenes, On the people of Megalopolis. The Spartans now concluded peace with Megalopolis and acknowledged its autonomy. But their hostility did not cease, and Megalopolis entered into friendly relations with Philip of Macedon. Twenty years later, when the Spartans and their allies rebelled against Macedon, Megalopolis, loyal to its allegiance, stood a long siege. After the death of Alexander, it was governed by native tyrants. In the war between Cassander and Polyperchon it supplied 15,000 men to the former and was besieged by the latter. In 234 B.C. Lydiades, the last tyrant of Megalopolis, resigned, and the city joined the Achaean League, earning again the hatred of Sparta. In 222 Cleomenes plundered it, but in the next year its inhabitants were reinstated by Philopoemen, a native of the city. After this, it sank into insignificance and in the time of Pausanias it was in ruins. Its only great men were Philopoemen and Polybius the historian. Lycartas, the father of the latter, may be accounted a third. In the time of Pausanias, the city was mostly in ruins.

The site was excavated by the British School at Athens in 1890–1892. The description of Pausanias tallies closely with the reality. The town was divided into two approximately equal parts by the river Helisson, which flows through it from east to west. The line of the walls may be traced, partly by remains, partly by the contours it must have followed, and confirms the estimate of Polybius that they had a circuit of 50 stades, or about 5½ miles. The foundations, formerly supposed to belong to a bridge, are substructures of the precinct of Zeus Soter. The buildings north of the river were municipal, grouped round the square agora. The portico of Philip, on the N., was 300 ft. long, with three rows of columns running its whole length, and a projecting wing at either end. East of it stood the municipal offices (Archeia). At the south-west is the precinct of Zeus Soter, surrounded by a double colonnade, with a small temple on the west and an entrance on the east. In the midst was a substructure either for an altar or for the great group of Zeus and Megalopolis. North of this the Stoa Myropolis formed the E. boundary. These buildings were of various dates, but harmonious plan. On the S. bank of the river were the chief federal buildings, the theatre (noted by Pausanias as the largest in Greece), and the Thersilion or parliament hall; the great portico of the Thersilion facing the orchestra of the theatre. In consequence, the plan of the theatre is abnormal, for the portico, which has its base about 4 ft. 6 in. above the level of the orchestra, was too lofty for a proscenium; yet, a proscenium of the ordinary type would hide the lower part of the columns. Such a proscenium was actually erected later; but beneath it were foundations for a wooden proscenium, probably erected only when required. Later, steps were added, from the portico to the orchestra. The theatre was probably used, as at Athens, for political assemblies; but the adjoining Thersilion provided cover for the "ten thousand" in wet weather. It is unique in plan, its floor sloping up towards all sides like a theatre, with roof-columns set radially so as to obscure as little as possible the view from the centre.

See Society for the Promotion of Hellenic Studies, ***Excavations at Megalopolis (1892)***; W. Dorpfeld, ***Das griechische Theater;*** O. Puchstein, ***Griechische Bühne;*** Pauly-Wissowa, *s.v.*

MEGALOSAURUS, an extinct carnivorous bipedal reptile from the Jurassic rocks of west Europe. *Allosaurus* from the Jurassic of Colorado is allied and much better known. Both belong to the theropodous division of the Dinosauria. The animal was from 15 to 20 ft. long with formidable teeth, strong hind limbs and long heavy tail. See also DINOSAUR.

MEGAPODE, the name given to a small family of birds confined to the Australian region and notable for their habit of burying their eggs in the ground or in mounds of earth, decaying vegetation, etc., which they scratch up, and leaving them there to hatch. This mound-making habit is communal. The young actually fly from the moment of hatching, a unique feature. The commonest form is the East Australian brush-turkey (Catheturus *lathami*), about the size of a hen-turkey. The South and West Australian mallee-bird or "native pheasant" (*Lipoa* ocellata) has shorter tarsi and toes and lacks the bare head of the last. Another form (Megacephalon maleo) inhabits the Celebes. It has a helmet-like protuberance on the back of the bare head. The genus Megapodius ranges from Samoa to the New Hebrides, North Australia and New Guinea. The birds are about the size of small fowls, generally crested, with short tails and enormous feet. They are shy, terrestrial birds, but have a powerful flight.

See A. R. Wallace, ***Geogr. Distr. Animals*** and ***Malay Archipelago.***

MEGARA, an ancient Greek town on the Saronic gulf, between Attica and Corinth. Its district, Μεγαρίς or ἡ Μεγαρική, is bounded by Attica, Boeotia, Corinth, and the two gulfs, Mount Geraneia extending across the country from east to west, forms a barrier between continental Greece and the Peloponnesus. The shortest passage of this range is along the eastern side of the mountains, through the celebrated Scironian rocks, where Theseus destroyed the robber Sciron. The only lowland was the White Plain, in which was the city, Megara. The modern town occupies two low hills within the ancient site; it is the chief town of the eparchy of Megaris; pop. (1920) 9,531. Its Easter dances attract visitors. There are remains of the aqueduct made by the architect Eupalinus for the tyrant Theagenes.

History. — In prehistoric days Megara had intercourse with the southern Aegean. The early inhabitants were extirpated in the Dorian migration, for in historic times the city had a homogeneous Dorian population. Favoured by its proximity to two great waterways and by its two ports, Nisaea on the Saronic and Pegae on the Corinthian Gulf, Megara took a prominent part in commerce from the 8th century. Its trade was with Sicily, where Megarian colonies were established at Hybla (Megara Hyblaea) and Selinus, and with the Black sea, in which region the Megarians were pioneers of Greek commerce. In the Sea of Marmora they had to face the competition of the Samians and of Miletus; but on the Bosporus they established themselves by means of settlements at Chalcedon (675 B.C.) and Byzantium (658 B.C.). In the Black sea they exploited the shores of Pontus and Scythia. Their chief colonies were Astacus and Heracleia in Bithynia, and another Heracleia in the Crimea. Later this trade dwindled in

face of the commercial activity of Miletus, and that of Athens on the Hellespont. Megarian commerce in Sicily was supplanted by Corinth and Corcyra.

Megara's economic development entailed a change in political power. The land-holding aristocracy began to lose its grip upon the community of artizans. A short tyranny followed. The power of the nobles was broken in a war with Athens, in which Megara lost the island of Salamis (about 570 B.C.; see SOLON); after a period of democracy the constitution was fixed as an oligarchy of a moderate type. During the Persian wars the state, which joined the Peloponnesian League, could muster 3,000 hoplites. But the expansion of Athens ruined the commerce of Megara. In 459 an attack by Corinth induced the people to summon the aid of the Athenians, who secured Megara in battle and by the construction of long walls between the capital and its port Nisaea. In 43j the Megarians massacred their .Athenian garrison. The Athenians retaliated by placing an embargo upon Megarian trade throughout their empire (432), and in the Peloponnesian War, reduced their neighbours to misery by blockade and devastations. In 424 they nearly captured Megara, in collusion with a democratic party within the town, and secured Nisaea, which they held until 410. In the 4th century Megara recovered some measure of prosperity, but played an insignificant part in politics, and finally was incorporated in the Achaean League (*q.v.*). Megara suffered severely in the civil war of 48 B.C. It maintained itself as a place of some size in subsequent centuries, but was depopulated by the Venetians in A.D. 1 joo. The inhabitants of the modern village are mostly of Albanian origin.

MEGARA HYBLAEA (*see* also HYBLA), an ancient city on the east coast of Sicily. 12 mi. N.N.W. of Syracuse, founded about 728 B.C. by Megarian colonists. A hundred years later it founded Selinus. It was destroyed by Gelon about 483. In the Athenian expedition against Syracuse (415) Lamachus proposed (it being then deserted) to make it the Athenian base of operations; but this was not done, and in the next spring the Syracusans fortified it. It had a brief independent existence in the 4th century, when it coined (perhaps after Timoleon's expedition); but it is heard of mainly as a fortified place in 309 and-in 214 (when Marcellus captured it). Fortifications discovered in recent excavations belong to the war against Sextus Pompeius (36 B.C.). Excavations begun in 1891 revealed part of the town wall, an extensive cemetery, about 1,000 tombs of which have been explored, and a deposit of votive objects from a temple built over the ditch enclosing a late neolithic village of the Stentinello period. Excavations were resumed in 1949; these uncovered part of the inhabited area and threw much light on the earliest years of the city. (T. J. DN.)

MEGARIAN SCHOOL OF PHILOSOPHY. This school was founded at the beginning of the 4th century B.C. by Euclid (Eucleides) (*q.v.*) of Megara in Greece, a pupil of Socrates and the author of dialogues in the Socratic manner. The evidence for Euclid's teaching is fragmentary, but he is said to have held that "the good is one, though it is called by many names, sometimes wisdom, sometimes God and sometimes reason"; and that "the contrary to the good has no reality." These statements suggest that, besides the paramount influence of Socrates, a secondary influence operated from the first in the Megarian school, namely that of the Eleatics Parmenides and Zeno.

The Eleatics, however, started with the intention of proclaiming a view of reality and used their dialectic to shatter the objections of opponents. The Megarians, at least so long as Euclid himself was at the helm, had an ethical and educational purpose, and it was in this spirit that the unity of goodness was defended by them. They were, nevertheless, men of theory by comparison with other self-styled followers of Socrates, such as the Cyrenaics and Cynics. They consciously cultivated dialectical skill and could rightly claim that this was part of the master's procedure. It was the Socratic method of question and answer, rather than any positive doctrine, which linked them together. After Euclid's death (probably c. 365 B.C.), the practical and dialectical interests began to fall apart, and one wing of the school studied and propounded paradoxes in the manner of Zeno and otherwise advanced toward an independent treatment of logic.

Among Euclid's successors we know the names of Polyxenus and Bryson, the former of whom propounded the well-known "third man" objection to Plato's doctrine of ideas (see UNIVERSAL). Eubulides (*q.v.*) took the lead in Megarian criticism of Aristotle. The objection was to Aristotle's doctrine of categories, to his definition of, and belief in, movement and to his concept of potentiality (according to the Megarians only that which is now actual is possible). Some passages in Aristotle's writings are probably retorts to Megarian criticism. Though the chronology is obscure, it is certainly Aristotle who should have the credit for making the first theoretical study of the forms of inference; but whereas Aristotelian logic was applicable to predicates or classes, the Megarians specialized in a complementary branch of logic, that of propositions. It was Chrysippus, a Stoic, who completed this work, but his debt to Megarian predecessors was evidently considerable. (*See* LOGIC, HISTORY OF.)

Other Megarians were Diodorus Cronus (*q.v.*) and Stilpo, a representative of the older tradition inasmuch as he subordinated dialectic to a moral purpose. Stilpo was one of the teachers of the Stoic Zeno and of Menedemus (*q.v.*), leader of the Eretrian school. The Megarian school disappears from history at the beginning of the 3rd century B.C. and is notable more for its criticism of Aristotle and for its influence upon the Stoic logic than for any positive assertions.

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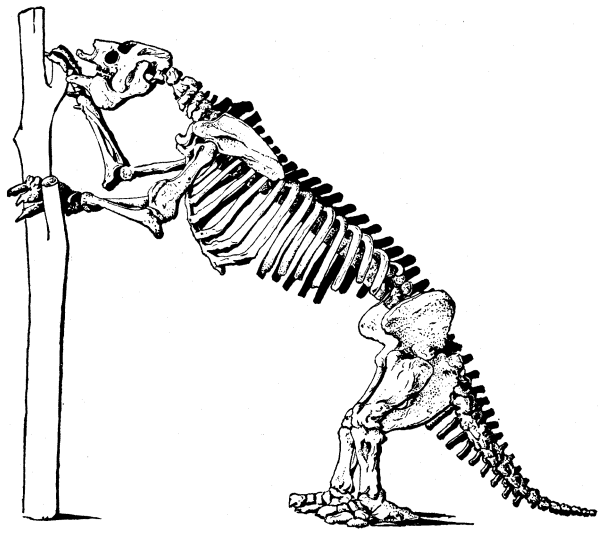
MEGARON, in Bronze Age Greece and Anatolia the house and then the main room of the palace, in the men's quarter. Rectangular with entrance porch, hearth and sometimes columns supporting roof; *e.g.*, palaces at Mycenae, Tiryns, Pylos (*c.* 1400–1200 B.C.).

MEGATHERIUM, the largest of the ground sloths, an extinct group of edentate mammals related to the modern tree sloths. It is best known from skeletons obtained in Argentina. It equalled the elephant in bulk but was of very different proportions, with short, massive hind limbs, heavy tail, long, slender loose-jointed fore limbs and large powerful claws on fore and hind foot. The head has a rather long muzzle, apparently heavy and fleshy, no front teeth, and the cheek teeth, five above and four below on each side of the jaw, are square prisms, rootless and nearing on the cronn into two cross crests. Various species of *Megatherium* have been found in Pleistocene formations all over South America and in North America as far north as New Jersey. The ancestry of the family is found in the middle Tertiary of South America. *Megalonyx* and its allies form a separate family Megalonychidae, related to the Megatheriidae. The members of the Megalonychidae can be distinguished from the



BY COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY
THE SKELETON OF MEGATHERIUM, AN ENORMOUS EXTINCT MAMMAL WHICH EXISTED DURING THE PLEISTOCENE AGE

Megatherids by teeth of oval or rounded cross section and by more primitive characters in the feet. *Megalonyx* has a pair of tusklike teeth in front, much as in the two-toed sloth (*Choloepus*), and was about as large as an ox. A smaller genus, *Nothrotherium,* lacks the tusklike teeth. Both these genera are chiefly known from North America, but were immigrants from South America. Allied. mostly smaller, genera inhabited the larger West Indian islands during the Pleistocene. (W. D. M.; X.)

MEGHNA, a river of East Pakistan formed, on the borders of Mymensingh and Sylhet districts, by the confluence of the Surma and lesser rivers. Total course, about 150 mi. Below Chandpur, about 80 mi. from the Bay of Bengal, it becomes the great estuary of the Bengal delta, conveying to the sea the main body of the waters of the Ganges and the Brahmaputra. The united waters, turbid and of great depth, enter the sea by four principal mouths — Tetulia river, Shahbazpur river, Meghna proper and Bamni river with Sandwip channel — enclosing 14 islands of various sizes. The Meghna is navigable by small boats and river steamers all the year; but the navigation is difficult and sometimes dangerous on account of shifting sandbanks and snags, and boisterous weather when the monsoon is blowing. The most favourable season is between November and February. Deposition of silt and its erosion are constantly taking place, especially along the seaboard. The regular rise of the tide is from 10 to 18 ft., and at springs the sea rushes up in a dangerous bore. It is greatest at the time of the biennial equinoxes, when navigation is sometimes impeded for days together. A still greater danger is the "storm wave" which occasionally sweeps up the Meghna under a cyclone.

MEGIDDO, BATTLES OF, 1918. This is the name usually given to the brilliantly conceived operations whereby Allenby (*q.v.*) broke the Turkish front in Palestine on Sept. 19, 1918, and completed his success by surrounding and rounding up the bulk of the Turkish forces in the next few days. This decisive victory was followed by a pursuit to Damascus and then to Aleppo, which ended with the capitulation of Turkey. For an account of this plan and its execution, *see* PALESTINE, OPERATIONS IN.

MEHEMET ALI: *see* MOHAMMED ALI.

MÉHUL, ÉTIENNE HENRI (or ÉTIENNE NICOLAS) (1763–1817), French composer, was born at Givet, Ardennes, on June 24, 1763. of poor parents, and the boy made his way in music with great difficulties. He received much kindness and help from Gluck, but it was only after wearisome disappointments and delays that his *Euphrosine et Coradin* was performed at the Opéra Comique in 1790. His opera of *Stratonice* was also received with enthusiasm in 1792. After several unsuccessful operas, his *Adrien* appeared, and added much to his fame, which was further increased by his three best works, *Le Jeune Henri, Uthal* and *Joseph,* in which Méhul's powerful genius is seen at its best. *Uthal* was written for an orchestra without violins. Méhul became one of the four inspectors of the Paris Conservatoire. After writing 42 operas, besides a number of songs for the festivals of the republic, cantatas, and orchestral pieces of various kinds, his health gave way and he died on Oct. 18, 1817 in Paris. In the sincerity and nobility of his inspiration Méhul showed himself a worthy successor of Gluck.

See Lives by Pougin (1889), Viellard (1859), and Quatremère de Quincep (1818).

MEIGMEN, ARTHUR (1874–1960), Canadian statesman, was born at Anderson, in the county of Perth, Ont.. on June 16, 1874, the son of Joseph and Mary Meighen. He was educated at St. Mary's collegiate institute and at Toronto university, and became a barrister-at-law. He married in 1904 Jessie Isabel Cox, daughter of the late Charles Cox of Granby, Que. His political career began in 1908 when he was elected to the house of commons as the Conservative member for Portage la Prairie in the province of Manitoba. In 1913 he became solicitor-general in the government of Sir Robert Borden; and in Oct. 1917 secretary of state and minister of mines. Later he became minister of the interior. In 1918 he accompanied the Canadian prime minister to England to attend the Imperial conference, and on Sir Robert Borden's retirement Meighen became prime minister and secretary of state for external affairs on July 10, 1920. In June 1921 he attended the conference of prime ministers in London.

Meighen held the office of prime minister until the general elections in 1921, when the Conservative party was defeated; he then became the leader of the Opposition, and for four years was a vigorous opponent of the Liberal government. He supported the disarmament resolution introduced by the prime minister, Mackenzie King.

The Military Service act, under which conscription was enforced in 1917, was largely, in so far as its legal preparation was concerned, the work of Meighen, and the vigour with which he supported it in parliament drew upon him the hostility of all those opposed to that measure. As the sentiment against conscription was especially strong in Quebec, the feeling against him in that province was intense, and prevented the policy of his party from receiving the due consideration of the electors. Meighen consistently repelled the personal attacks made upon him as the enemy of the French Canadians, but without much success. In the elections of 1925 the Conservatives, under the leadership of Meighen, were overwhelmingly victorious in Ontario and the maritime provinces, but with a practically solid Quebec against him it was impossible to obtain a majority, and the government remained in the hands of the Liberals. In June 1926, on the resignation of Mackenzie King, Meighen took office as premier, but his government was immediately defeated and a general election took place.

The adoption by the United States of protection, as well as the great industrial development of that country, placed Canada, in Meighen's view, at a disadvantage. He therefore strongly advocated protection for his own country, in order to prevent the United States from capturing the home markets. He was convinced also of the necessity for preserving the natural resources of Canada, in particular the water and forest resources. He resisted all attempts made by the United States to secure for its territories electrical power generated from watercourses in Canada.

Meighen was elected to the Canadian senate in 1932 after several years of retirement and served until 1935 as minister without portfolio in the Conservative cabinet headed by Richard B. Bennett. He was leader of the Conservative party, 1941–1942. He died in Toronto, Ont.. hug. 5, 1960. (A. G. D.; X.)

MEIJI TENNO (MUTSUHITO), Tenno, or Emperor of Japan (1852–1912), was born on Nov. 3, 1852, succeeded his father, Komei Tenno, the former emperor, in Jan. 1867, and was crowned at Osaka on Oct. 31, 1868. The country was then in a ferment because of the concessions which had been granted to foreigners by the preceding shogun Iyemochi, who in 1854 concluded a treaty with Commodore Perry by which it was agreed that certain ports should be open to foreign trade.

This convention gave offense to the more conservative daimios, and on their initiative the mikado suddenly decided, in the face of strong opposition, to abolish the shogunate. The reigning shogun, Keiki, yielded to the decree, but it was only by force of arms that the new order was imposed. The main object of those who had advocated the change was a reversion to the primitive condition of affairs, when the will of the mikado was absolute and when the presence of the hated foreigner was unknown in Japan.

The reactionary party was not allowed to monopolize revolutions. The powerful daimios of Satsuma and Chōshū suddenly declared themselves to be in favour of opening the country to foreign intercourse, and of adopting far-reaching reforms. With this movement Meiji Tenno was cordially in agreement, and he invited foreign representatives to an audience on March 23, 1868. When Sir Harry Parkes, the British minister. was on his way to this assembly, he was attacked by samurai. The outrage was regarded by the emperor and his ministers as a reflection on their honour, and they made reparation.

Meanwhile, the emperor, with his advisers, was maturing a political constitution providing for the assumption by the emperor of direct personal rule. As a step in this direction, Meiji Tenno transferred his capital from Kiōtō to Yedo, the former seat of the shoguns' government, and marked the event by renaming

the city Tōkyō.

In the same year Meiji Tenno took oath to institute certain reforms, including the establishment of a deliberative assembly. He was supported by the majority of the daimios. who in a supreme moment of patriotism surrendered their estates and privileges to their sovereign. This was the death knell of the feudalism which had existed for centuries, and gave Meiji Tenno a free hand A centralized bureaucracy arose, and the nation rapidly progressed. Torture was abolished (1873), and a judicial code, adapted from the Code Napoléon was authorized. The first railway—from Yokohama to Tokyo—was opened in 1872; the European calendar was adopted, and English was introduced into school curriculums. In all these reforms Meiji Tenno took a leading part.

There was opposition to such sweeping changes between 1876 and 1884. Three serious rebellions took place in the provinces. These the emperor suppressed; and simultaneously he inflicted a check on the empire of China As the Chinese government declared itself unable to punish Formosan pirates for outrages committed on Japanese ships (1874), Meiji Tenno landed a force on the island, chastised the bandits and remained in possession of certain districts until the compensation was paid. The unparalleled advances made by the new government were now held to justify a demand for the revision of the foreign treaties, and negotiations were opened They failed, and the consequent disappointment gave rise to a strong antiforeign reaction. Foreigners were assaulted and even the Russian tsarevitch, afterward the tsar Nicholas II. was attacked in the streets of Tōkyō. A renened attempt to revise the treaties in 1894 was more successful, and in that year Great Britain concluded a revised treaty nith Japan Other nations followed. and by 1901 all those obnoxious clauses suggestive of political inferiority had disappeared from the treaties.

In the same year (1894) war broke out with China. Meiji Tenno reviened the troops as they left Japan for Korea and Manchuria. and personally distributed rewards to those who had won distinction. In the war with Russia. 1904–5, the same was the case. and it was to the virtues of their emperor that his generals ascribed the Japanese victories.

In his wise patriotism as in all matters, Meiji Tenno always placed himself in the van of his countrymen. He led them out of feudalism, and lived to see his country advanced to the first rank of nations: and he was the first oriental sovereign to form an offensive and defensive alliance with a first-rate European power.

In 1869 Meiji Tenno married Princess Haru, daughter of Ichijō Tadaka, a noble of the first rank. He had one son and several daughters. Mutsuhito adopted the epithet of Meiji. or "Enlightened Peace," as the nengo or title of his reign. Thus the year 1901, according to the Japanese calendar, was the 34th year of Meiji. He died at Tōkyō on July 30, 1912. He was posthumously styled the emperor Meiji Tenno, according to the custom of Japan. He was succeeded by his son Yoshihito.

MEIKTILA, a district in the Mandalay division of Burma. The district lies in the dry zone, but it includes also a strip of the wetter forested Shan hills on the east. Except for this portion it is a slightly undulating plain, with stretches of dark "cotton" soil, suffering from a low rainfall which is uncertain. The climate is healthful except in the eastern tracts: though the heat of April, as in Mandalay, is severe—the thermometer rising in the afternoons to over 100° F. from March to June. The chief agricultural products are rice (grown on land irrigated by streams from the Shan hills), sesame, cotton, peanuts, peas, maize. millet and gram. In the heart of the district is an interesting lake. It is artificial, and according to Burmese legend was begun 2,400 years ago by the grandfather of Gautama Buddha. It is 7 mi. long. averages half a mile broad, and covers an area of 3½ sq.mi. With the Minhla and other connected lakes it irrigates a large extent of country.

The area of the district is 2.238 sq.mi., and the population (1941), 344,02j. The vast majority of the population is Burmese Buddhist. The headquarters town, Meiktila, stands on the banks of the lake, which supplies good drinking water. Pop. (1953) 25,180. A branch railway connects it at Thazi station with the Rangoon-Mandalay line, and continues westward to its terminus on the Irrawaddy at Myingyan. From Thazi, the Shan States railway ascends the hills to the hill station of Kalaw and 3j mi. beyond.

MEINONG, ALEXIUS (1853–1920), Austrian philosopher and psychologist, celebrated for his *Gegenstandstheorie,* was born in Lemberg on July 17, 1853. A pupil of Franz Brentano (*q.v.*) in Vienna from 187j to 1878, he became in 1882 extraordinary professor and in 1889 ordinary professor of philosophy at Graz, where he remained until his death on Nov. 27, 1920. Among his more important writings are *Über Annahmen* (1902; and ed., 1910), a study of supposals; *Über Möglichkeit* und *Wahrscheinlichkeit* (1915); *Über emotionale* Prasentation (1917); and the articles collected as Gesammelte *Abhandlungen,* 2 vol. (1913–14; 2nd ed , 1929).

Meinong's theory is rooted in the philosophical psychology of Brentano. He assumes throughout that "intentionality" or directedness-to-objects is the basic feature of mental states, but draws a distinction between two aspects of every experience: (1) a content (*Inhalt*), which gives it a direction to one particular object rather than another; and (2) an act, which represents the manner in which the experience approaches its object. Mental states are classified into (1) presentations (*Vorstellungen*); (2) thought experiences, nhich include judgments and certain judgmentlike experiences, of which the most interesting are supposals (*Annahmen*); (3) emotions; and (4) desires.

Meinong's most original contribution to philosophy lies in his object theory (*Gegenstandstheorie*), in which he postulates many classes of mind-independent objects corresponding to various kinds of mental approach.

Atnong the objects of presentation are particular things and their qualities, nhose being (if they have any) is existence (*Existenz*), and relations and relational complexes. whose being (if they have any) is subsistence (*Bestand*). The objects of the thought experiences are called "objectives": these correspond to the objective propositions of Moore and Russell, they may be facts or nonfacts, and, if they are facts, they subsist. To emotions there correspond "dignitatives" (the agreeable. the beautiful, the true and the good): and to desires "desideratives" (various types of "ought"). Meinong holds, further. that objects remain objects and have a definite character and definite properties (*Sosein*) even if they have no being (Sein): thus a golden mountain is golden and is a mountain. even though no such object exists. Meinong did not teach that nonexistent objects enjoyed subsistence. though Russell imputed this doctrine to him and was led by it to his own theory of descriptions.

See G. Dames Hick's "The Philosophical Researches of Meinong," in *Mind,* "New Series,"31 (1922), reprinted in Critical *Realism* (1938); J. N Findlay, *Meinong's Theory of* Objects (1933). (J. N. F.)

MEÏR, Jewish rabbi of the 2nd century, A.D. was born in Asia Minor. He was the most notable of the disciples of Akiba ben Joseph, and after the Hadrianic repressions of A.D. 135 was instrumental in refounding the Palestinian schools at Usha. Among his teachers was also Elisha ben Abuyah (*q.v.*), and Mei'r continued to be devoted to Elisha after the latter's apostasy. Meïr's wife. Beruriah, a daughter of the martyr Hananiah ben Teradion, is often cited in the Talmud as an exemplar of generosity and faith. Meïr himself was the author of many famous sayings. His wisdom mas proverbial, and to him in particular was assigned an intimate acquaintance with fables. "With the death of Rabbi Mei'r." says the Mishnah, "fabulists ceased to be." Mei'r contributed largely to the material from which finally emerged the Mishnah (see TALMUD). Of his great dialectic skill it was said jestingly that he could give 150 reasons to prove a thing clean and 150 to prove it unclean. His balanced judgment fitted him to carry on Xkiba's work, sifting and arranging the oral traditions, and thus preparing the ground for the Mishnaic code. Mei'r left Palestine some time before his death, owing to disagreements between him and the patriarch.

Meïr died in Asia Minor.

MEIR OF ROTHENBURG (*c.* 1215–1293), the greatest rabbinical authority of German Jewry of the 13th century, was born in Worms He studied under the French glossators (*tosaphists*) in Paris. where he witnessed, in 1242 or 1244, the public burning of the Talmud.

On settling in Rothenburg and opening a Talmudic school there, he soon became famous as an authority on rabbinic law. His *responsa* (answers to questions regarding law and ritual) contain elaborate discussions of the democratic principles underlying community government of his day. For nearly half a century he acted as the supreme court of appeals for Germany and surrounding countries. When in **1286** Emperor Rudolf I attempted to abrogate the political freedom of the Jews, and to force upon them the status of *servi camerae* ("serfs of the treasury"). Meir became the central figure in the tremendous struggle for freedom that ensued. Eventually he led a mass exodus out of Germany. After crossing the Alps, however, he was apprehended. brought back and imprisoned. Since the struggle of the Jews for freedom continued unabated, he was kept in prison as a pawn in the political game until his death in 1293; and his body mas not delivered for burial until 1307.

Meir wrote glosses to the Talmud *(tosaphoth)* and numerous *responsa* of the utmost value for historical research. His main teachings, however, were included in numerous literary compositions by his disciples, compositions that became classical textbooks of law and ritual for Ashkenazic Jews of all subsequent generations.

See L. Ginzberg, in *Jewish Encyclopedia,* vol. viii; Irving **A** Agus, *Rabbi Meir of Rothenburg* (1947) (I. **A.** A.)

MEISSEN. The mark of Meissen was originally a district centring round the castle of Meissen or Misnia on the middle Elbe, which was built about **920** by the German king Henry **I** the Fowler, as a defense against the Slavs After the death of Gero, margrave of the Saxon east mark, in **965,** his territory was divided into five marks, one of which was called Meissen In 985 the emperor Otto III bestowed the office of margrave upon Ekkard **I,** margrave of Merseburg, and the district comprising the marks of Meissen, llierseburg and Zeitz was generally known as the mark of Meissen. When Ekkard II died (1046) it was divided, and Meissen proper was given successively to William and Otto, counts of Weimar, and Egbert II, count of Brunsmick. Egbert was a rival of the emperor Henry IV and died under the imperial ban in 1089, when Meissen was bestowed upon Henry **I,** count of Wettin, but when in turn his son Henry II died without issue in 1123 Meissen mas given by the emperor Henry V to Hermann II, count of Wintzenburg; but Henry I's second cousin Conrad eventually obtained possession of Meissen in 1130. Conrad, called the Great, extended the boundaries of Meissen before abdicating in **1156** in favour of his son Otto. known as the Rich. Otto appointed his younger son Dietrich as his successor and was attacked and taken prisoner by his elder son Albert: but, after obtaining his release by order of the emperor Frederick **I,** he had only just renewed the war when he died in 1190. During his reign silver mines were opened in the Harz mountains, towns were founded, roads were made and the general condition of the country was improved. Otto mas succeeded by his son Albert called the Proud, who was engaged in warfare with his brother Dietrich until his death in 1195. As Albert left no children. Meissen was seized by the emperor Henry VI as a vacant fief of the empire; but Dietrich, called the Oppressed. secured the mark after Henry's death in 1197. Dietrich married Jutta, daughter of Hermann I, landgrave of Thuringia. and was succeeded in **1221** by his infant son Henry, surnamed the Illustrious; who on arriving at maturity obtained as reward for supporting the emperor Frederick II against the pope a promise to succeed his uncle, Henry Raspe IV, as landgrave of Thuringia. In 1243 Henry's son Albert was betrothed to Margaret. daughter of Frederick II; and Pleissnerland, a district west of Meissen, was added to his possessions Having gained Thuringia and the Saxon palatinate on his uncle's death in 1247, he granted sections of his lands to his three sons in **126;.** but retained Meissen. A series of family feuds followed.

Eventually, Albert's son Frederick obtained possession of the greater part of the mark, and was invested with it by the German king Henry VII in 1310. During these years the part of Meissen around Dresden had been in the possession of Frederick, youngest son of the margrave Henry the Illustrious, and when he died in **1316** it came to his nephew Frederick. About 1312 Frederick, who had become involved in a dispute with Waldemar. margrave of Brandenburg, over the possession of lower Lusatia, was taken prisoner. Surrendering lower Lusatia he was released, but it was only after Waldemar's death in 1319 that he obtained undisputed possession of Meissen. Frederick, who was surnamed the Peaceful, died in 1323 and was followed as margrave by his son Frederick II, called the Grave, who added several counties to his inheritance. From this latter Frederick's death in 1349 until **1381** the lands of the family mere ruled by his three sons jointly: but after the death of his eldest son Frederick III in **1381** a division was made by which Meissen fell to his youngest son William **I.** In 1407 William was succeeded by his nephew Frederick, called the Warlike, who in 1423 received from the emperor Sigismund the electoral duchy of Saxe-Wittenberg. The mark then became merged in the duchy of Saxony.

MEISSEN, a town in the district of Dresden, Ger., in the former *Land* of Saxony, on both banks of the Elbe, **1j** mi. N.W. from the city of Dresden on the railway to Leipzig via Dobeln. Pop. (1950) 49,455. Meissen was founded about 920 by Henry the Fowler and from **968** to **1581** was the seat of a line of bishops, who ranked as princes of the empire. The town suffered greatly during the various wars of religion. Kolln on the right bank of the Elbe was incorporated with Meissen in 1901. The old town lies on the left bank of the river, between the streams Meisse and Triebisch. The cathedral, one of the finest early Gothic buildings in Germany, stands on the Schlossberg, above the town. It is said to have been founded by the emperor Otto the Great, but the present building was begun in the 13th century and was completed about 1450. A restoration, including the rebuilding of the two toners, was carried out in 1903–08. Adjoining the cathedral is the castle, dating from 1471–83, but restored about **1676,** and after **1860.** The convent of St. Afra, which stood on the Xfraberg, was suppressed by Duke Maurice in **1j43,** and was converted by him into a school (the Fürsten Schule), one of the most renowned classical schools in Germany, which counts Lessing and Gellert among its former pupils. Other public buildings of interest are the town hall, built in 1479 and restored in **1875;** and the Franciscan church now used as a museum of objects connected with the history of Meissen. Since 1710 Meissen has been the seat of the manufacture of Dresden china. Meissen also contains iron foundries, factories for making earthenware stoves, pottery, glass, pianos, explosives and matches. sugar refineries. breneries and jute works. A considerable trade is carried on in the nine produced in the surrounding vineyards. *See* Index references under "Meissen" in vol 24.

MEISSONIER, JEAN LOUIS ERNEST (1815–1891), French painter and illustrator of military and historical subjects, was born at Lyons on Feb. **21.** 181**j.** He studied first under Jules Potier, then in the studio of Léon Cogniet and first exhibited at the Salon in **1834** the picture "Les Bourgeois Flamands," which is possibly the one afteraard in the Wallace collection, London, entitled "Dutch Burghers." In his early years Meissonier spent much time making illustrations for the publishers Curmer and Hetzel. but he exhibited regularly at the Salon and received the highest official honours from the middle of the 1840s onward. He died in Paris on Jan. **31,** 1891.

The greater part of Meissonier's painting is on a small scale and is concerned with military subjects or with genre in a historical setting. "Solferino" **(1863)** and "La Rixe" **(18**55) are examples in these two categories, though both pictures are somewhat larger than usual. Meissonier's minute and scrupulous technique was largely derived from the study of Dutch painters of the 17th century. but the documentary approach of his preparatory study of costume and armour and of his detailed observation of nature (such as his systematic analysis of the movements of horses) links him with the scientific spirit of the 19th century.

The largest collection of Meissonier's pictures is in the Louvre,

Paris, and includes "Self-portrait" (1889), "L'homme a l'épée" (1851), "Les amateurs de peinture" (1860), "Napoleon III at Solferino" (1863) and "Campagne de France, 1814" (1864). The 16 pictures in the Wallace collection include "The Hired Assassins" (1852) and "The Roadside Inn" (1865).

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MEISSONIER, JUSTE AURÈLE (1675 or 1693–1750), French goldsmith, architect and interior decorator, also sculptor and painter, mas born at Turin, Italy, in 1675 or 1693. He early migrated to Paris, where he worked until his death, July 31, 1750.

Meissonier's powerful and fertile imagination, his animated, unsymmetrical compositions uniting the most contrasting, original motifs, raised him to leadership among the insurgent creators of the rococo, a style of considerable though short-lived influence. He received his warrant as master goldsmith from Louis XV in 1724 and was appointed designer for the king's bedchamber and cabinet in 1726. Meissonier's fine sketches for interior decoration, furniture and goldsmith's work can be seen in his well-known collections: *Livre d'ornements* en trente *pièces,* Livre *d'orfèvrerie d'église en* six *pièces* and *Ornements* de la carte *chronologique du* roi. He ranged with equal facility from snuffboxes to watch cases or to sword hilts. As a goldsmith, moreover, he was especially remarkable for the boldness of his conceptions; *e.g.,* the two tureens and the centrepiece for a table supplied to the duke of Kingston in 1735.

As an architect Meissonier distinguished himself with a plan for the façade oi the church of St. Sulpice in Paris; and Count Bielinski, grand marshal of the court of Poland, commissioned him for the decoration of his drawing room. Meissonier also planned the details of the firework display in honour of the birth of Louis XV's son, the dauphin.

See H. Nocq, Le *Poinçon* de Paris, vol. iii, p. 225 (1928). (S. GR.)

MEISTERSINGER, the name used by certain German musicians and poets, chiefly of the artisan and trading classes, in the 14th, 15th and 16th centuries. They claimed to be heirs of 12 old "masters," accomplished poets skilled in the medieval *artes* and in musical theory (Heinrich von Meissen, called "Frauenlob" [*q.v.*] was said to be their founder); their true predecessors, however, were probably fraternities of laymen, trained to sing in church and elsewhere. Later—since music and poetry were "crafts" to be taught and learned—these fraternities became *Singschulen* ("song schools"), organized like craft guilds; and their principal activity became the holding—still in church—of singing competitions. Composition was restricted to fitting new words to tunes ascribed to the old masters; subject matter, metre, language and performance were governed by an increasingly strict code of rules (*Tabulatur*). These deadening restrictions led Hans Folz, a barber-surgeon from Worms (died *c.* 1515), to persuade the Niirnberg Singschule to permit a wider range of subjects and the composition of new tunes. These reforms, adopted elsewhere, restored some life to the *Singschulen;* henceforth a member, having passed through the grades of *Schüler, Schulfreund,* Singer and *Dichter,* became a "master" by having a tune of his own approved by the *Merker* ("adjudicators"). In this freer atmosphere Hans Sachs (*q.v.*) flourished—though some regard the 16th century as a period of decline rather than of flourishing.

Nevertheless, music, form and subject matter remained remarkably constant through the centuries. The music, derived from Gregorian chant, determined the metre (Ton meant both "metre" and "melody"). Each strophe (*Gesätz*) consisted of two identical Stollen, forming the *Aufgesang,* and an *Abgesang* with its separate metrical scheme—a form derived from *Minnesang.* Verses were based on syllable counting regardless of stress or quantity: rhyme schemes were often elaborate. Three strophes, or a multiple of three, constituted a song (Bar); for large subjects several Tone were used. Songs were unaccompanied solos. For the *Singschulen* in church a wide range of religious subjects (*e.g.,* the nature of the Trinity. episodes from the Bible and from Jewish history, praise of the Virgin Mary) were versified! learnedly but without much original thought; after the Reformation the text of Luther's Bible was rigidly adhered to. From the 15th century serious secular subjects are also found. At the *Zechsingen,* held afterward in a tavern (perhaps not an official part of the Sing*schule*), subjects were humorous. sometimes obscene.

From the earliest centres, Mainz, Worms and Strasbourg, the movement spread all over south Germany and to Silesia and Bohemia; north Germany had individual *Meistersinger,* but no Singschulen. The best documented centre is Niirnberg. The *Meistersinger* were not popular figures, as Wagner's opera Die *Meistersinger* suggests; they were largely ignored by professional men, humanists and the general populace, their craft was esoteric and their songs were not published. They produced few outstanding artists or songs. Their importance lies rather in their devotion to their art in a troubled age and in their constant efforts to inculcate religious and moral principles. After 1600, attempts—mostly unsuccessful—at modernization were made; but the Sing*schulen* slowly declined and disappeared, though the last one, at Memmingen, was not disbanded until 187 j.

BIBLIOGRAPHY.—Collections are *Meisterlieder* der *Kolmarer Hand*schrijt, ed. by K. Bartsch (1862); Die Meisterlieder des Hans Folz, ed. by A. L. Mayer (1908). Full discussion and bibliography in A. Taylor, The Literary History of Meistergesang (1937); W. Stammler, Von der Mystik *zum* Barock, 2nd ed. (1950); B. Nagel, Der Deutsche *Meister*sang (1952). (J. R. WE.)

MEITHEI, the principal tribe inhabiting the valley of Manipur in Assam; probably of mixed origin and related to the Kuki and Naga tribes, the Ao in particular, also probably to the Syntengs and Kacharis. They have a culture probably Shan in origin, though never Buddhist, and Hinduized in the first half of the 18th century A.D. They are great rice growers, fishermen and horse breeders; polo and hockey are national games and boat racing an annual pastime. The head of the people is a Maharaja, under whom is a judicial body known as the Chirap court; the state is divided into adminstrative areas called lam, each with central and village officials. The ancient civil and military organization was by functional divisions like that of the Ahoms. There are seven patrilineal exogamous clans, and marriage into the mother's clan is forbidden for one generation Head-hunting was practised until Hinduism became general, before which the Meithei were meat eaters and buried their dead. They now burn them and have an institution called *singlup*—a sort of burial club for ensuring the provision of wood for the cremation of contributors. In spite of the Hindu religion animistic beliefs and practices are strong. *Maiba* and *maibi*—Medicine men and women—are numerous and popular; forms of ancestor worship. traces of snake worship, witchcraft, tabu, vampires, whose astral bodies devour men's livers, all flourish, and animistic deities are worshipped no less than orthodox Hindu gods. Indeed, a special custodian of ancient godlings holds one of the most prominent religious posts.

The Maharaja is the divine head of the state. both religious and secular, and is the chief rain maker. Like the Ahom princes he has a human scapegoat provided on certain occasions to take on him all the Maharaja's guilt.

The language spoken is Tibeto-Burman and allied to the Kuki tongue. There is an archaic form of the language, now incomprehensible, and though the present script is derived from the Bengali. there is a tradition that the Chinese first taught them writing.

See T. C. Hodson, The *Meithei* (1908). (J. H. H.)

MEKNÈS (MEQUINEZ), a city of Morocco. some 1,670 ft. above the sea, about 70 mi. from the vest coast and 36 mi. W.S.W. of Fez, on a long spur in a plain bounded on the north by the massif of Jebel Zerhoun and on the south by the plateaus of mid-Atlas on the borders of the Wad Bou Fekrane, on the road to Rabat, in 33° 56′ N., 5° 50′ W. The town wall, with its four-cornered towers, is pierced by nine gates. A lower wall of wider circuit protects the luxuriant gardens in the outskirts. Meknès, at a distance, appears to be a city of palaces, but it possesses few buildings of any note except the palace and the mosque of Mulai Ismaïl, which serves as the royal burying place. The palace, founded in 1634, was described in 1721 by John Windus in his Journey to *Mequinez* (1725) as "about 4 mi. in circumference, the whole building exceeding massy, and the walls in every part very thick; the outward one about a mile long and 25 ft. thick."

The interior is composed of oblong courtyards surrounded by buildings and arcades. These buildings are more or less square, with pyramidal roofs ornamented outside with green glazed tiles, and inside with richly carved and painted woodwork in Mauresque style. The walls are tiled to a height of 4 or 5 ft., and above they are finished in plaster, whitewashed or carved into filigree work.

The ancient stables are particularly fine. One may note also some beautiful gateways, especially Bab-Mansour-el-Euldj (18th century), on the square El-Hedim, Bab-el-Khamis, on the west of the Mellah. Outside the walls to the northwest is the tomb of Sidi-Mohammed-ben-Aïssa, patron of Meknks and of the religious brotherhood of the Ai'ssaouas, well known for its strange rites. The new town stretches to the east of the original one, in a very open situation, near the railway station, which links it with Fez, Tangier and Casablanca. Meknks is a makhzen or imperial town, one of the residences of the sultan. It is located in the middle of vast, fertile plains at the exit from the mid-Atlas and Jebel Zarhoun. The population (1960) was 175,943, of whom 160,736 were natives.

Meknès is named from the great Zenata tribe of the Miknassa. It was at first an Almohade citadel called Tagraret. Its great importance dates from the 17th century; it was the favourite residence of Moulai-Ismaïl, who, during his long reign of 55 years, raised there the buildings which gave to Meknès the name of "Moroccan Versailles." Gen. Moinier entered it on June 8, 1911, and the surrounding region was afterward pacified.

See O. Houdas, *Monographie de Meknès,* traduit de I'arabe (1885); Ed. Arnauld, *Monographie de la region de Meknès* (1917).

MEKONG (ME NAM KONG), sometimes known as the Cambodia river, a great river of Asia, has its origin in the Tibetan highlands. It is one of the longest rivers in Asia. It is about 2,500 mi. in length, of which 1,100 flow through China and 1,400 through Laos, Cambodia and Vietnam. Its sources are supposed to rise on the slopes of Dza-Nag-Lung-Mung in about 33° N., 93° E., at an altitude of 16,700 ft. above sea level. Throughout the greater part of its course in Tibet, where it is called the Dza-Chu, it flows southeastward to Chiamdo, on the great east and west caravan route from China to Lhasa. At this point it is about 10.000 ft. above sea level. From here it flows southward through little-known mountain wastes. Below Dayul in lat. 29° it is known by the Chinese name of Lantsan Kiang. For the next 300 mi. of its course the Lantsan Kiang, or, as it is called among the Thai peoples inhabiting its rugged valley, the Mekong, is very little known to us. The river flows beneath bare and rocky walls with the speed of a mountain torrent, although at its exit from Chinese territory its width reaches 300 to 400 yd. In 25° 18′ N. the Tali-Bhamo caravan route crosses the river by an iron suspension bridge at a height of 4,700 ft. above sea level. From this point to Chieng or Keng Hung, the head of the old confederacy of the Sibsawng Punna or Twelve States, it is little known; the fact that it falls some 900 ft. for each degree of latitude indicates the character of the river, the course of which is constantly deviated by the varying directions of the mountainous massifs through which it passes. Under the provisions of the Anglo-French agreement of January 1896, from the Chinese frontier southward to the mouth of the Nam Hok the Mekong forms the frontier between Shan state on the west and the territories acquired from Thailand by France in 1893. By the treaty of 1893, from that point southward to about 13° 30′ N. it is also the frontier between Laos, Cambodia and Thailand. Between the Siamese Shan town of Chieng Sen and Luang Prabang it is joined by some important tributaries: the Nam Beng, the Nam-Hou and the Nam-Khan. This portion is obstructed by rapids. From Luang Prabang the river cuts its way for two degrees through a lonely jungle country among receding hills of low elevation. From Chieng Khan the river forces its way through its most serious rapid barrier, and receives some important tributaries from the highlands of Tung Chieng Kum and Chieng Kwang. In 104° E. the river resumes its course through a country thinly peopled. At Kemarat (16° N.) the fourth serious rapid barrier occurs, some 60 mi. in length, and the last at Khong in 14° N. From there to its outfall in the China sea the river winds for some 400 mi. through Cambodia, where it divides into three arms, and Vietnam, regions formed of the alluvium of the delta which is ceaselessly gaining on the sea. In origin a mountain stream, it becomes swollen at the melting of the snows. As a plateau river it is increased from June to Oct. by the rains of the southwest monsoon. From Oct. to May it occupies only a portion of its bed. In the plain and delta part of its course, it floods Cambodia and Vietnam, which owe to it their fertility.

MELA, POMPONIUS, of Tingentera (Algeciras?) in southern Spain, the earliest Latin geographer, who wrote De *Chorographia,* a short handbook for the general reader, about A.D. 43 or 44. According to Mela the earth, at the centre of the universe, was divided into five zones: the two temperate ones were habitable, but only one of them (the northern one) was known. The surrounding ocean cut into it in four seas, the most important of them the Mediterranean. Mela followed the coast line of the Mediterranean anticlockwise from the Straits of Gibraltar and listed islands (books i and ii). Then (book iii) he moved clockwise round the ocean coasts of Europe, Asia and Africa (of which he knew little); he mentioned islands at convenient intervals, but often neglected the interior.

Mela laid no claim to originality; his information, in fact, was frequently obsolete. Thus he repeated a theory (abandoned generations earlier) giving the Danube both an Adriatic and a Black sea mouth. His style showed echoes of Sallust's geographical passages and he aimed at being readable. Thus he avoided technical details, like distances and orientations, and, though he occasionally gave bare lists, he usually selected the significant and in a short phrase indicated the interest of places mentioned. Less was said of familiar regions than of distant countries, where even fabulous material was freely admitted.

Mela was used by the elder Pliny and is occasionally cited by later writers.

See C. Frick (ed.), ***De Chorographia*** (1880). (E. BA.)

MELAMPUS, a legendary seer and physician, son of Amythaon and Eidomene, brother of Bias, and eponym of the family of the Melampodidae. Two young serpents, whose lives he had saved, licked his ears while he slept, and from that time he understood the language of birds and beasts. In the art of divination he received instruction from Apollo himself. To gain the consent of Neleus, king of Pylos, to the marriage of his daughter Pero with Bias, Melampus undertook to obtain possession of the oxen of the Thessalian prince Iphiclus. As Melampus had foretold, he was caught and imprisoned, but was released by Phylacus (the father of Iphiclus) on giving proof of his powers of divination, and was finally presented with the oxen as a reward for having restored the virility of the son. Melampus subsequently obtained a share in the kingdom of Argos in return for having cured the daughters of king Proetus. He was worshiped at Aegosthena in the Megarid. In his character of physician, he was the reputed discoverer of the herb melampodium, a kind of hellebore. (See Roscher's Lexikon.)

Melampus is also the name of the author of a treatise on Divination by means of Palpitation (*Palmon*) and Birthmarks ('Elaion), probably of the 3rd century B.C. Edition by J. G. Franz in Scriptores physiognomiae veteres (1780).

MELANCHTHON, PHILIPP (1497–1560), German theologian, reformer and educator, was born at Bretten in Baden on Feb. 16, 1497. His father, Georg Schwarzerd, mas an armourer under the Palatinate princes; his mother, Barbara Reuter, a niece of Johann Reuchlin (*q.v.*), was shrewd, thrifty and affectionate. Reuchlin, famed Hebraist and humanist, supervised Philipp's education, recommending Johann Unger as a private tutor and then directing him to the Pforzheim Latin school, where he studied under Georg Simler and Johann Hiltebrant, both Reuchlinists. In recognition of Philipp's achievements in the Greek classics, Reuchlin, following a contemporary custom, named him Melanchthon (the Greek form of *Schwarzerd,* "black earth"). He went in 1509 to Heidelberg, where he took the B.A. degree, and in 1512 to Tiibingen, where he earned the M.A. The only other academic distinction he accepted was the B.D. from Wittenberg (1519).

While at Heidelberg and Tiibingen, Melanchthon was influenced by studying Rudolph Agricola, John Wessel and William Occam, and he began to question many of the truisms of scholastic theology. His wide reading in the Greek classics and Hebrew Scripture strengthened his critical outlook, and prepared him for an acceptance of the evangelical doctrines he encountered later at Wittenberg. At Heidelberg he did his first teaching as a tutor, and at Tiibingen his first lecturing as a *Privatdocent* in the classics. These effortswere markedly successiul. Before leaving Tübingen in 1518, Melanchthon had published translations of Plutarch, Pythagoras and Lucidas, a grammar on the rudiments of the Greek language, and had projected works on both Aratus and Aristotle. He was praised by Erasmus and was known to huinanists as far away as England

In 1518 Reuchlin relayed a call from the elector of Saxony for Melanchthon to teach Greek at Wittenberg. Four days after his arrival in Wittenberg, on Aug. 29, 1518, Melanchthon delivered an address on The *Improvement of* Studies that set the stage for a new educational program at Wittenberg. He proposed in effect to rejuvenate society and regenerate instruction by dropping traditional methods and secondary studies and returning to original sources. He began his own lectures with Homer and the Epistle to Titus. Luther was greatly impressed and received a fresh impulse toward the study of Greek; his translation of Scriptures. begun as early as 1517, now made rapid progress, Melanchthon helping to collate the Greek versions and revising Luther's translations. Melanchthon felt the spell of Luther's personality, and became so much a part of the evangelical movement that late in 1519 he openly broke with Reuchlin.

In 1520 Melanchthon married Katharine Krapp of Wittenberg; four children — Anna, Philipp. Georg and Magdalen—were born.

Melanchthon was first drawn into the Reformation controversy through the Leipzig Disputation (June 27–July 8. 1j19). Johann Eck reproved him for giving aid to Luther and Karlstadt during the debate, and later assailed him in a pamphlet. Melanchthon replied in a brief and moderately worded treatise, setting forth Luther's first principle of the supreme authority of Scripture in opposition to the patristic writings on which Eck relied. In 1521, during Luther's confinement in the Wartburg, Melanchthon was leader of the Reformation cause at Wittenberg. He was unable to curb the excesses of Karlstadt and the Zwickau enthusiasts who chose to inaugurate new reforms by violence. The enthusiasts' opposition to infant baptism seemed to Melanchthon not altogether irrational, and he felt that only Luther could judge whether their claims of personal inspiration were from God or Satan. In the same year. 1j21, Melanchthon published his Loci *communes rerum* theologicarunz, the first systematized presentation of the reformed theology. It immediately established him as a theological leader.

After the first diet of Speyer (1526), where a precarious peace was patched up for the reformed faith, Melanchthon mas deputed as one of the 28 commissioners to visit the reformed states and regulate the constitution of the churches. In 1528 this resulted in the publication of *Unterricht* der Visitatoren, a set of instructions for the visitors. In addition to a statement of evangelical doctrine, it contained an outline of education for the elementary grades which was enacted into law to establish the first real Protestant public school system. Melanchthon's school plan, copied far and wide in Germany, along with his many textbooks, the training of teachers at Wittenberg, his work in establishing universities and his advice on revising school courses, earned for him the title "Preceptor of Germany."

Melanchthon was present when the protest, from which the term "Protestant" originated, was lodged in the name of freedom of conscience against the Roman Catholic majority at Speyer (1529). At the diet of Augsburg (1530) Melanchthon was the leading representative of the Reformation, and it was he who prepared the Augsburg Confession (*q.v.*), which influenced every subsequent major credal statement in Protestantism. In the confession he tried to be conciliatory without sacrificing evangelical conviction. He held conferences with papal divines appointed to adjust differences,and afterward wrote a spirited defense of the confession known as the Apology, one of the best writings of the Reformation.

After the Augsburg conference further attempts were made to settle the Reformation controversies by compromise, and Melanchthon. from his conciliatory spirit and facility of access, appeared to the defenders of the old faith the fittest of the reformers with whom to deal. Despite frequent charges of collaboration with Roman Catholicism, Melanchthon staunchly upheld the evangelical doctrines of justification by faith and scriptural authority. For the sake of unity. he accepted papal government, although he mould not accept any inherent papal superiority. His views on the papacy were appended to the Smalkald Articles (1537) in an Appendix on the Papacy.

The year after Luther's death, when the battle of Mühlberg (1547) had given a seemingly crushing blow to the Protestant cause. an attempt was made to unite the Evangelicals and Romanists in the provisional agreements of the Augsburg Interim. Melanchthon refused to accept the Interim until justification by faith was ensured as a fundamental doctrine. Then, for the sake of order and peace. he declared that those principles which did not violate justification by faith might be observed as *adiaphora* or nonessentials. He allowed the necessity of good works to salvation, but not in the old sense of meriting righteousness; and he accepted the seven sacraments, but only as rites that had no inherent efficacyto salvation. and so on. Melanchthon was bitterly criticized for his stand on the Interim, though he never really swerved from his own former views nor from those of Luther as expressed in their previous writings. His later years were occupied with controversies within the Evangelical church and fruitless conferences with his Romanist adversaries. He died in his 63rd year. on April 19, 1560, and his body was laid beside that of Martin Luther in the Schlosskirche at Wittenberg.

Melanchthon's ready pen, clear thought and elegant style made him the scribe of the Reformation. and the representative of the evangelicals at numerous colloquies. He never attained entire independence of Luther. though he gradually modified some of his positions. These modifications centred around the Eucharist, man's part in conversion and the place of good works.

As late as 1530 Melanchthon agreed with Luther on the Lord's Supper. At Marburg (1529) he objected to the "memorial" view of Zwingli and Oecolampadius, but in that same year his own view began to shift from Luther's "consubstantiation" to a more spiritual concept. The changes that Melanchthon introduced in 1540 in the tenth article of the Augsburg Confession indicated that his view on the Eucharist paralleled Calvin's. After Melanchthon's death. many of his followers were attacked as crypto-Calvinists.

Melanchthon also came to believe that man has a part in conversion. At first, following Luther's cardinal doctrine of grace, Melanchthon seemed to reject free will. In the Loci of 1521 he renounced Aristotle and philosophy in general, since "philosophers attribute everything to human power, while the sacred writings represent all moral power as lost by the fall." He pushed the Augustinian doctrine of irresistible grace close to fatalism. However, his *Commentary* on Colossians (1527) implied a rejection of predestination, and he did not mention predestination in the Augsburg Confession. In the Apology of 1531 he spoke of the mercy of God being offered to all. By 1532 in the Commentary on Romans he spoke of man's struggle to accept or reject the love of God In the 1535 Loci he pointed out that man must at least accept the gift of God's salvation, and that man is therefore responsible for his destiny. This view is clearly expressed in De Anima (1540). "God draws. but he draws him who is willing." Melanchthon held that in justification there is a certain causality. though not worthiness, in the recipient, and that man's activity is concurrent as a cause with the Holy Spirit and God's word.

Because of his interest in ethics, Melanchthon increasingly emphasized good works as the inevitable fruits of iaith. Luther was disposed to make faith itself the principle of sanctification. Melanchthon laid more stress on law. In his visitation articles of 1528 he urged pastors to instruct people in the necessity of repentance and to bring the threat of the law to bear upon men in order to instill iaith. This brought upon him the opposition of the Anti-

nomian Johannes Agricola. In the Loci of 1535 Melanchthon sought to put the fact of the coexistence of justification and good works in the believer on a secure basis by declaring the latter "necessary" to eternal life. In the Loci of 1543 he did not say that good works were necessary to obtain salvation, and in the Leipzig Interim he declared that good works in no way implied that eternal life is merited by the worthiness of our own actions. For the sake of public order Melanchthon was led to lay more and more stress upon the law and moral ideas, but his evangelical position was that man is saved by faith and that good works are the "necessary" expression of faith, for good works flow from faith.

The principal works and correspondence of Melanchthon are contained in the Corpus *Reformatorum*, 28 vol. (1834–60), edited by K. G. Bretschneider and E. Bindseil, to which must be added *Supplementa* Melanchthoniana (1910–) by O. Clemen et *al.* See Index references under "Melanchthon, Philipp" in vol. 24.

BIBLIOGRAPHY.—The earliest biography of Melanchthon was written by Joachim Camerarius (1566). German biographies include those by Georg Ellinger (1902) and Karl Schmidt (1861). English biographies include works by J. W. Richard (1898) and George Wilson (1897). Karl Hartfelder's *Philipp Melanchthon als Praeceptor Germaniae* (1889) presents Melanchthon as a humanist and gives a bibliography of all his works and all the works written about him up to that time. Later works on Melanchthon include *Melanchthons Werke* (1951–), ed. by Robert Stupperich; Hans Engelland, *Melanchthon, Glauben und Handeln* (1931); *The Loci Communes of Philip Melanchthon* (1944), trans. by C. L. Hill; Clyde L. Manschreck, *Melanchthon: The Quiet Reformer* (1958). (C. L. MK.)

MELANESIA (Gr. μέλας, black, and νῆσος, island), one of three great geographical divisions of oceanic islands in the central and western Pacific. It embraces the Bismarck archipelago, northeast of New Guinea, the Louisiade, Solomon. Santa Cruz, New Hebrides and Loyalty islands, New Caledonia, Fiji and intervening groups.

Native Population. — Because the majority of Melanesians are dark skinned, they have been regarded by many as members of the Negro race. Genetic variation, however, permits light brown skinned individuals, who prevail in some communities. Hair form ranges from straight to very curly. the characteristic frizzy appearance being deliberately cultivated. From group to group differences in nose form and stature are considerable. The heavy lips of West African Negroes appear infrequently. Common features are large jaws with "shovel shaped" incisor and large molar teeth. Melanesians appear to represent an old, rather primitive southeast Asiatic strain of Homo *sapiens* which has been overlaid in varying degrees by newer strains also coming from southeast Asia.

Language. — In the interior of the Solomons. New Britain and New Guinea the languages spoken are collectively known as Papuan, though their relations to one another are unknown. On the coasts of these islands and throughout the rest of Melanesia the languages (usually known as Melanesian) all belong to the Malayo-Polynesian or Austronesian family. which includes the languages of Indonesia, the Philippines. aboriginal Formosa, Malaya and Madagascar. All derive from a common ancestral language which was probably spoken 4,000 to 5,000 years ago along the south China coast.

Speakers of Papuan languages were first in Melanesia, inhabiting the larger islands. Three thousand years ago Malayo-Polynesian speakers began coming in as sea gypsies, living largely as traders and fishermen, settling on the smaller islands and along the coasts of the larger ones. Here and there they merged with their Papuan-speaking predecessors. This process continued, resulting in a complicated patchwork of small groups speaking mutually unintelligible dialects. Carrying past the northern islands and their Papuan inhabitants. the Malayo-Polynesian drift peopled New Caledonia and the New Hebrides, whence came the movements which settled Fiji, most of Micronesia and all of Polynesia. As the oldest area of human settlement in the Pacific islands, Melanesia is the most differentiated and complex.

Economy. — Native subsistence is based on tropical forest agriculture. in which garden land must lie fallow 10 to 15 years, necessitating reclearing of dense second growth before reuse. Important crops are taro, yams, sweet potatoes and sugar cane. while the breadfruit, coconut, pandanus and banana are cultivated fruit trees. Fishing and hunting add to the food supply. Domestic animals include only pigs, dogs and chickens. Tobacco is widely grown and used along with a traditional narcotic made from the pepper plant (chewed with betel nut and lime in most of Melanesia and drunk as kava in Fiji).

Throughout Melanesia are extensive trading networks, a famous one being the kula of the Trobriand islands. While some trade is in practical commodities, such as pottery, obsidian and food, it is mostly in prestige items: shells, used as fluid wealth in social as well as economic transactions, and dances and rituals, whose copyrights are privately owned and widely traded.

Social Organization. — Most communities are small and parochial in outlook. Occasionally they form larger political units. but most Melanesian villages are independent of each other. Peaceful intercourse between them is traditionally conducted by private individuals. following the lines of kinship, trading partnerships and common clan and totemic affiliation. Relations between communities as such are predominantly competitive in a game of hit-and-run warfare, with the score carefully counted in heads taken or victims eaten.

Competition also characterizes relations within communities. Individuals gain prestige sometimes from fighting prowess, more often from successfully manipulating wealth. Hard work, skill in trading and the ability to keep others obligated enable one to underwrite community festivals. sponsor clubhouses and purchase wives for kinsmen. Thereby one becomes a community leader, arbitrating disputes and playing host to visitors. With his wealth he can hire sorcerers to punish troublemakers. Rivalry for prestige and power within a village often leads to the formation of new villages by dissident factions.

Religion. — Lacking elaborate cosmogonies or cosmologies, Melanesians believe that spirits of their dead kinsmen take active interest in their welfare. A major problem in life is to keep safe from sorcerers and evil spirits. Rituals centre around masked impersonations of spirits, progressive initiations into higher mysteries of the spirit world and memorial feasts for the dead. It is widely believed that women of child-bearing age are ritually unclean and therefore to be excluded from the higher mysteries.

Post-European Conditions. — Early contacts with Europeans were disastrous for many Melanesian communities. New diseases, firearms and forced labour took a frightful toll. Responsible European governments later ended abuses and began to provide medical and educational services. Economic development and the elimination of warfare increased peaceful intertribal contacts, with pidgin English the lingua franca. Europeans also introduced new economic wants and religious beliefs. After World War II, many native politico-religious movements arose in response to the cumulative stress of changing conditions.

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MELANESIAN LANGUAGE: see MALAYO-POLYNESIAN LANGUAGES.

MELANISM, the prevalence of black colouration in animals normally of lighter colour. Conspicuous among these is the black leopard. fairly common in the hlalay peninsula. which in certain lights shows a pattern like black waved silk. Black cats. dogs and horses are examples of melanism. which is described, rather than explained, by attributing it to the presence of the black pigment, melanin. In the United States melanistic varieties of the gray squirrel are found occasionally in the east, more commonly about the Great Lakes. In England the peppered moth (Anthydasis detzilaria), normally marked by scattered black dots. has a melanistic variety. which is now becoming common in the smoky districts of the Black Country. Kindred phenomena are albinism (whiteness) and erythrism (redness); the latter appearing in the

ruddy phases of some owls. All three tendencies are illustrated among domestic pigeons. (See ALBINO; PIGMENTS OF SKIN AND HAIR.)

MELASTOMATACEAE, a large family of dicotyledonous plants, comprising 200 genera and 2,500 species, nearly all tropical and subtropical. The family is represented in the eastern and southern United States by about 10 species of *Rhexia* (meadow-beauty). A few yield dyes and many are cultivated for their ornamental flowers. Some species live in harmony with ants. the ants finding shelter within the plant, which is thus protected from the ravages of the leaf-cutter ants. (See MEADOW BEAUTY; SOCIAL INSECTS.)

MELBA, DAME NELLIE (HELEN PORTER MITCHELL) (1861–1931), Australian operatic soprano, was born at Burnley, near Melbourne, Austr. She sang at a local concert when six years old. and was given a good musical education but was not allowed to study singing until after her marriage in 1882. In 1886 she went to study in Paris under Mathilde Marchesi. In 1887 she made her debut in opera at Brussels, taking the stage name of Melba from her connection with Melbourne. In the next year she sang the part of Lucia di Lammermoor at Covent Garden; and, though critics complained of her coldness as an actress, her liquid voice and brilliant execution henceforth made her famous as the greatest successor to Patti, in pure vocalization, on the operatic stage. For 20 years she toured widely, among her most famous parts being Mimi, Violetta, Marguerite and Hélène. In 1918 she was created D.B.E. She retired to Australia in 1926, becoming president of the Melbourne conservatoire, and died in Sydney on Feb. 23, 1931.

See her autobiography, *Memories and Melodies* (London, 1925; Garden City, N. Y., 1926) ; A. Murphy, *Melba, A Biography* (London, 1909).

MELBOURNE, WILLIAM LAMB, 2ND VISCOUNT (1779–1848), English statesman, was twice prime minister and an early adviser to Queen Victoria. He was born on March 1j, 1779, the second son of Peniston Lamb, the first viscount: and Elizabeth Milbanke. He was educated at Eton and Trinity college, Cambridge. and called to the bar at Lincoln's Inn in 1804. In 1805 he contracted his ill-starred marriage with Lady Caroline Ponsonby, only daughter of the third earl of Bessborough. She was soon infatuated with Lord Byron; eventually, in 1825, he was separated from her, and she died in 1828.

When his elder brother died in 1805 Lamb gave up the bar for politics, and was elected member of parliament for Leominster in 1806 as a Whig. He was defeated in 1812, largely because he supported Catholic emancipation, and did not re-enter parliament until he became M.P. for Northampton in 1816. He was never a strong party man, spoke seldom in the commons, and felt free to vote as he chose. He became a friend of George Canning, who made him Irish secretary on becoming prime minister in March 1827. Lamb retained this position under Lord Goderich and the duke of Wellington, till he resigned with the other Canningites in May 1828. Next year he succeeded to his father's peerage, and entered the house of lords.

In Lord Grey's ministry of 1830 he was home secretary. He resisted pressures to strengthen the existing laws for the maintenance of public order, but applied these laws firmly; he was responsible, for example, for the transportation in 1834 of six labourers of Tolpuddle in Dorset for the crime of administering trade unionists' oaths. He was also responsible in the cabinet for Irish policy; differences with his colleagues over this brought the ministry down in July 1834, and hlelbourne reconstructed it with himself as prime minister. Its members were still much divided; and when its strength in the commons was reduced by Lord Althorp's succession to the house of lords in Nov. 1834 (*see* SPENCER, JOHN CHARLES SPENCER. 3rd earl) the king dismissed them all. Melbourne accepted the sentence with equanimity.

Sir Robert Peel's government lasted only six months, and in April 183j Melbourne formed his second administration. He was hampered by the smallness of his majority in the commons and by the king's hostility; to these difficulties was added the embarrassment of his appearance as a corespondent in the case of *Norton* v. *Norton and* Melbourne (see NORTON, CAROLINE ELIZABETH SARAH). in which he was satisfactorily acquitted in June 1836. William IV's death on June 20, 1837, saved Melbourne from the danger of another dismissal. He at once assumed the role of mentor to the young Queen Victoria. He spent much of his time at Windsor, accommodating his very worldly manners and his usually free conversation to the atmosphere of the new court; practically, he acted as the queen's private secretary as well as her first minister. He showed the queen unceasing and understanding devotion, and secured her sincere attachment to himself and (for a time) to his party. He never abused the intimacy thus created, and used it to impress on her the main principles of the English' constitution. He remained her minister for four years, resigning in hlay 1839 but resuming office after an absurd dispute. known as the "bedchamber question." between Peel and the queen about household appointments. His government had no firm policy at home. where the Chartist agitation was busy, or in Ireland or Canada, constant subjects of dispute; and no control over its brilliant foreign secretary, illelbourne's brother-in-law, Lord Palmerston. It was defeated by one vote in the commons in May 1841, and the Whigs did badly in the consequent general election; Melbourne resigned at the end of August. In Oct. 1842 he retired from active politics, after an attack of paralysis. He died, without surviving children, on Nov. 24, 1848.

Melbourne was an exceptionally charming companion; his memory for the classics was prodigious, he talked and rode well, and was an excellent shot. In politics he was always something of a dilettante, not inclined to unnecessary exertions, but capable of standing firm when he thought honour required it.

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(M. R. D. F.)

MELBOURNE, capital of the state of Victoria. Austr.. and second largest city in Australia, is situated in the central south of the state, around the northern shores of Port Phillip bay, several suburbs stretching along the banks of the Yarra river. Pop. (1954) 1.524,111. The climate is temperate (average rainfall 25.66 in.; mean temperatures 50°–67.6° F.; highest temperature ever recorded, 114.1° F.), and the summer lasts from December until March.

Melbourne and the Port Phillip districts were surprisingly long in being established. The first fleet reached Botany bay in 1788, Hobart was established in 1803–04, Perth in 1829 and Adelaide in 1836, but it was not until 183j that Port Phillip was colonized although it had been discovered in 1802 by Matthew Flinders, and a small convict settlement had been established in 1803 but abandoned the year after. Although the capital and the largest city in Victoria. Melbourne was not the first permanent settlement. In 1834 Portland, 200 mi. to the west, had been settled by the Hentys. Melbourne arose out of the separate unauthorized expeditions of John Batman and John Pascoe Fawkner who successfully fought every attempt to make it into a penal colony. Each came across Bass strait from Launceston. Batman entered Port Phillip in May 183j, and in August an expedition organized by Fawkner (he did not accompany it because of illness) arrived and was the first to occupy the present site of Melbourne, being joined there in November by Batman. Competition between the two parties and illegality in claims of land acquisition, arising from the famous treaties with the natives, characterized the early period; but cultivation and grazing were soon under way.

.The first census of colonists in May 1836 gave the population as 177 persons—142 males and 3j females. In Sept. 1836 Captain Lonsdale arrived to take charge of the settlement. In 1837. Sir Richard Bourke, governor of New South Wales, visited the area, agreed to the selection of the site and to the naming of the town after Lord Melbourne, then prime minister of England. The first overland contact between New South Wales and Melbourne was at the end of 1835 when John Gardiner brought over a herd of

cattle in three weeks. In Oct. 1839 Charles La Trobe. with the title of superintendent, succeeded Lonsdale. The Imperial Australian Colonies act (1842) established the Port Phillip settlement as the southern district of New South Wales, and provided the district with representatives in the enlarged legislative council of New South Wales. There was. by this time, a separate administration in Port Phillip arid in 1831 a supreme court was established. Soon after a strong movement for separation from New South Wales became discernible. With growth in population and wealth, this movement succeeded and in July 1851 the southern district of New South Wales was constituted "Victoria." with a legislative council of its own. In that year the population of Xlelbourne was 23.000. and that of Victoria 77.000. The total of exports and imports of the colony amounted to just over 2.000.000 sterling.

m July 1851 public announcements of gold discoveries were made and in a few months rich yields were coming from Ballarat, Bendigo and other places in Tictoria. This meant a great influx of people from Tasmania and south .Australia. and then from overseas. For a considerable time the monthly immigration to Melbourne was between 10.000 and 20.000 persons. People overflowed outside the town and the countryside was soon dotted with tents. The population of the colony increased steadily in the years that followed: it was 168.321 in 1852 and it had risen to 537.846 by 1860, but by 1858 alluvial gold mining had come to an end. Mining became a matter of deep shafts and costly quartz-crushing machines. This meant that most of the population was soon in search of land and work. Nearly all the accessible land had already been taken up, and Melbourne became the centre of political activities seeking to "unlock the land." and to obtain protective tariffs to encourage the growth of local industries. Slowly small farmers supplemented the gold and wool output of the colony and then factories and workshops increased rapidly in number. Railways and roads were built into the interior and the outlet was the port of Melbourne. Under this influence Melbourne grew rapidly and soon was the largest city in Australia.

Melbourne is situated in the centre of a lowland area, bounded from the southeast to the southwest. at a distance of about 40 mi., by a rim of plateau-like highlands of an average elevation of about 2.000 ft. In the south is the shallow Port Phillip bay, having two channels carrying 36 ft. and 40 ft. of water, and a narrow mouth of rough and choppy seas ("The Rip").

The city was laid out as a rectangular block of more than a square mile, but it has expanded in all directions, following generally a rectangular street pattern. The city proper contains numerous fine streets: Bourke. Flinders and Collins (named after the founder of Tasmania), also St. Kilda road, nearly 300 ft. nide. consists of a series of roads and footpaths separated by plantations and ornamental palms. Its suburban cities range from highly industrialized centres. Footscray. Williamstown. Collingwood, Abbotsford. Richmond. with their closely packed dwellings. to beautiful residential areas. hlelbourne is striking for its extensive public gardens, tree-lined streets and separated private houses. each with its surrounding garden.

Geographical features have played an important part in its development. Victoria has a railway and road network which converges on Melbourne as the central port of overseas trade. This has meant that Melbourne from the beginning became a financial and commercial centre. Most .Australian banks have their head office in Melbourne. and the city has large wool-selling auctions. In addition to rich agricultural and dairying industries in the basin immediately surrounding Melbourne. the city draws on the fertile areas of Gippsland, noted for dairying, and the wheat lands of the Wimmera and Mallee. and the pastoral western, northeastern and highlands areas. Indeed the whole of the commerce of the Murray valley. and a considerable part of the riverina in New South Wales, centres on Melbourne. This situation gave Melbourne superiority in trade and population among all Australian cities from 1860 to 1920. Sydney in 1920 became the largest city, growing at a slightly more rapid rate than Melbourne under the influence of a more marked manufacturing development.

Melbourne's manufacturing industries were influenced in their nature and development, first by the Victorian tariff from about 1870 to 1901, then by the commonwealth tariff after federalism. A disadvantage was the relative shortage of poner resources. There is very little black coal near Melbourne, most of it having to be imported from New South Wales. After 1919 there was rapid development of brown coal as a base for electrical power and this was important in allowing greater manufacturing development. Melbourne's industries range from those found in any industrial centre to heavy earth-moving equipment and production of internal-combustion motors and motorcars. The city is situated about 40 mi from the ocean. ships having to pass through the shallow Port Phillip bay.

Docking facilities are at Port Melbourne, 3 mi. from the city, where the large ocean liners are accommodated, and extensive wharves are situated 2 mi. along the Yarra river where most interstate and overseas cargo is handled.

Melbourne is famed for its annual race meeting at Flemington racecourse at which the Melbourne cup is run for, as well as for other meetings throughout the year at which valuable stake money is offered to competition among the best thoroughbreds in the country. Sport is popular in Melbourne. some of the city's sports grounds being of outstanding quality. The city has two cathedrals, a university, a technical college. museums, art gallery and an active cultural life. The 1956 Olympic games were held in Melbourne.

See Ernest Scott. "Historv of Victoria." *Victorian Year* Book. *1916–17*. (J. F. C.)

MELCHERS, (JULIUS) GARI (1860–1932), U.S. portrait and figure painter. was born at Detroit. Mich., on Aug. 11, 1860, the son of a sculptor. At 17 he was sent to Diisseldorf. Ger., to study art under Gebhardt. and after three years went to Paris, where he uorked at the Académie Julien and the École des Beaux Arts. Attracted by the pictorial side of the Netherlands, he settled at Egmond. His first important Dutch picture. "The Sermon," brought him honourable mention at the Paris Salon of 1886. He became a member of the National Academy of Design, New York city; the Royal Academy of Berlin; Societe Nationale des Beaux Arts, Paris; International Society of Painters, Sculptors and Engravers, London; and the Secession society, Munich.

Besides portraits. his chief works are: "The Supper at Emmaus"; "The Family"; "Mother and Child." Art Institute of Chicago; the decoration at the Congressional library, Washington, D.C., "Peace and War."

Melchers' portrait of Pres. Theodore Roosevelt is in the Freer Gallery of Art, Washington. D.C.

Melchers died on Nov. 30. 1932, at Belmont, near Fredericksburg, Va.

MELCHETT, ALFRED MORITZ MOND, BARON (1868–1930), British politician. nas born at Farnworth, near Widnes. Lancs., on Oct. 23. 1868, the son of the famous chemist Ludwig Mond (*q.v.*). He was educated at Cheltenham and St. John's college. Cambridge. and afterward at Edinburgh university. In 1894 he was called to the bar. and afterward joined the North Wales and Chester circuit. He entered the firm of Brunner, Mond and company. becoming a director in 1895, and subsequently chairman of the Mond Nickel company and a director of the South Staffordshire Mond Gas company and various other companies. He was elected to parliament in 1906 as Liberal member for Chester. losing his seat in 1910, but the same year was elected for Swansea and created a baronet. In 1913 he was sworn of the privy council. On the formation of Lloyd George's ministry in 1916 Alfred Mond became first commissioner of works. and in 1921 minister of health. He lost his seat at the general election of 1923, but was returned for Carmarthen in Oct. 1924. In Jan. 1926, because of his profound disagreement with the principles embodied in Lloyd George's land policy, Alfred Mond seceded from the Liberal party and transferred his allegiance to the Conservative party. Mond was created a peer, with the title of Baron Melchett in 1928. In 1928, he organized the Mond conference, at which problems relating to industrial reorganization and industrial relations were discussed by a group of employers, headed by Lord Melchett, and the Trades Union congress general council. The first report of the conference, which appeared in July 1928, em-

bodied a proposal for the establishment of a National Industrial council, whose functions would be to further Britain's industrial progress, (a) by consultation, (b) by the establishment of suitable machinery for research and conciliation. He published many articles on the alkali trade in scientific and economic journals, besides a volume of essays. *Questions oj To-day and To-morrow* (1912).

MELCHIADES or MILTIADES (other forms of the name being Meltiades, Melciades, Milciades and Miltides), pope from July 2, 311, to Jan. 11, 314. He appears to have been an African by birth. The toleration edicts of Galerius and of Constantine and Licinius were published during his pontificate, which was also marked by the holding of the Lateran synod in Rome (313) at which Caecilianus, bishop of Carthage, was acquitted of the charges brought against him and Donatus condemned. Melchiades was preceded and followed by Eusebius and Silvester I, respectively.

MELCHITES, the name given in the 5th century to those Christians who adhered to the creed supported by the authority of the Byzantine emperor. The Melchites therefore are those who accept the decrees of Ephesus and Chalcedon as distinguished from the Nestorians and Jacobite Church. Their name literally means "Royalists" from the Syriac *Melcha*, a king. They number about 80.000 and are found in Syria and Egypt.

MELCHIZEDEK, king of Salem and priest of "supreme El" who brought forth bread and wine to Abraham on his return from the expedition against Chedorlaomer, and blessed him in the name of the supreme God, receiving from Abraham tithes of his booty (Gen, xiv. 18–20). Biblical tradition tells us nothing more about Melchizedek (cj. Heb. vii. 3); but the majestic figure of this pre-Mosaic king-priest to whom even the father of all Israel paid tithes suggested a figurative or typical application: (1) in Psalm cx to the vicegerent of Yahweh, the king of Israel who is also priest after the order of Melchizedek; and (2) after the Gospel had ensured the Messianic interpretation of the Psalm (Matt. xxii. 42 *seq.*), to the kingly priesthood of Jesus. as that idea is worked out at length in the Epistle to the Hebrews. The name may mean "king of righteousness."

MELCOMBE, GEORGE BUBB DODDINGTON, BARON (1691–1762), English politician (known as "Bubb Doddington"). His father's name was Bubb, but the son took the name of Doddington on inheriting a large property from an uncle of that name. He was educated at Oxford. In 1715 he was returned to parliament for Winchelsea, and was sent as envoy extraordinary to Spain. From 1722 to 1754 he sat in parliament for Bridgewater; from 1724 to 1740 was a lord of the treasury; and. in 1744 and in 1755 was treasurer of the navy. In 1761 he was raised to the peerage as Baron Melcombe of Melcombe Regis in Dorsetshire. He died at Hammersmith on July 28, 1762. He was a wit and a good scholar; Thornson's "Summer" was dedicated to him, Fielding addressed to him an epistle and Edward Young a satire. He was a leading spirit of the "Hell-fire" club. whose members, called "Franciscans" from their founder Sir Francis Dashwood (d. 1781), held their revels in the ruined Cistercian abbey of Medmenham, Bucks.

His interesting diary appeared in 1784 (4th ed. 1828). *See L.* Sanders, *Patron and Place-Hunter: A Study of G. B. Doddington* (1919).

MELEAGEK, in Greek Μελέαγρος, son of Oeneus, king of Calydon, and his queen Althaea. Oeneus, says Homer (*Il.,* ix. 529 ff.), forgot to sacrifice to Artemis when offering hecatombs to the other gods; she, in wrath, sent a great boar to ravage his land. Meleager gathered a band of huntsmen from many cities and killed the beast. Then arose a quarrel over the spoils between the Calydonians and the Curetes, which resulted in war. At first the Calydonians had the better of it; but presently Althaea's brother was killed (apparently by Meleager), and she cursed her son; he, in high dudgeon, refused to take any further part in the war, until the Curetes' missiles were striking the chamber in which he lay; then at last he yielded to the entreaties of his wife Cleopatra. At some time after defeating the enemy and before the Trojan war he died, Homer does not say how (*Il.,* ii. 642). Later tradition adds the following romantic details. One of the hunters was Atalanta (*q.v.*); Meleager was 'for giving her the spoils, because she was the first to wound the boar; his mother's brothers objected, and in the ensuing quarrel were killed by him. Now when he was born, his mother had overheard the Fates saying that he should live as long as a brand then on the fire was unconsumed; she had always kept this safely, and now threw it on the fire, and Meleager wasted away and died as it consumed. Althaea herself died, of grief or by her own hand, and Meleager's sisters so mourned for him that they were turned into *meleagrides* (guinea-fowl).

See H. J. Rose, *Handbook* of *Greek Mythology* (1928; bibl.).

MELENDEZ VALDES, JUAN (1754–1817), Spanish poet, became a professor at Salamanca, but the success of his poems (1785) induced him to resign his chair and try his fortune in politics. The friendship of Jovellanos obtained for him in 1789 a judgeship at Saragossa, whence he was transferred two years later to a post in the chancery court at Valladolid. On the fall of Jovellanos in 1798 Melendez Valdés was exiled from the capital; he returned in 1808 and accepted office under Joseph Bonaparte. He had previously denounced the French usurper in his verses. He now outraged the feelings of his countrymen by the grossest flattery of his foreign master, and in 1813 he fled to Alais. Four years later he died in poverty at Montpellier. In natural talent and in acquired accomplishment Melendez Valdés was not surpassed by any contemporary Spaniard; he failed from want of character, and his profound insincerity affects his poems. Yet he has fine moments in various veins, and his imitation of Jean Second's *Basia* is notable.

MELETIUS OF ANTIOCH (d. 381), Catholic bishop and saint, was born at Melitene in Lesser Armenia of wealthy and noble parents. He first appears (*c.* 357) as a supporter of Acacius, bishop of Caesarea, the leader of that party in the episcopate which supported the *Homoean* formula by which the emperor Constantius sought to effect a compromise between the Homoeusians and the Homousians. Meletius thus makes his début as an ecclesiastic of the court party, and as such became bishop of Sebaste in succession to Eustathius, deposed as an Homousian heretic by the synod of Melitene. The appointment was resented by the Homoeusian clergy, and Meletius retired to Beroea. According to Socrates he attended the synod of Seleucia in the autumn of 359, and then subscribed the Acacian formula. Early in 360 he became bishop of Antioch, in succession to Eudoxius, who had been raised to the see of Constantinople. Early in the following year he was in exile for uncertain reasons,

The successor of Meletius was Euzoeus, who had fallen with Arius under the ban of Athanasius. In Antioch itself Meletius continued to have adherents, who held separate services in the "Apostolic" church in the old town. The synod of Alexandria sent deputies to attempt an arrangement between the two anti-Arian churches; but before they arrived Paulinus had been consecrated bishop by Lucifer of Calaris, and when Meletius reached the city, he found himself one of three rival bishops. Twice, in 365 and 371 or 372, Meletius was exiled by decree of the Arian emperor Valens. Meletius had been more and more approximating to the views of the newer school of Nicene orthodoxy. Basil of Caesarea, throwing over the cause of Eustathius, championed that of Meletius who, when after the death of Valens he returned in triumph to Antioch, was hailed as the leader of Eastern orthodoxy. As such he presided, in Oct. 379, over the synod of Antioch, in which the dogmatic agreement of East and West was established; he helped Gregory of Nazianzus to the see of Constantinople and consecrated him; he presided over the second oecumenical council at Constantinople in 381. He died soon after the opening of the council. His body was carried to Antioch and buried with the honours of a saint.

Meletius was a holy man, whose ascetic life was all the more remarkable in view of his great private wealth. He was also a man of learning and culture, and widely esteemed for his honourable, kindly and straightforward character. He is venerated as a saint and confessor in both the Roman Catholic and Orthodox Eastern churches.

See the article G. F. Loofs in Herzog-Hauck, *Realencyklopädie* (ed. 1897, Leipzig), xii. 552, and authorities there cited.

MELETIUS OF LYCOPOLIS (4th century), founder of the sect known after him as the "Meletians," or as the "Church of the Martyrs," in the district of Thebes in Egypt. With Peter. archbishop of Alexandria. he was thrown into prison during the persecution under Diocletian. He refused to receive, at least until the persecution had ceased, those Christians who during the persecutions had renounced their faith and then repented. This refusal led to a breach with Peter and other Egyptian bishops who were willing to grant absolution to those who were willing to do penance for their infidelity.

Meletius, after regaining his freedom, held his ground and attracted many supporters, extending his influence even so far away as Palestine. He ordained 29 bishops and encroached upon Peter's jurisdiction. The council of Nicaea in 32j upheld the bishops. but Meletius was allowed to remain bishop of Lycopolis though with merely nominal authority. His death followed soon after. His followers took part with the Xrians in the controversy with Xthanasius and existed as a separate sect till the 5th century.

MELIACEAE, a large family of dicotyledonous plants with 50 genera and about 1,500 species, chiefly'trees, and pantropic in distribution. The leaves are mostly pinnate and the family is readily distinguished by having the stamens borne on the inside of or at the apex of a distinct staminal tube. Some of the genera are rich in species. such as *Turraea* in Africa and Asia, 90 species, *Trichilia* in Africa and the Americas, 230 species, *Guara* in tropical America, 170 species, Aglaia, Indo-Malaysia. perhaps 300 species, and *Dysoxylum,* Indo-Malaysia, about 100 species. The langsat or lansone (*Lansium domesticum*) is an important Malayan fruit tree, widely cultivated, while other genera yield important commercial timbers such as the true mahogany (Swietenia), cigar box cedar (Cedrela) and others. The chinaberry or pride of India (*Melia azedarach*) is widely planted in the warmer parts of the U.S., and is naturalized in the south. (E. D. ML.)

MELICERTES, in Greek mythology, the son of the Boeotian prince Athamas and Ino, daughter of Cadmus. Ino, pursued by her husband. who had been driven mad by Hera because Ino had brought up the infant Dionysus, threw herself and Melicertes into the sea from a high rock between Megara and Corinth. Both were changed into marine deities—Ino as Leucothea, Melicertes as Palaemon. The body of the latter was carried by a dolphin to the Isthmus of Corinth and deposited under a pine tree. There it was found by his uncle Sisyphus, who had it removed to Corinth, and by command of the Nereids instituted the Isthmian games and sacrifices in his honour.

It is uncertain whether Melicertes is Greek ("honey cutter," *i.e.,* "beekeeper," perhaps a minor deity presiding over apiculture) or Phoenician (Melqart). In either case, it is not easy to see why he should be called "wrestler" or why his legend is Boeotian and his cult Isthmian. At Rome, he was sometimes identified with Portunus (*q.v.*).

MELILITE. The melilite group of silicate minerals are sorosilicates of aluminum, calcium, magnesium and other metals. These minerals show extensive atomic substitution, important end-members being gehlenite. $Ca_2Al_2SiO_7$, åkermanite, $Ca_2MgSi_2O_7$ and hardystonite, $Ca_2ZnSi_2O_7$. Substitution by sodium, iron, potassium and manganese also occurs. Melilite usually forms in short tetragonal prisms of variable colour, sometimes honey coloured. whence the name from the Greek *meli* ("honey"). The crystal structure consists of twisted sheets of oxygen tetrahedra, linked together by calcium ions. Melilite is rare, occurring as sodic åkermanite in some basic rocks such as melilite-basalt, as gehlenite at limestone contacts, and as hardystonite in ores. It crystallizes from many artificial melts and commonly occurs in slags. (J. V. S.)

MELILLA, chief town of a Spanish military circumscription and the seat of an important garrison, on the northeast coast of Africa, south of Cape Tres Forcas and 13j mi. E.S.E. of Ceuta. Separate and distinct from the iormer Spanish zone as a place of national sovereignty, Melilla was formerly attached to the Spanish province of Malaga. The old town is built on a huge rock connected with the mainland by a rocky isthmus.

The new town, built on the west and the south, has an entirely European aspect. The equipment of the port, completed in 1914, and the occupation of the country behind it by Spain meant a rapid development of the town, which numbered hardly 3,000 inhabitants in 1895 and reached 76,247 in 1950. The rich mines of Beni-bou-Ifrour, 10 mi. from Melilla, with which they are linked by railway, give rise to an important trade.

The Phoenicians, then the Carthaginians and the Romans, had a settlement of Melilla, which was called Rusaddir. A Berber town succeeded it; it was conquered in 1470 by Spain, in whose possession it remained. Melilla was, with Ceuta, the most important of the ports or *presidios* which Spain revived on the coast oi Morocco, but until the beginning of the 20th century it remained closed and the history of the town was one long series of sieges, of which the last, that of 1893, necessitated an army of 25,000 men. In 1909 General Marina, after a hard campaign, occupied the massif of Gorougou and the hinterland of Melilla, and the Spaniards made themselves masters of the whole region between Oued Kert and Moulouya. In 1921 the tribes of the Riff. in revolt under the leadership of Xbdel Krim, inflicted upon them a costly defeat and pressed them back to the malls of Melilla. The east Riff was reoccupied in 1926 following the Franco-Spanish campaign which forced the submission of Abdel Krim.

MELILOTUS: see SWEET CLOVER.

MELISSUS (5th century B.C.), a Greek philosopher of the Eleatic school (*q.v.*), was a native of Samos, whose fleet he commanded against the Athenians in 441/440 B.C. His philosophy consisted in a clear but for the most part unoriginal defense (in prose) of Parmenides' doctrine that reality is a single undifferentiated whole. (See PARMENIDES.) While Zeno had defended Parmenides indirectly, by refuting those who claimed that "things" and change were real, Melissus preferred to do so positively by the same kind of deductive arguments as Parmenides had used. The argument of fragment eight, that changing qualities must be only apparent. is used virtually unaltered by Plato and Descartes. At two points? however. he departed from Parmenides: (1) instead of existing in an eternal or timeless present, "the one" (reality), he claimed, had and will have infinite duration; and (2) instead of being a finite sphere, "the one" was infinite in extension. Melissus is also said to have made "the one" incorporeal, but either this needs interpreting and qualifying or his having made it infinite in extension must be suspected. Unfortunately our knowledge comes from Aristotle, who underrated the ability of Melissus, or from sources dependent on Aristotle.

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MELITO, bishop of Sardis, a Christian writer of the 2nd century, mentioned by Eusebius (*Hist.* Eccl., iv, 21) along with Hegesippus, Dionysius of Corinth, Apollinaris of Hierapolis, Irenaeus and others, his contemporaries, as a champion of orthodoxy and upholder of apostolic tradition. The extant fragments of his works have been edited by Routh (Reliquiae sacrae, vol. i, 1814). These show that Melito took much part in the paschal Marcionite and Montanist controversies.

It seems more than doubtful whether the Apologia of *Melito* "the Philosopher," discovered in a Syriac translation by Henry Tattam (1789–1868) and subsequently edited by W. Cureton and by Pitra-Renan, ought to be attributed to this writer and not to another of the same name. The clavis, edited by Pitra-Renan, is a later Latin collection of mystical explanations of Scripture.

MELLITUS (d. 624), first bishop of London and third archbishop of Canterbury. was sent to England by Gregory the Great in 601. He was consecrated by St. Xugustine before 604, and a church was built for him in London by Aethelberht, king of Kent. About ten years later the East Saxons reverted to heathenism and the bishop was driven from his see. He took refuge in Kent and then in Gaul, but soon returned to England, and in 619 became archbishop of Canterbury in succession to Laurentius. He died on April 24, 624.

MELLON, ANDREW WILLIAM (1855–1937), **U.S.** banker and public official, secretary of the treasury from 1921 to 1932, was born in Pittsburgh, Pa., on March 24, 1855, and studied at Western university (now the University of Pittsburgh). He entered his father's banking house, which later developed into the Mellon National bank, the Union Trust company and the Union Savings bank, all of Pittsburgh. President of the Mellon National bank, he became an officer or director in various financial

and industrial corporations and also engaged in the development of many industrial enterprises.

In discussions concerning reduction of the national debt. $24,000,000,000 in 1920. as a result of World War I expenditures, Blellon held that continuance of the high wartime tax rates would discourage business expansion and hence reduce revenue. He also was a strong advocate of reduction of the surtax rates on incomes. Congress repealed the excess-profits tax and gradually lowered the income tax rate until in 1926 the maximum surtax was reduced to 20%. Further reductions in tax rates were later made; by June 30, 1928, the national debt had fallen to $17,604,000,000.

As chairman ex-officio of the World War I foreign debt commission, Blellon had a large share in formulating the policy of the United States in regard to funding the war debts of foreign governments owed to the U.S. government. After the onset of depression in 1929, he was continued in office until Feb. 1932, when President Hoover appointed him ambassador to England. enabling him to withdraw as secretary of the treasury. In 1937 he gave his valuable art collection and a gallery in Washington, D.C.. to the nation. Mellon died at Southampton, L I., on Aug. 26. 1937.

MELO, FRANCISCO MANUEL DE (1608–1666), one of the most talented and many-sided figures of the 17th century in Portugal, won fame as a poet. moralist, historian and literary critic besides serving as a soldier and diplomat. He nas born of aristocratic parentage at Lisbon on Nov. 23. 1608. He studied the classics and mathematics at the Jesuit College of Santo Antão, showing a precocious talent. He then entered the army and also. as an accomplished aristocrat, took part in the life of the royal court in Madrid. At Madrid he formed a friendship with Quevedo and earned the favour of the powerful minister Count Olivares. In 1639 he was appointed colonel of one of the regiments raised for service in Flanders, and in June took a leading part in defending Corunna against a French fleet commanded by the archbishop of Bordeaux. He came safely through the naval defeat in the English Channel suffered by the Spaniards at the hands of the Dutch admiral. Martin Tromp. and on the outbreak of the Catalan rebellion acted as chief of staff to the commander in chief of the royal forces; his *Historia de la guerra de Cataluña* became a Spanish classic. On the proclamation of Portuguese independence in 1640 he was imprisoned by order of Olivares. and when released hastened to offer his sword to John IV. He traveled to England, nhere he spent some time at the court of Charles I, and thence passing over to Holland assisted the Portuguese ambassador to equip a fleet in aid of Portugal, himself bringing it safely to Lisbon in Oct. 1641. For the next three years he was employed in various important military commissions. For reasons still obscure (perhaps some love affair or some suspicion of his loyalty to the newly restored Portuguese monarchy), he was arrested on Nov. 19, 1644, and was in prison or under police supervision for about 11 years. His sentence was commuted into one of exile to Brazil in 16jj but, owing to the death of John IV in 1656, he remained there for only three years, writing, and restoring his fortunes by participation in the sugar trade.

During his imprisonment he had continued to write incessantly: he finished and printed his history of the Catalan war in 1645. and published some verse in 1649 and the popular, much reprinted, discourse on marriage — though he himself never married — Carfa *de Guia de Casados* in 1650. He also wrote sections of his series of historical episodes, *Epanáforas de Vária História* (1660), some of the dialogues on social and literary topics, *Apólogos Dialogais* (published posthumously, 1721), poetry and the letters which, after amendments to content and style, were published under the title *Cartas Familiares* (1664). He returned home in 1658; in 1663 Xfonso VI charged him to negotiate with the papacy about the provision of bishops for Portuguese sees. On his way back to Portugal (1665) he published his *Obras Métricas* at Lyons. His early Spanish verses in this volume are influenced by Gongorism *(see* GÓNGORA Y ARGOTE, LUIS DE), but his Portuguese sonnets and verse epistles are notable for their power, sincerity and perfection of form. His verse comedy, the *Auto do Fidalgo Aprendiz* (included in the *Obras Métricas)* is considered by some to be an anticipation of Molière's Le *Bourgeois Gentilhomme*. Melo died at Alcbntara on Oct. 13, 1666.

A full list of Manuel de Melo's works is included in Edgar Prestage's detailed study of his life and work, *Dont Francisco Manuel de Melo, Esboço biográfico* (1914). (E. P.; N. J. L.)

MELODRAMA. The term melodrama was coined in Italy in the early 17th century to designate the newly originated musical drama, now called opera. Guilbert de Pixérécourt and Cuvelier de Trie popularized the term by applying it to the romantic and sensational drama with music which rose to prominence in the late 18th century. Another famous writer of early melodrama was Germany's August von Kotzebue. The first play produced in England under the designation, Thomas Holcroft's *A Tale of Mystery* (1802), was adapted from Pixérécourt's *Coelina, ou l'enfant du mystère;* but in the United States *The Ocean Spectre,* from the French, attributed to Cromwell, was printed and probably produced in New York city in 1795; and John E. Turnbull's *Rudolph;* or, *The Robbers of Calabria* was performed in Boston in 1799. Melodrama, eclectic in its origins, largely dominated 19th-century drama and fiction. In France and England hundreds of popular pieces by scores of writers were produced and widely adapted.

Among the popular British melodramas were W. T. Moncrieff's *Cataract of the Ganges;* or, *The Rajah's Daughter* (1823); John Buckstone's *Luke the Labourer* (1826); Douglas Jerrold's *Black-Eyed Susan;* or *All in the Downs* (1829); H. M. Milner's *Mazeppa;* or *The Wild Horse of Tartary* (1831); Edward Fitzball's *Jonathan Bradford;* or *Murder at the Wayside Inn* (1833); and Henry A. Jones and Henry Herman's *The Silver King* (1882). In the United States Dion Boucicault and Augustin Daly were among the many popular writers of stage melodramas; but perhaps the most popular melodrama ever staged was *Uncle Tom's Cabin* (1852), adapted by George L. Aiken and others from Mrs. Harriet Stowe's novel. The first sensational motion picture melodrama. *The Birth of a Nation* (1917), also was related in subject matter to the American Civil War. The very nature of melodrama made plays in this form easy to adapt internationally.

Though melodrama has elements similar to tragedy and to comedy, it belongs to that third form of drama, variously designated through the ages by such terms as tragicomedy, dramatic romance, and often merely by play or drama. Its action is only seemingly or momentarily serious; hence melodrama often combines both serious and comic episodes or incidents. It always has a double ending, reward for the sympathetic agents and punishment for the antipathetic.

The distinctive powers of melodrama are fear and hate; pity, when allowed, is usually in the form of pathos designed to enhance hate. Such moral comment as melodrama provides is largely in terms of the punishment of the villain. and not from the tragedy of the hero. The antagonist usually initiates the action and remains the most dynamic of the agents. The scheme of probability differs from that of tragedy, allowing more latitude to chance and coincidence, plot progresses usually in terms of successive contrivances, like that of comedy, and not in terms of successive moral choices by the protagonist. as in tragedy. Characters in melodrama, as in comedy. are static in that their determining moral choices arc made prior to the opening of the action; such significant choices as arc allowed them thereafter are on the level of expediency. Guilbert de Pixérécourt and other early 19th-century French critics noted the presence of four types of characters in early melodrama — the diabolically clever villain customarily engaged in the pursuit and persecution of a pure and lovely heroine, constantly foiled and finally defeated by a manly and honest hero, who is frequently aided by a comic personage. Hero and villain are essential agents; the heroine is seldom absent from any melodrama. The events which occur in melodrama are varied, gripping, sensational, thrilling, and manipulated to provide mounting suspense. Diction is minimized, with emphasis placed upon pantomimic action and stage spectacle in the telling of the story; hence cinema with the addition of "mood music" offers an ideal medium for the presentation of melodrama.

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MELODY is the organization of successive musical sounds in respect of pitch (Gr. melodia, "a choral song." from melos, "tune," and ode, "song"). In its most primitive state it already requires rhythm *(q.v.)*; but it can develop freely without the aid of harmony, which removes it into a wider category. Thus a "melodic scale'! is a scale that is not based on an harmonic system; and thus we call ancient Greek music "melodic." The popular conception of melody as "tunefulness" is modern and depends on symmetries of harmony and rhythm that seldom occur in recorded music before the 17th century, and are accidental, if frequent, potentialities in older folk music. For us a melody is

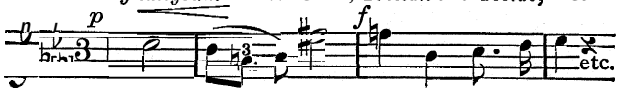
Ex. 1. Non-harmonic melody; a bag-pipe tune refractory to any harmonization beyond drones on A and E.

"MacRimmon's Lament."

*The F♯ is very flat and the G decidedly sharp.

Ex. 2. Unaccompanied melody with harmonic draughtsmanship capable of expressing an enharmonic modulation (F♯=G♭).

Mässig langsam WAGNER, *Tristan und Isolde*, Act I



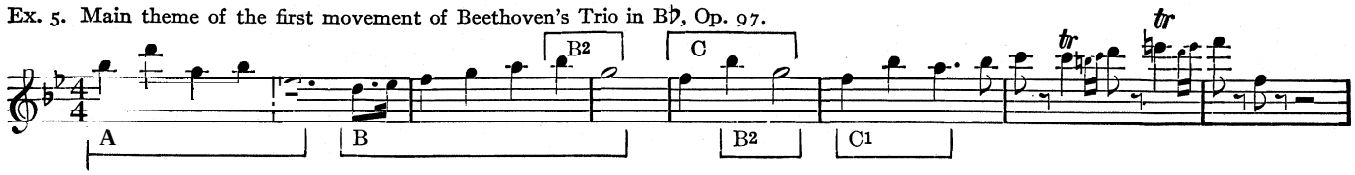
Westwarts schweift der Blick; ostwärts streicht das Schiff.

Ex. 3. *"Barbara Allen"* (showing the germ of binary form in the balance between A^1 on the dominant and A^2 on the tonic).

Ex. 4. Melody in keyboard polyphony, requiring two parts to complete the sense.

BACH. *Das Wohltemperirte Klavier II. Fugue 15.*

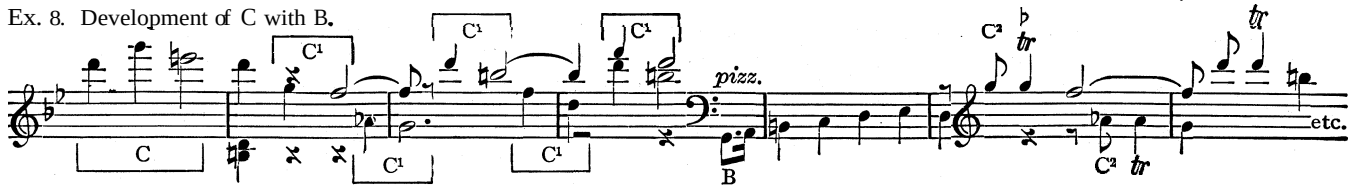
Ex. 5. Main theme of the first movement of Beethoven's Trio in B♭, Op. 97.



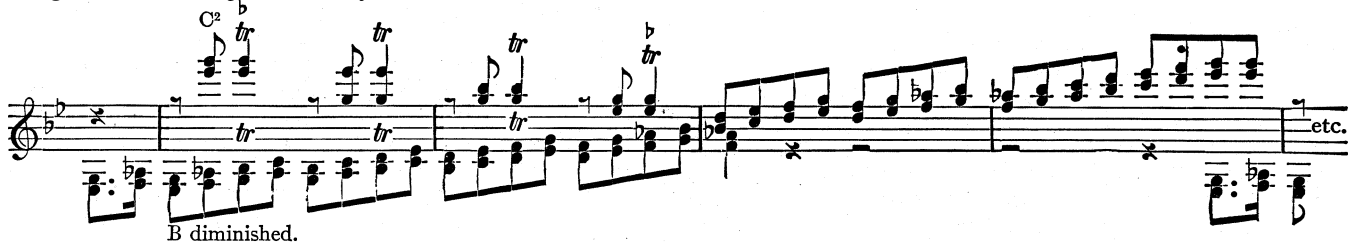
Ex. 6. Figure **A** of above developed in a new polyphonic 4-bar phrase.

Ex. 7. Further sequential developments of **A**.

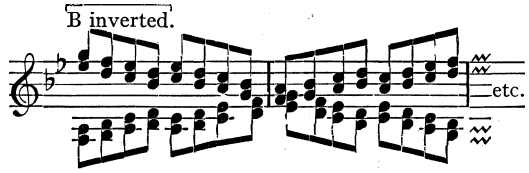
Ex. 8. Development of C with B.



Ex. g. Further development of B by diminution, in combination with the trills derived from C.



Ex. 10. Further development of B by diminution and contrary motion(inversion).



Ex. 11.

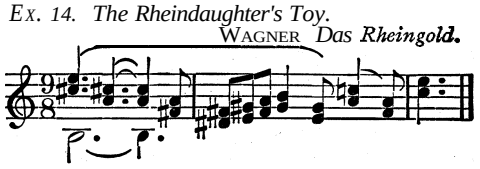
BRAHMS, *Quintet, Op. 34.*

Ex. 12. A and B^2 diminished.

Ex. 13.

Ex. 14. The Rheindaughter's Toy.

WAGNER *Das Rheingold.*



Ex. 15. *The Nibelung's Talisman.*

Ex. 16. *Walhalla.*

the surface of a series of harmonies, and an unaccompanied melody that fails to imply clear harmonies is felt to be strange and vague (see Ex. 1 and 2). Harmonic rationality and symmetrical rhythm thus combine to make a tuneful melody an epitome of musical form. The historical process is from the smaller to the greater. See SONATA FORMS for the gradations between such melodic forms as that of Barbara Allen (Ex. 3) and the larger dance forms of the suite and for'the gradation between these and the true dramatic forms of the sonata. Lastly, the most narrowly melodic element, the rise and fall of pitch, is a capacity of the human voice and in later forms is enlarged not less by the characteristics of instruments than by rhythm, harmony and form. Thus modern melody is the musical surface of rhythm, harmony, form and instrumentation; and, if we take Wagnerian Leitmotif into account, we may as well add drama to the list. In short, melody, whether it be in an inner part or on the top, is the surface of music.

An immense number of musical resources are manifested on the melodic surface; and the following definitions and illustrations will be found to cover a very wide ground. In fact, one of the principal dangers that beset the teaching of composition has been the notion that the logic of music can be placed in melodic relations without regard to rhythm (especially in its larger aspects of phrasing) as well as harmony.

1. A theme is a melody, not necessarily complete in itself, except when designed for a set of variations (*q.v.*), but recognizable as a pregnant phrase or clause. Thus a fugue-subject is a theme, and the expositions and episodes of the sonata forms are more or less complex groups of themes.

2. A figure is the smallest fragment of a theme that can be recognized when transformed or detached from its surroundings The grouping of figures into new melodies is the main resource of "development" or "working-out" in the sonata-forms (see Ex. 2–7) besides being the means by which fugues are carried on when the subjects and counter-subjects are not present as wholes. In 16th-century polyphony, melody consists largely of figures which are thus broken off from a canto *fermo*. (See COUNTERPOINT.)

3. A sequence is the repetition of a figure or group of chords at different levels of pitch. A real sequence repeats the initial group exactly and therefore changes its key. Thus in the first movement of Beethoven's Waldstein sonata, bars 5–8 are a step in real sequence below bars 1–4. A tonal sequence repeats the figure within the key and modifies details accordingly, tolerating things that would be inadmissible in the initial group. In the first movement of the Waldstein sonata the theme, with a brilliant counterpoint above, is treated in tonal sequence 40 bars from the end. Repetition at the same pitch is not sequence. Thus, in illustration, there are no sequences in Ex. 1, but Ex. 4, 7, 9 and 10 contain tonal sequences.

4. Polyphony is harmony made of melodic threads. Some classical melodies are polyphonically composite, requiring an inner melody, appearing through transparent places in the outer melody, to complete the sense. This well suits the pianoforte with its evanescent tone, but is even more frequent in music for earlier keyboard instruments, as in the keyboard works of Bach (see Ex. 4). Beethoven often divides a melody between voices in dialogue, as in bars 35–42 of the first movement of the Waldstein sonata, op. 53.

5. (a) Conjunct *movement* is movement along adjacent degrees of the scale (Ex. 5, fig. B).

(b) Disjunct *movement* often tends to produce *arpeggio* types of melody, *i.e.*, melodies which trace out a chord, as in Ex 11, 12.

The rigid devices of inversion, augmentation and diminution are illustrated in COUNTERPOINT and FUGUE.

The musical examples 5–10 show how Beethoven can develop a theme to results unrecognizable but for the intermediate steps. Ex. 11–16 show a later kind of metamorphosis requiring no intermediate steps, though the process in Wagner's *Ring* motif is gradual. (D. F. T.)

MELON, JEAN FRANÇOIS (1680–1738), French economist, was born at Tulle. With the Duke de la Force, he founded the academy of Bordeaux, afterwards serving as its secretary. Later he was secretary to the duke and to other Frenchmen of note, including Cardinal Dubois and Philip of Orléans, during the latter's regency. He is known for his *Essai politique sur le* commerce (1734) which was translated into English, Italian and German and attracted the favourable attention of Voltaire. In it are contained Melon's views on mercantilism, on which he was one of the earliest writers. He died in Paris, Jan. 24, 1738.

MELON, the trailing plant or the fruit of the muskmelon (*q.v.*) or the watermelon (*q.v.*).

MELORIA, a rocky islet, surrounded by a shoal, almost opposite Leghorn (Livorno), Italy, the scene of two medieval naval battles. The first, on May 3, 1241, was successfully fought by the fleet of the Emperor Frederick II, in alliance with Pisa, against a Genoese squadron bringing a number of English, French and Spanish prelates to attend the council summoned to meet at the Lateran by Gregory IX. The second, Aug. 6, 1284, was of higher historical importance for it accomplished the ruin of Pisa as a naval power. The long rivalry of that city and of Genoa had broken out for the last time in 1282, the immediate cause being the incompatible claims of the two cities to sovereignty over the islands of Sardinia and Corsica. The Genoese, who had the larger and more efficient fleet, sent their whole power, commanded by Uberto Doria, against their enemy. The Pisan fleet, commanded by the Podestà Morosini and his lieutenants Ugolino della Gherardescha and Andreotto Saraceno, came out in a single body. It is said that while the archbishop was blessing the fleet the silver cross of his archiepiscopal staff fell off, but that the omen was disregarded by the Pisans, who declared that if they had the wind they could do without divine help. The victory was decided for Genoa by the squadron of Giacaria, which fell on the flank of the Pisans. Their fleet was nearly annihilated, the Podesti was taken and Ugolino fled with a few vessels. As Pisa was also attacked by Florence and Lucca it could not recover. Two years later Genoa took Porto Pisano, the port of the city, and filled up the harbour. The count Ugolino was afterward starved to death with several of his sons and grandsons in the manner made familiar by the 32nd canto of Dante's Inferno.

MELOS (mod. *Milo*), an island belonging to Greece in the Aegean sea, at the S.W. corner of the Cyclades group, 75 mi. due E. from the coast of Laconia; about 14 mi. from E. to W., 8 mi. from N. to S.; area 71 sq.mi. Pop. (1951) 5,586. The greater portion is rugged and hilly, culminating in Mount Elias in the west (2,463 ft.). It is of volcanic origin, with tuff, trachyte and obsidian. In one of the caves on the south coast the heat is still great, and there are hot sulphurous springs.

The harbour, a crater with depths from 70 to 30 fathoms, entered from N.W., cuts the island in two, with an isthmus 1¼ mi. broad. Sulphur is found on Mount Kalamo and elsewhere. In ancient times the alum of Melos was reckoned next to that of Egypt (Pliny xxxv, 15 [52]). The Melian earth (γῆ Μηλιάς) was employed as a pigment by ancient artists. Millstones, salt and gypsum are still exported. Orange, olive, cypress and arbutus grow throughout the island. vine, cotton and barley are the main objects of cultivation. Above the harbour town, Adamanta, lie Plaka, the chief town, Kastro, on a hill above, and other villages. The ancient town occupied the slope between the village of Trypetè and the landing place at Klima. Here are a Roman theatre, town walls and other buildings, one with a fine mosaic excavated by the British School at Athens in 1896. Numerous fine works of art have been found on this site, notably the Aphrodite of Melos in the Louvre, the Asclepius in the British museum and the Poseidon and an archaic Apollo in Athens.

The position of Melos, between Greece and Crete, and its possession of obsidian made it an important centre of early Aegean civilization. At this time the chief settlement was at Phylakopi on the northeast coast. Here the excavations of the British school cleared many houses, including a palace of Mycenaean type. There was also a toun wall. The antiquities found were of three main periods, all preceding the Mycenaean age of Greece. Much pottery was found, including examples of a peculiar style, with decorative designs, mostly floral, and also considerable deposits

of obsidian. There are some traditions of a Phoenician occupation of Melos. In historical times the island was occupied by Dorians from Laconia. In the 6th century it again produced a remarkable series of vases. of large size, uith mythological subjects and orientalizing ornamentation. Melos was occupied by axis forces in World War II.

Melos sent a contingent to the Greek fleet at Salamis but held aloof from the Attic league, and remained neutral during the Peloponnesian War. But in 416 B.C. the Athenians attacked the island and compelled the Melians to surrender, slew all men of military age, enslaved the women and children and introduced 500 Athenian colonists. Lysander restored the island to its Dorian possessors, but it never recovered its prosperity. Later there were many Jewish settlers in Melos, and Christianity was introduced early.

Under Frankish rule the island formed part of the duchy of Naxos, except for the years (1341–83) when it was a separate lordship under Marco Sanudo and his daughter.

Antimelos or *Antimilo* (Eremomilo), 5½ mi. northwest of Melos, is an uninhabited mass of trachyte. Kimolos, or *Argentiera,* less than 1 mi. to the northeast, was famous in antiquity for figs and fuller's earth and contained a considerable city, the remains of which cover the cliff of St. Andrew.

Polinos, Polybos or *Polivo* (anc. Polyaegos) lies rather more than a mile southeast of Kimolos. It was the subject of dispute between the Melians and Kimolians but has long been almost uninhabited.

MELOZZO DA FORLÌ (1438–1494), Italian painter, a figure of cardinal importance in the history of Italian painting, was born at Forli (Romagna) in 1438. He is mentioned in his native town in 1460 and 1464, and between 1465 and 1475 probably was active at Urbino, where he came into contact with Piero della Francesca, the main source of his pictorial style, the architect Bramante, and the Flemish and Spanish painters employed by Federigo da Montefeltro. Alongside Justus of Ghent and Alonso Berruguete, Melozzo worked on the decorations of the *studiolo* and library of the ducal palace. The principal relics of this activity are the panels of "The Liberal Arts" conjecturally executed from his cartoons. About 1475 Melozzo moved from Urbino to Rome, where he may also have worked temporarily somewhat earlier. His first major work in Rome was a fresco in the library of Sixtus IV in the Vatican, now in the Vatican gallery. Completed in or soon after 1477, this shows the investiture of Platina as librarian to the pope.

Records of payments of 1480 and 1481 relate to subsidiary frescoes and decorative paintings in the library. In 1478 Melozzo became a member of the Compagnia di S. Luca, and about 1480 executed his most important work. a fresco of "The Ascension" in the SS. Apostoli. The central Christ from this work survives in the Quirinal, and fragmentary groups of angels are in the Vatican gallery. These athletic figures amply account for the reputation Melozzo enjoyed among Giovanni Santi and other contemporary writers as an exponent of perspective and, foreshortening. hlelozzo seems to have left Rome in 1484, on the death of Pope Sixtus IV, after completing the decoration of a chapel (destroyed) in Sta. Maria in Trastevere, and returned there in 1489. Probably during this second Roman period he prepared cartoons for mosaics in Sta. Croce in Gerusalemme.

In 1493 he was painting in the Palazzo Comunale at Ancona, and later in the year returned to Forli. where he died on Nov. 8, 1494.

At some time before 1484 he designed the cupola frescoes in the Cappella del Tesoro at Loreto (executed wholly by assistants), and after 1493 the decoration of the Cappella Feo in S. Biagio at Forli (destroyed in 1944). In the latter he was assisted by his pupil Marco Palmezzano. Little of his work has been preserved and none of his great decorative schemes survives intact. Melozzo's pre-eminence as a fresco painter in Rome is comparable with that of his contemporary Andrea Mantegna in north Italy.

(J. W. P.-H.)

MELROSE, a small burgh of Roxburghshire, Scot.. on the right bank of the Tweed. 47 mi. S.E. of Edinburgh by road. Pop. (1951) 2,146. The town figures in Sir Walter Scott's The *Abbot* and The *Monastery* as "Kennaquhair." The beauty of its situation between the Eildon hills and the Tweed, the literary and historical associations of the district and the famous ruins of Melrose abbey have attracted great numbers of visitors. It is also an agricultural market town. Skirmish hill commemorates the faction fight on July 25, 1526, in which the Scotts defeated the Douglases and Kers. The market cross, dated 1645 but with a much older shaft, stands in the triangular market place. Across the river are Gattonside, the monks' garden, still famous for its fruit, and Allerly, the home of Sir David Brewster (*q.v.*).

The original Columban monastery. colonized from Lindisfarne, was founded in the 7th century at Old Melrose, about 2½ mi. to the east, in the loop of a bend of the Tweed. It was burned by Kenneth Macalpin in 839 during the wars between Scot and Saxon and, though rebuilt. was deserted in the middle of the 11th century. The chapel, dedicated to St. Cuthbert continued to attract pilgrims, but the building was finally destroyed by English invaders. In 1136 David I founded an abbey dedicated to the Virgin, a little higher up the Tweed, the first Cistercian settlement in Scotland, with monks from Rievaulx in Uorkshire. Lying in the direct road from England, the abbey was frequently assaulted and in 1322 was destroyed by Edward II. Rebuilt, largely by means of a gift of Robert Bruce, it was nearly burned down in 1385 by Richard II. Erected once more, it was reduced to ruin by the earl of Hertford (afterward the Protector Somerset) in 1545. Later the Reformers dismantled much of what was left. The adaptation of part of the nave as a parish church and the use of the stones for house building in the town did further damage.

The ruins, then the property of the duke of Buccleuch, were presented to the nation in 1918. Of the conventual buildings, apart from the church nothing has survived but a fragment of the cloister with a richly carved round-headed doorway and some fine arcading. North of the abbey precinct a 15th to 16th-century house has been turned into an abbey museum. The cruciform abbey church is in the Decorated and Perpendicular styles, with pronounced French influence, due probably to the master mason John Morow, or Morreau. The south front is still beautiful. The west front and a large portion of the north half of the nave and aisle have perished; but the remains include the rest of the nave, the two transepts, the chancel and choir, the t o western piers of the tower and the sculptured roof of the east end. From east to west it measured 2j8 ft. The nave is 69 ft. wide and the width of the transepts from north to south is 115½ ft. Sir Walter Scott immortalized the east window in The Lay of the Last Minstrel, but the south window with its flowing tracery is even finer. In the carving of windows, aisles, cloister, capitals. bosses and doorheads no design is repeated. The heart of Robert Bruce was buried at the high altar, and in the chancel are the tombs of Sir William Douglas, the Knight of Liddesdale (1300–53); James, second earl of Douglas (1358–88), the victor of Otterburn; Alexander II (1198–1249); and Michael Scot "the Wizard" (?1175–c. 1232), though some authorities say that this is the tomb of Sir Brian Layton, who fell in the battle of Ancrum moor (1544). At the door leading from the north transept to the sacristy is the grave of Joanna (d. 1238), queen of Alexander II.

Near Newstead, an eastern suburb, was the great Roman fort of *Trimontium.* Darnick tower (1 mi. W.) is a well-preserved Border peel tower originally built in 142j and rebuilt in 1569.

The muniments of the abbacy, preserved in the archives of the earl of Morton, were edited for the Bannatyne club and published in 1837 under the title of *Liber* sancte Marie de *Melros.* Among the documents is one of the earliest specimens of the Scots dialect. The Chronica de *Mailros,* preserved among the Cotton manuscripts, was printed at Oxford in 1684 and by the Bannatyne club in 183;

MELROSE, a city of Middlesex county, Mass., U.S., is located 7 mi. N. of Boston. The territory now known as Melrose was originally part of Charlestown and was settled in 1633. Later known as North Malden and then Pond Feilde, the area took its present name from Melrose, Scot., and became a separate town in 1850. It was incorporated as a city in 1899. The Reading road, the old Indian trail from Chelsea to Reading, became a main thor-

oughfare to the north, and Main street in Melrose still follows its route. The Reading stage was the first means of public transportation to serve the town. Early industries included the manufacture of boots and shoes, needles, and picture moldings. In the late 19th century several factories were established, but by the second half of the 20th century Melrose was primarily a middle-class residential community with no large-scale manufacturing. Melrose was one of the first cities in Massachusetts to establish a planning board. For comparative population figures see table in MASSACHUSETTS: *Population.* (L. G. BA.)

MELROSE PARK, a village of Cook county, Ill., U.S., 12 mi. W. of the Chicago loop. Founded as a part of Maywood in 1869, it became Melrose Park in 1893. It is a mixed residential and industrial community, with over 100 industrial plants. The Proviso yards of the Chicago and North Western railway, a large railroad yard for the handling of freight cars, are in Melrose Park. For comparative population figures see table in ILLINOIS: Population. (WA. B. H.)

MELTON MOWBRAY, a market town and urban, district in the Melton parliamentary division of Leicestershire, Eng.. at the confluence of the Wreake and the Eye, 15 mi. N.E. of Leicester by road. Pop. (1951) 11,053. Area 8.9 sq.mi. It has a town estate and appoints town wardens annually. The church of St. Mary, which is Early English and later. was much enlarged in Elizabethan times. The town possesses a Bede house and a house forming part of the dower of Anne of Cleves. The Sarson Modern School for Girls was erected in 1952. Melton. the centre of an agricultural and celebrated hunting district. is also known for its pork pies and trade in Stilton cheese. Industries include a canning factory and woodworking and joinery works. Iron works in the neighbouring parish of Ashfordby employ many of its residents.

MELTZER, SAMUEL JAMES (1851–1920), U.S. physiologist, n-as born March 22. 1851, in Russia. Before he was 20, he had moved to Königsberg, Prussia. where he attended school. Later he studied medicine at the University of Berlin, receiving his M.D. degree in 1882 and the following year worked his way to the United States as surgeon of the ship on which he travelled, settling in New York city on his arrival. He had already begun his career as a physiologist in Berlin. where. with his teacher. Hugo Kronecker, he made a series of studies on the swallowing mechanism which resulted in what is known as the Kronecker-Meltzer theory of deglutition. After his arrival in New Tork city, he practised medicine until 1906, when he became head of the department of physiology and pharmacology of the Rockefeller Institute for Medical Research. He held this position until his death in New York city. Nov. 7, 1920.

Meltzer is particularly noted for his u-ork on the treatment of tetanus and on artificial respiration. He found that magnesium sulphate has anaesthetic properties and that a solution of it injected into the spine may be used in the treatment of lockjaw. This discovery. which came during World War I. was widely employed in the care of wounded soldiers. He also evolved a method of intratracheal insufflation which greatly simplified the problems of surgeons operating on the thoracic cavity and later he was chiefly responsible for the invention of a device which induced artificial respiration by introducing air into the lungs through the pharynx. He was founder and first president of the Society for Experimental Biology and Medicine and during his lifetime held the presidency of five other scientific societies. He wrote prolifically on scientific subjects, leaving more than 200 publications at his death.

MELUN, a town of northern France, capital of the *département* of Seine-et-Marne, situated north of the forest of Fontainebleau. 28 mi. S.S.E. of Paris by rail. Pop. (1954) 18,391. In Caesar's Gallic wars Melun (*Melodunum*) was taken by his lieutenant Labienus, with a view to attacking Lutetia by the right bank of the Seine It was pillaged by the Normans and afternard became the favourite residence of the first kings of the house of Capet In 1359 Melun was given up by Jeanne ot Navarre to her brother, Charles the Bad but was retaken by the dauphin Charles and Bertrand Dugueselin In 1420 it made a heroic defense against the English and Burgundians Ten years later the people of Melun, with the help of Joan of Arc drove out the English. It was occupied by the league in 1589 and retaken by Henry IV in 1590. The tonn is divided into three parts by the Seine. The principal portion lies on the slope of a hill on the right bank; on the left bank is the most modern quarter, while the old Roman toun occupies an island in the river. On the island stands the Romanesque church of Notre-Dame (11th century), formerly part of a nunnery. On the right bank of the river are the church of St. Aspais, an irregularly shaped structure of the 15th and 16th centuries; the *hôtel-de-ville* (1847). in the construction of which an old mansion and turret have been utilized; and the tower of St. Bartholomew of the 16th and 18th centuries. Jacques Xmyot. the translator of Plutarch, was born at Melun in 1513. In the neighbourhood is the fine chateau of Vaux-le-Vicomte. Melun is a market for grain and farm produce and has various small industries, the chief being the manufacture of wooden blinds and screens.

MÉLUSINE, tutelary fairy of the house of Lusignan. was a daughter of the fairy Pressine, to avenge whose wrongs she shut up her father in a mountain. For this she was metamorphosed every Saturday into a serpent from the hips down; and could be released only if she found a husband who would never see her on Saturdays. Such a husband she found in Raymond of Poitiers, who became by her means rich and powerful. She built the castle of Lusignan and many other of the family fortresses. When at length her husband. yielding to curiosity, saw her taking the purificatory bath on a Saturday. she flew away in serpent form. Thenceforward the death of a Lusignan was heralded by her cries.

This history is related at length. with the adventures of Mélusine's numerous progeny. by Jean d'Arras, in his *Chronique* de la *princesse,* written in 1387 at the desire of John, duke of Berry, for the amusement of the duke and of his sister Marie of France. duchess of Bar. It is charming and natural in spite of the free use of the marvellous. An attempt was made by Jules Baudot in Les Princesses *Yolande* et *les ducs* de Bar (1900) to make it a *roman à clef* and to identify the personages. Mélusine, Mellusine or Merlusine is, however, simply the spirit of the fountain of Lusignan, and the local Poitevin myth is attached to the origin of the noble house. Some writers have supposed Merlusine to be a corruption of mère Lucine, the deity invoked in childbirth. She has been identified with Mélisende, widow of a king of Jerusalem, and with Mervant. wife of Geoffroi de Lusignan.

The work of Jean d'Arras was printed by Steinschaber (Geneva, 1478) and reprinted many times in the 15th and 16th centuries. Modern editions: Brunet (1854); Lecesne for the Arras academy (1888). English trans. from unique manuscript in Brit. Mus. ed. by Donald, E.E.T.S. (1895). The versified iorm of the story by the 14th century poet Couldrette was published in 1853 by Fr. Michel.

MELVILLE, ANDREW (1545–1622), Scottish scholar, theologian and religious reformer, was born at Baldovy near Montrose, on Aug. 1. 1545. His father fell at the battle of Pinkie (1547). The boy was educated at the grammar school of Montrose, after leaving which he learned Greek from Pierre de Marsilliers, a Frenchman settled at Montrose. When Melville went to the University of St. Andrews he excited astonishment by using the Greek text of Aristotle. which no one else there understood. Melville left St. Andrews in 1564 for the University of Paris. He there studied Oriental languages. He attended the last course of lectures delivered by Turnebus in the Greek chair, as well as those of Peter Ramus. whose philosophical method and plan of teaching he afterward introduced into the universities of Scotland. From Paris he proceeded to Poiticrs (1566) to study civil law and was apparently at once made a regent in the college of St. Marceon. Political troubles compelled him to leave France, and he went to Geneva, where he was welcomed by Theodore Beza and appointed to the chair of humanity in the academy of Geneva. From Cornelius Bertram, one of his brother professors, he acquired a knowledge of Syriac.

In 1574 Melville returned to Scotland. and almost immediately was appointed principal of Glasgow university. which had fallen into an almost ruinous state, the college having been shut and the students dispersed. Melville enlarged the curriculum at the college and established chairs in languages, science, philosophy

and divinity, which were confirmed by charter in 1577. Students flocked from all parts of Scotland and even beyond, till the classrooms were overflowing. Melville assisted in the reconstruction of Xberdeen university in 1575 and was appointed principal of St. Mary's college, St. Andrews, in 1580. The reforms, however, which his new modes of teaching involved. and even some of his new doctrines, such as the noninfallibility of Aristotle, brought him into collision with other teachers in the university. He was moderator of the general assembly in 1582, and took part in the organization of the Church.and the Presbyterian method. Troubles arose from the attempts of the court to force a system of Episcopacy upon the Church of Scotland (see SCOTLAND. CHURCH OF), and Melville prosecuted one of the "tulchan" bishops (Robert Montgomery, d. 1609).

Melville was summoned before the privy council in Feb. 1584 and had to flee into England. He returned to Scotland in November 1585 and in March 1j86 resumed his lectures in St. Andrews, where he continued for 20 years; he became rector of the university in 1590. During the whole time he protected the liberties of the Scottish Church against all encroachments of the government. In 1599 he was deprived of the rectorship. but was made dean of the faculty of theology. In 1606 Melville and seven other clergymen of the Church of Scotland were summoned to London in order "that his majesty might treat with them of such things as would tend to settle the peace of the Church." They told the king that the only way to settle affairs was to call a free assembly. hlelville delivered his opinion to that effect in two long speeches with his accustomed freedom, and, a sarcastic Latin epigram on some of the ritual practised in the chapel of Hampton Court having come to the king's ears, he was committed to the Tower, and detained there for four years. He was then invited to fill a professor's chair in the university of Sedan, and there he spent the last 11 years of his life. He died at Sedan in 1622 at the age of 77.

See McCries, *Andrew Melville,* 2 vol. (1819); Andrew Lang, *History of Scotland* (1902).

MELVILLE, GEORGE WALLACE (1841–1912), U.S. arctic explorer and naval engineer, was born in New York city on July 31, 1841, and educated at the Brooklyn Polytechnic institute. In 1861 he entered the United States navy as third assistant engineer and served throughout the Civil War. His first venture into arctic regions was as engineer of the "Tigress" in search of the ill-fated "Polaris." In 1879 he accompanied George W. de Long (*q.v.*) on his famous polar voyage in the "Jeannette." When the ship was crushed in the ice Melville was in charge of the only boat load of men that survived. They found help on the Lena river after a boat and sledge journey of many hundreds of miles. In the arctic night he led an expedition 500 mi. along the north Siberian shore in search of De Long and other survivors, and recovered the bodies and records of De Long's boat load. The incredible hardships of the expedition are modestly told in Melville's In *the Lena* Delta (1884). (See also ARCTIC REGIONS.) Melville was again chief engineer of the flagship "Thetis" in the historic Greely relief expedition of 1884.

In 1887 he was made engineer in chief of the U.S. navy. He retired in 1903, having been commissioned rear admiral in 1899. His ability as head engineer during a period when a new and more modern navy was being constructed made his services of much importance. He designed the machinery of 120 naval ships of more than 700,000 h.p.; three of them, the "San Francisco," "Columbia" and "Minneapolis," were for a time the fastest ships afloat. He introduced the triple screw, made the departure from horizontal to the more efficient vertical boilers and introduced boilers of the water-tube type. He carried out tests of oil fuel and predicted its future importance. Many minor improvements and a general reform of the entire naval engineering department are attributed to him. He died on March 17, 1912.

See W. L. Cathcart, "George Wallace Melville," *Amer. Soc. of Naval Engineers, Journal,* vol. xxiv, pp. 477–511 (1912) ; *U.S. Naval Institute Proceedings,* vol. 74, p. 613 (May 1948); *Cassier's Magazine* (Sept. 1903).

MELVILLE, HENRY DUNDAS, 1ST VISCOUNT (1742–1811), British statesman: fourth son of Robert Dundas (1685–1753), lord president of the Scottish court of session, was born on April 28, 1742, and educated at Edinburgh. He became solicitor general in 1766, was returned to parliament in 1774 and served as lord advocate from 1775 to 1783. Under William Pitt he was treasurer of the navy (1784–1800), commissioner of the Indian board of control (1784–93), home secretary (1791–94), secretary at war (1794–1801) and first lord of the admiralty (1804–05). In 1802 he was created Viscount Melville and Baron Dunira. His adroit control of Scottish politics earned him the nickname of "King Harry the Ninth" and made the "Dundas despotism" hateful to all reformers. Suspicion as to his financial management of the admiralty led to his impeachment in 1806; though this ended in an acquittal, and nothing more than formal negligence lay against him, he never again held office. An earldom nas offered in 1809 but declined. He died on May 28, 1811, at Edinburgh.

See H. Furber, *Henry Dundas, First Viscount Melville, 1742–1811* (1931); C. Matheson, *Life of Henry Dundas, First Viscount Melville* (1933). (G. S. P.)

MELVILLE, HERMAN (1819–1891), U.S. author, was born in New York city on Aug. 1, 1819, the third child of Allan and Maria Gansevoort Melville. His father, of Scottish descent, was then a prosperous importer, but in 1830, having suffered losses, he moved to Albany, N.Y., where his wife's relatives made efforts to help him. In 1832 he died, deeply in debt. The burden of supporting the family of four boys and four girls fell on the first-born son, Gansevoort. During the panic of 1837 his business also failed. Mrs. Melville moved to Lansingburgh, now a part of Troy, N.Y. She and her family were in fairly desperate straits. Herman's brothers would presently make their way in the world, Gansevoort as secretary to the U.S. legation in London (where he died in 1846) and Allan as a lawyer. Thomas, the youngest, eventually became a sea captain. For Herman, at 19, the sea offered self-support, and a life certain to be more exciting than the schoolteaching he had already tried. Shipping on a Liverpool trader in June 1839, he was back in the U.S. the following October. The experiences of this voyage were later to furnish him with material for his partly autobiographical novel *Redburn, His First Voyage* (1849). On Jan. 3, 1841, Melville again went to sea, in the whaler "Acushnet," bound from New Bedford, Mass.. for the south seas. In both sea ventures Melville was doubtless influenced by the experiences of the many members of his family, on both sides, who had shipped before the mast.

Having had enough of whaling, Melville jumped ship at Nukuhiva, Marquesas Islands. July 9, 1842. With a companion, Richard Tobias ("Toby") Greene, he made his way into the interior of the island where they soon found themselves the captives of the supposedly cannibalistic tribe of the Taipis. But the natives treated their guests most hospitably. Out of his experiences of the scant four weeks spent in the valley, Melville later compounded his first book, Typee (1846), by which his fame was established as "the man who had lived among cannibals." Two weeks after Toby escaped Melville also broke away from his island paradise and signed on the Australian whaler "Lucy Ann" (Aug. 9, 1842).

The adventures of the short voyage which followed—it ended at Tahiti, Sept. 20, 1842—his brief imprisonment in the island calaboose (for refusing to return to the ship), his escape with "Doctor" Long Ghost and their subsequent ramblings about the nearby island of Eimeo, furnished Melville with the substance of his second and most hilarious book, *Omoo.* In it he exaggerated, for the purposes of comedy, his part in the minor mutiny which got him and his shipmates into trouble with the acting British consul, but there are other passages which show Melville's distress at the degradation of native life and his scorn for the hypocrisy of the missionaries. The social criticism in *Omoo* aroused the wrath of pious readers and reviewers when it appeared in 1847.

Melville's next voyage, aboard the whaler "Charles and Henry," covered approximately the southern Pacific route which he described in his third book, *Mardi* (1849). Then followed, from May to August 1843, a stay at Lahaina, on Maui (one of the Sandwich Islands), and at Honolulu. When Melville shipped as an ordinary seaman on the frigate "United States," Aug. 17, 1843, he embarked on a new series of adventures which were to supply

him with the materials. supplemented with those of other voyagers, for *H'hite-Jacket* (1850), the deepest and richest of the five books which preceded *Moby-Dick*.

After being discharged at Boston on Oct. 14, 1844, Melville returned to his mother's home where by wintertime he had begun the composition of *Typee*. His brother Gansevoort, acting as his agent in London, persuaded John Murray to take *Typee* for his Home and Colonial Library. (Murray disliked fiction and supposed he had contracted for an entirely factual narrative.) For the most part reviewers were pleased with the novelty of *Typee* and its frank and straightforward style. *Omoo* followed the next year. With the sense of security afforded by the fame of his two books Melville married in Aug. 1847 Elizabeth Shaw of Boston, daughter of the chief justice of hlassachusetts. The young couple settled in New York city, where Melville was taken up by the Duyckinck brothers, whose literary circle was the most interesting and influential in the city. Melville read widely at this time (as he continued to do the rest of his life), making up for the deficiencies in his education which had taken him only part way through Albany academy. He borrowed from Evert Duyckinck's fine library the authors who were to have the most powerful effect on him — Carlyle. Sir Thomas Browne and Rabelais.

Early in 1847, Melville began *Mardi,* which was intended to be a sequel to *Omoo*. By the end of the year he had resolved to make the second part a political and moral allegory which would contain references to the ideas about contemporary western civilization and the nature of literature. religion and philosophy. Melville sent his hero, Taji, on a voyage with King Media through the island states of Mardi (the world). in which the countries bear transparent names for England. France, the United States and the lesser western nations. Traveling with the two are a poet, a philosopher and a historian. The conversations of this company evidently relieved the young novelist of the new intellectual burden he was carrying, but the critics were not pleased. Melville retreated to what they had liked before, turning out in rapid succession *Redburn* and *White-Jacket* (whose "man-of-warish" style he regarded highly). In order to make satisfactory arrangements for the publication of *White-Jacket,* Melville went to England in 1849. returning in 1850 after a brief trip to the continent. Though this trip lasted only three months, its effects on Melville's later writing were extensive.

Home again. Melville began work on *Moby-Dick*. In the fall of 1850 he bought a farm near Pittsfield. Mass., in a region he had known and loved from boyhood. He named his place "Arrowhead" and it was in this house that *Moby-Dick* was completed a year later. There was time for visits from New York friends and especially for hours in the company of Nathaniel Hawthorne, his neighbour and new-found friend. Hawthorne's example gave him courage to write the mighty book he was determined to write, The many levels of meaning and the allegorical significance of *Moby-Dick* owe much to Hawthorne's influence. A mixed reception greeted *Moby-Dick* in 1851. Most reviewers were puzzled by it; some were abusive; only a few sensed its power. The dominant theme of the nature of evil and the author's ambiguous attitude toward nature and God were out of tune with the optimistic. romantic, Transcendental temper of the age, and its symbolistic style ran counter to the new realism in fiction writing.

But Melville had not finished what he had to say about man's place in the cosmic scheme of things. He plunged at once into the writing of *Pierre* (1852), which was to tell his readers what happens to a young man who tries to live by heaven's time in this world where the accepted measures are prudence, compromise and casuistry. In *Moby-Dick* Melville permitted his readers to know, through the mind of the narrator: Ishmael, how he viewed the monomaniac vengefulness of Captain Ahab, but in *Pierre* he provided no such compass. His attitude toward his hero wavers and in the end Pierre's tragedy shows him not so much a modern Hamlet (probably Melville's intention) as a self-deluded youth who believes, as one critic says. that he is motivated by Agape while all along it is "Eros that is impelling him." Though *Pierre* is a partial failure. it anticipated the use of depth psychology by 20th-century novelists.

There is evidence that Melville suffered a near breakdown after finishing *Pierre,* but he continued to write steadily through 1856. He published two novels: *Israel Potter* (1855), the story of a soldier in the American Revolution who suffers extreme hardship, and *The Confidence-Man* (1857), a sharp allegorical satire on mid-century American concepts and attitudes. Melville also contributed a dozen stories and sketches to *Putnam's* and *Harper's,* collecting six of them in *The Piazza Tales* in 1856. Outstanding among these pieces are "The Encantadas," a series of sketches about the Galapagos, a group of mysterious barren islands on the equator; "Bartleby." a moral allegory; "Benito Cereno." perhaps his best short story; and "The Bell Tower," another allegorical piece. The subjects of these stories differ notably from the metaphysical themes of *Moby-Dick* and *Pierre.* They show that Melville was preoccupied with man's isolation. with pride and individual courage. with human failure and the possibility or' recovery by reconciliation to defeat. They mirror his mind and reveal his effort to work his way to solid ground after his struggles with the form and matter of the two novels which preceded them.

To regain his health, again precarious. Melville journeyed to Europe and the Holy Land in 1856–57, stopping briefly on the voyage out to visit Hawthorne, then consul in Liverpool. After his return to the United States in May 1857, Melville lectured intermittently in the east and middle west. Unsuccessful in obtaining a government appointment. he sold his Pittsfield farm to his brother Allan in 1863. and moved to New York city. In Dec. 1866 he was made a district inspector of customs. which humble post he held until Dec. 1885, when, through family bequests, he and his wife were comfortably circumstanced. Their first son, Malcolm. had died by his own hand in 1867; their second boy, Stanwix. died after a long illness, in 1886. alone in a hospital in San Francisco. An unmarried daughter, Elizabeth (Bessie), lived with her parents. The fourth child. Frances. married Henry B. Thomas in 1880. From this marriage the family line, though not the Melville name, descended.

Melville ceased to be a "public" writer after the appearance of his poems about the Civil War. *Battle-Pieces.* in 1866. In 1876 he published a long narrative poem. *Clurcl,* filled with memories of his visit to the near east but in essence a series of conversations about religion. science and politics. Two other volumes of verse were privately printed toward the end of Melville's life. *John Marr and Other Sailors* (1888) and *Timoleon* (1891). Among the projects. completed and half-finished, which Melville left at his death, three works are notable: the two travel-diaries (of 1849 and 1856–57) and the superb short novel *Billy Budd, Foretopman.*

Melville had so long lived in obscurity in New York that the newspaper notices of his death, on Sept. 28. 1891, were scanty. The *Press* was correct in observing: "Probably. if the truth were known, even his own generation had long thought him dead, so quiet have been the later years of his life."

Yet during Melville's silent years and for three decades after his death he had a kind of subterranean reputation. Following the centennial of his birth in 1919 and the publication of the first biography. R. M. Weaver's *Herman Melville, Mariner and Mystic* (1921), an extraordinary revival of interest in his work occurred, comparable in extent to the "recovery," in the same years, of Donne and the other metaphysical poets and of G. M. Hopkins. Melville took his place as one of the greatest of American writers, and *Moby-Dick,* at least, was read the world over. Within 30 years a veritable library of Melville scholarship and criticism was published.

Melville's **Nature.**—Melville's temperament was complex and this complexity accounts for the shifts and changes in his themes and in his prose style. Fundamentally he was a rebel and a questioner. in revolt against many of the accepted social and moral standards of his time and in search of answers to metaphysical questions which have always baffled inquiring minds. At times convivial. Rabelaisian even in the stories of his adventures which his friends delighted to hear him tell. enjoying good food, good wine and good talk, he was at other times withdrawn and solitary. By birth and inclination a patrician. he was also passionate in his "ruthless democracy"; a man who had lived with the dregs of

humanity in the forecastle yet could write in *Moby-Dick:* "But this august dignity I treat'of, is not the dignity of kings and robes. but that abounding dignity which has no robed investiture. Thou shalt see it shining in the arm that wields a pick or drives a spike; that democratic dignity which, on all hands. radiates without end from God." In revolt against the surviving Calvinism of his day. as well as the narrow evangelical piety which supported its missionaries handsomely in the South Seas. Melville could never drive from his mind the glory and the misery which Christ's sacrifice brought into the world. Though he rejoiced in having written a wicked book when *Moby-Dick* was finished. he makes one of his characters in *Clarel* say (21 years later) of the Christ:

> [Thou] shalt the Medusa shield replace;
> In beauty and in terror too
> Shalt paralyze the nobler race.

Melville's conviviality and zest for adventure are shown in *Typee*, *Omoo*, *Redburn* and *White-Jacket*. For the first time, in these books the common sailor had a voice which spoke of his trials and his daydreams, the excitement of seeing strange lands and peoples, the filth of port cities as well as the élite companionship of the maintop. Small wonder that his readers nanted Melville to continue in this vein and were puzzled when he decided, in *Mardi,* to explore the "world of mind." This first excursion into ideas is largely concerned with a criticism of existing states and speculation about the ideal social order. Entwined with it is Taji's quest for the ideal (whether of beauty or of truth it is difficult to say, by means of which. for the first time. Melville struggles with a theme that in varying forms would reappear in *Moby-Dick, Pierre, The Confidence-Man* and *Billy Budd.* He states it thus in *Pierre:* "Ah. if man were wholly made in heaven. why catch we hell-glimpses? Why in the noblest marble pillar that stands beneath the all-comprising vault. ever should we descry the sinister vein?"

The Deeper Novels.—In *Moby-Dick* this theme is incarnated in Captain Xhab's vengeful search for the white whale. who represented for him all the evil in the world, "visibly personified and made practically assailable." If he can strike his harpoon into Moby-Dick, he may be able to destroy him and what he symbolizes. At least he will strike through the mask of sinister whiteness to the agent or the principal within or discover (desperate thought) that "there is naught beyond." But Ahab's Promethean quest changes to personal vengeance on the sea-beast who has maimed him. He turns from the creative principle of light to the false god of fire whose "right worship is defiance.!' In the end he and his ship and its crew are destroyed by >loby-Dick. Only Ishmael, the narrator. survives. one to whom Ahab's quenchless feud at first seemed also to be his. He deserves to survive because he has learned that in this world "there is a wisdom that is woe; but there is a woe that is madness.'! Let man not look too long in the face of the unholy fire.

In *Pierre, or the Ambiguities* Melville was much less sure of his bearings. but again the theme is that of a man whose native resolution to follow his faith is corrupted and defeated. At times Melville seems to jeer at his hapless and feckless hero, but he is more certain than in *Moby-Dick* that the fault lies in heaven where the corrosion of evil first touched man's nature. Heaven gives perplexed man no answer to this ambiguity. "Silence is the only Voice of our God." Once again before *Billy Budd* Melville touched this theme which had obsessed him for many years. But in this final effort before the silent years set in. *The Confidence-Man,* the theme is muted to a series of variations on the idea that when we lose that confidence between man and man which holds society together. we become the victims of the confidence man with his nostrums and plausible falsehoods.

The power of the narrative and the beauty of the prose of *Billy Budd* suggest that in the last months of his life Melville finally arrived at a satisfactory resolution of his problem. When young Billy. "the handsome sailor." is impressed from the "Rights of Man" and taken on board the British seventy-four. H.M.S. "Indomitable." we catch a glimpse of Adam before his expulsion from Paradise. In the world of good and evil which he now enters. the good is represented by the father-figure of Captain Vere, the evil by the master-at-arms, Claggart, who accuses Billy of mutiny. But when Billy kills Claggart in a reflexive defense of his honour, Vere is the one who must ask the court. "How can we adjudge to summary and shameful death a fellow-creature innocent before God and whom we feel to be so?" And Vere tells his fellow officers that the verdict must be death. The agony is Billy's; the tragedy is the captain's. He knows that in this world we fight at command, though for the law and the rigour of it we are not responsible.

In *Moby-Dick* and again in *Billy Budd* Melville reached the heights of which he was capable as a writer of prose. Allusive, eloquent, highly figurative. subtly symbolic, it was strong enough to carry the mighty theme for which it n-as constructed.

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MELVILLE, SIR JAMES (1535–1617), Scottish diplomatist and memoir writer, was the third son of Sir John Melville, laird of Raith, who was executed for treason in 1548 In 1549 he went to France as a page of Mary Queen of Scots, and at the battle of St. Quentin in 1557 was taken prisoner. He subsequently conducted various diplomatic missions for Henry II of France. On Mary's return to Scotland in 1j61 she gave Melville an appointment in her household, and employed him as special emissary to reconcile Queen Elizabeth to her marriage with Darnley. After Mary's imprisonment Melville again conducted several diplomatic missions, and won the confidence of James VI when the king took over the government. In 1603 he retired to Halhill where he wrote *Memoirs of* My *O m Life,* a valuable authority for the history of the period (first published in 1683, new ed. 1820). Melville died at Halhill on Nov. 13, 1617.

See A. F. Steuart, ed.. *Memoirs of Sir James Melville* (1930).

MELVILLE, JAMES (1j56–1614), Scottish reformer, nephew of Andrew Melville (*q.v.*), was born on July 26, 1556. He was educated at Montrose and St. Leonard's college, St. Andrew~. He was one of the regents of Glasgow university, and then professor of oriental languages at St. Andrews. In 1584 he joined some of the leaders of the Scottish Presbyterian party in London for a short time. From 1586 to his death he took an active part in Church controversy. In 1589 he was moderator of the general assembly and on several occasions represented his party in conferences with the court. Despite his antagonism to James's episcopal schemes, he appears to have won the king's respect. He answered, with his uncle, a royal summons to London in 1606 for the discussion of Church policy. Andrew Melville was sent to the Tower, and James was placed in easy detention within ten miles of Newcastle-on-Tyne. In 1613 negotiations were begun for his return to Scotland, but his health was broken, and he died at Berwick in Jan. 1,614.

Melville has left ample materials for the history of his time from the Presbyterian standpoint, in (a) correspondence with his uncle Andrew Melville (manuscript in the library of the University of Edinburgh), and (*b*) a diary (manuscript in the Advocates' library. Edinburgh). His sketch of John Knox at St. Andrews is one of his best passages. The Dzary was printed by the Bannatyne club in 1829, and by the Wodrow society in 1842. Large portions of it are incorporated in David Calderwood's (1575–1650) History of *the* Kirk of Scotland (first printed in 1678).

See Thomas M'Crie, ***Life*** of *Andrew Melville,* 2 vol. (1819); Sir J. Melville, Memoirs, ed. by A. F. Steuart (1930).

MELVILLE, LAKE, a tidal extension of Hamilton inlet on the Labrador coast of Canada. Separated from the inlet by The Narrows, it is 66 mi. long and 12 mi. wide. Adjoining lakes and bays include Goose bay and Grand lake, both at the southwestern end, and the Backway, Lake Melville's outlet to the Atlantic prior to the Ice Ages. east of The Narrows. Depths are greatest in the southeastern half, probably exceeding 1,000 ft. Lakeside settlements include Rigolet, Happy Valley, Northwest River and Goose Bay airport, built as a military air base during World War TI and later used as a rescue base and emergency field for transatlantic flights. (J. D. I.)

MEMEL (KLAIPEDA), a town of the Lithuanian S S.R., U.S S.R.. on the bank of the sound through which the Kurisches Haff and the Nemunas. or Niemen, river (called Memel in its lower course by the Germans) connect with the Baltic. Timber is floated down the river. Pop. (1959 est.) 89,000.

History.—Memel was founded in 1252 by Poppo von Osterna, grand master of the Teutonic Order, and was at first called New Dortmund and afterward Memelburg. It soon joined the Hanseatic League. During the 13th, 14th and 15th centuries it was repeatedly burned by the Lithuanians and Poles. When the order lost its independence in 1466 the grand master retained Memel. In the 17th century the town remained for some time in the possession of Sweden. In 1757 and again in 1813 it was occupied by Russian troops. After the battle of Jena King Frederick William III retired to Memel, and there in 1807 a treaty was concluded between England and Prussia.

Before World War I Memel, with a strip of territory east of the Niemen, belonged to Germany, while the hinterland belonged to the Russian empire. Under the Versailles treaty Germany ceded all its territory east of the river to the Allied and associated powers and undertook to accept whatever disposal they made of it. Upon the ratification of the treaty the Allies occupied and administered the territory for three years. Lithuanians seized the town in a surprise attack on Jan. 15, 1923. On Feb. 16 the conference of ambassadors proposed that Memel should be handed over to Lithuania, subject to local autonomy and to freedom of transit for Poland. In Sept. 1923 the case was referred to the League of Nations. A commission of inquiry presented a draft convention to the council in March 1924. The convention was signed on May 8, 1924. While securing to Lithuania the country's only possible outlet to the sea, it curtailed Lithuanian sovereignty by giving the territory a responsible local government with an elected chamber and a governor appointed by the president of Lithuania.

The total area of the territory was 1.081 sq.mi. In March 1939 the population was estimated at 153,000, including 86,000 Lithuanians and 9,000 Jews, the Germans predominating in the town which had rnore than 47,000 inhabitants. In the face of a German ultimatum, Lithuania yielded Klaipeda to the Reich on March 22, 1939. During World War II the Russians occupied Klaipeda (Jan. 1945) and the territory was restored to Lithuania, which had in the meantime been annexed by the U.S.S.R.

MEMLING (MEMLINC), **HANS** (c. 1430–1494), Flemish painter whose art was significant to Bruges amid political and commercial decline. Memling was a skilled artist before he settled at Bruges. He probably served his apprenticeship at Cologne, and later worked under Rogier van der Weyden. The inventories of Margaret of Austria, made in 1524, describe a triptych of which the central panel was by Rogier, the wings by "Master Hans." Another clear proof of the connection of the two masters is afforded by an altarpiece ordered for a patron of the house of Sforza. It is now in the Brussels gallery. The date of it is fixed at about 1460–62 by the apparent ages of Francesco Maria Sforza, Bianca Visconti and their son Galeazzo, whose portraits appear upon it. The central portion of the triptych was obviously done in the studio of Rogier; the wings appear to be by Memling, and were probably done by him in Rogier's workshop. Moreover in Memling's later work certain figures seem borrowed directly from pictures by Rogier. Memling, therefore, may have stayed in Brussels working under Rogier before going to Bruges. He resided at Bruges from about 1465 until his death.

The earliest work which can be dated is the triptych in the collection of the duke of Devonshire at Chatsworth hall, Derbyshire. It was painted for Sir John Donne of Kidwelly, who, nith his wife and daughter, appears in the foreground as donor kneeling before the Virgin enthroned. On the wings are two saints. Sir John was one of the English courtiers who attended the marriage of Margaret of York to Charles the Bold which took place in Bruges in 1468. The picture was commissioned on that occasion. In the background of the left wing the artist painted himself peering behind a column. He seems to be about 35 years old and it may be surmised that he was born about 1430. This picture is typical of Memling's art. His later works are painted in the same style.

The great "Last Judgment" altarpiece in St. Mary's church at Danzig is generally ascribed to Memling. It was ordered by Angelo Tani, the representative of the Medici in Bruges, and was finished in 1472. Destined for Florence, the ship that carried it was made a prize of war by Danzig vessels in 1473. It is a picture measuring about 72 sq.ft. with more than 150 figures.

In 1477 Memling was under contract to furnish an altarpiece for the guild chapel of the booksellers of Bruges, now preserved, under the name of the "Seven Griefs of Mary," in the gallery of Turin. The effect of the whole is chaotic. Peter Bultync ordered a similar picture, the "Seven Joys of Mary," for presentation to the guild of the tanners in 1480. This panel is now in the Munich Pinakothek. All of Memling's pictures that have survived in Bruges, except one, are in the chapter house of the Hospital of St. John. Of these the first in order of date is the great triptych of 1479. The subject of the central panel is "The Mystic Marriage of St. Catherine." On the wings are "The Martyrdom of St. John the Baptist," and "The Vision at Patmos." In the background is a view of Bruges. On the back of the wings are shown the donors, two brothers and two sisters of the hospital, presented by their patron saints.

In the same year he painted another triptych on a smaller scale and finely finished. An inscription on the frame states that it was painted for John Floreins. The central panel represents the "Adoration of the Magi," that on the left "The Nativity" and the other panel "The Presentation in the Temple." The triptych, when closed, shows the figures of St. John the Baptist and St. Veronica. Another triptych, painted in 1484 in honour of St. Christopher, is in the Municipal gallery at Bruges.

A beautiful diptych, painted in 1487 for Martin van Nieuwenhove, is now in the I-Iospital of St. John. The left panel shows "The Virgin and the Child," the right has a portrait of the donor with his hands clasped in prayer and an open breviary before him. This is one of Memling's finest portraits. The portraits of the donors on Memling's pictures are distinguished and lifelike, as are the groups of the family of James Floreins—father, mother and children—which fill the noble altarpiece in the Louvre. As single portraits the busts of Burgomaster Moreel and his wife (in the museum of Brussels) and their daughter the "Sibyl Zambetha" (1480) in the hospital at Bruges are outstanding.

Memling was favoured as a portraitist by Italians. The Antwerp museum has the portrait of the medalist, Niccolo Spinelli, who was engaged as a seal engraver by Charles the Bold from 1467 to 1468. He is depicted holding a medal against a landscape background. In the Altman collection, Metropolitan Museum of Art, New York, a pair of portraits represent Thomas Portinari and his wife; in the J. P. Morgan collection is the Machiavellian "Man With a Pink." These four are early pictures. The portraits of a married pair of mature age, formerly at Milan, are now divided

between the Berlin and the Louvre galleries. They are full of character and expression as is the portrait of an old man in the Altman collection. New York.

It has been suggested that three panels of equal size (one dated 1437) may have been framed together: a Madonna (at Berlin); and two, representing St Benedict and a praying donor, at the Uffizi. The latter came from the Sta. Maria Nuova hospital in Florence. If they belong together the young donor was doubtless named Benedict. and he may be Benedetto Portinari, whose family was closely associated aith Bruges and the Sta. Maria Nuova hospital. The portrait of a young man. again mobably an Italian, in the Dun collection, has a distinct personality and a determined expression. The Madonna pictures possess unusual charm. One of the earliest is the full-length standing Virgin (1472) in the Liechtenstein collection. The Virgin of the "Annunciation" in the Lehman collection, New York, is one of the finest.

BY COURTESY OF NATIONAL GALLERY, LONDON

"A YOUNG MAN AT PRAYER," BY HANS MEMLING. IN THE NATIONAL GALLERY, LONDON

The masterpiece. of Memling's later years, a shrine containing relics of St. Ursula in the museum of the Bruges hospital, is supposed to have been ordered and finished in 1489. The delicacy of its miniature figures, the variety of its landscapes and costume, the marvelous patience with which its details are given are all matters of enjoyment to the spectator. There is a later work of the master, a large "Crucifixion," with scenes from the Passion (1491) in the Lübeck cathedral. As the close of Memling's career nears, it is observed that his practice has become larger than he can compass alone, and the labour of disciples is substituted for his own. Moreover. it is hard to distinguish which work may be attributed to his studio and which to his followers. Memling's influence is felt in the work of his contemporaries and in that of the next generation.

Memling died on Aug. 11, 1494, at Bruges. The trustees of his will appeared before the court of wards at Bruges on Dec. 10, 1495, and it is gathered from records of that date and place that Memling left behind several children and a considerable property.

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MEMMINGEN, a town of Germany, situated in the Land of Bavaria. on the Ach, a tributary of the Iller, 35 mi. S.W. of Augsburg on the railway to Ulm-Kempten. Pop. (1959 est.) 29,818. Memmingen, first mentioned in a document of 1010, belonged originally to the Guelf family and later to the Hohenstaufens. In 1286 it became a free city of the empire, a position which it maintained until 1802, when it was allotted to Bavaria. It is partly surrounded with walls, and has some old gates and houses. It. contains the Gothic church of St. Martin! which contains beautifully carved choir stalls, and a town hall dating from about 1580. Its industries include linen spinning and weaving, and the manufacture of woolen goods, soap, ropes, emery cloth and machinery. Trade is carried on in cattle, timber, cloth and wine.

MEMNON, in Greek mythology, son of Tithonus and Eos (Dawn), king of the Ethiopians. Although mentioned in Hesiod and the *Odyssey,* he is instead a post-Homeric hero. After the death of Hector he went to assist his uncle Priam against the Greeks. He performed prodigies of valour, but was slain by Achilles after he had himself killed Antilochus, the son of Nestor and the friend of Achilles. His mother, Eos, removed his body from the field of battle, and it was said that Zeus. moved by her tears, bestowed immortality upon him. His mother wept for him every morning, and the early dewdrops were said to be her tears. His companions were changed into birds, called Memnonides, that came every year to fight and lament over his grave, which was variously located. The story of Memnon was the subject of the lost *Aethiopis* of Arctinus of Miletus; the chief source from which knonledge of him is derived is the second book of the *Posthomerica* of Quintus Smyrnaeus (itself probably an adaptation of the works of Xrctinus and Lesches). As an Ethiopian. Memnon was described as black, but was noted for his beauty. The fight between Achilles and Memnon was often represented by Greek artists. Later, the story was rationalized.

In Egypt the name of Memnon was connected with the colossal statues of Amenhotep III near Thebes, two of which still remain. The more northerly of these was partly destroyed by an earthquake in 27 B.C. and the upper part thrown down. A curious phenomenon then occurred. Every morning. when the rays of the rising sun touched the statue, it gave forth musical sounds like the twang of a harp string. This was supposed to be the voice of Memnon responding to the greeting of his mother Eos. After the restoration of the statue by Septimius Severus (AD. 170) the sounds ceased. The sound, heard also by modern travelers, is attributed to the passage of the air through the pores of the stone, chiefly due to the change of temperature at sunrise.

MEMOIRS: *see* AUTOBIOGRAPHY; BIOGRAPHY.

MEMORIAL DAY (DECORATION DAY). in the United States, a holiday observed in the northern states on May 30. originally in honour of soldiers killed in the American Civil War but subsequently also in honour of those who fell in later wars. Before the close of the Civil War. May 30 was also celebrated in several of the southern states. In the north there was no fixed celebration until 1868, when (on May 5) Commander in Chief John A. Logan of the Grand Army of the Republic issued a general order designating May 30, 1868. "for the purpose of strewing with flowers or otherwise decorating the graves of comrades who died in defense of their country during the late rebellion"; Logan did this "with the hope that it will be kept up from year to year." The Slay 30 date was made legal in Rhode Island in 1874, Vermont in 1876 and New Hampshire in 1877. By the second half of the 20th century it nas recognized in all the states and territories except Alabama, Arkansas. Florida, Georgia, Louisiana. Mississippi, North Carolina. South Carolina and Texas. The May 30 celebration in Virginia was regarded as a Confederate Memorial day. Confederate Memorial days are celebrated in Louisiana, Tennessee and Arkansas on June 3 (birthday of Jefferson Davis); in Alabama, Florida, Georgia and Mississippi on April 26; and in North Carolina and South Carolina on May 10. (A. McQ.)

MEMORY. In its most complete form, memory implies a capacity to make use of events and experiences which are treated as belonging to the past life of the person who now describes and uses them. In this fully literal sense. nhat is remembered can be given a more or less sharply defined position in time and a setting of related events and experiences.

Two less complete forms of memory are also generally recognized. In these something belonging to the past life of the person or animal concerned is brought into use again or "repeated," either in a form of words (reciting something learned by heart) or as a style of bodily behaviour (carrying out a series of skilled movements). In such cases, as a rule, no specific personal reference is made and no temporal mark is assigned. The second of these two cases, involving the re-employment of learned bodily movements. was called "habit memory" by Henri Bergson, and this descriptive term is often used. It is however misleading, for most instances of skilled movement are not "habits," although they are obviously possible only when there is a basis of earlier learning. All the many views about memory appear to accept, without specifically stating, the fact that whenever and however the past is used over again, it is in attempts to deal with some immediately present situation. Memory is thus based upon earlier perceptual activity and also normally requires some current perceptual activity to set it into operation.

From the earliest speculation about remembering to most of

the latest experimentally based views, it is assumed that the critical problems are concerned with how events and experiences can be retained so that they can be reproduced, either in their original mode or with the help of signs and symbols which are regarded as equivalent to that mode. Memory is thus usually considered to function perfectly in proportion to its literal accuracy of reduplication. The ordinary man and the scientist alike generally suppose that when anything happens which affects the behaviour of an organism with a central nervous system. it leaves behind some "trace" or group of traces. So long as these traces last they can in theory, under appropriate conditions, be restimulated, and then the event or experience which first set them up will be remembered. The experimental psychology of remembering—and all modern experts claim to base their views upon experiment—sets out to discover methods for establishing the requisite conditions for the persistence and length of persistence of traces and for their restimulation.

In fact, in this as in other fields of psychology, controlled experiments came very late upon the scene. It was not until after the publication of Hermann Ebbinghaus' book *Über* das *Gedächtnis,* in 1885, that they began to be taken seriously. Ebbinghaus, strongly influenced by Gustav Theodor Fechner, the German founder of psychophysics, and by contemporary physical science, introduced two master principles. The first was that all exact experiment upon mental events must be repeated, under as nearly the same environmental conditions as may be possible, a great number of times. Accidental manifestations will then be canceled out and the statistical uniformities will appear which indicate the basic laws of mental activity. The second was that all material to be used in psychological experiments must be set in a form that is devoid of meaning. If this is not done, the people who are experimented upon will have different initial biases of which nothing quantitative can be known.

In the case of memory, Ebbinghaus satisfied his first principle by carrying out heroically protracted experiments upon himself, in the course of which he established his famous "curve of forgetting." This shows that there is a rapidly accelerating early decay of memory during the first 24 hours or so after learning, followed by a very much slower drop, so that what can be remembered after five to ten days shows exceedingly little further decline for long periods. Other experimenters have since shown that, in the statistical sense, memory for many kinds of meaningful material follows the same general course, though the initial loss may be less rapid and the subsequent decay more prolonged.

To satisfy his second principle, Ebbinghaus hit upon the device of the nonsense syllable—an initial and a final consonant, with a vowel interposed so as to indicate a sound for which there is no meaningful word in the language that is being used. Nonsense syllables were welcomed by experimental psychologists because it seemed that they could be used, with major and minor differences of detail, in many varieties of experiment to show such things as the effects of the amount of material to be memorized, of the lapse of time between memorization and recall, and of the specific results of interpolated activities of various controlled kinds before recall; to measure what were called "association strengths" between any two or more different members of a nonsense series; to establish economical methods of memorization and the normal results of different groupings of the material to be remembered, and of periods of practice.

To study these, and many related questions, conventional methods were established in the period following Ebbinghaus. These were: (1) the learning method, counting the number of repetitions required for a first correct reproduction of the series used; (2) the saving method, counting the number of repetitions similarly required after known intervals; (3) the prompting method, using imperfect memorization and counting the number of times and places at which prompting is required for perfect recall; (4) the scoring method, using prescribed intervals after the original presentation, or number of presentations, of the series. then exposing one syllable and requiring recall of another one, the "score" being the proportion of right answers in the whole series. Reference to any reputable textbook of experimental psychology will yield details of these conventional methods and of their principal established results.

It will be noticed that the Ebbinghaus technique—and exactly the same is true of the great mass of research modeled upon it—subscribed to the view that memory is ideally an exact reproduction. "Right" recall. upon which all the main generalizations established by nonsense-syllable experiments depended, was literally accurate recall. The truth is that, except under the special conditions laid down by the experimentalist himself, the circumstances which call memory into play can rarely be satisfied by literal reduplication. The exclusive use of meaningless material in psychological experiment, although it may have many advantages in the laboratory, suffers from most serious drawbacks as soon as it is taken outside. Normally, when memory is effective in the constantly changing environment within which human beings live, what is remembered has to be altered, adjusted, in a way distorted, to serve immediate or prospective interests.

A move toward less readily controlled approaches began near the end of the 19th century. Perhaps the most influential exponent was Sigmund Freud. Rather surprisingly his theory of memory, as formally expounded, remained fundamentally associationist, but in fact he was strongly preoccupied with common changes, their directions, significance and condition in the material of recall. His activities of repression. of sublimation, transformation, distortion and symbolization are far removed from anything contemplated by Ebbinghaus or his more faithful followers.

Somewhat later the *Gestalt* psychologists, with a wholly different outlook in their concern with normal mental functioning and their determination to find firm experimental foundations for their views, laid great stress upon the study of changes in the material of recall. They claimed experimental backing for the view that memorized material remained in a sense active, even when it was not being openly used, and that it developed toward some kind of better articulated structure or *Gestalt,* the terminal or approximately terminal stages of this development being common to all normal remembering.

Obviously most learning and all subsequent use of material or movements learned involve memory, at least in one of the two less complete forms already described. At the same time as the psychoanalytic and *Gestalt* movements were gathering strength, there were lively developments in the study of learning problems, especially by experiment and particularly in animal behaviour. These have continued and many of them have had a profound effect upon the ways in which outstanding problems of memory are most frequently regarded. In I. P. Pavlov's "conditioning," for example, the conditioned response may have demonstrably different properties from those of the original reflex, and it can be evoked by conditions different, within a determinable range, from the original ones. Many investigations on the behaviour of animals when placed in a maze demonstrated that behaviour based upon earlier learning, and impossible apart from this, can nevertheless take highly flexible forms and did much to establish both the basic conditions and the limitations of such flexibility. F. C. Bartlett perhaps was the first to publish a full-scale study, experimental and theoretic, of remembering treated as an essentially constructive function. In doing this, however, he was synthesizing or summing up changed approaches and views that were already in rapid growth.

World War II brought new streams of influence upon the psychological scene. For practical reasons considered almost everywhere to be of the first importance, many types of machines capable of exercising continuous automatic control and recording were designed, made and put into use. Some of the most intriguing of these had to do with the transmission of information. Often enough the messages communicated from one place to another must be received and stored in some form, and then sooner or later brought out of storage and used over again. The experts responsible for the design and use of these machines began to wonder, from their special mathematical and physical points of view, whether possibly the central nervous system might normally operate somewhat after the manner of electronic com-

puters. There grew up, principally in the United States, but also during the same period in Great Britain, the views which are generally known as "cybernetics" and "theory of information." (*See* also CYBERNETICS; INFORMATION THEORY.)

By the beginning of the 1960s it was uncertain whether this latest of all approaches, in its bearing upon memory, would develop fundamentally new and different experiments and ideas or whether. as has often happened in other directions in the history of psychology, it would do little more than introduce a new and perhaps more exact vocabulary for the expert. The critical questions remained as they had been ever since remembering began to be investigated: how to understand and reconcile the conflicting demands for the accurate and literal reinstatement of events and experiences at the time when they "go into storage," and the equally urgent requirement that when they come "out of storage" it should be in forms sufficiently flexible to meet the challenges of a constantly changing world. Questions of the nature and location of the persistent effects of original experiences ("traces") had been subjected to an enormous amount of study and research. There were still no completely assured answers. It became more and more likely that they are organized into patterns of response which spread widely in the central nervous system and that they are, or at any rate are indicated, by-directions and -pathways of electrical conduction. But how these generate the meaningful behaviour of remembering is unknown and their location, if, in any strict sense, they can be said to possess one, remains a matter for vigorous dispute.

One of the odd things about memory is that it is apt to be highly specialized: the same person may consistently remember some classes of experience well and others ill. If he can find a way of coding the material that he normally recalls badly in terms of that which he can cope with well, his practical efficiency may be increased. Many attempts have been made to invent generalized codes to improve all-round capacity to remember, and these have been called mnemonic systems. In fact, mnemonic devices, all of which depend upon the use of some method of coding of what is to be remembered, may be very useful in limited fields and especially if the coding is made up by the person who is going to use it. In completely generalized and impersonal ways they are apt to break do n, largely because of their inevitable complexity and ambiguity, and their importance has declined. *See* ASSOCIATION, MENTAL: CONDITIONING: LEARNING; PSYCHOLOGY; *see* also references under "Memory" in the Index volume.

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MEMPHIS, the capital of Egypt through most of its early history, now represented by the rubbish mounds at Bedreshen on the west bank of the Nile 14 mi. S. of Cairo. As the chief seat of the worship of Ptah, the artisan god (Hephaestus), Memphis must have existed from a very remote time. But its greatness probably began with Menes (*q.v.*), who united the kingdoms of Upper and Lower Egypt and is said to have secured the site for his capital near the border of the two lands by diverting the course of the river eastward. The residence there of Pepi I of the 6th dynasty, as well as his pyramid in the necropolis, was named Men-nefer. and this gradually became the usual designation of the whole city, becoming Menfi, Membi in late Egyptian; *i.e.,* Memphis. It was also called Hakeptah. "Residence of the ka of Ptah," and this name furnishes a possible origin for that of Egypt. Memphis remained the centre of the government and the largest city in Egypt until the New Empire (18th to 20th dynasties), when Amen worship replaced that of Ptah and Thebes took the lead. After the conquest of Alexander the city quickly lost its supremacy to his new foundation, and although it remained the greatest native centre, its population was less than that of Alexandria. Its final fall was a result of the rise of the Arabic city of Fostat on the right bank of the Nile almost opposite the northern end of the old capital; and its ruins, so far as they still lay above ground, gradually disappeared, being used as a quarry for the new city, and afterward for Cairo. Now the ruins of the city, the great temple of Ptah, the dwelling of Apis and the palaces of the kings are traceable only by a few stones among the palm trees and fields and heaps of rubbish. But the necropolis has been to a great extent protected by the accumulations of blown sand. Pyramids of the Old and Middle Kingdoms form a chain 20 mi. long upon the edge of the valley from Giza to Dahshur. At Saqqara, the step pyramid of Zoser of the 3rd dynasty. several pyramids of the 5th and 6th dynasties and mastaba tombs of the Old Kingdom are crowded together. Later tombs are piled upon and cut through the old ones.

MEMPHIS, a city and seat of Shelby county, Tenn., U.S., on the lower Chickasaw bluff on the blisssissippi river in the extreme southwestern corner of the state. Pop. (1960) city 497.524; standard metropolitan statistical area (Shelby county) 627.019. For comparative population figures for the city *see* table in TENNESSEE: *Population.* Whitehaven, Millington, West Memphis (Ark.) and Germantown are its main suburbs.

History.— Founded in 1819 by several rich proprietors from middle Tennessee and named for the ancient Egyptian city, Memphis by 1860 had a population of 22.623, making it the sixth city in size in the south, and had become a serious economic competitor of St. Louis and New Orleans. Its growth resulted from the expansion of cotton raising in the south-central states and from its transportation facilities by railroad and river. It was incorporated in 1826 and chartered as a city in 1840. A railroad connecting it with the Atlantic (at Charleston. S.C.) was completed in 1857 and it had become second to New Orleans as a cotton market. A cosmopolitan metropolis, with a third of its residents from Ireland and Germany. it had a mercantile aristocracy; though, as an old river town. it had an underworld which rivaled Natchez-under-the-Hill. Occupied by Union forces early in the American Civil War. Memphis soon became a centre for contraband trade which attracted many enterprising Yankees. Its population doubled within the decade and its improved economic position gave it justifiable hopes of becoming the "New York of the south."

In the 1870s three epidemics of yellow fever devastated Memphis, killing 8.000 residents. The Irish died. the Germans left, the city became bankrupt and surrendered its charter and the population dropped to 33.000 in 1880. But shortly thereafter drastic sanitary reforms were carried out and the debt was paid. At the turn of the 20th century Memphis stood second to New Orleans in the south. its economic recovery deriving largely from its central location; it became the largest hardwood lumber market in the world, the fifth wholesale grocery market in the United States (ahead of St. Louis) and it led New Orleans in the value of its industrial output. But the set-back of the 1870s enabled Atlanta and Dallas ultimately to surpass it. The cultural consequences of the fever epidemics were more serious. Rlemphis became a provincial town peopled by recent migrants from the adjacent countryside in Mississippi; Arkansas and Tennessee. In 1918 less than 2% of its white residents had been born in the city. Old in time, it was as new and as provincial in cultural continuity as the younger cities of the new south. In the 1920s it had the reputation of being the most vice-ridden city in the nation and was notorious for the number of its murders.

Its comparative economic advance did not continue in the 20th century; in 1930 it had dropped to sixth place among southern cities. By the second half of the 20th century it had passed Atlanta and Birmingham but remained well behind the Texas cities. As the leading metropolis of the mid-south it attracted increasing numbers of northerners and increasing amounts of northern capital. After 1930 Memphis won national awards for safety, sanitation and noise abatement. Much of this progress took place under Edward H. ("Boss") Crump. Elected as a reform mayor in 1909

when the commission form of government was inaugurated, Crump was ousted by the courts in 1915 for his failure to enforce the state prohibition law. With the victory of the candidates he supported in the municipal election of 1927, the "Crump ticket"—Watkins Overton and Clifford Davis—his local power became absolute and through it his control of the state. For 20 years his local candidates, hand-picked by himself, received no opposition in four out of five municipal elections. In effect, he was an extralegal city manager. After his death in 1954 his machine was broken up, though some of its members continued to hold office, and elections again became spirited contests between rival candidates.

Population Characteristics.— The Negro population dropped from 48% in 1900 to 37.2% in 1950; the number of northern-born and local-born residents increased considerably. In 1950 the population of the city was 61.7% native-born white, 1.1% foreign-born white and 37.2% Negro.

Commerce and Industry.— Memphis is a major cotton and inland hardwood lumber market, wholesale centre, producer of mixed feeds and distributor of drugs and chemicals. It serves an extensive agricultural area noted particularly for its cotton but also increasingly an area of diversified crops? including corn, alfalfa, truck produce, soybeans and livestock. A dam across a chute of the river provides a $50,000,000 harbour with adjacent industrial sites. A four-lane highway bridge across the Mississippi was completed in 1949, providing better access to the west. Its trading area extends in all directions and is easily accessible by railroads, highways, airlines and rivers. One of Memphis' main advantages is the distance which separates it from other large cities—St. Louis to the north, New Orleans to the south, Birmingham and Atlanta to the east and the Texas cities to the southwest. Consequently many national firms have established branch offices or factories there.

Education:— Facilities for higher education include Southwestern at Memphis, a Presbyterian college established in 1848; Lemoyne, a Congregational Christian college, established in 1871; Christian Brothers, a Roman Catholic college for men, established in 1871; Memphis State university established in 1909; and several divisions of the University of Tennessee, the largest of which is the college of medicine, dentistry and pharmacy.

Parks and Recreation.— The city has over 70 public parks and a free zoo. It is the site of the Cotton carnival, a week-long festival held every May. Memphis is the home of the "blues," a form of jazz (*q.v.*) associated particularly with W. C. Handy, which immortalized Beale Street.

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(G. M. CA.)

MEMPHREMAGOG, LAKE, an elongated finger-lake that crosses the U.S.-Canadian border about 5 mi. N. of Newport, Vt. Extending about 27 mi. from Newport to Magog, Que., the lake is only one to two miles wide for most of its length, but there are several large embayments. These include Fitch bay on the east shore about 17 mi. south of Magog and Sargents bay on the west shore about 10 mi. south of Magog. A small-scale hydroelectric development has grown at the north end of the lake where it drains by way of the Magog and St. Francis rivers into the St. Lawrence. Depths average 50–75 ft. with shallows at the south end. The deepest part, about 350 ft., is at the narrows near the entrance to Fitch bay. Lake Memphremagog is well stocked with fish and is used by small pleasure boats. There are floatplane anchorages near Magog and Newport. The surrounding country is rolling wooded upland with poor soil. Local deposits of copper and asbestos have been exploited intermittently, but the importance of the area lies in its dairy, pulp wood and timber industries and the rapidly growing tourist trade. The first settlers came from Connecticut, New York and Massachusetts in the last decade of the 18th century. (F. K. HE.)

MENA, JUAN DE (1411–1456), Spanish poet, was born at Córdoba, and died at Torrelaguna. His chief work is El *Laberinto de Fortuna* (1444), long-known as *Las Trezientas* (since in its final form it contains 300 stanzas); it is a Dantesque allegory, but carried in its time a political message for John II. Its heavily rhythmical *arte mayor* metre (lines of 12 syllables) is often monotonous, but there are passages of rare power and music. Mena's language, rich in Latinisms and rhetorical devices, had great influence; in this, in his imitation of Virgil and Lucan, and in his references to classical personages, he took an important step toward the Renaissance.

See M. R. Lida de Malkiel, *Juan de Mena, poeta del prerrenacimiento español* (1950). (C. C. SH.)

MENA, PEDRO DE (1628–1688), Spanish baroque sculptor, creator of numberless statues and busts of polychromed wood for churches in Spain and Latin America, was born in Granada on Aug. 20, 1628. He was a pupil of his father, and from 1652 to 1657 was an assistant of Alonso Cano. Mena's style, thoroughly indebted to Cano, is more theatrical and realistic, in keeping with the late baroque. His faces tend to be less forceful. In 1658, Mena went to Málaga and began work on 40 choir stalls, finished in 1662, for the cathedral. Technically highly proficient. he achieved there individuality, vitality and lifelikeness. In 1663 he visited Madrid and Toledo, and was named sculptor of Toledo cathedral. One of his most stirring works, a St. Francis (Toledo cathedral) with keen upward gaze and half-open mouth, suggests ascetic ecstasy. Many of his sculptures at Málaga, to which he returned in 1664, were destroyed in the riots of 1931, including his masterful "Virgin of Bethlehem" at Santo Domingo church, which combined dignity and playfulness, seriousness and extrovert grace, typical of Andalusia. The Virgin of Sorrows and the *ecce homo* were favourite themes. He died in Malaga, Oct. 13. 1688. Compared with him. José de Mora (1642–1724), the other Granadine pupil of Alonso Cano, may be called more exquisite and precious.

See Ricardo de Orueta, *Pedro de Mena* (1914); George Kubler and Martin Soria, *The Art and Architecture of Spain and Portugal and their American Dominions 1500–1800* (1959). (M. S. S.)

MENAGE, GILLES (1613–1692), French man of letters, well-known in his lifetime as a scholar and as a critic and after his death as the eponym of a book of anecdotes, was born at Angers on Aug. 15, 1613. A lawyer's son, he practised at the bar in Angers and, from 1632. in Paris. There he began about 1639 to frequent Mme. de Rambouillet's circle of Précieuses, under whose influence he fell and whose ideals he was to defend. Gradually abandoning the law for the church, he attached himself to the future cardinal de Retz from 1643 to 1652, then to the finance ministers Abel Servien and Nicolas Fouquet, to whose memory he remained remarkably loyal after Fouquet's disgrace. His *Mercuriales* or "Wednesday meetings." at which poets and critics discussed literary matters, began in 16 j6. Mme. de Sévigné and Mme. de La Fayette enjoyed his society, but his gallant attentions to ladies provoked much ridicule, and his malice many enmities (the pedant Vadius in Molière's *Les Femmes savantes* is a caricature of him). He died in Paris on July 23, 1692.

Ménage's writings include controversial tracts (from 1636 onward), a book on the pleasures of civil law (1644), insipid poems in Latin, Greek, French and Italian (1st ed. 1656; 8th ed.. augmented, 1687), a history of women philosophers (1690) and numerous commentaries on ancient and modern authors, as well as two more valuable philological works, *Les Origines de la langue françoise* (1650) and *Observations sur la langue françoise* (1672). After his death his friends published his jokes, retorts, miscellaneous judgments and curious observations as *Menagiana* (1693; 3rd ed., 4 vol., 1715), an entertaining compilation that was read with pleasure throughout the 18th century.

For the *Mercuriales* see the *Chronique des chapons et des gelinottes du Mans*, ed. by F. Lachèvre (1907). *See* also H. Ashton, *Ménage et ses élèves* (1920); A. Adam, *Histoire de la littérature française au XVII^e siècle*, 5 vol. (1948–56).

MENAHEM, king of Israel, seized the throne *c.* 745 B.C., after the death of Zechariah, whose reign lasted only six months. Events of his reign are related in II Kings xv, 14–22. From his headquarters at Tirzah, the old royal city of Israel, he advanced against Shallum, a rival aspirant to the throne who maintained royal state in Samaria for a month, and slew him. He was not accepted by the district of which Tappuah was the centre, and

made his position good only by bitter fighting! after which he inflicted barbarous punishment on those who would have thwarted him. Toward the end of his ten-year reign the peoples of Syria formed an anti-Assyrian coalition. Tiglath-Pileser III advanced against the rebels (738 B.C.) and crushed them.

The Assyrian king, in an inscription recording his successes, names among the kings who paid tribute Menahem of Samaria. The narrative in II Kings xv confirms this, and indeed suggests that Tiglath-Pileser advanced against Israel itself. The inscription is silent on this latter detail, and probably Menahem thought it wise to pay tribute before this pass was reached. Menahem was succeeded by his son Pekahiah.

MENAI STRAIT, a channel of the Irish sea, separating Anglesey from Caernarvon, north Wales, extending 15 mi. from Beaumaris to Abermenai and varying in breadth from 200 yd. to 2 mi. It is famous for the suspension and tubular bridges which cross it.

The origin of the Menai strait has been much discussed *(see* E. Greenly. "Geology of Anglesey." *Mem. Geol. Survey,* 1919). The channel consists of an'eastern and a western reach joined by a middle reach. 2 mi. long. having a north to south direction. The two longer arms are typical valleys, belonging to a system of parallel valleys upon the Menaian platform. In preglacial times the location of the strait was marked by three rivers corresponding to the later reaches. In late glacial times the western and eastern reaches came into existence, but the water of the latter was dammed back by the Ogwen glacier from the mainland. thus forming a long glacial lake which overflowed into what is now the middle reach, following the line of the southward flowing river. the valley of which it quickly deepened and thus emptied the lake. Postglacial subsidence and scouring by the tides have completed the work. On the Caernarvon side is Vaynol park with its herds of deer. and wild cattle which are thought to be descendants of *Bos primigenius.* In the strait was recorded for the first time in Britain (1830–31) the American hooded merganser *(Mergus cucullatus).*

MENAM CHAO PHYA or **CHAUPAYA,** chief river of Thailand (Siam), annual floods of which enrich the densely populated central plain where most of the country's rice is grown. Rising in the north, it is known as Nam Ngob, then as Nam Nan. It flows southward between high forested ranges and, notwithstanding the frequent rapids, it is used for transport of hill produce. At Utaraditra it enters the great plain and flows through forest and swamp, the latter providing vast overflow basins for the yearly floods. Below Pitsanulok it is joined by the Menam Tom, upon which two ancient capitals. Sawankalok and Sukotai, were situated. At Paknam Po (about 90 mi. irom the sea), the main western tributary comes in—the shallow Me Ping. Near Chainat the Tachin branches off—a western stream parallel to the main river down to the Gulf of Thailand. Numerous minor streams and navigable canals provide an excellent system of inland navigation between the two rivers. At Ayuthia *(q.v.)* the Nam Sak or Lopburi river enters from the northeast. affording communication with the tobacco district of Pechabun, and draining the western slopes of the Rorat escarpment.

MENANDER (Μένανδρος) *(c.* 343/2–291/0 B.C.), the chief poet of the Greek New Comedy, was the son of a wealthy Athenian, Diopeithes, of the deme Cephisia, and his wife, Hegesistrate. Alexis, the distinguished poet of the hfiddle Comedy, was his uncle. Of his uneventful life almost nothing is known. He was a pupil of Theophrastus (Diog. L., v.36) as was also Demetrius of Phalerum (Diog. L., v. 39, v. 75), who in 317 B.C. had been appointed by Cassander to be governor of Athens, and with whom hfenander was on friendly terms (Diog. L., v.79). Phaedrus, *Fab.* v. 1, tells how Demetrius was fawned upon not merely by prominent politicians but also by retired lovers of ease: "among whom Menander, famous for his comedies—whom Demetrius had not known personally though he had read him and admired his genius—came, perfumed and in flowing robe, with languid step and slow. Seeing him at the end of the line the tyrant asked "What effeminate is that who dares to enter my presence?" Those nearest replied "This is Menander, the writer!" He was no doubt acquainted also with his distinguished contemporary, Epicurus (Strabo, 638). He declined an invitation from the court of Macedon, as also one from Ptolemy Soter to Alexandria (Plin. N H. vii. 111. Alciphr, *Ep.* iv.18) and remained in Athens till his death, which is said to have occurred through drowning in the Bay of Phalerum (schol. Ovid, *Ibis).* His tomb beside the cenotaph of Euripides between Athens and the Peiraeeus was seen by Pausanias. Of his personal appearance we are told that he had a squint (Suidas, *s.v.* Μένανδρος). His portrait is supposed to be represented by a head in the Vatican.

He appears to have produced his first play, the Ὀργή, in 324 and he won his first victory, according to the *Marmor Parium,* in 316/5. According to Apollodorus *ap.* Aul. Gell. xvii. 5 hfenander "of Cephisia, son of Diopeithes, wrote 105 dramas and died at 52," but won the prize only eight times. In his own day Philemon was preferred to him, (Quintil. x.1.72) "Yet other comic poets . . . and especially Philemon, who, if by the verdicts of his own time he was oiten wrongly preferred to Menander, is universally allowed to have deserved to be considered second to him" *(cf.* Aul. Gell. xvii. 4.1). Menander was often defeated by Philemon, by no means his equal as a writer, through canvassing and faction. Meeting him on one occasion "Excuse me, Philemon," he said, "when you defeat me, do you not blush?" (Martial v.10 *Rara coronato plausere theatra Menandro).* But after his death he came to be regarded not merely as the leading poet of the New Comedy, but as the chief representative of comedy in general.

At the beginning of the 19th century all that was extant of Menander was a number of fragments, some of uncertain source, quoted by grammarians or other writers, and a collection of single lines of a sententious character (Μενάνδρου γνῶμαι μονόστιχοι), 850 in all, and not all of them authentic. Considerable information as to the character of his plays was to be gathered at second-hand from the use made of them by Plautus, who based his *Bacchides* on the *Dis Exapaton,* his *Poeizulus* probably on the *Karchedonios,* his *Stichus* on the *Adelphoi,* one of the two plays of that name written by Menander; and still more from Terence —who is saluted by Julius Caesar in the well known epigram (Sueton. *Vit. Ter.)* as "dimidiate Menander," "Menander in half" —of whose plays the *Andria* is a "contamination" of Menander's *Andria* and *Perinthia,* the *Eunuchus* a "contamination" of the *Eunouchos* and *Kolax,* the *Heautontimorumenos* a version of a play of the same name by Menander, while the *Adelphoi* is based on Menander's *Adelphoi* and the *Synapothneskontes* of Diphilus.

But since 1844 when C. Tischendorf found in the monastery of St. Catherine on Mt. Sinai three papyrus fragments containing 52 lines from the *Phasma,* 41 from the *Epitrepontes,* six from an uncertain play—all in a more or less mutilated condition—the Menander *corpus* has been greatly augmented by fresh papyrus discoveries. Incomparably the most important is the Cairo papyrus, discovered in 1905 by G. Lefebure at Aphroditopolis, containing 6j9 lines from the *Epitrepontes,* 83 from the *Heros,* 341 from the *Samia,* 324 from the *Perikeirowzene,* and 61 from an uncertain play. In addition 87 lines of the *Georgos* were recovered in Egypt by I. Nicole in 189;. A series of Oxyrhynchus papyri published by Grenfell and Hunt restored to us, in 1899, 51 lines of the *Perikeiromene;* in 1903 and 1914, 115 (fragmentary) lines of the *Kolax;* in 1908, 23 lines of the *Perinthia;* in 1910 and 1920, some 80 (fragmentary) lines of the *Misoumenos.* A Berlin papyrus (pub. 1907) gives 93 (fragmentary) lines of the *Kitharistes,* while another (pub. 1918) contains 23 lines of the *Misoumenos.* Some mutilated lines of the *Georgos* are given in a Florence papyrus (pub. 1912) and 20 (mutilated) lines of the *Koneiazomenai* in a Dorpat papyrus.

In structure, in subject matter, and in general tone, the New Comedy, which is essentially a comedy of manners, presents a marked contrast to the Old Comedy as we know it in the plays of Aristophanes. The chorus as an organic element in the play has wholly vanished—although there seems to have been some sort of choric interlude between the acts, as indicated in our texts by the single word ΧΟΡΟΥ—and with it the Parabasis, and the agon, the central element in the Old Comedy, in the sense of a formal debate between two clearly defined antagonists, has also disap-

peared. The theme is no longer some high question of political or social or religious moment, but merely the presentation of some commonplace complication of ordinary Athenian life, in which common types of character — the wealthy father, the dissolute son, the cunning slave — play their part, the complication being most commonly due to love (Ovid, Trist. II. 369 *Fabula iucundi nulla* est sine *amore* Menandri) in its least lovely guise, and the disentanglement being usually effected, more or less plausibly, by recognition (Ἀναγνώρισις), *i.e.*, by the timely discovery that some supposed stranger is in reality a long lost son or daughter, who had disappeared, whether by exposure in infancy or by shipwreck in a foreign land or other similar misfortune. The humour, whether of situation or of character, is of a subdued type, and the general atmosphere is quiet and little charged with emotion. A glance at the titles of Menander's plays, such as Κόλαξ, The Flatterer, Δεισιδαίμων, The *Superstitious* Man, and the like, suggest the prominence of character study, while the long list of such titles as Ἀνδρία, The Lady from Andros, Κνιδία, *The* Lady from *Cnidus*, etc., emphasize the place of recognition as a mode of dénouement, the supposed foreigner being discovered to be a true-born Athenian.

"Truth to life," his scrupulous observation of "propriety" or what the Greeks called τὸ πρέπον, was the great merit which the ancients recognized in Menander. "Ὦ Μένανδρε καὶ βίε, πότερος *tip'* ὑμῶν πότερον ἀπεμιμήσατο; O Menander and Life, which of you imitated the other?" so runs the highly flattering apostrophe to Menander attributed to Aristophanes of Byzantium. So Quintilian X. 1.69 writes of "Menander who, in my judgment, would alone, if carefully read, be sufficient to illustrate all my precepts: so well has he expressed the whole picture of life (*omnem vitae imaginem* expressit), such copiousness of invention has he, such a gift of speech, so appropriate is he in all his incidents, characters, emotions." Cf. Dio Chrysos. xviii. 7. Plutarch *comp. Menand.* et *Aristoph.* p. 853. A.P. vii. 370. ix. 187. The subtle presentation of character is perhaps a thing too delicate in its nature to exert its full appeal after the lapse of more than 2,000 years, but even the broken fragments of his work that remain enable us as assent to the judgment of antiquity.

Lastly it may be remarked that the sententious character, which he shared with Euripides (of whom he was a confessed admirer and imitator, Quintil. x. 1. 69) is not nearly so marked in the new fragments as one might have expected from the Μονόστιχοι, two of which — "Whom the gods love dies young" (ὃν οἱ θεοὶ φιλοῦσινἀποθνήσκει νέος) and "Evil communications corrupt good manners" (φθείρουσιν ἤθη χρήσθ' ὁμιλίαι κακαί — *cf.* N. T. I Corinth. xv., 33) — are known to multitudes who never heard the name of Menander.

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(A. W. MA.)

MENANDER (MILINDA), a Graeco-Indian dynast. When the Graeco-Indian king Demetrius had been beaten by Eucratides of Bactria, about 160 B.C., and the kingdom of Eucratides (*q.v.*) dissolved after his assassination (c. 150 B.C.), a Greek dynasty maintained itself in the Kabul Valley and the Punjab. The only two kings of this dynasty mentioned by classical authors are Apollodotus and Menander, who conquered a great part of India. Trogus Pompeius described in his forty-first book (see the prologue) "the Indian history of these kings, Apollodotus and Menander," and Strabo, xi. 516, mentions from Apollodotus of Artemita, the historian of the Parthians, that Menander "conquered more tribes than Alexander, as he crossed the Hypanis to the east and advanced to the Osamus; he and other kings (especially Demetrius) occupied also Patalene (the district of Patala near Hyderabad on the head of the delta of the Indus) and the coast which is called the district of Saraostes (*i.e.*, Syrastene, in mod. Gujarat, Brahman *Saurashtra*) and the kingdom of Sigerdis (not otherwise known); and they extended their dominion to the Seres (*i.e.*, the Chinese) and Phryni (?)." The last statement is an exaggeration, probably based upon the fact that from the mouth of the Indus trade went as far as China. That the old coins of Apollodotus and Menander, with Greek legends, were still in currency in Barygaza (mod. Broach), the great port of Gujarat, about A.D. 70 we are told by the *Periplus maris Erythraei*, 48. Their reigns may be placed about 140–80 B.C. Menander appears in Indian traditions as Milinda; he is praised by the Buddhists, whose religion he is said to have adopted, and who in the *Milindapanha* or *Milinda Pañho* (see below), "the questions of Milinda" (Rhys Davids, Sacred Books of the East, xxxv., xxxvi.) relate his discourses with the wise Nāgasena. Plutarch (Praec. *reip.* ger. 28, 6) relates that "when Menander, one of the Bactrian kings, died on a campaign after a mild rule, all the subject towns disputed about the honour of his burial, till at last his ashes were divided between them in equal parts." (The Buddhist tradition relates a similar story of the relics of Buddha.) Besides Apollodotus and Menander, we know from the coins a great many other Greek kings of western India, among whom two with the name of Straton are most conspicuous. The last of them, with degenerate coins, seems to have been Hermaeus Soter. These Greek dynasts may have maintained themselves, with diminished realms, in some part of India till about 40 B.C. (See INDIA: History.)

The *Milinda Pañho* is preserved in Pali, in Ceylon, Burma and Siam, but was probably composed originally in the extreme northnest of India, and in a dialect spoken in that region. Neither date nor author is known; but the approximate date must have been about the 2nd century of our era. The work is entitled *Milinda Pañho*—that is, The Questions of King *Milinda*. The work is several times quoted as authority by Buddhaghosa, who wrote about A.D. 450, and it is the only work, not in the canon, which received this honour. In it the king is represented as propounding to a Buddhist Bhikshu a number of problems, puzzles or questions in religion and philosophy; and as receiving, in each case, a convincing reply. The questions chosen were just those which would appeal to the intellectual taste of India of that age.

MENANDER PROTECTOR (fl. second half of 6th century A.D.). Byzantine historian whose fragments are a valuable authority for the 6th century, especially on geography and ethnography, held military office (*protiktor*), which was perhaps honorary. He studied law, abandoned this, and then at the suggestion of the emperor Maurice (582–602) he wrote a history modeled on Agathias. It begins at the point where Agathias (*q.v.*) left off, and the surviving text includes the period from the arrival of the Kotrigur Huns in Thrace in 558 down to the negotiations with the Avars about Sirmium in 582. Considerable fragments are preserved in the excerpts of Constantine Porphyrogenitus and in the Suda lexicon.

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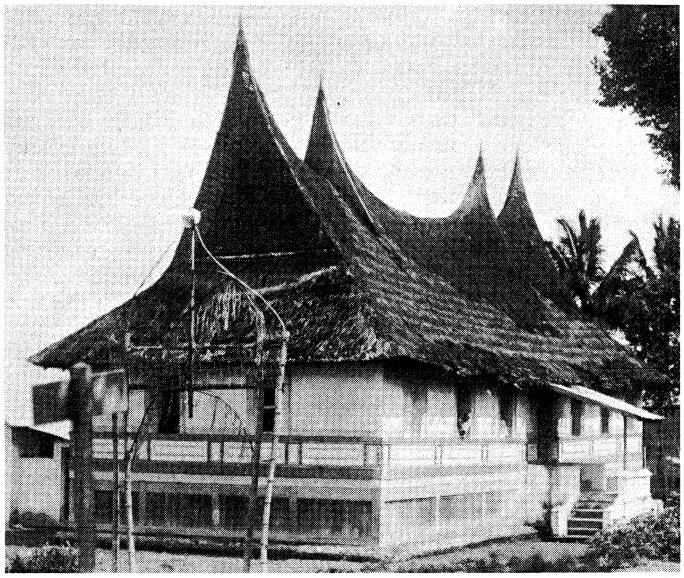
(J. M. HY.)

MENANGKABAU (MINANGKABAU), a powerful Malayan people inhabiting the Padang Highlands of central Sumatra. Under early Indian influence they became the centre of the Hindu-Malayan empire of Malayu, a state which once dominated most of the plateau area, and sent colonists to the west coast of the Malay peninsula (Negri Sembilan). Even toddy Indian tradition is strong in material culture as well as in mythology.

The Menangkabau have much in common with the coastal Malay, but differ radically in social organization. Despite the fact that they are converts to Islam, the position of women is high and a matrilineal system exists. The smallest unit in this scheme is the community house, in which a head woman, her sisters, their daughters and their children live. Several of these houses make up the clan, within which no marriage is allowed. Sons always remain members of the mother's house but they are only visitors in the homes of their wives. Descent and inheritance is through the mother's line. Several clans make up the negari, or "phratry"—the largest native element of government. Each house is represented in the clan council by a male member, and each clan likewise participates in the larger unit.

The family house is a large rectangular structure, raised high



BY COURTESY OF CHICAGO NATURAL HISTORY MUSEUM

A TYPICAL COMMUNITY HOUSE OF THE MENANGKABAU PEOPLE ON SUMATRA

above the ground, with a saddle-shaped roof. A main room occupies much of the structure. Adjoining this are living compartments, each occupied by a woman, her children and her husband when present. The Moslem religion allows four wives and divorce is easy. If a man avails himself of the privilege of plural marriage, he must arrange his affairs so as to devote equal time to each spouse.

Much of the wealth—especially land and heirlooms—belongs to the house or family, but individual possessions are allowed and many of the men are traders to neighbouring islands. Despite the fact that the Menangkabau are now Moslems and that some have made the pilgrimage to Mecca, many basic Malayan religious ideas persist. Mediums combine their activities, such as soul-catching and magic, with simple curative practices. Professional magicians, with trained accomplices, furnish charms and formulas and carry out ceremonies intended to bring rain or sunshine, to compel love, or to confound enemies. Magical formulas are mixtures of pagan and Moslem ideas.

The Menangkabau have extensive, terraced fields and garden plots in which they raise irrigated rice, tobacco and cinnamon, as well as fruits and vegetables. They are excellent wood carvers and metalworkers and produce the finest weaving found in Indonesia. Although they numbered only about 3,000,000 (1951 est.), the Menangkabau played an important role in the Indonesian independence movement, and several members filled important positions in the government.

See F.-C. Cole, *Peoples of Malaysia* (New York, 1945); E. Loeb, *Sumatra; Its History and People* (Salzburg, Vienna, 1935); L. C. Westenenk, *De Minangkabausche Nagari* (Weltevreden, Java, 1918).

(F.-C. CE.)

MÉNARD, LOUIS NICOLAS (1822–1901), French writer whose vision of ancient Greek religion and philosophy influenced the Parnassian poets (*q.v.*), nas born in Paris. Oct. 19, 1822. He was educated at the Collège Louis-le-Grand and the École Normale. A gifted chemist as nell as a painter and historian, he discovered collodion (*q.v.*) in 1846, but its importance was not then recognized and brought him no prestige. He nas a socialist republican and was condemned to prison in 1849 for his *Prologue d'une révolution,* but escaped to London and lived in exile, returning to Paris in 1852. Thereafter he devoted himself to classical studies, the fruits of which include his *Poèmes* (1855), *Polythéisme hellénique* (1863), his doctorate thesis *La Morale avant les philosophes* (1860) and *Histoire des Grecs* (1884–86). He spent several years painting in Barbizon and exhibited several canvases in the Salons (1857–69). In 1871 he supported and defended the Commune and in 1876 published *Rêveries d'un païen mystique,* which expounds his philosophy. He later held academic chairs in decorative art and universal history. He died in Paris, Feb. 9, 1901. His poems pale beside those of Leconte de Lisle and José María de Heredia, both of whom he influenced considerably: his short novel *La Légende de Saint-Hilarion* (1875) inspired Anatole France's *Thai's* (1890). His importance can best be seen in his historical and critical works, which demonstrate his belief in the truth and power of polytheism.

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MENASHA, a city of Winnebago county, Wis., U.S., 94 mi. N.W. of Milwaukee, with the adjoining city of Neenah forms one industrial community. often called Neenah-Menasha. Both cities overflow into the surrounding rural areas. The Fox river there issues from Lake Winnebago in two channels, each providing water power. Neenah developed on the south, Menasha on the north channel; and each city has part of Doty Island, the land between. Permanent settlement of both began in the 1840s. Neenah was incorporated in 1873 and Menasha in 1874. Neenah was at first knonn for its flour mills; but beginning about 1870 papermaking gradually became its chief occupation. Menasha's industry has always been more diversified; in early days it was best known for lumber and woodenware, in the 20th century the largest among its many enterprises are papermaking and printing. The presence of Lake Winnebago helped in the creation of beautiful parks and residential areas, while sailboating and yachting are popular recreations. In the language of the Winnebago Indians Neenah means "water"; Menasha, "waves." For comparative population figures *see* table in WISCONSIN: *Population.* (W. F. RY.)

MENCIUS (Latinized form of MENG-TZU, "Master Meng"; private name K'o) (371–289 B.C.?), Chinese philosopher, whose life is strikingly similar to that of Confucius (*q.v.*). Like Confucius, he was born in what is modern Shantung province, lost his father at about the age of three (according to tradition), lived in a period of political chaos, social and cultural disorganization, and intellectual conflict, became a professional teacher, served briefly as an official (in the state of Ch'i from 319 to 312 B.C.), traveled for about 40 years from state to state advocating reform, and finally was disappointed and retired.

Unlike Confucius. however, he had a teacher, either Confucius' grandson Tzu Ssu or his pupil. He was more self-confident, asking, "If Heaven wishes peace and order for the world, who is there besides me to bring it about?" He was highly argumentative, very dogmatic, and at times radical. Like Confucius, he idolized the legendary sage-emperors but also declared that "it is better not to have any history than to believe all histories." He was relentless in attacking opposite schools and staunchly defended Confucius as a sage and master. There is no information about his family, except the traditional stories that his mother moved twice to be near a school so that her son could imitate scholars and that, as an object lesson, she cut the cloth she was weaving when the boy interrupted his school and returned home.

The keynote to Mencius' philosophy is his doctrine of the original goodness of human nature, the first such in Chinese history. According to him, "Human nature follows the good just as water seeks the lower level." "All men originally have the feeling of commiseration, the feeling of shame and dislike, the feeling of deference and compliance, and the feeling of right and wrong," he asserted. These are the "four beginnings" of love, righteousness, propriety and wisdom, respectively. "They are not drilled into us from outside. We are originally provided with them." This can be shown by the facts, he said, that children naturally love their parents and that when men suddenly see a child about to fall into a well, a sense of distress and alarm is instinctively aroused in them. This doctrine of original goodness is diametrically opposed to that of his junior contemporary, Hsun-tzu (*q.v.*), and has been a basic doctrine in Confucianism (*q.v.*) in the last 2,000 years.

Since man is originally good, it follows that he possesses "native knowledge" of the good and "native ability" to do good. If one "develops his mind to the utmost," he can fulfill his nature, establish his destiny, and serve Heaven. Evil and failure are not

due to man's original nature but to one's "losing the originally good mind," "self-destruction and self-abandonment," or "lack of effort." Consequently, one must seriously "seek for the lost mind," which is the end of education.

Since love is inborn, one who fulfills his nature will "embrace all in his love." Mencius bitterly attacked the egoism of Yang Chu, who "would not pluck a single hair to benefit the world." But he insisted that the practice of love must start with the family, and strongly opposed Mo-Ti's doctrine of universal love *(see* Mo-TI) which to him meant that "no peculiar affection is due a father. To acknowledge no father . . . is to be a beast." Instead he taught the doctrine of "love with distinctions," that is, that there must be an order or gradation in love, starting with filial piety. Actually this does not contradict universal love, for he desired to "treat with respect the elders in my family, and then by extension also the elders in other families."

Mencius regarded filial piety as fundamental to all the virtues, especially those in the five human relations — affection between father and son, righteousness between sovereign and minister, attention to their separate functions between husband and wife, proper order between old and young, and good faith between friends. The most filial deed is honouring parents, and the most unfilial is to have no posterity. He thought the way of the wife is to obey. At the same time, he stressed that all men are equal, because moral nature and moral power are inherent in all. Therefore everyone is "complete in himself," and "All men can become sage-emperors like Yao and Shun."

Because his age was in great disorder, he emphasized righteousness equally with love, saying that "love is man's mind and righteousness man's path." These two are to be the guiding principles in government. He freely lectured the feudal rulers on "benevolent government" and vigorously advocated righteousness as opposed to utility and profit. He wanted to overcome "the way of the despot" or the way of force by the "kingly way" or the way of moral power.

Following Confucius, he maintained that only good men should rule. A ruler's right to rule comes from the mandate of Heaven, which is revealed in the conditions and sentiments of the people. To him in a state "the people are the most important, territory is secondary, and the ruler the least important." Bad rulers are to be overthrown, by revolution if necessary, for they have lost Heaven's mandate.

For practical measures, he recommended establishment of schools, promotion of agriculture, permanent property for the people, restoration of the ancient nine-square system with eight families each cultivating one square but jointly cultivating the ninth for the state, equal distribution of wealth, little punishment, light taxes, and protection of the old and the weak.

His teachings are found in the *Book of Mencius* (*Meng-tzu*) compiled after his death. They have been regarded as orthodox Confucianism and have exerted tremendous influence on Chinese thought, especially on neo-Confucianism. He was China's greatest sage after Confucius in the neo-Confucian hierarchy.

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MENCKEN, HENRY LOUIS (1880–1956), U.S. writer and controversialist, for two decades the most pungent critic of American life, was born in Baltimore, Md., on Sept. 12, 1880. After attending the Baltimore Polytechnic institute he became a reporter on the *Baltimore Morning Herald*, later joining the staff of the *Baltimore Sun*.

From 1908, when the *Smart Set* magazine hired him to do its book reviewing, until 1929, when the stock market crash made his caustic wit seem out of place, he jabbed his pen at many an American weakness. He often used literary criticism as a point of departure, though he wrote enough reviews and miscellaneous essays to fill six volumes of aptly titled *Prejudices* (1919–27). In literature he fought against what he regarded as the fraudulent successes of the time (the Harold Bell Wrights, for example) and for the recognition of such newcomers as Theodore Dreiser and Sinclair Lewis. His most famous forum for this and other causes was the *American Mercury*, which he helped to found in 1924, after leaving the *Smart Set*, and edited until late 1933. On both the *Smart Set* and the *American Mercury* he was associated closely with George Jean Nathan (*q.v.*).

Before 1929 Mencken's influence on the literary world was great, but his effect on American culture in general was equally marked, if it can be judged by the rage he aroused. In mid-career he could — and did — publish an entire book made up of denunciations of him. He jeered at organized religion, he ridiculed business and the middle class, and he called the sensitive south "the Sahara of the Bozart." Yet many readers found it refreshing, after hearing others eulogize their nation, to read in Mencken that the American people constituted "the most timorous, sniveling, poltroonish, ignominious mob of serfs and goose-steppers ever gathered under one flag in Christendom since the end of the Middle Ages." (H. L. Mencken, "On Being An American," *Prejudices: Third Series*, Alfred A. Knopf, Inc., New York, 1922.)

Mencken's view of life changed little during his career. In the '30s and '40s he altered considerably less than the world around him, with the result that his influence almost disappeared. Few people found the Great Depression a subject for satire of any sort, yet he was as satirical about Roosevelt as he had been about Hoover. Similarly, when the German culture he had enjoyed began to be marred by Hitler and fascism, Mencken was slower than some of his public to realize it and to take the fact seriously. But he still had another contribution to American culture to make. This took a surprising form, and one that survived his lessened popularity. In 1919 he had published a solid volume, *The American Language*, an attempt to bring together examples of American, rather than English, expressions and idioms. The book at once attracted attention. It grew with each reissue through the years, and in 1945 and 1948 Mencken published a substantial supplement. By the time of his death, he was the leading authority on the language of his country.

However memorable his role as a literary or social critic, or even as a linguistic scholar, Mencken always thought of himself as a newspaperman. Throughout most of his life he had worked for the *Baltimore Sun*, doing everything from police reporting to national political news. Much of the liveliest writing in his autobiographical trilogy, *Happy Days* (1940), *Newspaper Days* (1941) and *Heathen Days* (1943), is devoted to his experiences in journalism. He died in Baltimore on Jan. 29, 1956.

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MENDE, a town of southeastern France. capital of the *département* of Lozere, 59 mi. N.E. of Millau by rail. Pop. (1954) 5,840. Mende (Mimate) grew up around the hermitage, partly excavated in the side of the Mimat cliff, to which St. Privat. bishop of Javols, retreated after the destruction of that town, and where he was subsequently slain in 408 by the Vandals. In the 14th century the new town became the civil. as it had previously been the ecclesiastical, capital of the Gévaudan district. Mende is situated on the left bank of the Lot, and at the foot of the Causse de Mende. The town is the seat of a bishopric under the archbishop of Albi. Its cathedral of St. Peter was founded in the 14th century by Pope Urban V, a native of the district. but the two towers were added in the early 16th century. Partly destroyed during the devastation of the town by the Protestants in 1579 and 1580, it was rebuilt in the 17th century. A Renaissance tower of the ancient citadel now serves as the belfry of the church of the Penitents, and a 14th century bridge crosses the Lot. The town is a convenient centre for visitors to the gorges of the Tarn. The chief industry is the manufacture of serges and shalloons, known as Mende stuffs.

MENDEL, GREGOR JOHANN (1822–1884). Austrian Augustinian monk who discovered the first laws of heredity, was born in Heinzendorf, which was then in Austrian Silesia, on July 22, 1822. His interest in natural science developed early. After two years' study at the Philosophical institute at Olmutz (Olomouc), he entered the Augustinian monastery at Brünn (Brno) in 1843

and was ordained priest in 1847. During the period of his monastic training he taught himself a certain amount of science. From 1849 he acted for a short time as teacher of Greek and mathematics in the Gymnasium at Znaim (Znojmo), near Brunn, and was then sent by his abbot to the University of Vienna. where he studied physics, chemistry, mathematics, zoology and botany (1851–53). In 1854 Mendel returned to Brunn and taught natural science in the technical high school there until 1868, although he never succeeded in passing the examination for a teacher's licence. In that year he was elected abbot of his monastery.

The experiments which led to his discovery of the basic principle of heredity and subsequently to the science of genetics, for which his work laid the foundation, were begun in the small monastery garden in 1856 He worked for himself but in an atmosphere conducive to scientific interests. Among his colleagues at the high school were several men active in science, some of whom founded in Brunn in 1862 the Katural Science society (Naturforschenden Verein), in whose meetings Mendel took an active part. The libraries of both monastery and school contained essential scientific books, especially on agriculture, horticulture and botany, subjects in which Mendel's interest had been aroused by experience in his father's orchard and farm. That Mendel himself bought new books in these fields as they appeared is shown by his marginal notes in the works of Charles Darwin which appeared in the 1860s and 1870s. But it is certain that he had begun his experiments before Daruin's first book was published and before the essential role assigned to heredity as the basis of evolutionary change had been widely recognized. In fact, when he reported the results of his experiments to the Katural Science society on Feb 8 and March 8, 1865, he referred to his field of interest as "plant hybridization," and after indicating his familiarity with the work of his predecessors in this field, he boldly stated that "among all the numerous experiments made, not one has been carried out to such an extent and in such a way as to make it possible to determine the number of different forms under which the offspring of hybrids appear, or to arrange these forms with certainty according to their separate generations or definitely to ascertain their statistical relations." It mas this formulation by Mendel of the essential requirements for the experimental study of heredity and his provision of experimental data satisfying these requirements, both for the first time, that led him to the solution of a problem which underlies not only the understanding of heredity and of evolution but of biological processes generally.

Mendel crossed varieties of the garden pea which had maintained under his observation constant differences in such single alternative characters as tallness and dwarfness, presence or absence of colour in the blossoms and axils of the leaves and similar alternative differences in seed colour, seed shape, position of the flowers on the stem and form of the pods. In each cross (such as that between tall and dwarf) he found only one of the alternative types (referred to by him as the dominant character) in the hybrids; but when these produced (by self-fertilization) a second generation, both grandparental types always reappeared in the same constant proportion, about three-fourths with the dominant character, one-fourth with the recessive. He proved, by individually testing these second-generation hybrids, that about one-fourth of them resembled, in the single character under observation, one of the pure parent varieties from which it was descended, one-fourth resembled the other pure variety, and one-half resembled, both in appearance and in breeding behaviour, the first generation hybrid.

Mendel's explanation of these results was stated by him as follows: "it is now clear that the hybrids form seeds having one or the other of the tno differentiating characters." The essential feature of his hypothesis was that the occurrence of the visible alternative characters of the plants, in the constant varieties and in their descendants, is due to the occurrence of paired elementary units of heredity, now knonn as genes, which he symbolized by letters, assuming them to occur in alternative forms AA and aa for the constant parental varieties, Aa in the hybrids. Where the character of one parent, such as tallness, appeared in the hybrid to the exclusion of the other (Aa resembling AA) he called this the dominant; the other (such as dwarfness) found in aa individuals was termed the recessive. (For the behaviour of these in heredity, see GENETICS.) The novel feature of his interpretation, amply confirmed by subsequent observations on other plants and on animals, including man, and later on microorganisms, is that these units obey simple statistical laws, chief of which is that in the reproductive cells of the hybrids half transmit one parental unit, such as A, and half transmit the other, such as a. The separation of alternatives in the reproductive cells, now known as Mendel's first law, or the principle of segregation, adequately accounts for the results when single pairs of alternative characters are observed through several generations, and serves reliably as a basis of prediction. He showed, moreover, that when several pairs of alternative characters are observed, the several pairs of elements enter into all possible combinations in the progeny. In the pea varieties at his disposal he observed that the seven pairs of differentiating characters recombined at random, according to the law or principle of independent assortment, and he worked out the arithmetical or statistical consequences of this principle and confirmed them by experiment. It is known now that this principle applies only to units (genes) which are transmitted in different "linkage groups" or chromosomes in which genes are organized. Likewise the dominance in the hybrid of one of the alternative characters, which was true of all seven pairs observed by him proves on wider experience not to be true of all alternatives. But neither of these limitations affects the fundamental truth of the system of particulate heredity by units or genes which he was the first to prove. This system, which in the early years of the 20th century, while it was being tested and confirmed, was called Mendelism, proved to be of general application and is one of the basic principles of biology. This theory and the description of the experimental results from which it was deduced were presented in two papers which he read at meetings of the Natural Science society early in 1865 and published in detail in the transactions of the society in 1866. They appear to have had no effect whatever on the biological thinking of his time in Briinn or elsewhere, although his publication reached the principal libraries in Europe and America.

After this momentous publication, Mendel continued his research, attempting to test his theory by experiments with other plants. One further paper was published in 1869, but the plant he chose — the hawkweed (*Hieracium*) — was inherently unsuited to serve as test material and no corroboration was obtained. In this genus the embryo is formed from the ovum without fertilization (somatic parthenogenesis). Although Mendel's interest and work in botany, bee culture and meteorology continued almost until his death, science ceased to occupy the central position in his life, for his election as abbot of his monastery in 1868 brought with it a host of administrative duties and a protracted struggle with the Austrian government over the taxation of the monastery.

Mendel died on Jan. 6, 1884, respected and loved by his fellow monks and townsmen but unknown as the great biological scientist that he was.

Fame came to him only after his death. In 1900 three other European botanists, K. E. Correns, E. Tschermak von Seysenegg and H. de Vries, independently obtained results similar to Mendel's and in searching the literature found that both the experimental data and the general theory had been published 34 years previously. What followed is now a part of the history of genetics: confirmation and extension of his theory by biologists in many countries, and its incorporation as the basis of a rapidly developing science with primary influence on the understanding of evolution, development, physiology, biochemistry, medicine, agriculture and social science. Its influence on these fields was surveyed at the 50th anniversary of the "rediscovery," especially in the volume issued by the Genetics Society of America as a result of its 1950 meetings.

See also GENETICS; GENETICS OF POPULATIONS; HEREDITY; EVOLUTION, ORGANIC; etc.

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Rediscovery of His Work," Scientific Monthly, vol. 81, pp. 187–195 (1955). (L. C. D.; J. RM.)

MENDELEVIUM. The synthetic chemical element mendelevium has the symbol Md and the atomic number 101. It occupies a position in the periodic system of the elements as the twelfth member of the actinide series, a transition series similar to the rare-earth elements, which includes the heaviest known elements and in which an inner electron shell (the 5f shell) is being filled (for an account of its discovery. see TRANSURANIUM ELEMENTS). The first isotope identified was Md^{256}, which has a half life of approximately one hour.

The chemistry of mendelevium was studied by means of the tracer technique, and it appeared to have the predominant oxidation state III in aqueous solution. Its ion-exchange and elution properties were investigated, and it seemed to behave in the manner expected for an actinide element homologous to the rare-earth element thulium. (G. T. Sg.)

MENDELÉYEV (MENDELÉEFF or MENDELEJEFF), **DMITRI IVANOVICH** (1834–1907), Russian chemist, arranged the chemical elements in the periodic table according to their atomic weights and predicted the existence of the elements gallium, scandium and germanium before their discovery. The youngest of a family of 17, he was born at Tobolsk, Siberia, on Feb. 7 (new style; Jan. 27, old style), 1834. After attending the gymnasium of his native place, he went to study science at St. Petersburg, where he graduated in chemistry in 1856, subsequently becoming *Privatdozent* (official but unpaid lecturer) and pursued further studies abroad with Henri V. Regnault and Robert W. von Bunsen. He became professor of chemistry in the technological institute at St. Petersburg in 1863, and three years later succeeded to the chair in the university. In 1890 he resigned the professorship and in 1893 became director of the bureau of weights and measures, a post which he occupied until his death at St. Petersburg on Feb. 2 (N.S., Jan. 20, O.S.), 1907.

Mendeléyev's name like that of Lothar Meyer (*q.v.*) is best known for his work on the periodic law (*q.v.*). Various chemists had traced numerical sequences among the atomic weights of some of the elements and noted connections between them and the properties of the different substances; but it was left to him to give a full expression to the generalization, and to treat it not merely as a system of classifying the elements according to certain observed facts, but as a "law of nature" which could be relied upon to predict new facts. Thus in 1871 he was led by certain gaps in his tables to assert the existence of three new elements so far unknown to the chemist, and to assign them and their compounds definite properties. These three he called eka-boron, eka-aluminum and eka-silicon. His prophecy was completely vindicated within 15 years by the discovery and study of gallium in 1875, scandium in 1879 and germanium in 1886. Again, in several cases he ventured to question the correctness of the "accepted atomic weights," on the ground that they did not correspond with the periodic law, and here also he was justified by subsequent investigation. Mendeléyev also devoted much study to the nature of solutions, which he looked upon as homogeneous liquid systems of unstable dissociating compounds of the solvent with the substance dissolved. He investigated the thermal expansion of liquids and devised a formula for its expression. As far back as 1861 he anticipated T. Andrews' conception (1869) of the critical temperature of gases (see LIQUEFACTION OF GASES), by defining the absolute boiling point of a substance as the temperature at which cohesion and heat of vaporization become equal to zero and the liquid changes to vapour, irrespective of the pressure and volume. He also gave much time to the study of the nature and origin of petroleum. He speculated intensely on the nature and properties of the luminifesous ether.

Mendeléyev's best-known hook is The Principles of *Chemistry*, which was written in 1868–1870, and has gone through many subsequent editions in various languages (Eng. ed., 2 vol., 1905). He was awarded the Davy medal of the Royal society in 1882, and in 1905 he received its Copley medal. He was one of the greatest teachers of his time. His lecture room was always thronged with students. "Many of them," writes one of these, "I am afraid, could not follow Mendeléyev, but for the few of us who could it was a stimulant to the intellect and a lesson in scientific thinking which must have left deep traces in their development."

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MENDELSOHN, ERIC (1887–1953), German architect, mas born at Allenstein in East Prussia on March 21, 1887, and became one of the most prominent German architects. He employed at different times many methods of construction and a wide selection of materials. Among his works may be mentioned the Mosse-haus, Berlin (in collaboration with R. Neutra and R. P. Henning), with its interesting interplay of horizontal and vertical lines, completed in 1923; the Potsdam observatory [Einstein tower). 1920–21, a poetic conception, moulded rather than erected, which illustrates the dynamic tendency of contemporary architecture; the Mosse-Pavillon at the Pressa exhibition, Cologne, 1928; the Hotel Blackpool, England, 1937; World University project, Berkeley, Calif., 1942; and the Maimonides Health centre, San Francisco, Calif., 1950. In 1933 he left Germany. He became a British subject in 1938 and a U.S. citizen in 1948. Mendelsohn died in San Francisco, Calif., on Sept. 15, 1953.

See G. A. Platz, *Die Baukunst der neuesten Zeit* (1927); A. Whittick, *Eric Mendelsohn* (1940).

MENDELSSOHN, MOSES (1729–1786), Jewish philosopher. was born in Dessau. Ger.. in 1729. His early education was cared for by his father and by the local rabbi. David Fränkel. The latter. besides teaching him the Bible and Talmud. introduced to him the philosophy of Maimonides (*q.v.*). Fränkel removed to Berlin in 1743, where Mendelssohn joined him a little later. With his scanty earnings he bought a Latin copy of Locke's Essay Concerning *Human* Understanding, and mastered it with the aid of a Latin dictionary. In 1754 he was introduced to Gotthold Lessing. Just as the latter afterward makes Nathan the Wise and Saladin meet over the chessboard, so did Lessing and Mendelssohn actually come together as lovers of the game. Lessing had already begun his work on toleration, for he had recently produced a drama (Die *Juden*, 1749), the motive of which was to prove that a Jew can be possessed of nobility of character, and in Mendelssohn he found the realization of his dream. Mendelssohn had written in lucid German an attack on the national neglect of native philosophers (principally Leibniz), and lent the manuscript to Lessing. Without consulting the author. Lessing published anonymously Mendelssohn's *Philosophical* Conversations (*Philosophische Gesprache*) in 1755. In the same year there appeared in Danzig an anonymous satire, Pope a Metaphysician (Pope ein *Metaphysiker*), the joint work of Lessing and Mendelssohn. Mendelssohn now became (1756–59) the leading spirit of the Bibliothek and the *Literaturbriefe*, and ran some risk (which Frederick's good nature obviated) by somewhat freely criticizing the poems of the king of Prussia. In 1762 he married Fromet Gugenheim and in the year following won the prize offered by the Berlin academy for an essay on the application of mathematical proofs to metaphysics. In Oct. 1763 the king granted Mendelssohn the privilege of Protected Jew (*Schutz-Jude*)—which assured his right to undisturbed residence in Berlin.

As a result of his correspondence with Abbt, Mendelssohn resolved to write on the immortality of the soul. His *Phädon* (1767), modeled on Plato's dialogue of the same name, possessed some of the charm of its Greek exemplar, and its author was hailed as the "German Plato," or the "German Socrates."

Meridelssohn resolved to devote his life to the culture and the emancipation of the Jews. He began by his German translation of the Pentateuch and other parts of the Bible. This work (1783) constituted Mendelssohn the Luther of the German Jews. From it, the Jews learned the German language; from it they imbibed culture; with it there was born a new desire for German nationality; as a result of its popularity was inaugurated a new system of

Jewish education. Mendelssohn was the first great champion oi Jewish emancipation in the 18th century. He put forward his plea for tolerance in *Jerusalem oder über religiose Macht und Judenthum* (1783; Eng. trans. 1838 and 1852). He asserted the pragmatic principle of the possible plurality of truths: that just as various nations need different constitutions — to one a monarchy, to another a republic. may be the most congenial to the national genius — so individuals may need different religions. The test of religion is its effect on conduct. This is the moral of Lessing's *Nathan the Wise,* the hero of which is undoubtedly Mendelssohn. Having been taught that there is no absolutely true religion, Mendelssohn's own descendants — a brilliant circle. of nhich Felix was the most noted — left the synagogue for the church. Despite this. Mendelssohn's theory was found to be a strengthening bond in Judaism. Mendelssohn's *Morgenstunden, oder über das Dasein Gottes* appeared in 1785, and he died in 1786.

Mendelssohn had six children. His sons were: Joseph (founder of the Mendelssohn banking house, and a friend and benefactor of Alexander Humboldt), whose son Alexander (d. 1871) was the last *Jewish* descendant of the philosopher; Abraham (who married Leah Bartholdy and was the father of Fanny Hensel and J. L. Felix Mendelssohn-Bartholdy); and Nathan (a mechanical engineer of considerable repute). His daughters were Dorothea, Recha and Henriette, all brilliantly gifted women.

See the biography by his grandson G. B. Mendelssohn prefixed to his *Sämtliche Werke* (7 vols., Leipzig, 1843–44) and by M. Brasch in the edition (2 vols., Leipzig, 1880) of his *Schrijten zur Philosophie, Aesthetik und Apologetik;* also *M.* Kayserling, *M. Mendelssohn's Leben und Wirken* (2nd ed., Leipzig, 1888), and *Moses Mendelssohn Ungedrucktes und Unbekanntes von ihm und über ihn* (2nd ed., *Leipzig,* 1888); *L.* Goldstein, *Moses Mendelssohn und die deutsche Asthetik* (Konigsberg, 1904); H. Scholz, *Die Hauptschriften zum Pantheismusstreit zwischen Jacobi und Mendelssohn* (1916).

MENDELSSOHN-BARTHOLDY, JAKOB LUDWIG FELIX (1809–1847), German composer, grandson of Moses Mendelssohn (*q.v.*) was born in Hamburg on Feb. 3, 1809. His father, Abraham Mendelssohn, caused Felix, with his brother and two sisters, to be baptized as Lutheran Christians; and during the French occupation of Hamburg the family migrated to Berlin and lived with Abraham Mendelssohn's mother. Under the teaching of their mother and of other good musicians, Felix and his sister Fanny (some of whose compositions are included in Mendelssohn's songs and *Lieder ohne Worte),* soon showed extraordinary musical talent.

At the age of nine he played in public, and at 11 composed voluminously. He and Fanny played their own (or each other's) pianoforte compositions, and his sister Rebecka sang and his brother Paul played the violoncello. Five symphonies were written for this string-band in 1821, in which year Felix produced unaccompanied motets, two and a half operas and an immense amount of other music. The violin sonata of 1820 was published as op. 4.

In 1821 Mendelssohn, with Zelter as his bear-leader, visited Goethe. It is hard to say which of the two impressed the other most. Goethe had not been lucky in his musical acquaintances. Beethoven had repelled him. And now Goethe met this wonderful grandson of "Nathan der Weise," with gifts equal to Mozart's. The boy soon tried, with partial success, to convert Goethe to the gospel of Beethoven.

Before Mendelssohn was 17 he had composed his wonderful octet (op. 20) and a 13th symphony in C minor which he published as his first. A pianoforte quartet in B minor, the last of three, was dedicated to Goethe. Meanwhile he was making important discoveries apart from his own work. At the age of 12 he had read Bach's *Matthew Passion* in the autograph in the royal library, and was so excited by it that his mother had a copy made for him as a birthday present.

A visit to Paris in 1825 brought him into contact with many famous musicians, notably Rossini and Meyerbeer, and he found congenial friends in the great virtuosos of the pianoforte and violin, Hummel, Rode, Baillot and others. He also showed his compositions to the formidable Cherubini, whom he described as "an extinct volcano still throwing out occasional sparks and ashes." Cherubini astonished all musical Paris by praising Mendelssohn to his face, though in the third person. "Le garcon est riche: il fera bien. Mais il faut couper."

Perhaps Mendelssohn's parents overshot the mark in their anxiety to protect him from the dangers of conceit. He saw no great merit in his own smooth technique and was the less inclined to think that there was anything inherently noble in clumsiness. Yet his quick temper was so manifestly generous that artists like Schumann adored him as man and as musician.

After returning from Paris, Abraham Mendelssohn removed from his mother-in-law's house to a spacious old mansion with a music-room and grounds containing a "Gartenhaus" capable of seating several hundred persons. In Aug. 1826 Felix's overture to *A Midsummer Night's Dream* was performed here. He was only 17½ years old; but in later years he rarely equalled and never surpassed this work, which, written in the years of Beethoven's last quartets, belongs not only to fairyland but to an orchestration which Rimsky-Korsakov might have thought up-to-date.

A full-sized opera, *Die Hochzeit des Camacho,* on an episode in the story of Don Quixote, had been finished in 1825, and was produced under Spontini on April 29, 1827. After one much applauded performance Mendelssohn's opera was shelved, and violently abused by the critics.

This organized failure depressed Mendelssohn, but did not check his activity. Besides his usual flood of composition he collected a choir for the study of Bach's choral works (not one of which was then in print); and he succeeded, in 1829, in persuading the Berlin Sing-Akademie to perform the Matthew Passion, under his direction, with a chorus of some 350 voices. This was the first known performance of a choral work of Bach since his death in 1750.

In April 1829 Mendelssohn paid the first of ten visits to England, the last being shortly before his death, in 1847. From the outset he was received with unparalleled enthusiasm. The Philharmonic Society had forgotten the lesson in conducting given by Spohr in 1820; and Mendelssohn, on his first appearance, was obliged to conduct his C minor symphony from the pianoforte; a useless survival of the days of *continuo* orchestration *(see* INSTRUMENTATION). As Spohr said, "Of the two conductors not one is real; the leader of the orchestra has no score and cannot beat time while he is playing; while the gentleman at the pianoforte has no use for his instrument and cannot control the players." In later visits Mendelssohn changed all that. For this first concert he replaced the minuet of his symphony by a wonderful orchestration of the scherzo of his octet. This remained unpublished until 1911. He introduced Beethoven's concerto in E flat to English audiences and, during a visit five years later, the concerto in G. He was one of the first to play a concerto by heart in public; but though this was no effort to his Macaulayesque memory, he cared so little for display that once, when the score of one of his trios was mislaid, he put another volume upside down on the desk and asked somebody to turn the pages in order that he might not be seen to be playing by heart when his colleagues were playing from notes. After the first London performance of the *Midsummer Night's Dream* overture a friend left the score in a cab; but Mendelssohn rewrote it from memory.

During his visits to England his organ recitals revolutionized English organ-playing, and his productions of *St. Paul* and *Elijah* (the latter receiving its first performance at the Birmingham festival of 1846) established his influence on English music as co-equal with that of Handel.

One thing he emphatically did not establish. He did not found the "Mendelssohn tradition" in conducting. That accusation is one of Wagner's calumnies, and Wagner refutes it in the telling. He tells us that when he conducted in England he found that our overloaded programmes compelled him to concentrate his rehearsal on a few items and pull the rest through by bluff. Mendelssohn had had the same experience in the years from 1829 to 1847, and this was what the orchestral players chose to call "the Mendelssohn tradition." Wagner's vitriolic pen has saved him from having his own bluff immortalized by orchestral old stagers as "the Wagner tradition." The true Mendelssohn tradition was represented by Joachim (*q.v.*). It is a tradition of love and

reverence for the intentions of classical composers, and of a spirit of service in the highest interests of art. Mendelssohn also tried to introduce Schubert's C major symphony in London, but the orchestral players laughed so uncontrollably at the finale that he had to withdraw the work.

The first visit to London had been followed by a tour in Scotland, in which a visit to Staffa inspired him with the theme of his overture *The Hebrides* (or *Fingal's Cave).* The whole British campaign was the first instalment of a grand tour which Abraham Mendelssohn had planned for the enlargement of his son's mind. Accordingly Felix refused the offer of a professorship in Berlin and spent most of 1831 in Italy, reaching Rome on Nov. 1, 1830.

Abraham Mendelssohn felt deeply the duty which orthodox Jews owed to the memory of his father, who had brought his race out from the ghetto and created its modern social position; and he considered that in baptizing his children as Christians he ought to renounce for them that great Jewish name. Accordingly he provided Felix with visiting-cards which added his mother's maiden name, Bartholdy, and expected Felix eventually to drop the name of Mendelssohn. But it was too late; to Abraham's regret Felix's reputation was already established under his grandfather's name.

The main fruit of the Italian tour was the Italian symphony, which gave Felix much trouble and, according to his own account, "some of the bitterest moments" in his experience. The widely-stretched rhythms of the brilliant and spirited first movement are the kind of things that very easily upset a composer's calculations, and perhaps it was these that caused Mendelssohn bitter moments before he achieved their present easy and satisfactory balance. His letters on the music of the Sistine Chapel show keen observation and little disposition to be overawed by tradition; and it is not likely that he would have been more impressed by the Gregorian chanting of Solesmes than he was by the Palestrina tradition under the direction of Baini, who was then master of the pontifical choir. But he was as enthusiastic as Baini himself about Palestrina's *Improperia* and *Lamentatione,* and the famous *Miserere* of Allegri, with its exquisite modern *abellimenti.*

In 1832 his wonderful conducting of the Lower Rhine festival at Dusseldorf led to his appointment as general music-director to the town. This implied the management of the music in the principal churches, at the theatre, and at two concert-halls. Mendelssohn succeeded brilliantly in his organization of the church-music and the concerts; but in attempting to look after too many details himself he rather lost ground with the theatre. Still, he was happy at Dusseldorf, where he began his first oratorio, *St. Paul;* and he might have stayed there longer but for an invitation to take the permanent direction of the Gewandhaus concerts at Leipzig. This was the highest musical position in Germany, and accordingly Mendelssohn went to Leipzig in Aug. 1835, where he was received with acclamation. The reputation and prosperity of the Gewandhaus concerts increased, and meanwhile *St. Paul* was finished in time to crown the Lower Rhine festival at Düsseldorf next year.

On March 28, 1837, Mendelssohn married Cecile Jeanrenaud. The marriage was happy, and the descendants of Felix Mendelssohn are at the present day numerous and widely dispersed, but united in a great tradition of musical and general culture. The year 1840 is the date of the *Lobgesang,* and of the erection (mainly at Mendelssohn's expense) of a monument to Bach at Leipzig.

In 1841 the king of Prussia called Mendelssohn to Berlin, with the title of Rapellmeister. This resulted in the composition of choruses and incidental music to *Antigone, Oedipus Coloneus,* Racine's *Athalie,* and the rest of the *Midsummer Night's Dream* music. But Mendelssohn flatly refused to write music for the *Eumenides* as well, and found his Prussian appointment nothing but a vexation and a strain. He continued his direction of the Gewandhaus concerts, and his visits to England, where he conducted his Scottish symphony and dedicated it to Queen Victoria, with whom and with the Prince Consort he spent some hours which gave great pleasure to all three. In 1843 he founded the great conservatoire of Leipzig. In Sept. 1844 he induced the king to reduce his Berlin duties to something manageable with less detriment to his wider activities. He introduced Jenny Lind (*q.v.*) to the Gewandhaus concerts in 1845, and finished *Elijah* in 1846, conducting its first performance at the Birmingham festival on Aug. 16.

Its triumph was the culminating point of his life. The spirit of service was making him wear out his constitution. In May 1847 the news of his sister Fanny's death was told him abruptly. He lost consciousness at the shock and never recovered his health. In June a journey by easy stages to Interlaken refreshed him, and when he returned to Leipzig in September he had written some numbers of an oratorio, *Christus,* and of an opera, *Loreley,* besides a remarkable string quartet in F minor (with an astonishingly powerful second movement) and two movements (Andante and Scherzo) of another quartet. On Sept. g, a sudden seizure prostrated him. He died on Nov. 4, 38 years of age.

The death of Mendelssohn was, perhaps, one of the most inopportune events in musical history; inopportune for his reputation as soon as the period of funeral oratory was past; disastrous for many musicians who hoped to learn from him; and doubly inopportune as making it impossible for him and the pioneers of new musical developments to learn from each other. So docile a nature as Mendelssohn's would surely have learnt in time that Wagner, of whom he knew nothing later than *Tannhauser,* and Brahms, whom he did not know at all, were opening up worlds beyond the fairyland of *A Midsummer Night's Dream* and the Judaism of *Elijah.* It is unlikely that Mendelssohn would have tolerated Wagner's erotic vein; but he would soon have seen the reality of Wagner's new sense of movement, and would have experimented with it. And Mendelssohn's experiments were apt to succeed in the long run; his pianoforte concertos led to that violin concerto which has ever since been the model for almost all concertos not on classical lines *(see* CONCERTO); the ill-fated Reformation symphony of 1832 proved capable of revival when it was published posthumously; and the thoroughly experimental *Lieder ohne Worte* were a tremendous success from the first set in 1832 to the last posthumous gleanings from the waste-basket.

Very different is the estimate grounded on the Hebrides overture, the whole *Midsummer Night's Dream* music, the Italian symphony, the violin concerto, most of the Scotch symphony, a selection of movements from his chamber-music and a large anthology from his smaller works. The range of this selection is not confined to fairyland. Its deeper notes are human. The weaknesses are those of an artist who must write constantly if he is to write at all; and the emotional inadequacies do not show the character of the man.

More serious is the sentimentality of Mendelssohn's efforts at a religious style. The opening of the Andante religioso in the *Lobgesang* is the origin of almost all that is sickly in English church music, and *Elijah* contains things hardly better. But there are many noble features in *Elijah:* and the introductory recitative with the overture and first chorus form a fine scheme, much of the point of which is lost by the English translator, whose reverence for the Authorized Version has made him destroy the rhythm of *Ich sage es denn* which pervades the overture. The scene of the earthquake, the fire and the still small voice is treated by Mendelssohn in a style that justifies the attempt, and the quiet chorus *He that shall endure to the end* raises Mendelssohn's most reckless prettiness to the height of great music, which choral societies do not seem to appreciate when they omit it and insist on retaining *O rest in the Lord,* which Mendelssohn wished to cut out, and which is in any case sung by Jezebel to save the expense of a second alto. (D. F. ***T.***)

MENDES, CATULLE (1841–1909), French poet and man of letters, of Jewish extraction) was born at Bordeaux on May 22, 1841. He attained notoriety by the publication in the *Revue fantaisiste* (1861) of his "Roman d'une nuit," for which he was condemned to a month's imprisonment and a fine of 500 francs. As a poet, he was allied with the Parnassians from the beginning of the movement, and displayed extraordinary metrical skill in his first volume of poems, *Philomkla* (1863). His later volumes are: *Poésies, Ière skrie* (1876), which includes much of his earlier verse, *"Soirs moroses," Contes épiques, Philomkla,* etc., *Poésies*

(7 vols., 1885), a new edition largely augmented; *Les Poésies de Catulle Mendès* (3 vols., 1892); *La Grive des vignes* (1895), etc. His best novels are: *Le Roi vierge* (1880) in which he introduces Louis II. of Bavaria and Richard Wagner; *La Maison de la vielle* (1894), and *Gog* (1897). He married in 1866 Mlle. Judith Gautier, younger daughter of the poet, and herself a distinguished poet, from whom he was subsequently separated. On Feb. 9, 1909, early in the morning, his dead body was discovered in the railway tunnel of Saint Germain.

MENDICANCY, a state or condition of being a beggar, the practice of obtaining a livelihood by asking alms. The word "mendicant," also found in the French form "mendiant," appears to have come into use through the begging friars.

MENDICANT MOVEMENT AND ORDERS. The facts concerning the rise of the Orders of Mendicant Friars are related in the articles on the several orders (FRANCISCANS, DOMINICANS, CARMELITES, AUGUSTINIAN HERMITS). The striking phenomenon in connection with the beginnings of the mendicant orders is the rapidity with which the movement spread. Within a generation of the death of the two great founders, Dominic (1221) and Francis (1226), their institutes had spread all over Europe and into Asia, and their friars could be numbered by tens of thousands. In all the great cities of Western Europe friaries were established, and in the universities theological chairs were held by Dominicans and Franciscans. And when at the middle of the century the other great mendicant orders of Carmelites and Austin Friars, and also Servites (*q.v.*) arose their propagation showed that the possibilities of the mendicant movement had not been exhausted by the Dominicans and Franciscans. Lesser mendicant orders sprang up in all directions — Gasquet mentions half a dozen such that found their way into England (*English Monastic Life*, p. 241) — in such numbers that the Council of Lyons in 1274 found it necessary to suppress all except the orders already named. Moreover, besides the various orders of friars, there were the lay Tertiaries that arose and spread far and wide in connection with the Franciscans and other mendicants, and the similar institute of the Humiliati (*see* TERTIARIES). These facts clearly show that the Mendicant Movement responded to widely spread and deeply felt needs of the time. These needs found expression not only in the Mendicant orders within the Church, but also in a number of more or less heretical and revolutionary religious sects. There was this in common among the Cathari, Waldenses, Albigenses and other heretical bodies that overran so many parts of Western Europe in the second half of the 12th century and the beginning of the 13th, that they all inveighed against the wealth of the clergy, and preached the practice of austere poverty and a return to the simple life of Christ and the Apostles. Probably the most crying need was that of priests to minister to the great city populations, at that time growing up with such rapidity, especially in Italy. During the 10th, 11th and 12th centuries the Church had been organized on the lines of the prevailing feudal system — the bishops and abbots were feudal barons, and the effects of the system were felt throughout the ranks of the lower clergy. The social fabric was built up not on the towns, but on the great landlords; and when the centre of gravity began to move, first of all in Italy, to the towns, and crowded populations began to be massed together in them, the parochial systems broke down under the weight of the new conditions, and the people were in a state of spiritual and moral no less than physical destitution. So, when the friars came and established themselves in the poorest localities of the towns, and brought religion to the destitute and the outcasts of society, assimilating themselves to the conditions of life of those among whom they worked, they supplied a need with which the parochial clergy were unable to cope.

The friars responded not only to the new needs of the age, but to its new ideas — religious, intellectual, social, artistic. It was a period of religious revival, and of reaction against abuses that followed in the wake of the feudal system; and this religious movement was informed by a new mysticism — a mysticism that fixed its attention mainly on the humanity of Christ and found its practical expression in the imitation of His life. A new intellectual wave was breaking over Western Europe, symbolized by the university and the scholastic movements; and a new spirit of democratic freedom was making itself felt in the growing commercial towns of Italy and Germany. A few words are necessary on the central idea from which the Mendicants received their name — the idea of poverty. This was St. Francis's root idea, and there is no doubt — though it has been disputed — that it was borrowed from him by St. Dominic and the other Mendicant founders. St. Francis did not intend that begging and alms should be the normal means of sustenance for his friars; on the contrary, he intended them to live by the work of their hands, and only to have recourse to begging when they could not earn their livelihood by work. But as the friars soon came nearly all to be priests devoted to spiritual ministrations, and the communities grew larger, it became increasingly difficult for them to support themselves by personal work; and so the begging came to play a greater rôle than had been contemplated by St. Francis. But his idea certainly was that his friars should not only practice the utmost personal poverty and simplicity in their life, but that they should have the minimum of possessions — no lands, no funded property, no fixed sources of income. The maintaining of this ideal has proved unworkable in practice. In the Dominican Order and the others that started as mendicant it has been mitigated or even abrogated. Among the Franciscans themselves it has been the occasion of endless strife, and has been kept alive only by dint of successive reforms and fresh starts, each successful for a time, but doomed always, sooner or later, to yield to the inexorable logic of facts. The Capuchins (*q.v.*) have made the most permanently successful effort to maintain St. Francis's ideal; but even among them mitigations have had to be admitted. In spite, however, of all mitigations the Franciscans have nearly always presented to the world an object lesson in evangelical poverty by the poorness and simplicity of their lives and surroundings.

On the subject-matter of this article the best thing in English is the Introductory Essay by the Capuchin Fr. Cuthbert on "The Spirit and Genius of the Franciscan Friars," in *The Friars and how they came to England* (1903); *see* also the earlier chapters of Emil Gebhard's *Italie mystique* (1899). (E. C. B.)

Indian. — From early times detachment from the world and the practice of austerities have been regarded in India as conducive to a spirit of godliness, and ultimately to a state of ecstatic communion with the Deity. On these grounds it was actually laid down as a rule for a man solicitous for his spiritual welfare to pass the last two of the four stages (*āśrama*) of his life in such conditions of renunciation and self-restraint. These tendencies have been most extensively cultivated in connection with the Siva cult. Indeed, the personality of the stern God himself exhibits this feature in a very marked degree, whence the term *mahāyogī* or "great ascetic" is often applied to him.

Of Saiva mendicant and ascetic orders, the following may be mentioned: (1) *Dandis* (Saivaite mendicant order) or staff-bearers, who carry a wand with a piece of red cloth, containing the sacred cord, attached to it, and also wear one or more pieces of cloth of the same colour. They worship Siva in his form of Bhairava, the "terrible." A sub-section of this order are the Dandi Dasnamis, or Dandi of ten names, so called from their assuming one of the names of Sankara's four disciples, and six of their pupils. (2) *Yogis* (or popularly, Jogis), *i.e.*, adherents of the Yoga philosophy and the system of ascetic practices enjoined by it with the view of mental abstraction and the supposed attainment of superhuman powers. (3) *Sannyaszs*, devotees who "renounce" earthly concerns, an order not confined either to the Brahmanical caste or to the Saiva persuasion. Those of the latter are in the habit of smearing their bodies with ashes, and wearing a tiger-skin and a necklace or rosary of *rudraksha* berries (Elaeocarpus Ganitrus, lit. "Rudra's eye"), sacred to Siva, and allowing their hair to grow till it becomes matted and filthy. (4) *Paramahamsas, i.e.*, "supreme geese (or swans)," a term applied to the world-soul with which they claim to be identical. This is the highest order of asceticism, members of which are supposed to be solely engaged in meditating on the Brahma, and to be "equally indifferent to pleasure or pain, insensible of heat or cold, and incapable of satiety or want." Some of them go about naked, but the majority are clad like the Dandis. (5) *Aghora Panthis*, a vile and

disreputable class of mendicants, now rarely met with.

MENDIP HILLS, Somerset. Eng. The eastern boundary is formed by the upper valleys of the Frome and Brue, and the depression between them. The range extends from these northwestward with a major axis of about 23 mi.. while the outliers of Wavering down and Bleadon hill continue it toward the Bristol channel. The range is generally about 6 mi. in width. Its southwestern face descends to the low "moors" drained by the Axe and other streams, and the towns of Axbridge, Cheddar and Wells. Toward the northeast its limits are less clearly defined, being high ground, intersected by narrow vales. A depression, followed by the Radstock and Wells road, strikes across the range; the principal elevations lie west of this, and to the area thus defined the name Mendips is sometimes restricted. The summit of the hills is a gently swelling plateau, which reaches its extreme height in the north—1,068 ft. The Mendips consist principally of Carboniferous Limestone. Fine cliffs and scars occur on the flanks of the plateau, as in the gorge of Cheddar, and there is a wonderful series of caverns, the result of water action. The surface is often broken by deep holes ("swallets") into which streams flow. Some caves have yielded large quantities of animal remains (hyenas, bears and others) together with traces of prehistoric human occupation. Lead was worked among the Mendips at a very early period. Roman workings have yielded pigs of lead, etc.. inscribed with the names of emperors of the 1st and 2nd centuries.

MENDOZA, ANTONIO DE (1490–1552), first Spanish viceroy of New Spain (Mexico), was born probably in 1490, at Alcala la Real. near Granada, the second son of Iñigo Lopez de Mendoza, captain-general of the Christian forces investing Granada. At the age of 45, after military and administrative experience in the wars against the Moors, and as royal chamberlain and ambassador to Hungary. Antonio de Mendoza was appointed "viceroy, governor and president of the audiencia" of New Spain on April 1;. 153j. and arrived in Mexico in October of the same year. His administration was marked by broad understanding of the problems at hand, by energy in attacking them and by moderation and integrity. Though obstructed by intrigue at court, opposition among his subordinates, uprisings of the partly subjected Indians and the negro slaves, Mendoza laid the foundation of colonial structure and viceregal procedure in Mexico which endured until the 19th century. He succeeded in instituting a thoroughly sound political and financial policy in the country; established means of defense, as well as public works and roads; suppressed a religious rebellion of the natives, north of Guadalajara, known as the Mixton War, 1541–42; he inspired discovery and exploration in New Mexico (1540–42, *see* CORONADO), California (1540–43) and the far distant Philippine Islands (1542–44); he supported the church in all their endeavours to convert, to educate and to protect the native Indians; he stimulated agriculture. mining and industries of various kinds; and introduced printing (1536). In 1551, having firmly impressed the royal authority upon New Spain and made it the best organized of Spain's new world colonies, Mendoza was promoted to the viceroyalty of Peru. He arrived there in Sept. 1551, but. health failing, he died in Lima on July 21. 1552. He was the greatest of all the Spanish viceroys in the new world.

The best account of Mendoza is by A. S. Aiton: *Antonio de Mendoza* (Durham, N.C., 1927), which contains a full bibliography.

(W. B. P.)

MENDOZA, DIEGO HURTADO DE (1503–157j), Spanish diplomatist, historian, scholar and poet, son of the count of Tendilla and great-grandson of the marquis of Santillana, born at Granada. He served under Charles V in Italy. and preserved his confidence in spite of the failure of his mission in 1537, when he was sent to England to arrange a marriage between Henry VIII and the duchess of Milan. as well as a marriage between Prince Louis of Portugal and Mary Tudor. Ambassador at Venice in 1539, he patronized the Aldi, procured copies of the Greek manuscripts of Cardinal Bessarion, and other rare codices from the monastery of Mount Athos. The first edition, of Josephus was printed (1544) from the texts in Mendoza's collection. He was military governor of Siena, represented Spain at the Council of Trent and was special plenipotentiary at Rome from 1547–54. He was never a favourite with Philip II, and a quarrel with a courtier resulted in his banishment from court (June 1568). The remaining years of his life, which were spent at Granada, he devoted to the study of Arabic, to poetry, and to his history of the Moorish insurrection of 1568–70, the *Guerra de Granada* (Lisbon, 1627). In some passages of this work the author deliberately imitates Sallust and Tacitus.

See A. Señan y Alonso, D. *Diego Hurtado de Mendoza* . . . (Granada, 1886); *Calendar of Letters and Papers Foreign and Domestic, Henry VIII,* vol. xii, xiii; C. Graux, *Essai sur les origines du fonds grec de l'Escurial* (1880); R. Foulché-Delbosc, *Etude sur la "Guerra de Granada,"* in *Revue Hispanique,* vol. i, pp. 101–165, 338 (1894).

MENDOZA, PEDRO GONZÁLEZ DE (1428–1495), Spanish cardinal and statesman, fourth son of Ifiigo López de Mendoza, marquess of Santillana, was born on May 3, 1428, at Guadalajara. The house of Mendoza claimed to descend from the lords of Lladio in Alava, and to have been settled in Old Castile in the 11th century. Pedro González was an example of the worldly, political and martial prelates of the 15th century. Appointed bishop of Calahorra by John II in 1452, in his secular capacity as civil and military ruler of the town and its dependent district, he led the levies of Calahorra in the civil wars of Henry IV. He fought for the king at the second battle of Olmedo (Aug. 20, 1467), and was wounded in the arm. During these years he became attached to Doña Mencia de Lemus, a Portuguese lady-in-waiting of the queen. She bore him two sons, Rodrigo, who was once selected to be the husband of Lucrezia Borgia, and Diego, the grandfather of the princess of Eboli. In 1468 he became bishop of Siguenza. In 1473 he was created cardinal. promoted to the archbishopric of Seville and named chancellor of Castile.

During the last years of the reign of Henry IV Mendoza was the partisan of the princess Isabella, afterward queen. He fought for her at the battle of Toro (March 1, 1476). and had a prominent part in placing her on the throne. In 1482 he became archbishop of Toledo. During the conquest of Granada he contributed largely to the maintenance of the army. On Jan. 2. 1492, he occupied the town in the name of the Catholic sovereigns. More soldier and statesman than priest, the "Great Cardinal." as he was commonly called, did not neglect his duty as a bishop. He devoted part of his revenue to charity and endowed the college of Santa Cruz at Valladolid. He died at Guadalajara, Jan. 11, 1495.

See Salazar de Mendoza, *Cronica del gran cardinal Don Pedro González de Mendoza* (Toledo, *1625);* W. H. Prescott, *History of the Reign oj Ferdinand and Isabella,* 3 vol. (1838).

MENDOZA, a province of western Argentina! bounded north by San Juan. east by San Luis and the province of La Pampa, south by La Pampa and the province of Neuquén and west by the republic of Chile. Pop. (1956 est.) 768.637. Area 58,239 sq.mi. The Andes form the western boundary and a considerable part of the territory is covered by the great Cordillera. its foothills and flanking ranges. The eastern part is an arid, sandy, level plain with extensive saline basins. having no vegetation other than coarse grasses and thickets of low, spiny mimosas and "chañar" (*Gourliaea decorticans).* The fertile, populated districts border on the Cordillera, particularly in the north where several streams from the snow-clad summits supply water for irrigation. The secondary ranges in this part of Mendoza are the Sierra de los Paramillos, which enclose the Uspallata valley, and the Sierra del Tunuyán. Farther south the country becomes more arid and sparsely populated, and unsubdued tribes of Indians for a long time prevented its exploration. In this region the Sierra de Payén and Sierra del Nevado (otherwise known as the Sierra Quero Matro Pellón) extend in a northeasterly direction. With the exception of the Rio Grande in the southwest. which forms the principal source of the Colorado, all the rivers of the province flow east and south into the great saline depression of western Argentina. which includes a great part of Mendoza, San Luis and La Pampa. The Mendoza, Tunuyán, Diamante and Atuel, with their numerous tributaries, all discharge into the sluggish river which flows from the Huanacache lagoons on the San Juan fron-

tier southward to the marshes and lagoon of La Pampa. The upper part of this brackish, swampy stream is called the Desaguadero, and the lower the Salado. With the exception of the elevated districts of the Andes, the climate is hot and dry.

Mendoza was settled by Spanish colonists from Chile as far back as 1559 but later development was hindered by its remoteness from the Río de la Plata. This isolation was broken in 1884 by the completion of the Argentine Great Western railway to the provincial capital. Subsequently the Transandine railway was built (connecting with the Chilean railway system) and branches of the Pacific and Western railways were extended to many parts of the eastern plain.

In addition to Mendoza, the capital of the province, the principal towns are San Rafael. Godoy Cruz, Rivadavia, Luján, Colonia Alvear, Junin and Lavalle. There are several popular resorts in the mountains. notably Villavicencio (thermal springs), Cacheuta (mineral baths) and Potrerillos (skiing).

Agriculture is the principal occupation where irrigation can be used but less than 2% of the total area of the province is cultivated. Mendoza has a high reputation for its raisins and wines. and produces also peaches, apples. pears and many other fruits. Alfalfa (lucerne) is an important product, grown for fattening the cattle driven through the province to the Chilean markets. A wide variety of minerals is found, such as wolfram and sulfur, and the province ranks high among the Argentine states in the production of petroleum. (GE. P.)

MENDOZA, Argentine city and capital of the western province of Mendoza (*q.v.*). Pop. (1960) 109.149. The city is located at 2,970 ft. elevation on a broad plain at the foot of the secondary Andean range, Sierra de los Paramillos. Although the climate is dry. irrigation has covered the surrounding area with gardens, orchards and vineyards. The intensive cultivation supports a population of 250,000 in the immediate vicinity of the capital. known as greater Mendoza. Water for irrigation and for the urban area comes from the Mendoza, or Luján, river, 15 mi. south of the city, via a natural channel called El Zanjón which traverses the city.

The city was founded and relocated several times in the early 1560s by Spaniards arriving from Chile, and its early history was intimately linked with Chile. Not until 1776 did control of this region known as Cuyo pass from the local Spanish administration in Chile to the newly created viceroyalty of Río de la Plata at Buenos Aires. During the movement for independence from Spain. Mendoza was the headquarters of Gen. José de San Martin and the expeditionary force which he organized to cross the Andes to Chile in 1817.

In 1861 the city was totally destroyed by earthquake with an estimated loss of 12,000 lives. Two years later a new city was planned in close proximity to the ruins. Consequently broad tree-lined streets and numerous public squares and parks characterize the modern Mendoza. On the west side of the city is the attractive General San Martín park of 150 ac. with a large artificial lake, while the same name is given the principal north-south avenue of the city.

Several theatres, a number of museums commemorating the colonial and independence eras. the national university of Cuyo and the institutes of ethnology and agriculture are some of the cultural aspects of Mendoza.

The wine and raisin industry is the principal one of the city while the surrounding irrigated districts produce fruit. vegetabies, alfalfa and cereals. Its commercial importance is assured by direct rail lines and highways which link it to the principal Argentine Ports such as Rosario, Buenos Aires and Bahia Blanca. A highway. follows the former railroad bed to Chile via Paso de Bermejo, 12,917 ft. above sea level, but there is little economic orientation toward the neighbouring country. The city has an airport. (JS. R. S.)

MENEDEMUS (338?–265 B.C.), Greek philosopher, the founder of the Eretrian school, was born, of a noble but impoverished family, at Eretria (he is to be distinguished from Menedemus of Pyrrha, a member of the Academy in Plato's lifetime). During a military expedition to Megara he formed a lifelong friendship with an older man named Asclepiades. They attended the lectures of Stilpo (see MEGARIAN SCHOOL OF PHILOSOPHY) and later joined themselves to the school founded by Phaedo at Elis. This school was transferred by Menedemus to his native town and so came to be called Eretrian. After a time Menedemus took a leading part in public affairs. His policy of placating whichever Macedonian prince was in the ascendant secured a relative freedom for Eretria for many years; but about 273 B.C. his regime was overthrown, and he was driven into exile by patriots who charged him with subservience to Macedonia. Six years later his policy was vindicated, for Antigonus took the city; but Menedemus, in grief at his inability to repair the harm done by his successors, eventually took his own life. He was a man of austere life and keen wit. His philosophy seems to have owed something to the teaching and example of Socrates, as filtered down through the Megarian school. Skill in dialectic was highly valued, but was imparted to the pupil with an ethical purpose. In logic, he followed Stilpo in pronouncing the use of "is" as a copula to be illegitimate and, for reasons connected with this, denied the validity of both negative and complex propositions. (D. J. A.)

MENELAUS, king of Sparta, brother of Agamemnon (*q.v.*) and husband of Helen (*q.v.*). On the voyage from Troy his fleet was scattered by a storm, which drove him to Egypt. After eight years' wandering, he landed on the island of Pharos, where Proteus revealed to him the means of appeasing the gods and securing his return.

After a long and happy life in Lacedaemon, Menelaus, as the son-in-law of Zeus, did not die, but was translated to Elysium. His grave and that of Helen were shown at Therapnae, where he was worshipped as a god.

MENELEK II. (SAHALA MARIEM) (1844–1913), emperor of Abyssinia, officially negus negusti (king of kings) of Ethiopia, son of Haeli Melicoth, king of Shoa, was born in 1844, and claimed to be a direct descendant of Solomon by the queen of Sheba. Menelek was the real creator of the modern Abyssinian state. On the death of his father in 1855 he was kept a prisoner at Gondar by Kassai, the governor, who had seized the throne under the title of Theodore III. After the death of Theodore in 1868 he continued to struggle against his successor, the emperor Johannes (better known to Europeans as King John of Abyssinia). Being again unsuccessful, he resolved to await a more propitious occasion; so, acknowledging the supremacy of Johannes, in 1886 he married his daughter Zauditu (1876–1930) to the emperor's son, the Ras Area; he was thereupon declared heir to the empire, and on his side acknowledged the Ras Area as his successor. Ras Area died in May 1888, and the emperor Johannes was killed in a war against the dervishes at the battle of Gallabat (Matemma) on March 10, 1889. The succession now lay between the late emperor's natural son, the Ras Mangasha, and Menelek, but the latter was elected by a large majority on the 4th of November, and consecrated shortly afterwards. Menelek had married in 1883 Taïtu (b. 1854), a princess of Tigré, a lady who had been married four times previously and who exercised considerable influence. Menelek's clemency to Mangasha was ill repaid by a long series of revolts.

In 1889, at the time when he was claiming the throne against Mangasha, Menelek signed at Uccialli a treaty with Italy acknowledging Italian claims to the Asmara district. Finding, however, that according to the Italian view of one of its articles the treaty placed his empire under Italian domination, Menelek denounced it; and after defeating the Italians at Amba-Alagi, he compelled them to capitulate at Adowa in February 1896, and a treaty was signed recognizing the absolute independence of Abyssinia. His French sympathies were shown in a reported official offer of treasure towards payment of the indemnity at the close of the Franco-Prussian War, and in February 1897 he concluded a commercial treaty with France on very favourable terms. He also gave assistance to French officers who sought to reach the upper Nile from Abyssinia, there to join forces with the Marchand Mission; and Abyssinian armies were sent Nilewards. A British mission under Sir Rennell Rodd in May 1897, however, was cordially received, and Menelek agreed to a settlement of the Somali boundaries, to

keep open to British commerce the caravan route between Zaila and Harrar, and to prevent the transit of munitions of war to the Mahdists, whom he proclaimed enemies of Abyssinia.

In 1898 the Sudan was reconquered by an Anglo-Egyptian army and thereafter cordial relations between Menelek and the British authorities were established. In 1889 and subsequent years, Menelek sent forces to co-operate with the British troops engaged against the Somali mullah, Mohammed Abdullah. Menelek had in 1898 crushed a rebellion by Ras Mangasha (who died in 1906) and he directed his efforts henceforth to the consolidation of his authority, and in a certain degree, to the opening up of his country to western civilization. He had granted in 1894 a concession for the building of a railway to his capital from the French port of Jibuti, but, alarmed by a claim made by France in 1902 to the control of the line in Abyssinian territory, he stopped for four years the extension of the railway beyond Dire Dawa. When in 1906 France, Great Britain and Italy came to an agreement on the subject, Menelek officially reiterated his full sovereign rights over the whole of his empire. In May 1909 the emperor's grandson Lej Yasu, or Jeassu, then a lad of thirteen, was married to Romanie (b. 1902), granddaughter of the negus Johannes. Two days later Yasu was publicly proclaimed at Adis Ababa as Menelek's successor. At that time the emperor was seriously ill. He died in 1913. *See* Hentze, *Am Hofe des Kaisers Menelek volt Abessynien* (1905); Rossetti, *Storia diplomatica dell Etiopia durante il regno di M II.* (1910).

MENENDEZ DE AVILÉS, PEDRO (1519–1574), Spanish seaman, founder of St. Augustine, Florida, was born at Avilés in Asturias on Feb. 15, 1519. At the age of 14 years he ran away to sea, and was engaged in piracy till he was thirty. In 1549 he was commissioned by the emperor Charles V. to clear the north coast of Spain and the Canaries of French pirates. In 1554 he was appointed captain-general of the "flota" or convoy which carried the trade between Spain and America. The appointment was made by the emperor over the head and against the will of the Casa de Contratacion, or governing board of the American trade. His steady refusal to receive bribes, as the reward for permitting breaches of the regulations, made him unpopular with the merchants, while his high-handed ways offended the Casa de Contratacion. Re-appointed commander in 1557, and knowing the hostility of the Casa, he applied for service elsewhere. Until the close of 1559 ample occupation was found for Avilés in bringing money and recruits from Spain to Flanders. In 1560 he was again appointed to command the flota, and he made a most successful voyage to America and back in that and the following year. His relations with the Casa de Contratacion were, however, as strained as ever. On his return from another voyage in 1563 he was arrested by order of the Casa, and imprisoned for twenty months.

On his release he prepared to sail to the Bermudas to seek for his son Juan, who had been shipwrecked. At that time the French Huguenots were endeavouring to plant a colony in Florida. The Spaniards claimed the country as theirs, and its position on the track of the home-coming trade of Mexico rendered its possession by any other power highly dangerous. Philip II. made an *"asiento"* or contract (March 20, 1565) with Avilés, by which he advanced 15,000 ducats and constituted him proprietor of any colony which he could establish in Florida, on condition that the money was repaid. Avilés sailed on July 28 of the same year with one vessel of 600 tons, ten sloops, and 1,500 men. On Aug. 28 he entered and named the Bay of St. Augustine and began a fort there. He took the French post of Fort Caroline (Sept. 20, 1565) and in October exterminated a body of Frenchmen who, under the Huguenot Jean Ribault, had arrived on the coast of Florida. The Spanish commander, after slaying nearly all his prisoners, hung their bodies on trees, with the inscription, "Not as Frenchmen but as Lutherans." A French sea-captain named Dominique de Gourgues revenged the massacre by capturing in 1568 Fort San Mateo (as the Spanish had renamed Fort Caroline), and hanging the garrison, with the inscription, "Not as Spaniards but as murderers." Till 1567 Avilés remained in Florida, busy with his colony. In that year he returned to Spain. He made one more voyage to Florida, and died on Sept. 17, 1574.

See *The Spanish Settlements within the Present Limits of the United States, Florida, 1562–74,* by Woodbury Lowery (1905).

MENENDEZ BIDAL, RAMON (1869–), Spanish philologist, was born on March 13, 1869, at Corunna, and studied at the universities of Madrid and Toulouse. He was professor of romance philology at the University of Madrid (1899–1939) and director of the Spanish academy (1925–39), a position to which he was named again in 1948. He was visiting professor at Buenos Aires university (1914) and Columbia university, New York city (1938). His grammar, text and vocabulary of the *Cantar de Mio Cid* (1908) opened new possibilities not only to Castilian philology but to historiography in general. He became the leader of the Centro de Estudios Históricos, the main house of learning in philology and historical matters in Spain, and editor of the *Revista de filología española.* His other works include *Primera crónica general* (1906); *L'Épopée Castillane à travers la litte'rature espagnole* (1910); *Gramática histdrica española* (1904); *La España del Cid* (1929); and *Historia y epopeya* (1934).

MENÉNDEZ Y PELAYO, MARCELINO (1856–1912), Spanish scholar and critic, became famous through his *Ciencia espaiiola* (1878), a collection of polemical essays defending the national tradition against the attacks of political and religious reformers. The unbending orthodoxy of this work was, if possible, still more pronounced in the *Historia de los heterodoxos españoles* (1880–81), and the writer was hailed as the champion of the ultramontane party. His lectures (1881) on Calderón established his reputation as a literary critic; and his work as a historian of Spanish literature was continued in his *Historia de las ideas este'ticas en España* (1883–91), his edition (1890–1902) of Lope de Vega, his *Antologia de poetas liricos castellanos* (1890–1908), and his *Orígenes de la novela* (1905).

MENES, the name of the founder of the 1st dynasty of historical kings of Egypt. He appears at the head of the lists not only in Herodotus and Manetho, but also in the native Turin Papyrus of Kings and the lists of Abydos, while the list of Sakkara begins with the sixth king of the 1st dynasty, a fact which may throw some doubt on the supposed foundation of Memphis by Menes. He was probably ruler of Upper Egypt and conquered the separate kingdom of Lower Egypt. His grave was discovered by De Morgan at Negadr in Upper Egypt in 1897.

See EGYPT; *K.* Sethe, "Menes und die Grundung von Memphis," in his *Untersuchungen zur Geschichte und Alterthumskunde Aegyptens,* iii: 121.

MÉNESTREL DE REIMS, RÉCITS D'UN, an anonymous chronicle written *c.* 1260, purporting to deal, in a medley of traditional stories, fables and historical facts, with the first crusade and events in the Holy Land, France, England, Flanders and the Holy Roman empire. Without chronological order and popular in conception, its style is free and lively. Eight manuscripts are known.

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MENGELBERG, WILLEM (1871–1951), Dutch composer, was born at Utrecht on March 28, 1871. He received his musical education at the Cologne conservatory, where he studied piano with Isidor Seiss and composition and conducting with Franz Wiillner. His first post was that of musical director at Lucerne, Switz. In 1895 he went to Amsterdam to conduct the Concertgebouw orchestra, which under his direction became one of the most famous in Europe. From 1907 to 1920 he conducted the Museum concerts at Frankfurt, Ger., as well as the Amsterdam series, and directed the choral subscription concerts in both places. Before World War I he regularly visited London as a conductor, and he was a guest conductor in Philadelphia, Pa., and New York city, 1921–29. He also toured extensively with his Amsterdam orchestra.

Important festivals conducted by Mengelberg were the Netherlands-Hamburg in 1920, the French Music festival in 1922 and

the Strauss celebration in 1924. In 1945 the Dutch council found him guilty of collaboration with the nazis. and he was exiled from the Netherlands. He died near Chur, Switz., on March 21, 1951.

MENGS, ANTON RAPHAEL (1728–1779), German painter, whose style is the epitome of neoclassicism, was born in 1728 at Aussig in Bohemia and studied first under his father in Dresden. In 1741 he went to Rome, where he copied Raphael's "Stanze" in miniature for August III of Saxony. Appointed a court painter in 1744, he worked on religious subjects and portraits, the latter especially in pastel. In 175j he settled in Rome, where he entered into close relations with J. J. Winckelmann. At this period he was commissioned by the duke of Northumberland to copy Raphael's "School of Athens." The completion of Mengs's fresco "Parnassus" at the Villa Albani in 1761 created a sensation in Rome and established the ascendancy of neoclassical painting. In 1760. Mengs visited Naples to execute an altarpiece for the king, and afterward he worked in Madrid, partly on the decoration of royal palaces. From 1769 to 1772 he was in Rome decorating the Camera dei *Papiri* in the Vatican. He was in Rome again when he died in 1779.

Mengs was widely regarded as the greatest living painter. and at Madrid his art completely triumphed over the rococo style of his rival, G. B. Tiepolo. His theoretical writings were influential and are essential to the understanding of neoclassicism.

See *The Works of A. R. Mengs,* ed. *by J.* N. d'Azara, 2 vol., Eng. trans. (1796); P. F. Schmidt in Thieme-Becker *Allgemeines Lexicon der Bildenden Kunstler,* vol. xxiv with full bibliography (1930).

(F. J. B. W.)

MENG-TZU, also spelled Mengtze and Mengtsz, town in the southeastern part of Yunnan province, China, 130 mi. S.S E. of Kunming, on a spur of the railroad linking Kunming with the port of Haiphong in North Vietnam; 23° 20' N., 103° 23′ E. Meng-tzu is in a fertile, cultivated basin on the high plateau at an elevation of 4,300 ft. Its climate, tempered by the high altitude, is equable and healthful despite the subtropical latitude. Meng-tzu developed after 1888 as a treaty port and the centre of French overland trade between Yunnan and Tonkin. The principal export commodity of Meng-tzu is tin mined at nearby Ko-chiu. At first the tin was shipped along the Red river by small steamers and junks. In 1910 the trade shifted to the Yunnan-Tonkin railroad built by the French. The railroad was destroyed during World War II. but was reopened to traffic in 1958.

In 1957 Meng-tzu was made the capital of the Hung Ho (Red river) Hani-Ti Autonomous chou (district), a national autonomous area whose population of 1,480,000 (1953 est.) included 260.000 Hani and 380,000 Yi. The Hani and Yi are minorities of the Tibetan-Burman language branch. The population of Meng-tzu hsien (county) mas about 190,000 in 1953. (T. Sᴅ.)

MENHADEN (Brevoortia *tyrannus*), a Clupeoid fish of the western Atlantic, related to the shads (*q.v*), but distinguished by the pectinated scales, and by the very long and exceedingly numerous gill rakers.

The menhaden reaches a length of 18 in.; it feeds on plankton, particularly microscopic plants, and approaches the coast to breed in very large shoals. It is the object of an important fishery, being valuable for oil and manure.

MÉNIÈRE'S DISEASE, a form of auditory vertigo, first described in 1861. It usually attacks persons of middle age whose hearing has been previously normal. It is characterized by sudden intermittent attacks of dizziness. noises in the ears and partial deafness. The individual may suffer one attack only but usually the condition is progressive, seizures occurring at irregular intervals of days or weeks. The cause is not understood. Some observers believe it to be associated with an allergic response; others hold there is a faulty water and electrolyte balance.

MENINGES AND CEREBROSPINAL FLUID. The meninges (singular. meninx) are three membranous envelopes, pia mater. arachnoid and dura mater, that surround the brain and spinal cord. The cerebrospinal fluid is the fluid that fills the ventricles of the brain and the space between the pia mater and the arachnoid. The chief function of meninges and cerebrospinal fluid is to protect the central nervous system. (X.)

Inspection of a fresh brain and spinal cord would reveal their softness and delicacy and would indicate the considerable amount of damage that might be done by physical forces that in other parts of the body would be innocuous. It is not surprising to find, therefore, that great protection has been given to the central nervous system. A large share of this protection comes from the skull and vertebral column; an important part comes also from the meninges and from the cerebrospinal fluid.

Meninges.—*Pia Mater.*—The pia mater is the meningeal envelope that is directly applied to the surface of the brain and spinal cord and firmly adherent to them. It is a very thin membrane composed of fibrous tissue lined on its outer surface by a sheet of flat, polygonal cells believed to be impermeable to fluid. The pia mater is pierced by blood vessels that pass through it to reach the brain and spinal cord. It follows these blood vessels for an undetermined distance into the depth of the brain, where it adheres closely to the nervous tissue and is separated from the blood vessels by a small space, called the perivascular space.

Arachnoid Mater.—Over the pia mater and separated from it by a space called the subarachnoid space is a second meningeal envelope of the central nervous system, the arachnoid mater. This membrane is very thin and is remarkable for its delicacy and transparency. It is composed of fibrous tissue and, like the pia. is covered by flat, polygonal cells also believed to be impermeable to fluid. Unlike the pia, the arachnoid does not follow the irregularities of the surface of the brain, and so it is to be visualized as a loosely fitting sac with a variable distance. in certain regions relatively large and in others minute, between its walls and the surface of the nervous system.

In the region of the brain particularly, a large number of fine filaments pass from the arachnoid through the subarachnoid space to blend with the tissue of the pia mater. These filaments are called arachnoid trabeculae. They are remnants from embryological life of the common origin of the arachnoid and pia mater. and they have the frail structure characteristic of these two of the meninges. Because of their common embryological origin and because they are thin and delicate membranes. the pia mater and arachnoid are called collectively the leptomeninges.

Dura Mater —The outermost of the three meninges is the dura mater, a strong. thick and dense membrane also referrec! to, because of its thickness as the pachymeninx. The dura mater is composed of dense fibrous tissue. and its inner surface is covered by flattened polygonal cells like those present on the surfaces of the pia mater and arachnoid The arrangement of the dura mater is more complex than that of the leptomeninges. It can be regarded most simply as a sac that envelops the arachnoid and that has been modified to serve several functions.

Within the skull the dura mater surrounds and supports the large venous channels carrying blood from the brain toward the heart It also is prolonged into several partitions or septa which may be regarded as lending support to the brain. One of these. called the falx *cerebri,* is a sickle-shaped partition lying betneen the two hemispheres of the brain. Another, the *tentorium cerebelli,* provides a strong. membranous roof over the cerebellum. A third, the falx cerebelli, projects downward from the *tentorium cerebelli* and lies between the two hemispheres of the cerebellum. The outer portion of the dura mater over the brain serves as a covering or periosteum of the inner surface of the bones of the skull.

Within the vertebral canal, the dura mater splits into two sheets. These are separated by a space. called the epidural space, which is filled with fat and thin-walled veins. The outer of these two sheets of the dura mater constitutes the periosteum of the vertebral canal. The inner sheet of dura mater, like the dura mater over the brain, is ieparated from the arachnoid by a narrow space. called the subdural space, which is filled nith fluid.

In a few places, however, the subdural space is absent and the arachnoid is intimately fused with the dura mater The most important area of fusion between these tno meninges is in the malls of the large venous channels of the dura mater There elongations of the arachnoid, like fingers. penetrate the dura mater and project into the veins. These fingerlike processes of the arachnoid are

known as arachnoid villi or arachnoid granulations. They may in certain instances be seen with the unaided eye, protruding into a venous channel that has been laid open; and with the microscope it can be determined that they are separated from the venous blood only by the thin lining of the vein. Essentially similar structures are present in the walls of the larger veins of the spinal region. The function of these structures, the arachnoid villi, are discussed below.

Cerebrospinal Fluid.— The fluid that fills the ventricles of the brain and the subarachnoid space is known as the cerebrospinal fluid. Several questions must be answered for a proper understanding of this fluid. What are its principal physical and chemical characteristics? Where is it formed? What is its pathway of circulation and its site of absorption? What are its functions?

The cerebrospinal fluid is clear and watery. It normally has from one to ten white blood cells per cubic millimetre and contains, at approximately the concentrations found in blood plasma, all the important constituents of the plasma except protein. Sugar, urea, uric acid, lactic acid, amino acids, creatinine, sodium, potassium, calcium, chloride, phosphate and carbonate are present. The protein concentration of the fluid, however, is only about 0.4% that of the plasma. It is because of its low protein content that the fluid as a first approximation may be regarded as a practically protein-free filtrate of the blood; in its formation, the large protein molecules of the plasma are filtered out by the organ responsible for its production.

The fluid is formed in major part by the chorioid plexuses of the four ventricles of the brain. These plexuses can readily be seen by opening the ventricles; they are then evident as relatively large, reddish, tufted organs with a large surface exposed to the cavity of the ventricles. On microscopic examination the plexuses are found to be rich in blood vessels, which are separated from the cavity of the ventricles by a single layer of cells of secretory type. Since the only conceivable source of the fluid is the blood, as is true for all the fluids of the body, the very rich blood supply of the plexuses must lead to the supposition that they are important in its formation; this supposition was substantiated by a great deal of investigation. Many authorities, however, believe that there is a second source of cerebrospinal fluid. In the discussion of the pia mater, above, it was pointed out that there are spaces, the perivascular spaces, around the blood vessels of the brain. These spaces communicate with the subarachnoid space, which lies between the pia mater and arachnoid. The perivascular spaces are filled with fluid derived from the blood vessels that they surround, and this fluid is believed to flow slowly into the subarachnoid space to be added to the cerebrospinal fluid that has originated in the chorioid plexuses of the ventricles.

Since the cerebrospinal fluid is being formed continuously by the chorioid plexuses and the blood vessels with their perivascular spaces, it is obvious that there must be a mechanism for its absorption. This occurs in major part through the arachnoid villi, which have been described as projecting like fingers into the large veins lying within the dura mater of the brain. The fluid in the subarachnoid space of the head may be visualized as seeping through the arachnoid villi into the large venous channels to be returned in this way to the general blood circulation. A small amount of fluid is also believed to be absorbed by the arachnoid villi in the spinal regions and an undetermined but small amount into the veins that traverse the subarachnoid space.

An attempt might be made to follow the pathway of circulation of the cerebrospinal fluid by adding a small amount of dye to the fluid in the lateral ventricles of the brain. If this were to be done, and if tracing this coloured fluid were possible without disturbing the brain, the following observations could be confidently expected: The fluid would be seen to leave each of the lateral ventricles by way of a circular opening, called the interventricular foramen, to enter the third ventricle. In the third ventricle the colour would be diluted by the fluid formed by the chorioid plexus of this ventricle. From the third ventricle the fluid would be seen to flow into the fourth ventricle by way of a narrow tube called the aqueduct of Sylvius. In the fourth ventricle the colour of the fluid would again be diminished by the fluid derived from its chorioid plexus. From the fourth ventricle the fluid could be seen escaping into the subarachnoid space by way of three openings in the pia mater, which covers the roof of the ventricle. It mould then circulate slowly and sluggishly, most of it toward the top of the brain, the smaller part through the spinal subarachnoid space to be absorbed largely by the arachnoid villi in these two areas.

The cerebrospinal fluid serves several purposes. It affords protection to the central nervous system, helping to support the weight of the brain, tending to distribute equally the force of blows and serving as a lubricant between the skull and vertebral column and the brain and spinal cord. In addition to these rather obvious purposes, it has another important mechanical function. Because of their rigidity, the skull and vertebral column have an almost invariable capacity and both are completely filled with central nervous system and its blood vessels and with cerebrospinal fluid. Variation in the volume of any one of these constituents must be met by reciprocal compensation in the volumes of the others. The cerebrospinal fluid, therefore, through alteration in its quantity, permits changes in the volume of the central nervous system and its blood vessels. Because changes in its volume probably occur relatively slowly, it serves to protect the central nervous system from sudden changes in the amount of blood coming to it. The fluid serves still another purpose, probably of considerable functional significance: All the organs of the body, except the central nervous system, have lymphatic vessels whose function is to drain away a part of the fluids collecting in the tissues. The perivascular spaces appear to fill this need within the brain and spinal cord. Fluid leaves the capillaries of the central nervous system to nourish its cells, and that part, with its products of metabolism, not returned directly to the blood flows through the perivascular spaces to the subarachnoid space to be absorbed by way of the arachnoid villi. *See* also BRAIN; SKULL; SPINAL CORD.

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MENINGITIS is an inflammation of the meninges, the membranes covering the brain and spinal cord. Any micro-organism that reaches the meninges and causes inflammation there produces a meningitis. Meningitides from all causes have certain symptoms in common, but there are features which characterize specific forms of meningitis. The term is most frequently associated with the specific disease caused by the meningococcus which is contagious and often occurs in epidemics.

Epidemic Meningitis.— This disease has been called by many names: epidemic meningitis, cerebrospinal meningitis, cerebrospinal fever, spinal meningitis, meningococcus meningitis and spotted or petechial fever. Meningococcus meningitis and cerebrospinal fever are the terms of choice. Meningococcaemia is the term applied to that form in which the meningococcus infection is primarily in the blood and meningeal symptoms do not develop.

Meningococcus meningitis was first recognized as a specific disease by Gaspard Vieusseux of Geneva, who reported an epidemic of 36 cases in 1805. Quite independently, L. Danielsson and E. Mann reported an outbreak in Medfield, Mass., in 1806. In 1887 Anton Weichselbaum of Vienna discovered the meningococcus, the specific cause, recovering it in culture from six cases.

The Meningococcus.—Although first called *Diplococcus intracellularis meningitidis* by Weichselbaum, later taxonomists agreed upon the name *Neisseria meningitidis,* although occasionally it is called *Neisseria intracellularis.* It is commonly designated the meningococcus. Like all members of the genus *Neisseria,* the organisms have a characteristic appearance under the microscope. The round gram-negative cocci occur commonly in pairs, and the adjacent sides are flattened as though they had been pushed together. They can be differentiated from each other by bacteriological methods.

Cultivation of the meningococcus is not difficult if it is remembered that it prefers an enriched medium containing blood or serum, and that it is easily killed by unfavourable temperatures.

Its optimum temperature for growth is about 36° C. The meningococcus autolyzes easily and the autolysate is quite toxic for both man and some lower animals. These endotoxins are heat resistant. Soluble exotoxins have been described.

Meningococci are not all alike serologically. Recognition of two broad groups on the basis of agglutination goes back to the observations of C. A. H. Dopter in France in 1909. He called these "meningococcus" and "parameningococcus."

During World War I serious outbreaks of meningitis necessitated much study of the meningococcus. The French recognized two great serological groups which they designated as A and B; they also described C and D, which were less common. Most British workers, too, placed all meningococci in two broad groups, I and II, which corresponded with the French A and B. M H Gordon and E. G D. Murray of London, by agglutinin absorption, divided group I into types I and III and group II into types II and IV. For practical purposes this splitting of groups into types is rarely done, though it is of epidemiological value.

A specific carbohydrate was demonstrated in the capsules of group I meninpococci (Geoffry Rake and Henry W. Scherp. 1935), but none from strains of group II examined. The later recognized group II alpha (Sophia M. Cohen, 1940; Sara E. Branham, 1942) also has its own specific capsular substance.

Group I was shown (Branham. 1936) to be responsible for 95% to 97% of the cases in the United States epidemics of 1927–28 and 1936. Similar findings by the United States army during 1941–45 confirmed the role of group I meningococci as the chief cause of epidemics. The more heterogeneous group II is found more commonly in sporadic cases and in chronic carriers. The role of the less common group II alpha is not yet well understood. It is apparently related to the old French group C. The International Committee on Bacteriological Xomenclature recommended that serological groups of bacteria be designated by capital letters, and that types within the groups be indicated by Arabic numerals. If this is done, groups I. II and II alpha become, respectively A. B and C, reverting to the old French designation. The relationships of the rare French D and of the Gordon-Murray type IV are unknown.

The meningococcus causes spontaneous infection only in man, but experimental infection can be produced by intracisternal or intracerebral injection in a number of animals and when given intraperitoneally to mice, if suspended in mucin (C. P. Miller. 1933).

Epidemiology.—Meningococcus meningitis occurs all over the world. A small number of sporadic cases occur every year—less than 2 j per 100 000 population, according to James P. Leake—but occasionally epidemics occur which spread irregularly and which may reach vast proportions. These epidemics have a wavelike rhythm (A. W. Hedrich, 1931), tending to recur every 8 to 12 years.

Meningococcus infection occurs at all seasons, but especially during late winter and early spring, and it is more common in cities than in the country. All ages may be affected. but it is primarily a disease of youth. It .is especially common in children under five years of age, and has its highest mortality in infants. Outbreaks in military barracks are common, and war always brings epidemics.

The disease is spread by carriers who harbour the meningococcus in the nasopharynx and disseminate it by droplet infection. Relatively few people among those exposed actually contract meningitis. Individual susceptibility is an important factor, as is also the virulence and dosage of the meningococcus transmitted.

Since epidemic cases are caused primarily by group I meningococci, it follows that a few carriers of group I can be more dangerous than many carriers of group II organisms. Group I carriers are usually few and temporary, but during an epidemic they can spread the infection rapidly. Chronic carriers commonly harbour group II, and these are probably responsible for the sporadic cases among susceptible individuals during interepidemic years. The number of Group II cases is apparently fairly constant.

Clinical Pictures.— llleningococcus infections may vary widely in symptoms, severity and duration. The incubation time) or period between infection and development of symptoms, may vary greatly but is most often about four to five days.

At first the meningococcus is harboured in the nasopharynx, where it multiplies and may be found abundantly. This first stage of the disease is often without local symptoms and is usually unrecognized, though coryza, pharyngitis or sinusitis may occur. Often infection proceeds no further and such a person is actually a temporary carrier.

The next stage in the susceptible individual is invasion of the blood by the meningococcus. Typically, this involves a toxaemia, often very profound, an irregular fever and a marked hypersensitiveness to external stimuli. Pulse and respiration may be rapid. The patient is apathetic, curls up into a characteristic position and does not like to be disturbed. After a few hours a rash often develops, crops of petechiae appearing together. Sometimes these petechiae are merely red, but in se ere cases they may be haemorrhagic. There is an increase in the number of white cells in the blood, the count being as a rule more than 15,000, and the meningococcus can usually be recovered in blood culture at this time.

This blood stream infection may be so overwhelming that the body may be largely covered with the haemorrhagic rash, and death occurs within a few hours.

On the other hand, this septicaemic stage may be so mild that the disease never progresses further and the patient remains ambulant. During interepidemic years such mild sporadic cases, usually caused by group II meningococci of low virulence, are often mistaken for other diseases associated with a petechial rash, such as endemic typhus. In such cases there is no real meningitis and the term "meningococcaemia" is applicable.

In the majority of cases a meningitis develops. The meningococcus disappears from the blood stream and localizes in the meninges. This stage presents the picture usually described, and, unfortunately, the disease is often unrecognized until these symptoms develop.

Meningitis usually begins with vomiting, and a severe bursting headache develops. This is caused by inflammation of the meninges and by the pressure of the increased cerebrospinal fluid. Constipation and retention of urine may occur early in this stage. Then a stiffness of the neck muscles develops, because of the irritation of the roots of the spinal nerves supplying them. The degree of neck stiffness varies, but it is nearly always impossible for the patient to flex his chin. The stiffness may be so marked that the head is retracted (opisthotonos) and, in small children, the head and spine may be drawn backward like a bow. Brudzinski's sign is usually positive and is an aid in diagnosis. To elicit this, the head of the patient is flexed with one hand, the other exerting counterpressure upon the chest to prevent the shoulders' rising. With a positive reaction the thighs flex upon the abdomen and the knees bend.

The deep reflexes are exaggerated and there is a generalized tenderness. In infants there is often bulging of the fontanelles. Convulsions may occur in infants and small children. In this stage both pulse and respiration may be slow.

Complications.— Sometimes the purulent cerebrospinal fluid becomes so thick that the passage between the ventricles of the brain and the spaces in the spinal meninges become blocked. Pressure may become so great that an internal hydrocephalus results, producing dilation of the ventricles and flattening of the convolutions of the brain. Unless this is relieved. death ensues.

Certain of the nerves arising from the brain may also become involved. Swelling of the optic nerve may produce temporary blindness, and that of the acoustic nerve may cause transient deafness. If the nerve sheaths of the acoustic nerves become actually infected, the deafness is permanent. Deaf-mutism may resulr from such loss of hearing in infants and very young children.

Infection of the optic nerve may lead to panophthalmitis and destruction of the eye. Fortunately, both eyes are rarely involved.

Herpes frequently accompanies meningitis, usually appearing on the third to the fifth day.

In the early septicaemic stage polyarthritis is common. with redness, pain and swelling of joints. In the later meningitic stage a monoarticular arthritis often develops, most commonly in the knee. There is swelling and exudate, but little tenderness.

Involvement of the brain itself is uncommon and mental se-

quelae are unusual. Aside from occasional loss of sight or hearing, minor neurological changes and occasional behaviour alteration on a nervous basis, there are usually no residua and, in most nonfatal cases of meningococcus infection, complete recovery is the rule.

Anatomical Picture.—Post-mortem examination of fatal cases has revealed congestion of the choroid plexus, which lines the ventricles, and of the meninges. A purulent exudate accumulates between the layers of the meninges containing leucocytes, fibrin and meningococci, as well as other cells. It lies abundantly along the blood vessels and in the depressions between the different parts of the brain. Often it fills the ventricles, and it may extend down the spinal canal. This exudate may be so thick that it blocks the passages between parts of the brain and cord.

In rapidly fulminating septicaemic cases, which are fatal within a few hours of onset, extensive haemorrhage into the adrenals is often found. Such a picture is known as the Waterhouse-Friderichsen syndrome.

Diagnosis.—The earlier septicaemic stage is easily recognized during an epidemic, but during interepidemic years the fever and rash are often confused with those accompanying other infections. Certain diagnosis depends upon examination of the blood and cerebrospinal fluid, and finding the meningococcus in these fluids or in the haemorrhagic petechiae of the skin.

Since early diagnosis is of the greatest importance, blood cultures should be made immediately in any case in which meningococcus infection is a possibility. About five millilitres of blood is drawn into a sterile syringe from a vein and added to a flask of warm culture medium as soon as possible. This is incubated at body temperature (36° to 37° C.) and examined at frequent intervals under a microscope to determine the presence of the meningococcus. A white blood cell count should also be made to determine the presence of a leucocytosis.

If meningeal symptoms develop, cerebrospinal fluid should be drawn without delay. This fluid is obtained by inserting a special needle into the spinal canal. The fluid is apt to be increased in volume and under pressure, so care must be taken not to allow it to come out too rapidly. The amount taken ordinarily is that which reduces the pressure to normal. If the pressure is not increased, a five-millilitre sample is enough.

Normal cerebrospinal fluid is clear. As meningeal infection develops, it becomes increasingly cloudy. It may sometimes have the appearance and consistency of thick pus, often with a greenish tinge. This cloudiness is caused chiefly by the leucocytes present.

A direct smear of the spinal fluid or of its sediment is stained and examined under a microscope for the presence of the meningococcus. Commonly, the organisms are seen singly or in pairs, lying free or inside of the leucocytes. Sometimes they are few and occasionally they are not seen.

If the meningococci are of groups I or II alpha and are sufficiently abundant, they may be typed directly in the spinal fluid by a capsule-swelling technique.

It is important to identify the meningococcus by bacteriological and serological means, since other bacteria may resemble the meningococcus in spinal fluid. The meningococcus should not only be completely identified, but also typed serologically. Information gained thus, although primarily of epidemiological value, may have a direct bearing on the treatment of individual cases.

Treatment.—General symptomatic treatment is important. Quiet surroundings, easing of pain, relief from retention of urine and prevention of dehydration by adequate administration of fluids are among some of the factors contributing to the welfare of the patient.

Specific treatment consists in the administration of (1) sulfonamides, (2) antibiotics or, when indicated, (3) serum.

Among the sulfonamides, sulfadiazine is the drug of choice, as it has fewer undesirable side effects than some of the others. Sulfamerizine is second choice and has the advantage of being excreted more slowly, thus allowing administration at longer intervals. A triple sulfonamide, consisting of these two plus sulfamethazine, has wide use.

These drugs are administered orally to patients able to take them. If patients are too ill to co-operate, the soluble sodium salts of these drugs are given intravenously. Many physicians give all patients an initial dose by this route in order to attain the desired concentration in the blood as early as possible. Thereafter, sulfadiazine is given every four hours, or sulfamerizine every eight hours. The amount given depends on the size and age of the patient and on the drug used. The object is to maintain a concentration in the blood which will control the infection with *a* minimum risk of toxic effects.

Sodium bicarbonate should be given in conjunction with sulfonamides to alkalinize the urine and lessen the chance of kidney damage. Adequate fluid intake is also necessary.

Most of the sulfonamides are carried by the blood to the meninges and are found in the cerebrospinal fluid in a concentration somewhat less than that in the blood. This makes local therapy unnecessary, and intraspinal administration of these drugs is rarely done.

Clinical improvement usually becomes evident in about 48 hours, but administration of the drug is continued until the patient's fever has gone. Too early discontinuance may result in recurrence. All strains of meningococci do not respond equally to sulfonamides. This is especially true of those found in sporadic cases. If no favourable results are obtained after 48 hours, supplementary treatment with some other agent should be considered.

Penicillin is a successful agent in the treatment of meningococcus infections. It is commonly given intramuscularly every three hours, or by continuous intravenous drip in physiological salt solution. Penicillin does not diffuse into the cerebrospinal fluid to any great extent, so that in cases of meningitis it is necessary to administer it intraspinally when it is the sole agent in treatment. Penicillin is less convenient to administer than the sulfonamides and is more expensive.

Although strains of meningococci vary in their susceptibility to penicillin, those which resist penicillin may respond to sulfonamides, and vice versa. Therefore, if a patient does not respond well to sulfonamides, penicillin may be added or substituted in treatment.

Meningococcus infections are also responsive to many other antibiotics; *i.e.*, aureomycin, chloromycetin and terramycin. These have no advantage over penicillin save in patients who are penicillin-sensitive. The rapid development of streptomycin-resistant and even streptomycin-dependent meningococci (Miller, 1947) contraindicated the use of this antibiotic in such infections.

For many years after its introduction in 1906 (Georg Jochmann, Simon Flexner) serum therapy was the only specific form of treatment. Advent of sulfonamides and of antibiotics changed this situation drastically. Use of polyvalent antimeningococci horse serum was discontinued. Monovalent serum prepared in rabbits with single groups of meningococci (*i.e.*, group I, group II and group II *alpha*), refined and concentrated, may be useful in refractory cases in which the serological group of meningococcus is definitely known. Such serum is usually given intravenously, much diluted, with physiological salt solution. Intraspinal administration is rarely indicated. As the number of useful antibiotics increases, cases requiring the use of serum grow fewer.

In fulminating cases which suggest the Waterhouse-Friderichsen syndrome, administration of adrenal cortex extracts with large quantities of physiological salt solution are given in addition to the usual sulfonamides or penicillin, with good results. Before the use of cortical extracts such cases were nearly always fatal, and autopsy revealed destruction of the adrenals by haemorrhage.

Prevention.—Successful vaccination against meningococcus infection had not been accomplished at mid-20th century. The best preventive measures are the avoidance of crowding, extreme fatigue, chilling and other conditions which tend to lower resistance. Known carriers of the meningococcus have been cleared by administration of sulfadiazine.

Other Purulent Meningitides.—Other bacteria can cause a meningitis if they reach the meninges. Many of these are accidental infections and follow head or spine injuries, boils, middle-ear infections, sinus or tonsil involvement or local infections elsewhere. In few of these does a rash occur. In all of these the causal organisms are usually found abundantly in the cerebrospinal fluid and

they can be isolated and identified by bacteriological means.

Gonococcus meningitis occurs more commonly than is thought. The gonococcus *(Xeisseria gonovrhoeae)* is a close relative of the meningococcus and the clinical and anatomical pictures are essentially the same. Differentiation is by isolation and bacteriological identification of the organism. Treatment is with sulfonamides or penicillin.

Meningitis caused by *Hemophilus influenzae* is the most common of the purulent meningitides not caused by the meningococcus. In nonepidemic times the number of cases may equal or even exceed those caused by the meningococcus. It is a disease of infants and young children and rarely occurs in older persons. The younger the child, the more serious the prognosis, and for many years it was almost universally iatal in iniants.

A special variety of H. *influenzae,* type b (Margaret Pittman, 1931, 1933), is responsible for most of these cases, which are usually secondary to an upper respiratory infection with that organism. The clinical picture is similar to that caused by the meningococcus but there is no rash. The tiny rodlike bacteria are usually abundant in the purulent cerebrospinal fluid. The organism may be cultivated on special culture mediums and identified bacteriologically, and by capsule swelling or precipitin tests mith the spinal fluid.

Treatment is with sulionamides, especially sulfadiazine; with streptomycin; or with a specific type b serum prepared in rabbits. It is advisable to use a combined therapy in this form of meningitis, employing at least two agents.

Pneumococcus meningitis, streptococcus meningitis and other purulent meningitides are also usually secondary to infections with those organisms elsewhere. Diagnosis of these is by demonstrating or recovering the causal microorganism from the cerebrospinal fluid. Treatment of these iniections is with sulionamides and penicillin.

Tuberculous Meningitis.— Usually secondary to a tuberculous lesion elsewhere. tuberculous meningitis occurs more commonly in young children than in adults. The iniection is carried to the meninges in the blood stream. Such spread in children usually arises from the primary lesion, oiten in an early stage. After this primary lesion is walled off the spread is not likely to occur, so in adults blood stream invasion usually follows development oi active secondary foci. or following miliary spread.

The symptoms are those of any acute meningitis, with headache, nausea and vomiting and stiff neck. While the course of infection is less rapid than that of meningococcus meningitis, untreated tuberculous meningitis is usually- fatal within a few weeks of onset.

Differential diagnosis of tuberculous meningitis is made from examination oi the cerebrospinal fluid. Such fluid is clear or opalescent, and is under increased pressure. Protein is increased, sugar and chloride are lessened and there is an increase in the number oi lymphocytes. A web oi fibrin often forms in the cerebrospinal fluid on standing, and it is in this web that the causative organism, *Mycobacterium tuberculosis,* can most easily be demonstrated by means of an acidfast stained smear.

Streptomycin is one of the agents used for treatment. Mortality has been reduced, and, in many cases that once would have been ultimately iatal, the course has been prolonged. The treatment of tuberculous meningitis is constantly changing as newer therapeutic agents are developed.

Syphilitic Meningitis.— In 0.2% to 0.5% of cases of early syphilis an acute meningitis develops. Such meningitis may occur in untreated patients, but especially develops in those who have had inadequate therapy. In mild cases patients may show symptoms for several weeks beiore the condition is recognized.

Here, too, diagnosis is made by examination of the cerebrospinal fluid, which is increased in amount and pressure. As in tuberculous meningitis such fluid is usually relatively clear, though the lymphocyte content is increased. The most valuable diagnostic signs are: positive complement fixation (Wassermann), high chloride content and finding the causative organism, *Treponema pallidum,* in stained smear or dark field examination.

Favourable outcome is directly dependent upon early and adequate treatment. For many years aiter Paul Ehrlich introduced salvarson in 1910, treatment of all iorms of syphilis consisted in long series of injections of arsenic, bismuth and mercury compounds. In 1943 J. F. Mahoney found penicillin to be effective in syphilis. By 1946 it had almost completely supplanted chemotherapy with metals. Penicillin, usually administered intramuscularly, became the treatment of choice. Aureomycin, terramycin and chloromycetin also gave promising results.

Differential Diagnosis.— Poliomyelitis presents symptoms suggesting meningitis: headache, hypersensitiveness and stiff neck. However, it usually begins with a gastroenteritis, the blood count shows few leucocytes and there is no rash. The cerebrospinal fluid is rarely cloudy and does not contain leucocytes. Not only the neck but the entire spine is stiff and there is oiten a paralysis. Cultures are negative.

In lymphocytic choriomeningitis headache, stiff neck and other signs of meningeal irritation are present. The spinal fluid is not purulent but contains a few lymphocytes, and the blood shows no leucocytosis. It is a relatively mild virus infection and recovery is the rule.

Meningismus is a symptom complex consisting of headache and stiff neck, often with some increase in cerebrospinal fluid which is, however, clear and sterile. It occurs in the early stages of a number of iniectious diseases, such as measles, mumps, influenza, typhoid fever, pneumonia and typhus. This syndrome is transitory and is found more commonly in children.

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MENIPPUS, of Gadara in Coele-Syria. Greek cynic and satirist, lived during the 3rd century B.C. According to Diogenes Laërtius (vi. 8) he was originally a slave. amassed a fortune as a moneylender. lost it. and committed suicide through grief. His works, which were written in a mixture of prose and verse! are all lost. The Menippean satires of M. Terentius Varro, fragments of which give an idea of this kind of composition. were called after him *(see* W. Teuffel and L. von Schwabe, *Geschichte der römischen Literatur,* § 16 j, 3).

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MENISPERMACEAE, the moonseed family comprising about 63 species of dicotyledonous woody or herbaceous largely twining vines, chiefly tropical, and so named because of the half-moon-shaped seeds. They have alternate, simple but sometimes lobed leaves, small inconspicuous dioecious flowers. and drupaceous fruits. Because *Cocculus* and *Menispermum* have attractive foliage and fruits on the carpellate plants they are used for covering walls and arbours. (J. M. BL.)

MENKEN, ADAH ISAACS (1835?–1868), U.S. actress and poet. was born probably near New Orleans, La.. in 1835. Facts concerning her family name and early life are obscure. She was left in poverty at an early age, however, and appeared on the stage in New Orleans and other U.S. cities. In 1856 she married Alexander Isaacs Menken, and thereafter bore his name through various matrimonial ventures. In 1864 she appeared at Astley's theatre in London as Mazeppa, a performance of an athletic dramatic type suited to her fine physique. She previously played the role in the United States and was widely celebrated for her daring act of appearing almost nude, strapped to a running horse. In England and France she became intimate with many literary men—Xlgernon Swinburne. Charles Reade. Charles Dickens (to whom she dedicated in 1868 a volume of verse. *Infelicia*), Théophile Gautier and Alexandre Dumas the elder. Paris saw her for 100 nights in *Les Pirates de la Savane,* and she also played in Vienna and London. She died in Paris on Aug 10, 1868.

MENLO PARK, a city of California. U.S., 31 mi. S.E. of San Francisco on the San Francisco peninsula; linked by Dumbarton bridge with the east shore of San Francisco bay. The second town to be incorporated in San Mateo county, in 1874. it disincorporated two years later and reincorporated in 1927. It occupies portions of an historic Spanish land grant and was named after Menlough. County Galway, Ire. former home of two settlers who, in 1854, purchased the original land holdings. (For comparative population figures *see* table in CALIFORNIA: *Population.)*

Menlo Park has some industry but is essentially a residential community. It has attracted national attention through its suburban professional-administrative zoning planned for executive offices in landscaped surroundings. One of these, headquarters of *Sunset Magazine,* has become a major tourist attraction. Also located there is the Pacific Coast centre of the U.S. geological survey, and Stanford Research institute, affiliated with nearby Stanford university. specializing in economic and scientific research for government and industry. (S. B. Ks.)

MENLO PARK, an unincorporated community of Middlesex county, N.J., U.S.; the site of the New Jersey Edison Memorial State park and museum, on the grounds of the experimental laboratories where Thomas A. Edison perfected many of his inventions. Nearby is the 131-ft. Edison memorial tower, on the spot where the first incandescent bulb was made. The tower is octagonal and is made of coloured concrete. with commemorative tablets listing his inventions. It is capped by a light bulb 14 ft. high and 9 ft. across; a perpetual light was placed at the base of the tower in 1929.

Menlo Park was established as a rural crossroad in the 17th century after the founding of East Jersey colony in 1674. It was a part of Raritan township (named after the Raritan division of Leni-Lenape Indians) which in 1954 was renamed Edison township in honour of the inventor. Menlo Park has been an evolving suburban section of the township since World War II; its population in the early 1960s was about 1,500.

It is adjacent to Metuchen, 7 mi. N.E. of New Brunswick, and 6 mi. due west of Staten Island. The township is the site of more than a score of nationally known industries. and is annually visited by thousands of people interested in the works of Edison.

(D. N. A.; M. P. M.)

MENNONITES, a body of religionists taking their name from Menno Simons. They reject sacerdotalism and a hierarchy, and recognize no other authority in religious matters than the Bible. Their understanding of Scripture differs somewhat from that of Protestantism generally in that they stress the contrasts between the Old and New Testaments, taking seriously the principle that Christ was the fullness of God's revelation to men, and understanding the teaching of Christ to constitute a genuine advance over the doctrines and standards of the Old Testament. The group originated in both Switzerland and the Netherlands. The Swiss founder was a young patrician and scholar, Conrad Grebel (c. 1498–1526), originally a follower of Huldreich Zningli, who in Jan. 1525 ventured to inaugurate believer's baptism and to set up a free church.

The members of the new church called each other Brethren. but were nicknamed Anabaptists (rebaptizers). The movement spread rapidly into other lands, especially Alsace and south Germany. These Swiss Brethren, as they came to be called, held to the major doctrines of Christianity such as a personal God existing eternally as a Trinity, the lost condition of mankind spiritually, salvation by God's grace through faith in Christ. and the two eternal destinies, heaven and hell. The major difference with the Reformed and Lutherans concerned the nature of the church, and the relation to the "world." Grebel's followers conceived of the church as a fellowship of converted people, baptized upon a commitment to Christ as Lord, and kept pure by discipline. The life of discipleship had to be in evidence, hence the moral and ethical earnestness of the group. For these quiet Anabaptists, in contrast with the later revolutionaries of Münster, Christian discipleship involved the rejection of all oaths, as well as the magistracy, the constabulary and the military; this position was based upon a literal acceptance of the ethic of Christ and the New Testament in contrast with the "lower" standards of the Old Testament on these points. The disciple of Christ must not resist an evil man (Matt. v, 38–48).

In spite' of severe persecution by both the Catholic and Protestant states, the Anabaptist movement spread rapidly, and ior many decades was a major concern to the state and to the territorial churches in all German lands. The founder of the similar Anabaptist movement in the Netherlands was Obbe Philips, a man who was originally a member of a small and short-lived sect called the Melchiorites (after its founder, Melchior Hofmann), and who left his Anabaptist flock about 1540. The new leader who quickly stepped to the front was Menno Simons, who had left the Catholic priesthood in 1536, and had been ordained as an Obbenite elder (a preacher with authority to baptize and to administer the Lord's Supper) about 1537. Within a decade these Dutch .Anabaptists were called Mennists, later Mennonites. Gradually irom the latter 19th century the descendents of the original Swiss Brethren also adopted the name Mennonite. From 1790 until past the middle of the 19th century, thousands of Mennonites, largely of Dutch extraction, migrated from Germany to south Russia where they prospered economically. After World War II the Mennonite colonies in the Ukraine no longer existed; and the Mennonites of the U.S.S.R. were to be iound east of the Ural mountains, possibly 50,000 in number. The Netherlands in the latter 1950s had 45,000 baptized Mennonites, Germany 12,000, France 3,000 and Switzerland 2,000. All the Mennonites of Europe are simple, conservative Christian believers with the exception of those in the Netherlands, where the group became partially theologically liberal after 1860.

United States.—The first colony of Mennonites settled in Germantown, Pa.. in 1683 to escape persecution in Europe. They became pioneers in Pennsylvania, Virginia, Ohio, Indiana and elsewhere, living hardy and useful lives, holding to freedom oi conscience and opposing slavery and warfare. Only after 1900 did a substantial number oi their congregations begin to give financial support to their elders and preachers: the traditional pattern was a free or self-supported ministry. After 1850 the transition from German to English, the adoption of such new institutions and practices as Sunday schools and evangelistic services, together with the problems associated mith the acculturation process, led to a number of divisions, although some branches were also imported from Europe. The largest by the latter 1950s were the (Old) Mennonite Church with 75,000 baptized members, most of them in the United States.; the General Conference Mennonite Church with 50,000; the Mennonite Brethren with 25,000; and the Old Order Amish mith 15,000. Most extreme are the Hutterian Brethren who live communally and practice community of goods (*cf.* Acts ii, 44). The total membership of all Mennonite bodies in North America in the latter 1950s was 225,000, with 160,000 in the United States, 55,000 in Canada, and 10,000 in Mexico. Their doctrine oi nonresistance was the occasion of some difficulty during the Revolutionary and Civil wars, and World War I, and their view of nonconformity often occasioned some misunderstanding. As a whole they are strict Biblicists, some of them observing footwashing as a literal ceremony (John xiii, 1–17). After 1890 the three largest groups began to establish academies, colleges and seminaries. All branches united in 1920 in a relief and humanitarian organization, the Mennonite Central committee. Their leading colleges are at Goshen, Ind., and North Newton, Kan.

Customs and Dress.—Some of the distinctive customs and religious practices of the more conservative groups of Mennonites are based on a literal obedience to various New Testament commands. Jesus, for example, told his disciples to wash one another's feet. Menno Simons therefore wrote: "Do n-ash the feet of your beloved brethren and sisters who are come to you from a distance, tired. Be not ashamed to do the work oi the Lord . . ." (*Writings,* 417, 1956). Later this ceremony was attached to the observance of the Lord's Supper. and is observed in this fashion: the sexes are separated, and two men, or two women, wash one another's feet, pair after pair. until all the members have participated, after which they greet one another with a holy kiss (Rom. xvi, 16), again a matter of literal obedience to the text of Scripture. The elder or bishop also gives this holy kiss to those whom he has just baptized, although his wife thus greets the women and girls baptized. The kiss is also used as a solemn greeting on various other occasions. particularly among the ministers. Since Paul required Christian women to be veiled while at worship (I Cor. xi, 2–16) Mennonite women still wear the small veil seen on the 1641 painting by Rembrandt of the "Mennonite Preacher" (C. C. Ansloo and wife); this veil also appears on the Quaker mother of Whistler, the American artist. Mennonites who are ill sometimes send ior the elders of the church to anoint them with oil (James v, 14, 15), not so much in the expectation of an instantaneous miracle of healing, but rather as an act of faith, looking to God to bless the efforts being made to overcome the illness. When bobbed hair became fashionable following World War I, Mennonite women resisted the iad because Paul teaches that woman's long hair is her "glory," that it was given her [by God] "as a covering" (1 Cor. xi, 15). This Biblicism, the appeal to the literal text of the Scriptures, was iound among the early Anabaptists, though some of the specific illustrations here given were not; the Swiss Brethren, for example, did not observe footwashing; that was introduced by Jakob hmmann in 1693, leader of the Amish division in Switzerland and Alsace. Furthermore, none of the Anabaptists are known to hare anointed the sick with oil. The other source of the distinctive customs of the more conservative Mennonite groups is the maintenance of obsolete cultural items from the conviction that Christians ought not to be conformed to the world (Rom. xii, 2). This has caused the Mennonites to become a plain people, shunning the newer conventions of dress, all jewelry, and in some cases even automobiles. The most conservative groups have no houses of worship, but assemble in private homes for their church services. Some groups require the men to wear plain black hats, 18th-century coats without lapels, and in some cases beards. Even groups that do not require the beard often proscribe the mustache because it seems to have smacked of the military when first worn. The stricter groups also require the women to wear a plain, early 19th-century headdress, the bonnet, a plain shawl rather than a coat, a small cape over the shoulders and extending down to the waist, evidently a cultural survival of part of a European peasant costume. These beards, plain coats, capes, bonnets, shawls, horse-drawn conveyances, etc., are most typical of the Old Order Amish Mennonites, who are strongly represented in Lancaster co., Pa.; Holmes co., O.; and Elkhart co., Ind. Much oi the literature about them, however, is not reliable.

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the Amish (1940); the *Mennonite Yearbook.* (J. C. WR.)

MENNO SIMONS (1496–1561), leader of the Anabaptists in Holland during 25 of their most difficult years, was born in 1496 at Witmarsum, Friesland. He was ordained priest and was curate at Pingjum, near his native birthplace. when he began to read Luther's tracts, to study the New Testament and to question infant baptism. The execution. in 1531, at Leeuwarden. of the tailor Sicke Freerks. who had been rebaptized at Emden, introduced further questions. Menno was not satisfied with the inconsistent answers which he got from Luther, Bucer and Bullinger. In 1j32 he exchanged his curacy for a living at Witmarsum. Anabaptism of the Münster type repelled him (see ANABAPTISTS), but on Jan. 12. 1536, he left the Roman communion and joined the Anabaptist movement. There were now four parties among the Anabaptists: the favourers of the Münster faction; the Batenburgers, extremists; the Melchiorites, followers of Melchior Hofmann: and the Obbenites, followers of Obbe Philips. For a time Menno remained aloof from both Melchior Hofmann and Obbe Philips, but before the year was out, yielding to the prayer of the leaders of the Obbenites, he became their minister. Obbe, though regarded as the actual founder of the Mennonites, later left the body.

Menno repudiated the formation of a sect; those who had experienced the "new birth" were to him the true Christian church. His Christology was in the main orthodox, though he rejected terms (such as Trinity) which he could not find in Scripture. and held a Valentinian doctrine of the celestial origin of the flesh of Christ. His church discipline was drawn from the Swiss Brethren. Neither baptism (by pouring on the head) nor the Lord's Supper (with the accompaniment of feet-washing) conferred grace; they were divine ordinances which reflected the believer's inward state. Marriage with outsiders was prohibited. Oaths and the taking of life were absolutely forbidden; hence the magistracy and the army were unlawful callings for the Mennonite; but magistrates were to be obeyed in all things not prohibited by Scripture.

Menno was an active missioner and his changes of place, often compulsory, are difficult to trace. He was apparently much in East Friesland till 1541; in North Holland. with Amsterdam as centre. from 1541 to 1533; again till 1545 in East Friesland (where he held a disputation at Emden with Jan Laski in 1544); till 1547 in South Holland; next. about Liibeck; at Wismar in 1j53–54 (holding disputations with Martin Micronius at Norden); lastly at Wüstenfelde. a village between Hamburg and Liibeck, where he died about Jan. 31. 1561.

The collection of Menno's Opera *Omnia Theologica* (1681), in Dutch comprises 24 tractates, his best-known work being his *Fundament-Boek* of 1539–40. His complete writings were published in English at Elkhart, Ind.. in 1871. See also MENNONITES.

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MENOMINEE. This Algonkin tribe of Indians, of the central group. has lived since its discovery early in the 17th century about Menominee river, northwest of Lake Michigan. They lived largely on wild rice (*Zizania*), and were generally at war with their Algonkin neighbours. About 1,700 survive in Wisconsin; the original population was little if any larger.

See W. J. Hoffman. *Bur. Am. Ethn. Rep. XIV* (1896); A. E. Jenks, *ibid.,* vol. xix (1901); A. Skinner, *Am. Mus.* Sat. *Hist. Anth. Pap.,* vol. xiii (1913–15), *Indian Notes and Monographs,* vol. iv (1920, 1921).

MENOPAUSE (CLIMACTERIC), a medical term meaning primarily the cessation of menstruation, but which has come to connote the permanent cessation of the monthly periods that forms the most obvious sign that the reproductive life of a woman has come to an end. Translated into popular language it is "the change of life."

The cessation of menstruation is but the outward indication of internal changes of which the primary one is the cessation of ovarian activity. Menstruation (*q.v.*) is determined by the periodic ripening and bursting of small sacs in the ovary containing the egg cells. Associated with these cyclical changes in the ovary are internal chemical (metabolic) changes in the body, in which other glands of internal secretion! particularly the thyroid and pituitary. play a part with the ovarian secretions. The result of the withdrawal of the ovary and its secretions is that the time of adjustment is sometimes associated with disordered health.

The age at which the menopause occurs has wide variations, but is usually between 45 and 50. The way in which the menopause occurs is also very variable. Menstruation may end suddenly and completely and without warning or it may gradually cease by diminishing losses and lengthening intervals spread over a year or more; occasionally, but not to the extent credited by the women themselves, these irregular periods may be accompanied by profuse losses.

Normally the adjustment to these internal bodily changes is made without disturbance of health of mind or body, or at most with trifling discomforts. Such as do arise are liable to be exaggerated in certain individuals and may require medical treatment. The commonest psychical change is mental depression with lack of energy, sleeplessness. headaches and neuralgias and disordered sensations of various kinds. It is the time at which the childless woman may think herself pregnant and even have a phantom enlargement of the abdomen and mock labour pains. In those exposed to mental stress at this time or hereditarily predisposed, there are increased risks of insanity, which would appear to be greater in the more educated and cultured classes. Among the nervous phenomena and most common are "heats" and "iiushes" with reddening of the face and neck, sometimes accompanied by sweating, which may be momentary or last for several minutes. More commonly a later effect, but sometimes beginning before the menopause. is a tendency to adiposity.

A *premature menopause* may occur at any age from disease of the ovaries or other glands of internal secretion or grave nutritional disorder, but is occasionally met with before 40 as the result of a serious illness or profound emotional stress. An *artificial menopause* is produced by the complete removal of both ovaries or by the destruction of their function by radium or X-rays. The earlier in a woman's life it is brought about, the more severe are the symptoms produced, the psychical and nervous disorders being specially exaggerated.

From the medical standpoint the most important feature of the menopause is concerned with the fact that as reproductive activity wanes there is a tendency to overgrowth (obesity, goitre) and new growth (tumours) of the uterus and ovary. for which a special watch must be maintained. Irregular bleeding is usually the first sign of cancer of the womb and increased menstrual losses of fibroid tumours. and both are prone to be ascribed by women to the "change of life" and their early stages to be disregarded. Also abdominal enlargement is liable to be considered as caused by obesity when it may be tumour formation. Hence it is important that a thorough investigation be made of all women in whom this time of life presents any marked deviation from the normal, particularly excessive bleeding from the womb. (J. S. FA.)

MENSA and MAREA, seminomad pastoral tribes of Africans occupying part of the Abyssinian highlands included in Eritrea, and the adjacent coast plains of the Red sea! the Marea chiefly in the valley of the Khor Anseba, the Mensa dwelling farther north. These tribes claim Arab origin, tracing their descent from an uncle of the prophet. Under Abyssinian rule they were Christians, but became Mohammedans in the 19th century. They speak a dialect of Tigriia (Abyssinian). On the death of a Marea the head of every dependent *tigré* or slave family must give his heirs a cow. The tribes punish an illegitimate birth by putting parents and child to death.

MENSHIKOV, ALEXANDER DANILOVICH, PRINCE (1663?–1729), Russian statesman. was born not earlier than 1660 nor later than 1663. At the age of 20 he was gaining his livelihood in the streets of Moscow as a vendor of meat pies. Fran-

çois Lefort, Peter's first favourite, took him into his service and finally transferred him to the tsar. On the death of Lefort in 1699, Menshikov succeeded him as prime favourite. Ignorant, brutal, grasping and corrupt as he was, he deserved the confidence of his master. He could drill a regiment, build a frigate, administer a province and decapitate a rebel with equal facility. During the tsar's first foreign tour, Menshikov worked by his side in the dockyards of Amsterdam, and acquired a thorough knowledge of colloquial Dutch and German. He took an active part in the Azov campaigns (1695–96), and superseded Ogilvie as commander in chief during the retreat before Charles XII in 1708, subsequently participating in the battle of Holowczyn, the reduction of Mazepa and the crowning victory of Poltava (June 26, 1709), where he won his marshal's baton. From 1709 to 1714 he served during the Courland, Holstein and Pomeranian campaigns, but then, as governor general of Ingria, with almost unlimited powers, was entrusted with a leading part in the civil administration. Menshikov was the right hand of the tsar in all his gigantic undertakings. But every time the tsar returned to Russia he received fresh accusations of peculation against "his serene highness." Peter's first serious outburst of indignation (March 1711) was a result of the prince's looting in Poland. On his return to Russia in 1712, Peter discovered that Menshikov had winked at wholesale corruptions in his own governor generalship. Peter warned him "for the last time" to change his ways. Yet, in 1713, he was implicated in the famous Solov'ey process over the export of corn, in the course of which it was demonstrated that he had defrauded the government of 100,000 roubles. He owed his life on this occasion only to a sudden illness. In the last year of Peter's reign fresh frauds and defalcations of Menshikov came to light, and he was obliged to appeal for protection to the empress Catherine. It was chiefly through the efforts of Menshikov and his colleague Petr Andreyevich, Count Tolstoi that, on the death of Peter in 1725, Catherine was raised to the throne. During her short reign (Feb. 1725–May 1727), Menshikov was practically absolute. He contrived to prolong his power after Catherine's death by means of a forged will and a coup d'état. While his colleague Tolstoi would have raised Elizabeth Petrovna to the throne, Menshikov set up the youthful Peter II, son of the tsarevich Alexius, with himself as dictator during the prince's minority. He now aimed at establishing himself definitely by marrying his daughter Mary to Peter II. But the old nobility overthrew him, and he was deprived of all his dignities and offices and expelled from the capital (Sept. 9, 1727). He died in exile at Berezov, Siberia, on Nov. 12 (O.S.), 1729.

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MENSHIKOV, ALEXANDER SERGEIEVICH, PRINCE (1787–1869), Russian general, born on Sept. 11, 1787, accompanied the emperor Alexander throughout his campaigns against Napoleon and retired from army service in 1823. At the time of the dispute as to the Holy Places he was sent on a special mission to Constantinople, and when the Crimean war broke out he was appointed commander in chief by land and sea. He commanded the Russian army at the Alma and in the field operations round Sevastopol. In March 1855 he was recalled. He died on May 2, 1869 at St. Petersburg.

MENSTRUATION. This phase of the female reproductive cycle is unique among normal bodily processes in that it involves a loss of blood. The appearance of menstrual bleeding is the most obvious and the most abrupt event in the menstrual cycle and is used for indicating the onset of successive cycles. Tradition has it that the human cycle is a lunar month in length *(mensis,* Lat. a month). Actually the cycle ranges from three to five weeks in length. Most cycles are evidently from 27 to 30 days long, but only 10% to 15% are exactly 28 days in length. It is well to remember that such statistics indicate probabilities; more important for the individual is the extent to which the time relations may vary. While some women are more "regular" than others, the majority are likely to err by several days in predicting the onset of the next flow. All who have kept accurate records for ten years or more have noted unexpected changes in cycle length; one of 32 days may follow one of 26 days.

Abrupt changes of climate or the like may also shorten or lengthen a cycle. Irregularity characterizes the early years after the establishment of the function of menstruation (menarche), which occurs in most girls between the ages of 12 and 16. The menarche is variable since many factors are involved; it may make its normal appearance as early as 9 years or as late as 18. Similarly, scanty or profuse flows or irregular cycles usually occur toward the end of the childbearing period, during the climacterium or "change of life" which most frequently begins between the ages of 45 and 50. It ordinarily spreads over a year or two and involves various disturbances in endocrine balance. The blood vascular system is upset so that "hot and cold flashes" and irregularities in the pulse appear. Periods of insomnia and depression are common. The complete cessation of menstruation (menopause) is usually followed by years of good health and increased vitality.

The menstrual discharge (menses or catamenia) consists of secretion and cellular debris as well as blood from the lining of the womb (uterus). It often begins gradually, becoming more profuse for a day or two and then gradually diminishes. The average duration of the flow is four days, but it may continue for a week. Blood comprises one-half to two-thirds of the discharge; the total blood loss is usually somewhat more than an ounce (37 c.c.) but may be less. Rarely seven ounces of blood may be lost without other indications of abnormality. The discharge does not normally clot.

The lining of the womb, called the endometrium, is a succulent mucous membrane with many microscopic glands and an unusually rich blood supply. It is constantly changing during the menstrual cycle. The process of menstruation is ushered in by a reduction in the flow of blood to the surface of the endometrium associated with a lowered content of ovarian hormone in the circulating blood. This preliminary phase varies from one to several days in duration, and some. women note such signs of the impending flow as mental depression or weariness. Transplants of endometrium are pale at this time and the blood flow in the smallest vessels (capillaries) may cease for minutes at a time. The membrane shrinks, for there is less blood in it and it is losing tissue fluids and secretion. In time, constrictions can be seen in the small vessels (arterioles) which carry blood to the surface. The reduction in the circulation results in serious injury to many cells near the surface. When the arterioles open up again, the walls of their smaller branches give way under the pressure and blood passes out into the tissue. Often blisters or lakes of blood are formed. They soon break and the blood which flows out does not clot; it has been changed by contact with the injured cells of the endometrium. This bleeding does not last for many minutes because the arterioles soon constrict again and their ends become sealed by degenerated cells. Since these changes in the arterioles do not occur at the same time throughout the entire endometrium one region may bleed on one day, another on the next. Gradually blood-soaked areas of endometrium crumble away, leaving blood vessels and glands projecting out from a raw wound surface. Under abnormal conditions the end of a superficial arteriole may open up and spout blood directly into the cavity of the womb, so that serious loss of blood occurs. Small veins normally remain open, and blood seeps from them especially on the later days of menstruation. Rhythmic contractions of the muscular wall of the womb gradually expel the discharge. They may be strong enough to cause pain. The blood supply of the endometrium is so arranged that the basal half or more does not suffer from a reduced circulation, and after the initial arterial bleeding in any area the blood again circulates through the intact part of the endometrial membrane. A day or more before the external flow has ended the processes of repair are well under way. A new surface is formed in very few hours by the migration of cells from the torn ends of the glands.

Although there are general bodily changes just before and during menstruation, many women experience no particular discomfort and their regular activities are not hampered. The basal metabolic rate and temperature fall somewhat, skin secretions and saliva change more or less and the capillary vessels of the skin bleed more readily. Bleeding from the nose, mouth, lungs or other organs is present in rare instances. Such vicarious menstruation may occur in the absence of the normal flow. These various conditions may well be the result of the entrance into the general circulation of substances derived from the injured cells of the endometrium. The general effects would naturally vary as the extent of the injury to the endometrium varied, as more or less absorption from the endometrium occurred or as the defense mechanisms of the body were more or less effective.

In the course of the human menstrual cycle an egg usually ripens and is liberated from the ovary, ready to be fertilized. The time of this event (ovulation) in the cycle is variable. From 10 to 14 days after ovulation regressive changes appear in the endometrium. The typical constrictions in the arterioles, the cell injury and the bleeding in the endometrium may, however, occur even though no egg has matured or left the ovary. Such anovulatory cycles often involve a normal menstrual flow at the expected time, although there have been no preparations in the endometrium for an expected egg. Anovulatory cycles are common for several years after the menarche and during the climacterium. All the essential features of menstruation can readily be produced in the absence of the ovaries by suddenly stopping the administration of the ovarian hormone estrin. Both ovulatory and anovulatory menstruation can be explained on the hypothesis that they are produced by rhythmic changes in hormone levels. All menstrual cycles are modifications of the pregnant cycle, for the hormonal changes differ only in degree. In all mammals cyclic changes more or

less like those of pregnancy are present where conception has not occurred. In primates the changes occur even when no egg has been liberated. After conception, at about the time of an expected menstrual flow there is often a show of blood. When it occurs in women it is usually slight but rarely it may be so profuse as to he mistaken for menstruation, introducing an error of a month in the computed time of delivery. This bleeding is always present in early pregnancy in macaque monkeys. There is evidence that it is due to spasms of arterioles in the area of the endometrium where the young "product of conception" has burrowed its way into the tissues. As a result, blood and injured cells are provided for the embryonic cells which at the time are engulfing and digesting maternal cells. This hypothesis necessarily assumes that the fall in hormone level at the beginning of pregnancy is slight and that the vascular constriction is brief and confined to the vicinity of the embryo. Both bleeding and tissue destruction are accordingly much less extensive than in the nonpregnant menstrual cycle.

Menstrual bleeding does not normally appear during pregnancy. This amenorrhoea may continue during the period of nursing even until weaning. Ovulation and conception may nevertheless occur during this time. Under any other conditions amenorrhoea is abnormal during the childbearing period. *(See* also GYNAECOLOGY; REPRODUCTIVE SYSTEM.) (G. W. B.)

MENSURATION, that branch of mathematics which deals with the measures or the approximate measures of lengths, areas and volumes. The present article mainly gives formulas. The proofs of these are in general parts of the subject matter of geometry or trigonometry, or in some instances of the calculus.

I. PLANE RECTILINEAR FIGURES

1. Elementary Plane Areas and Lengths.—When a unit of length has been chosen (the inch, foot, yard, mile, etc., or the centimetre, metre, etc.), the figure which yields the unit of area is the square whose side is of unit length. The area of this square is designated as one square unit, *i.e.* one square inch, one square foot, one square metre, etc., as the case may be. In terms of such units the area of any rectangle is obtained by multiplying the number of units in its length by the number of units in its width. The formula for this is $A=lw$, in which the symbols A, l and w stand respectively for the area, the length and the width. If the length of the diagonal of this rectangle is designated by L, it is given by the formula $L=\sqrt{l^2+w^2}$.

A parallelogram is a four-sided figure in which the opposite sides are parallel. The area of this figure is obtainable in the following way. Either pair of opposite sides may be called the bases. The perpendicular distance between their lines is then the height or altitude, *h*. If the length of a base is denoted by b, the area *A* is given by the formula $A=hb$. Beyond this the lengths D_1 and D_2 of the diagonals of a parallelogram are related to the lengths, a and b, of two adjacent sides by the equation $D_1^2+D_2^2=2(a^2+b^2)$.

Either diagonal of a parallelogram divides the figure into two equal triangles, and conversely any triangle may be thought of as so obtained. The base length and altitude of the parallelogram, moreover, appear thus as the base length and altitude of either one of the triangles. It is thus clear that the area of a triangle is given by the formula $A=\frac{1}{2}hb$. It is more convenient sometimes to calculate this area directly from measurements of the lengths of the sides. If these lengths are respectively denoted by a, b and *c*, and if half the distance around the triangle is denoted by s, namely $s=\frac{1}{2}(a+b+c)$, the formula for the area is

$$A=\sqrt{s(s-a)(s-b)(s-c)}. \qquad (1)$$

If two sides of a triangle are at right angles with each other the triangle is a right triangle. On designating the lengths of these two sides (the legs) by a and b, the area of the figure is given by the relation $A=\frac{1}{2}ba$. The length of the third side (the hypothenuse) is $c=\sqrt{a^2+b^2}$. This last relation is fulfilled by the values $a=3$, $b=4$, $c=5$. Hence if a triangle is constructed with sides of these lengths, the angle between the sides a and b will be a right angle.

Any quadrilateral (four-sided plane figure) two of whose sides are parallel is called a trapezoid. If h is used to denote the distance between the parallel sides (measured perpendicularly to them), and if the lengths of the parallel sides are respectively a and c, the area, *A*, of the trapezoid may be found from the relation

$$A=\tfrac{1}{2}(a+c)h. \qquad (2)$$

This formula is easily proved by observing that a diagonal divides the trapezoid into two triangles each of which has the altitude h and which have respectively the base lengths a and *c*.

2. General **Polygons—Areas** Under Rectilinear Graphs. — To find the areas of polygons of more general shape than those already considered, it is usually simplest to divide a figure into triangles or trapezoids. The total area is then the sum of the areas of the several parts. An important application of this is to the determination of the area "under" a graph made up of straight line segments. The figure in this instance consists of a base line (horizontal), two sides (vertical) and a top which is a broken line with some specific number of vertices. Distances along the line of the base are to be measured from any chosen point (the origin), and are to be denoted by x (the abscissa). If the points on the base which mark the sides and the projections of the vertices have thus in order the abscissas $x_0, x_1, x_2, \cdots, x_n$, while at these points the heights (the ordinates) of the figure are respectively $y_0, y_1, y_2, \cdots, y_n$; a consideration of the trapezoids into which the figure is divided by the vertical projecting lines and sides, yields for its area the formula

$$A=\tfrac{1}{2}(y_1+y_0)(x_1+x_0)+\tfrac{1}{2}(y_2+y_1)(x_2-x_1)+\cdots +\tfrac{1}{2}(y_n+y_{n-1})(x_n-x_{n-1}). \qquad (3)$$

II. CIRCLES

3. Lengths of Circular Arcs.—The circumference of a circle is a times as long as the diameter; namely, is of the length $2\pi r$, where r is the radius. The number π cannot be expressed exactly in terms of either common or decimal fractions. There are, however, approximate values of it which are very good. To four decimal places it is 3.1416, and the value $3\frac{1}{7}$ is too large by only about 1 part in 2,500. In a given circle the lengths of any two arcs of the circumference have to each other the same ratio as the angles which they subtend at the circle's centre. An arc of length s subtending an angle 0, and one of length s_1 subtending an angle θ_1, thus fulfill the relation s: $s_1=\theta:\theta_1$. This proportion may in particular be applied when the arc s_1 is a semicircle: namely, when $s_1=\pi r$ and $\theta_1=180°$. The formulas

$$s=\frac{\pi}{180}r\theta, \qquad \theta=\frac{180}{\pi}\frac{s}{r}, \quad (0 \text{ measured in degrees}) \qquad (4)$$

are thus obtained. For practical purposes it may be noted that the value $\pi/180$ is approximated by $7/400$ with an error of only about 5 parts in 2,000.

For use in scientific work the angular unit is generally not taken as the degree but as the radian. One radian is the angle which intercepts on the circumference an arc that is precisely as long as a radius. There are thus 2π radians in one complete revolution, namely 2π radians equal 360°. From this it follows that

$$1 \text{ radian}=\frac{180}{\pi} \text{ degrees}, \qquad 1 \text{ degree}=\frac{\pi}{180} \text{ radians} \qquad (5)$$

When in the proportion above $s_1=r$, then $\theta_1=1$, and the resulting formula is $s=r\theta$ (0 measured in radians).

It is sometimes necessary to find the length of a circular arc when the centre of the circle is not known or is inaccessible. This may be done approximately by the formula

$$s=\frac{8}{3}l-\frac{1}{3}c, \qquad (6)$$

in which *c* designates the length of the chord and *l* the (straight) distance from the end of the arc to its mid-point. The formula is accurate to within 1 part in 1,000, whenever the distance between the mid-point of the arc and the mid-point of the chord is not greater than $\frac{1}{5}c$. If such accuracy is desired in the case of a larger arc, it is best to divide the arc into pieces, to each one of which the formula may be applied.

4. Areas of Circular **Sectors** and Segments.—The area of a complete circle of radius r is given by the formula $A=\pi r^2$. Any portion of a circular disk which is bounded by two radii and the arc of the circumference joining their ends is a circular sector. The angle between the two radii is called the *angle* of the sector. The area A of any sector has the same ratio to the area of the complete circle as its angle θ has to the angle of a complete revolution. From this the area of the sector is found to be

$$A=\tfrac{1}{2}r^2\theta, \quad \text{(if } \theta \text{ is measured in radians)},$$
$$A=\frac{\pi}{360}r^2\theta, \quad \text{(if } \theta \text{ is measured in degrees)}. \tag{7}$$

The portion of a circular disk which is bounded by an arc of the circumference and the chord of this arc is called a circular segment. The chord is the base of the segment, and the distance between the mid-point of the arc and the mid-point of the chord is the height of the segment. If l is used to denote the (straight) distance from one end of the arc to its mid-point, while c and h are the base length and height, the area of the segment is given approximately by the formula

$$A=h\left[\frac{2}{5}c+\frac{8}{15}l.\right] \tag{8}$$

When the height does not exceed one-fifth of the base length, the formula is in error by only about 1 part in 3,000. When the height is as much as one-half the base length the error is about 1 part in 100.

III. QUADRATURE

5. Areas of Plane Curvilinear Figures.—The calculation of areas of plane figures that are bounded by one or more curved arcs, or by curves and straight lines, ordinarily requires the use of analytic geometry and the calculus. In the usual procedure a Cartesian system of rectangular co-ordinates (x, y) is first established in the plane of the figure. The boundary of the figure is then divided into arcs such that each one of these arcs is cut by a line parallel to the y-axis in at most one point, and is not cut by the x-axis. Any one of the arcs may then be regarded as a curve which is describable by an equation $y=f(x)$, the abscissas $x=a$ and $x=b$ with suitable values, a, b, marking the end points. The area enclosed between the x-axis and the curve, and between the lines $x=a$ and $x=b$ is then given by the formula

$$A=\left|\int_a^b f(x)\,dx\right|. \tag{9}$$

The area of the entire original figure is then obtainable by the suitable addition and subtraction of areas which can be found from formulas like (9).

The evaluation of the expression on the right of the formula (9) calls for a function $F(x)$ which has $f(x)$ as its derivative. So-called tables of integrals are useful for finding such a function $F(x)$. When the function is at hand, the relation

$$\int_a^b f(x)dx=F(b)-F(a), \tag{10}$$

gives the desired result.

6. Polynomial **Approximations—Lagrange's** Interpolation Formula.—The precise carrying out of the program thus outlined, requires that the arcs bounding the figure be expressible by an equation $y=f(x)$. When the curve is merely given by its graph, or merely by certain points on this graph, the determination of an equation for it may be unfeasible or impossible. It is then necessary to employ the process as best may be to obtain the approximate value of the integral on the left of the equality sign in formula (10). The projection of the curve upon the x-axis extends from $x=a$ to $x=b$. Let this interval be divided into equal parts by the points $x_1, x_2, \cdots, x_{p-1}$, and let $x_0=a$, $x_p=b$. The heights of the curve at these points form a sequence $y_0, y_1, y_2, \cdots, y_p$. A polynomial curve $y=Q^{(p)}(x)$ which coincides with the given curve at each of the points $(x_0, y_0), (x_1, y_1), \cdots, (x_p, y_p)$, is given by the formula

$$Q^{(p)}(x)=y_0+\frac{x-x_0}{x_1-x_0}\Delta y_0+\frac{(x-x_0)(x-x_1)}{(x_1-x_0)^2}\frac{\Delta^2 y_0}{2!}+\cdots+\frac{(x-x_0)(x-x_1)\cdots(x-x_{p-1})}{(x_1-x_0)^p}\frac{\Delta^p y^\circ}{p!} \tag{11}$$

(*c.f.* CALCULUS OF DIFFERENCES, §6, formula (24)). If the formula (11) is simplified until it appears in the form

$$Q^{(p)}(x)=k_0+k_1x+k_2x^2+\cdots+k_px^p, \tag{12}$$

with constant coefficients $k_0, k_1, \cdots, k_p$, then

$$\int_a^b Q^{(p)}(x)dx=k_0[b-a]+\frac{k_1}{2}[b^2-a^2]+\frac{k_2}{3}[b^3-a^3]+\cdots+\frac{k_p}{p+1}[b^{p+1}-a^{p+1}]. \tag{13}$$

This is an approximation to the integral (10), and therefore of the area (9), which can be made as accurate as may be desired by taking the number p large enough.

A formula which is alternative to (11) above, and which, moreover, is applicable even when the points $x_0, x_1, x_2, \cdots, x_p$, are not equally spaced is obtained by the following scheme. Let $q_j(x)$ designate the product of all factors $(x-x_0), (x-x_1), (x-x_2), \cdots, (x-x_p)$, except the jth one, j being any one of the numbers 0, 1, 2, $\cdots$, p. Then write

$$Q^{(p)}(x)=\frac{y_0q_0(x)}{q_0(x_0)}+\frac{y_1q_1(x)}{q_1(x_1)}+\cdots+\frac{y_pq_p(x)}{q_p(x_p)}. \tag{14}$$

This formula is known as Lagrange's interpolation formula. Its right-hand member is a polynomial of the degree p which at each of the values $x_0, x_1, \cdots, x_p$, takes the respective value $y_0, y_1, \cdots, y_p$. On reducing the formula to the form (12), the evaluation (13) again becomes applicable, and gives the approximate value of the integral (10).

IV. APPROXIMATE QUADRATURE

7. The Trapezoidal Rule.—The determinations of the polynomials (11) or (14) and their reduction to the form (12) are generally somewhat laborious. There are in common practice simpler rules for the approximation of the integral (10), and although these are ordinarily less accurate, they often suffice to give sufficiently precise evaluations of areas by the formula (9). If the points $x_0, x_1, x_2, \cdots, x_p$, and the corresponding heights $y_0, y_1, y_2, \cdots, y_p$, are again determined as was described in §6, an approximation to the graph $y=f(x)$ is obtained by joining each pair of consecutive points (x_k, y_k) and (x_{k+1}, y_{k+1}) by a straight line segment. The complete chain of segments then constitutes a broken line whose vertices lie on the curve. The area under the segment from the point (x_k, y_k) to the point (x_{k+1}, y_{k+1}) is a trapezoid, and has, therefore, in accordance with the formula (2), the value $\frac{1}{2}(y_{k+1}+y_k)(x_{k+1}-x_k)$. If these values are added for all indices k concerned, and if the equal differences $(x_{k+1}-x_k)$ are all denoted by h, the resulting formula is

$$\int_a^b f(x)dx=h[\tfrac{1}{2}y_0+y_1+y_2+\cdots+y_{p-1}+\tfrac{1}{2}y_p], \quad \text{(approximately)}. \tag{15}$$

This result is commonly known as the trapezoidal rule.

8. **Simpson's** Rule.—A rule which is ordinarily better than that given in (15) is available whenever the number p is even. In effect it consists of applying the formula (13), with p replaced by 2, to each of the pieces of the graph which project into a part of the base line between points x_{2r} and x_{2r+2} with any index r. The value thus found for the area of this piece is

$\frac{h}{3}[y_{2r}+4y_{2r+1}+y_{2r+2}]$, and upon adding these as to the index r, the formula obtained is

$$\int_a^b f(x)dx=\frac{h}{3}[y_0+4y_1+2y_2+4y_3+\cdots +2y_{p-2}+4y_{p-1}+y_p], \text{ (approximately). (16)}$$

This is known as Simpson's rule, and is obviously applicable to the mensuration of areas through the formula (9).

V. POLYHEDRAL VOLUMES

9. Prisms.—Any solid which is entirely bounded by plane surfaces (the faces) is a polyhedron. Each face of a polyhedron is necessarily a plane polygon. The solid which is taken as the basis for the expression of cubical content or volume is the cube, in many respects the simplest of the polyhedrons. When a unit of length has been chosen, the corresponding unit of volume is the content of the cube whose edges are of the unit length. Incidentally the faces of such a unit cube are, of course, of the unit area.

Any polyhedron of which two faces (called the bases) are equal polygons in parallel planes, while all the other faces (called the lateral faces) are parallelograms, is called a prism. The cube is a particular and simple kind of prism, in which any pair of opposite faces may be taken to be the bases. This last is the case with any prism all of whose faces are parallelograms (rectangular or not). Such prisms are commonly called parallelepipeds. If the faces are all rectangles the solid is a rectangular parallelepiped.

For any prism the distance between the bases (measured perpendicularly to their planes) is the altitude. The edges which do not lie in a base are the lateral edges. They are all equally long, and their length is the length of the prism. A section of the prism by a plane perpendicular to the lateral edges is called a right section. If in the notation chosen, A_b denotes the area of a base, A_R the area of a right section, h the altitude, l the length, and p the perimeter of a right section, the volume of the prism is given by either one of the formulas $V=A_bh$, and $V=A_Rl$. The lateral surface area is given by the formula $S_L=pl$, and the total superficial area is thus $S_T=2A_b+pl$. In case the prism is a rectangular parallelepiped (brick-shaped solid) of the length l, the width w and the height h, these formulas take the simpler forms $V=lwh$, and $S_T=2lw+2wh+2hl$. In this case the diagonal joining two opposite vertices is of the length

$$d=\sqrt{l^2+w^2+h^2}.$$

10. Pyramids.—A polyhedron is a pyramid if one face of it (called the base) is a polygon, while all the other faces (called the lateral faces) are triangles having one vertex in common. The vertex common to the lateral faces is the vertex of the pyramid, and the edges which meet at the vertex are the lateral edges. The distance h from the vertex to the base (measured perpendicularly to the plane of the base) is the altitude. With A_b denoting the area of the base, the volume of the pyramid is given by the formula $V=\frac{1}{3}A_bh$. A pyramid is a regular pyramid if its base is a regular polygon, and its lateral faces are all isosceles triangles. These triangles are necessarily equal, and their common altitude is called the slant height of the pyramid. If this slant height is denoted by h' and the perimeter of the base is denoted by p, the lateral surface area of the regular pyramid has the magnitude $S_L=\frac{1}{2}ph'$. The total superficial area of the solid is, of course, then $S_T=A_b+\frac{1}{2}ph'$.

A triangular pyramid (namely, one of which the base is a triangle) is also commonly called a tetrahedron.

If a pyramid is cut by a plane parallel to the base, the portion of it between this plane and the base is a frustum of the pyramid. The section by the cutting plane, which is a polygon similar to the base, is called the upper base of the frustum. The distance between the base and the upper base (measured perpendicularly) is the altitude of the frustum. With the symbols h, A, and A_b designating respectively the altitude, the area of the upper base and the area of the base, the volume of the frustum is given by the formula

$$V=\frac{h}{3}[A_b+\sqrt{A_bA_u}+A_u]. \quad (17)$$

11. **Prismoids.**—A polyhedron is a prismoid (or prismatoid) if all of its vertices lie in two parallel planes. A face which is not in one of these parallel planes is called a lateral face, and one that is in one of the parallel planes is called a base. A prismoid may have t o bases or only one. If the number of vertices in each one of the parallel planes exceeds two, each of these planes contains a base. The prism, or a frustum of a pyramid, may be thought of as examples of a prismoid with two bases. If one of the parallel planes contains only a single vertex, or just two vertices, there is no true base in this plane, the place of the base being taken by the vertex alone or by an edge. Such prismoids are exemplified by the pyramid, and by a triangular prism if the base of the latter is taken as one of its rectangular faces. Distinctions between prismoids of these different kinds may be avoided by the simple expedient of including either an edge or a vertex as a base of area zero. This will be done. The lateral faces of a prismoid are each either a rectangle or a triangle, and faces of both these types may occur in any given case. A base may be a polygon of any number of sides, and when there are two actual bases their numbers of sides may be different.

The distance between the parallel planes of the bases (measured perpendicularly) is called the altitude of the prismoid: The section of the prismoid by a plane parallel to the bases and midway between them is called the midsection. In terms of the altitude h, the base areas A_b and A, (of which one may be zero), and the area A, of the midsection, the volume of the prismoid is given by the formula

$$V=\frac{h}{6}[A_b+4A_m+A_u]. \quad (18)$$

This formula for volume is of very wide application. Since the polyhedrons of §9 and §10 are special forms of prismoids, the formula is applicable to each of them. It is also applicable to many solids which are not prismoids under the definition given above. This being so the formula is widely used for the approximate calculation of volumes in the case of solids such as casks, boles, etc., which are not of standard geometrical forms.

VI. CYLINDER, CONE AND SPHERE

12. **The** Cylinder.—When a straight line of indefinite length moves in space, not along its own length, but nevertheless so as to remain constantly parallel to its initial position, it sweeps out or generates a surface of a kind which is known as a cylindrical surface. The successive positions of the straight line are called the generators of the cylindrical surface, or sometimes the rulings of the surface. Any curve upon the surface in which it is intersected by a plane not parallel to a generator, is called a directrix of the cylindrical surface. The surface is often characterized in terms of a directrix. Thus, a cylindrical surface with an ellipse as directrix is designated as elliptic, whereas one with a hyperbola as directrix is characterized as hyperbolic, etc. If a directrix is a closed curve, the surface is a closed cylindrical surface.

Any solid that is bounded by a closed cylindrical surface and by two planes that are parallel but are not parallel to a generator of the surface is called a cylinder. The parts of the bounding surface in the parallel planes are called the bases, and the cylindrical part of the boundary is called the lateral surface. The distance between the bases, measured perpendicularly to their planes, is the altitude of the cylinder, while the distance along a ruling from one base to the other is the cylinder's length. The section of a cylinder by a plane that is perpendicular to a ruling is called a right section. In terms of the length l, the altitude h, and the base area A_b, or in terms of the area A_R and the perimeter p of a right section, the volume

of the cylinder is given by either one of the formulas $V=A_b h$, and $V=A_R l$. These are precisely the formulas which were given in §9 for the prism. It will not seem surprising, however, that prisms and cylinders are subject to the same formulas. The lateral surface area S_L is obtainable from the relation $S_L=pl$, and the total superficial area is given by the formula $S_T=2A_b+pl$.

The simplest and commonest of cylinders are the right circular cylinders. In these the bases are circles and are right sections, and the altitude and length are identical. For such cylinders the formulas above are, more explicitly, $V=\pi r^2 l$ and $S_T=2\pi r^2+2\pi rl$, the symbol r designating the radius of the base. The line joining the centres of the bases of a right circular cylinder is called the axis, and different cylinders having the same axis are designated as co-axial. Ordinary pipes may be regarded as being bounded inside and outside by co-axial cylinders. If the inside and outside radii are respectively designated by r_i and r_0, the volume of material in a segment of the pipe of length 1 is given by the formula $V=\pi l(r_0^2-r_i^2)$. The carrying capacity of this pipe segment is $\pi l r_i^2$.

It may be noted that after being slit open along a ruling any cylindrical surface admits of being rolled out flat upon a plane. Surfaces having this property are said to be developable. The determination of the area of any region on the lateral surface of a cylinder is thus reducible to the determination of a plane area.

13. The **Cone.**—When a straight line of indefinite length moves in space, not along its own length, but so as to pass constantly through a certain fixed point, it sweeps out, or generates, a surface of a kind known as a conical surface. The fixed point is called the vertex, and any position of the moving line marks an element or a generator, or a ruling of the surface. Any plane not passing through the vertex but cutting all the elements intersects the surface in a curve which is called a directrix. A conical surface which has a closed curve as a directrix is said to be closed. Each of the two parts into which a conical surface is divided by its vertex is called a nappe.

Any solid which is bounded by one nappe of a closed conical surface and by a plane which cuts it in a directrix is called a cone. The plane part of the boundary is called the base, and the distance from the vertex to the base (measured perpendicularly to the base) is the altitude. If the base area is A_b (whatever its shape may be) and the altitude is h, the volume of the cone is $V=\frac{1}{3}A_b h$.

A cone whose base is a circle and for which the line joining the vertex with the centre of the base is an altitude, is a right circular cone. This is the commonest and simplest type of cone. The length of one of its rulings (they are all equally long) is called the slant height. If this is designated by 1 and the base radius is r, then $l=\sqrt{r^2+h^2}$. The formula for the volume of such a cone is, more explicitly, $V=\frac{1}{3}\pi r^2 h$, and its total superficial area is $S_T=\pi r^2+\pi rl$. The lateral area alone is $S_L=\pi rl$.

If a cone is cut by a plane parallel to the base, the portion of it between this plane and the base is called a frustum of the cone. The section by the plane is called the upper base, and the perpendicular distance between the bases is the altitude. The volume of a frustum of a cone is given by precisely the same formula as the respective one for the frustum of a pyramid: namely, by the formula (17) above. In the instance of the frustum of a right circular cone with the base radii r_b and r_u the volume is more explicitly

$$V=\tfrac{1}{3}\pi h[r_b^2+r_b r_u+r_u^2]. \tag{19}$$

The slant height l is given by the relation

$$l=\sqrt{(r_b-r_u)^2+h^2}, \tag{20}$$

and the lateral and total superficial areas are subject to the evaluations

$$S_L=\pi l(r_b+r_u),\quad S_T=\pi[r_b^2+r_u^2+l(r_b+r_u)]. \tag{21}$$

The lateral surface of the cone, like that of the cylinder, may be slit open and rolled out flat upon the plane. Areas upon it may, therefore, be computed like plane areas.

14. The Sphere.—The volume of a sphere of radius R is $V=\frac{4}{3}\pi R^3$. The area of its surface is $S=4\pi R^2$. A plane through the centre of a sphere intersects its surface in a great circle. The radius of this is also R, and since its area is thus πR^2, the surface of the sphere is just four times the area of one of its great circles.

For any positive value H which is less than R, a plane which is at a distance H from the centre of a sphere cuts from the sphere a portion which is called a spherical segment of one base. The value h=(R−H), is called the height of the segment, and the plane part of its surface is called the base. This base is a circle, and if its radius is designated by r, the relations $r=\sqrt{R^2-H^2}$, and $r=\sqrt{2Rh-h^2}$ maintain. The volume of the segment is obtainable from the formula

$$V=\pi h^2(R-\tfrac{1}{3}h), \tag{21}$$

and its area inclusive of the base is given by the equation

$$S_T=\pi r^2+2\pi Rh. \tag{22}$$

The curved surface alone, therefore, has the area $S_L=2\pi Rh$.

A pair of parallel planes at the distances H_1 and H_2 from the centre of a sphere, with $H_1<R$ and $H_2<R$ cut from the sphere a solid which is called a spherical segment of two bases. The bases are, of course, the sections in the parallel planes. If the greater one of the distances, H_1, H_2, is the one denoted by H_2 and if the segment does not include the centre of the sphere (*i.e.* if the planes of the bases are on the same side of the centre), the volume of the segment is given by the formula

$$V=\pi[R^2(H_2-H_1)-\tfrac{1}{3}(H_2^3-H_1^3)]. \tag{23}$$

A formula alternative to this one, expressed in terms of the segment's height, $h=(H_2-H_1)$, and the radii r_1 and r_2 of its bases, is

$$V=\tfrac{1}{6}\pi h[3r_2^2+h^2+3r_1^2] \tag{24}$$

The curved part of the surface of the segment is of the area $S_L=2\pi rh$, and its total superficial area is

$$S_T=\pi[r_2^2+2Rh+r_1^2]. \tag{25}$$

The formulas (24) and (25) are applicable also to segments which include the centre of the sphere: namely, such as are cut from the sphere by planes which pass on opposite sides of the centre.

The solid which is cut out from a sphere by a right circular cone having its vertex at the centre of the sphere is called a spherical sector. It may be thought of as composed of a cone and a spherical segment of one base. In terms of the height h of this segment and of r, the radius of its base, the volume and area of the sector are $V=\frac{2}{3}\pi R^2 h$ and $S_T=\pi R(2h+r)$.

VII. VOLUMES AND SURFACE AREAS BY INTEGRATION

15. Simple Integrals.—The mensuration of solids other than those which have been specifically mentioned in the preceding sections is ordinarily possible only by the use of the calculus. In some cases it may be accomplished by the use of simple integrals, in others it is necessary to use multiple integrals. A general principle involved in this is the following one. If a given solid is such that when a suitable direction has been chosen to serve as that of an x-axis, the areas of sections of the solid by planes perpendicular to this axis are determinable as functions of x, then the volume may be found by a simple integration. With x=a and $x=b$ denoting the smallest and largest abscissas of points in the body, and with $A(x)$ denoting the cross-sectional area of the plane with the abscissa x, the formula for the volume of the solid is

$$V=\int_a^b A(x)\,dx. \tag{26}$$

All textbooks of the integral calculus include illustrative applications of this formula.

The largest single class of cases in which the formula (26) can be made more precise is that in which the solid may be generated by revolving a curve $y=f(x)$ about the x-axis. In such a case the cross-sectional area of the solid is a circle of the radius y. The formula for its volume is accordingly

$$V=\pi\int_a^b [f(x)]^2 dx. \tag{27}$$

The area of the surface which is swept out by the curve in this revolution about the x-axis, and which accordingly bounds the solid, is given by the formula

$$S_L=2\pi\int_a^b f(x)\sqrt{1+[f'(x)]^2}\,dx. \tag{28}$$

in which $f'(x)$ stands for the derivative of $f(x)$.

16. Multiple Integrals. — The solid which stands upon a certain region R of the (x,y) plane as a base, which is bounded laterally by the cylindrical surface with rulings perpendicular to the (x,y) plane, and which has as its upper boundary a surface expressible in the form $z=f(x,y)$, has a volume which is evaluated by the double integral

$$V=\int_R\int f(x,y)dxdy. \tag{29}$$

The area of its upper boundary is obtainable from the formula

$$S=\int_R\int \sqrt{1+\left[\frac{\partial f}{\partial x}\right]^2+\left[\frac{\partial f}{\partial y}\right]^2}\,dxdy. \tag{30}$$

The volume and superficial area of a solid may be directly computable from these formulas by the suitable choice of a rectangular (x,y,z) system of reference. When that is not so it may still be possible to subdivide the solid into parts to each one of which the formulas are applicable.

VIII. THEOREM OF PAPPUS

17. Centroids. — For any plane region R in the (x,y) coordinate plane the centroid is that point whose abscissa and ordinate are to be found from the formulas

$$\bar{x}=\frac{1}{A}\int_R\int x\,dy\,dx, \qquad \bar{y}=\frac{1}{A}\int_R\int y\,dx\,dy,$$

with A representing the area of the region. In the instance of many elementary figures the centroid can be found by reasoning based upon physical grounds. For if the region R is envisaged as a disk cut out of a homogeneous plate, the centroid is the centre of gravity. It is thus the point at which the disk would balance upon the point of a needle. The centroid of a circle is the centre of it. The centroid of a rectangle is the point where its diagonals intersect, and in a triangle the centroid is the point of intersection of the medians. A theorem which goes by the name of Pappus (a mathematician of Alexandria, c., 300 A.D.) states that: "If the region R is revolved about any axis lying in the (x,y) plane and not cutting it, the amount of the revolution being through any angle not greater than a complete revolution, the volume of the solid swept out is given by the formula $V=Ap$, where p is the length of the path traced out by the centroid."

IX. APPROXIMATE VOLUMES

18. Empirical Method. — With the volume of a solid given in the form of an integral, as it is by the formula (26), the methods of §§6, 7 and 8, for the approximate evaluation of an integral may be brought at once to bear upon the solid's empirical mensuration. Thus if the sectional area $A(x)$ is expressible in a form (12), the integral evaluation (13) yields the volume. If the sectional areas $A(x_0)$, $A(x_1)$, $A(x_2)$, ... , $A(x_p)$, at equally spaced abscissas x_0, x_1, x_2, ... , x_p are experimentally determinable, their values may be substituted for the respective values y_0, y_1, y_2, ... , y_p, in the formula (11). They yield thus an approximate formula of the form (12), and hence an evaluation of the volume (26) through the formula (13). At all events the trapezoidal rule,

$$V=h[\tfrac{1}{2}A(x_0)+A(x_1)+A(x_2)+\cdots+A(x_{p-1})+\tfrac{1}{2}A(x_p)], \tag{31}$$

and Simpson's rule,

$$V=\frac{h}{3}[A(x_0)+4A(x_1)+2A(x_2)+4A(x_3)+\cdots +2A(x_{p-2})+4A(x_{p-1})+A(x_p)], \tag{32}$$

are available. It is convenient to note in connection with these formulas that if the shape of the cross section is circular or nearly so, the area A is determinable at any point from the circumference C, through the formula

$$A=\frac{1}{4\pi}C^2.$$

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(R. E. L.)

MENTAL DEFICIENCY is a state of subnormal evolution of the human organism in consequence of which the individual affected is incapable of assuming those responsibilities expected of the socially adequate person, such as self-direction, self-support and social participation. While medically considered a constitutional aplasia, its practical manifestations are primarily educational, occupational and social. As distinguished from the insanities it (amentia) reveals developmental deficiencies of normal function whereas they (dementia) reflect disturbances or deterioration of normal function. Synonymous terms are feeblemindedness, amentia, mental defectiveness, oligophrenia. The term is sometimes, especially more recently, used to denote subnormal mental development; *i.e.,* serious intellectual retardation not necessarily associated with physical anomalies or social inadequacy. In more careful scientific usage, while intellectual retardation is a prerequisite of mental deficiency, the degree and kind of mental adequacy is assumed to result in social insufficiency. The condition has legal ramifications as a precondition of civil competence from the standpoint of guardianship or criminal responsibility, with relevant bearing on aptitude for responding profitably to public-school instruction and capacity for displaying conventional moral and social behaviour.

History. — Knowledge of this condition extends back to antiquity, the persons concerned being alternately thought of as possessed of demons or as *les enfants du bon Dieu.* They were sometimes destroyed, sometimes respected, sometimes treated as public fools. Some legal status was accorded them in early British law, but most commonly until the 19th century they were more or less hapless members of society under private guardianship or neglected public charges.

The modern movement for the scientific study and social supervision of the mentally deficient began at the turn of the 19th century with the capture of the wild boy of Aveyron. J. M. G. Itard, a French physician, undertook the training of this boy in order to demonstrate the influence of physiological education. Although the results of this experiment were relatively ineffectual, they led through the subsequent efforts of Edouard Seguin to systematic interest in the study, treatment and disposition of the feeble-minded. This movement, however, has been continuously embarrassed by moral attitudes (concept of the freedom of the will) and the controversy on the organic basis v. the environmental amelioration of the condition.

Modern Concept. — The modern view of mental deficiency regards it as a condition rather than a disease. Six characteristics are commonly accepted as parts of the complete concept; namely, (1) social incompetence, (2) mental incompetence, (3) deficiency or defects of development, (4) constitutional origin, (5) duration to adulthood (though commonly mental deficiency is detectable during the preadult period) and (6) essential impossibility of cure (although the consequences may be somewhat mitigated by suitable regimen). This concept reflects cumulative scientific study of the subject and practical experience with the feeble-minded with consequent legal bearing. Some confusion, however, arises in respect to the mildest degree of mental deficiency, namely the moron grade (in British usage "feeble-minded" is used both for

the mildest degree of mental deficiency and for the generic condition). The advent of mental tests, and especially the use of the Binet-Simon measuring scale for intelligence, has produced an overemphasis on the mental aspects of the condition as contrasted with its social consequences. This has led some to the erroneous assumption that mental deficiency is a low degree of intellectual development considered as a continuum with disregard of other mental manifestations and of the qualitative (variational) *v.* the quantitative (deviational) aspects of the symptom-complex consideration of the condition. Consequently some authorities have defined mental deficiency as the one percentile of the curve of distribution of human aptitudes, but with special emphasis on mental age alone, or more specifically a Binet-Simon I.Q. below 70. This nonclinical definition of mental deficiency has induced errors of theory and practice in scientific study and social disposition. The more careful workers continue to adhere' to a clinical evaluation of the condition as a whole, regarding it as a variation in kind as well as a deviation in degree from normal human efficiency.

Classification. — It is customary to consider mental deficiency from the standpoints of degree, aetiology and clinical variety (or grade, form and type). The condition as a whole is subdivided according to its severity as idiocy, imbecility and moronity. And these in turn are further divided among themselves as low, middle and high. These divisions are distinguished by some students as clinically differentiable categories, and by others according to Binet mental age. In the latter concept, idiots are adult persons with Binet mental ages below 3 years, or juveniles with I.Q.s (intelligence quotients, or mental ages divided by life ages) below approximately 20; imbeciles have mental ages from 3 to 7 years inclusive, or I.Q.s from 20 to 50 approximately; morons have mental ages from 8 to 12 years approximately, and I.Q.s from 50 to 70 approximately. The upper mental-age limit of the moron degree is debatable and somewhat indeterminate. The I.Q. limits are likewise debatable and somewhat indeterminate since they vary with both the test system employed and the method of calculating the I.Q. (or other mental index). Both M.A. and I.Q. standards are influenced by the adult-life age "ceilings" employed as the average normal adult limit of mental development as measured by these tests.

Clinically, and most often legally, idiocy is a degree of mental deficiency so severe that the individual is incapable of attending to his personal needs (eating, elimination, dressing), protecting himself from ordinary dangers, mastering any useful command of speech or performing any useful work. Idiocy is usually of extrafamilial origin resulting from adventitious circumstances influencing hereditary potential. It also includes the major anomalies of development, the more serious physical stigmata which may accompany the condition and the need for custodial care. Imbecility includes those who are able to perform the simple functions of self-help, develop some command of speech but only limited expression of ideas, perform simple tasks under immediate supervision, but who do not profit from scholastic instruction and exercise only a limited degree of social initiative and participation. Imbeciles are intermediate between idiots and morons from the standpoint of causes, characteristics and social needs. Moronity represents the mildest degree of mental deficiency and the condition is not easily distinguishable from marginal normality. While exceeding idiots and imbeciles in general ability, morons are incapable of sustained self-direction at other than simple levels of operation, succeed scholastically only up to about fourth- or fifth-grade achievement, perform only relatively unskilled occupational tasks, require more than ordinary social and occupational supervision and assistance, are incapable of insightful social judgment in unaccustomed situations and subsist at best at barely marginal levels of social adequacy. Numerically morons constitute the largest proportion of all the mentally deficient and are principally of familial (hereditary) origin. Whereas idiots and imbeciles are readily detectable, the recognition of the moron requires technical skill. And whereas idiots and imbeciles are principally a social burden, morons constitute a potential menace from the standpoint of their marked suggestibility, feeble inhibitions and poor judgment.

The aetiology of mental deficiency is of two major varieties; namely, familial and nonfamilial, hereditary and "accidental," endogenous and exogenous. The familial cases are those which reflect a biological continuation of feebly endowed ancestral background. The extrahereditary instances reflect modification of the familial potential resulting from numerous accidents of development. There is some confusion in the standard aetiological classifications as relating to the ontogeny of the condition and the manner or extent to which the hereditary potential may have been modified by extraneous influences. Some of these influences operate at the time of conception or immediately thereafter. Others operate at various stages of prenatal, natal and postnatal development. The causes are also related to the clinical varieties and to the degrees of mental deficiency; most morons represent reproduction in kind as reflections of their hereditary background, whereas most idiots and a majority of imbeciles reflect modification of the hereditary potential. It is further customary to recognize a mixed form where the extraneous influences operate on an initially low hereditary endowment.

The extraneous influences include fertilization of imperfect ova, imperfect implantation of the fertilized ovum, postconceptional anomalies in embryonic and foetal morphology, accidents and diseases incidental to the birth process (including prematurity as well as paranatal intracranial lesions referable to the *prepartum, partum,* and early *postpartum* periods), various traumata, illnesses, diseases, deprivative and degenerative circumstances during childhood and adolescence, as well as an appreciable number of obscure and unknown influences. These causes include in addition to anomalies of development such untoward events as Rh incompatibility, maternal rubella in early pregnancy, maternal embryonic irradiation, prematurity, birth accidents, specific infectious diseases, traumas, metabolic dysfunctions and other miscellaneous misfortunes. The terms endogenous and exogenous have come into relatively recent use, but are equivocal as to their connotations, being sometimes synonymous with familial v. nonfamilial and sometimes with germinal impairment v. postgerminal contingencies.

The clinical varieties of mental deficiency include various symptom complexes within the generic classification of mental deficiency. Feeble-mindedness as an over-all condition is not a clinical entity, but is made up of a number of syndromes, some of which appear to be clinical entities and others not. There is also some confusion between the clinical varieties as developmental anomalies in contrast with the consequences ensuing from specific or unknown causes. Familial mental deficiency may be thought of as a clinical variety representing simple or uncomplicated deficiencies of development resulting from limited hereditary potential. This condition is easily confused with marginal (sometimes called subcultural) degrees of social adequacy. The birth-injury group, more properly described as paranatal intracranial lesions, reflect handicaps to normal development caused by various circumstances attending the birth process as a whole and extending in point of time from the *prepartum* to the early *postpartum* period. Premature birth constitutes a hazard to sound development, and various other conditions outside the control of the obstetrician have a relevant bearing. The management of labour and delivery may be attended by various emergencies which affect the infant unfavourably. The Rh factor is a specific influence which may through various degrees and consequences of erythroblastosis foetalis produce serious defects of development.

On the other hand, the mongoloid type of mental deficiency is a clinical syndrome of obscure aetiology which is determined early in the embryonic period and results in a clinical variety of mental deficiency that is easily detectable from physical appearance and has functional consequences that are rather readily predictable, such as degree of mental development confined to idiot or imbecile level with characteristic personality make-up and rather uniform limitations of social aptitudes.

Microcephaly is a clinical variety characterized by limited cranial development caused by cerebral hypoplasia with associated characteristics of fairly constant pattern. This condition some-

times occurs in families as a recessive trait, although not as a reproduction of ancestral or parental pattern. It also occurs as a specific consequence of maternal pelvic irradiation.

Cretinism is a clinical variety caused by severe thyroid deficiency with consequent characteristic symptoms. This condition is particularly noteworthy for its response to chemotherapy.

There are numerous other clinical varieties which are of relatively infrequent occurrence, but which reflect anomalies of development of marked morphological significance. Likewise some conditions such as hydrocephalus and paranatal intracranial lesion are associated with either mental normality or mental deficiency and in that sense are not strictly clinical varieties of the latter condition. Mental deficiency may also be accompanied by incidental conditions which may or may not have a causal relation, such as epilepsy, congenital or acquired syphilis, various physical stigmata and incidental anomalies of development. While it is customary to describe these clinical varieties in some detail, the importance that attaches to them derives from their morphological significance rather than their numerical frequency.

Incidence. — The numerical occurrence of mental deficiency varies according to age, sex, environment and other circumstances. The reported incidence is materially affected by the criteria employed in determining the condition. We must therefore generalize the available information in terms of these variables. It is commonly accepted that about 1% of the total population is mentally deficient but that this incidence is probably closer to 2% among children. It is not entirely clear whether the incidence is greater among males as compared with females since the males are more likely to attract attention and females are more likely to be domestically safeguarded. The available figures suggest a larger incidence on the part of males, varying from a one-to-one to a two-to-one relationship. Similarly, mental deficiency seems to occur more frequently in rural as compared with urban environments, apparently because in rural situations the condition may be more readily recognized even though the social criteria are less stringent. The incidence varies appreciably with geographical isolation, some remote communities having extreme incidence while residential urban areas have minimum incidence. This is reflected in different areas of a given urban setting where mental deficiency is seen to be much more frequent in some schools than in others according to social-economic segregation. The incidence varies somewhat obscurely with race and nationality, but this is influenced by the standards of detection and by the environmental opportunities for personal-social expression. There is also the question whether differential standards should be employed for different social situations and for different racial and nationality groups. These problems are repeated when the incidence of mental deficiency is analyzed with respect to various social problems such as crime, illiteracy and social-economic status. This involves the relations of cause and effect which are not easily separable.

Relation to Social Problems.--Prior to the recognition accorded to the moron in comparatively recent years the problem of mental deficiency commanded relatively little social attention except as a burden or nuisance. But with the advent of the mental-test movement, the "discovery" of the moron and the studies of marginal families such as the Kallikaks, the relation of minimal social adequacy to many aspects of social welfare became alarmingly apparent. Coincidentally, studies of juvenile delinquents and adult offenders revealed a comparatively heavy proportion of mental deficients in these groups, the proportions varying with the standards of detection and with the selective factors affecting the populations. Similar studies in the fields of poverty, illiteracy, child neglect, occupational inadequacy and limited availability for military service revealed a hitherto unsuspectedly high occurrence of mental deficiency. Thus, in World War I about 1% of men available for military service were rejected by camp and local boards as mentally deficient, while the feeble-minded constituted approximately one-third of all discharges from military duty for neuropsychiatric conditions. In World War II the incidence of mental deficiency is not yet entirely clear from published evidence, and especially because the standards of detection were modified, being heavily influenced by illiteracy, "traits of character" and the absorption of marginal service personnel in special training units. Moreover, the experiences of World War II revealed a much more favourable degree of success on the part of military personnel previously institutionalized as mentally deficient than had been expected. And the record of similar civilian personnel in war industries was also relatively favourable. The years of 1900–46 have been described as an "alarmist period" in respect to the relation of mental deficiency to social ills. More recently one notes a marked reduction in emphasis on the influence of mental deficiency in the realm of social pathology. This is, however, partly caused by the swing from a clinical emphasis of mental deficiency to psychometric methods of evaluation without reference to social consequences.

Social Provision. — The movement for systematic social protection and control of the feeble-minded dates from about 1850 with the establishment of state and private institutions for the custody, care and treatment of the feeble-minded in the United States and abroad. Developments have been quite extensive in the British Isles and in some parts of continental Europe. On the whole the initial movement outside Great Britain has not had a development commensurate with the needs, and these developments were almost completely disrupted by World War II. Provision in Asia has been still more limited and presumably still further disrupted. Relatively little information was available in mid-20th century (but progress seems to have been meagre for soviet and presoviet Russia).

In the U.S. the movement for public institutional provision was extensive in the second half of the 19th century and gained appreciable impetus in the early quarter of the 20th century. By 1946 some states, as well as the federal government, had no systematic provision in public institutions, while other states provided for from 5% to 10% of the estimated number of those who presumably would be benefited by public institutional care. Likewise the first quarter of the 20th century witnessed a marked advance in provision for the mentally deficient of school age and aptitude in special classes of the public school systems, but these early advances were not commensurately continued in later years. Public provision has been supplemented by the establishment of numerous private schools and semiprivate institutions throughout the U.S., but principally in the northeast section. These movements for social control, as well as the U.S. movement for scientific study and treatment, are best reflected in the *Proceedings* of the American Association on Mental Deficiency as well as in that association's directory of members and institutions and its *American Journal of Mental Deficiency*.

Clinical Detection. — The competent clinical detection of mental deficiency is of paramount importance, particularly where specific action is relevant. Accurate diagnosis and classification are also crucial to the sound evaluation of scientific studies in this field. It is obvious that such detection must deal not only with the validation of the condition itself in each case, but also with reference to the characteristics involved in grade and clinical variety as well as the specific aspects of aetiology. It is now obvious that research in the field of mental deficiency must be considered inadequate unless the subjects of such research are clearly segregated not only as to the differential diagnosis of the condition itself but also as to its degrees, varieties and causes. The use of mental tests alone is to be deprecated as an inadequate guarantee of the condition, the more so if the tests employed and their differentiating standards are not clearly specified. The only satisfactory detection of mental deficiency is based on a comprehensive clinical appraisal which combines the evidence from history with multiple evidence on status. From the history the presumptive cause of the condition in each case should be established and also the ontogenetic course. Since feeble-mindedness is a developmental deficiency it cannot readily be differentiated from other neuropsychiatric conditions independently of the developmental history. Moreover, the history should discount all circumstances which spuriously simulate mental deficiency such as sensory handicaps, motor disabilities, emotional disturbances, behavioural disorders and environmental deprivation. And it must be recalled that the diagnosis of mental deficiency during the developmental period is

prognostic and therefore tentative. Much of the work on the environmental amelioration of mental deficiency is subject to the criticism that the initial diagnoses may not have been adequately established.

As to the status of the propositus at the time of diagnosis, multiple criteria should be employed, including at least social, mental, educational, anthropometric and somatic considerations. Since mental deficiency is best considered as a constitutional hypoplasia (or as a morphologically determined developmental incompleteness) the diagnosis on educational, social and mental manifestations alone must be considered inadequate. More particularly the mental criteria must be sufficiently varied to include the psychobiological organism as a whole and its many facets of expression, including personality organization and emotional motivation.

From the professional standpoint the differential diagnosis and subsidiary classification of mental deficiency is no simple matter. And more particularly at the moron limit where pseudofeeblemindedness and submarginal normality may result in false diagnosis (see Wood committee report in bibliography at end of this article). These embarrassments have been materially relieved by the use of the Vineland Social Maturity scale for the evaluation of the social criterion, just as the Stanford revisions of the Binet-Simon scale have had such a marked effect in clarifying the intellectual criterion. The measurement of intelligence must be regarded as unreliable by itself for detecting the moron degree of mental deficiency since there is a complete overlap in Binet mental ages as between the entire range of the moron and the lower range of normality. This dilemma is to be resolved only by the use of multifocal mental measurements as well as the use of other than mental criteria of the condition.

Disposition. — The question recurs, "Is feeble-mindedness curable?" If the traditional concept of essential incurability is adhered to, then the answer to this question must be in the negative except as the social manifestations of the condition may be ameliorated through various forms oi regimen. No significantly successful treatment of the feeble-minded has yet been established, although here also, and especially in the case of cretins, the condition has been somewhat improved through medication or surgery. Likewise, educational procedures have achieved a release of inherent aptitudes only through more effective expression without materially altering the nature of the essential condition in given cases. Methods of disposition, treatment and care, as well as policies of social control, must be founded on the concept of the essential incurability oi mental deficiency until this concept has clearly been set aside by more and better scientific evidence than is at present available. A critical issue here is the adequacy of both initial and later diagnoses. Consequently, the social disposition and control of mental deficiency are at present essentially custodial, supervisory and ameliorative rather than curative, restorative or rehabilitative.

Suitable care, training and supervision may be and most frequently are provided at home, especially when supplemented by special education in the public schools These may also be provided in public or private institutions and schools. Remedial treatment is better directed toward the amelioration of symptoms rather than the cure of the condition itself. Training is best adapted to the degree of mental deficiency and the accompanying characteristics. Amelioration may also be achieved in the resolution of the behaviour manifestations or socially regrettable consequences of the condition as well as in the inculcation of the optimum degrees of literacy, the maximum forms of occupational pursuits and self-direction, the inculcation of personal and occupational habits and particularly the expressive self-realization achieved through individual happiness and adjustment as far as this may be feasible. One form of social disposition which has had a limited development in the U.S., although its practicability has been amply demonstrated both in this country and abroad, is that of family care and its equivalents of hostel and colony care,

Preventive treatment is provided through the avoidance of those circumstances which are known to produce feeble-mlndedness or which aggravate its social consequences. A widely advocated preventive measure is that oi sterilization, but this is wisely applicable only to proved cases of endogenous or familial origin. The prospect of a significant reduction in the amount of mental deficiency from this source seems relatively meagre and not wholly practically realizable.

The most optimistic outlook is that doubtful cases of borderline feeble-mindedness may be elevated from marginal deficiency to marginal adequacy, that the behaviour problems may be materially mitigated by institutional and social supervision, that occupational efficiency may be materially increased through constructive oversight and that scholastic and vocational achievement may be enhanced through special education.

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MENTAL HEALTH cannot be defined with precision, since it is closely related to the customs and requirements of society. Since customs vary and societies differ, there is a multiplicity of variable factors. Excessive conformity may be as unhealthy as extreme deviation. What is healthy conformity in the person of limited intelligence might be unhealthy stifling to the genius. The physician is apt to think of mental health as the absence of mental illness. and such definition serves his purpose. Mental health in the broader sense suggests a degree of happiness and satisfaction, under conditions that warrant such a state of mind. and a capacity for making satisfactory personal and social relationships. These are a few of the many variables that have to be taken into account in assessing mental health.

History. — The mental health movement. like all social movements, did not have a single or sudden beginning The evolution of concern for the mentally ill, influenced by medicine and an interest in social nelfare and criminology. developed separately from positive mental health, which depended more on the field of education. Concern for the mentally ill has had a slow. irregular development over centuries marked by alternations of advances and regressions. In the history of medicine and in biblical writings there are ancient references to mental illness that recall modern humane attitudes. Interspersed there are instances of socially sanctioned cruelty based upon the belief that mental illness was the result of demoniac possession. Even reformers sometimes used harsh measures in treatment.

Modern public interest in the humane treatment of the mentally ill seems to have begun in the middle of the 18th century, the contributions of four men at the end of the 18th century being outstanding. Philippe Pinel and Jean Esquirol in France (*qq.v.*); William Tuke in England; and Benjamin Rush in America (q v.). But even these leaders were anticipated by less well-known reformers, such as Chiarugi in Italy. and by the more rational approach to the understanding and treatment of the mentally ill that was characteristic in the Moslem world centuries earlier.

In the 18th century. Bedlam (Bethlehem). founded in England in 1247, and Bicêtre in Paris were representative in their use of mechanical restraint, such as leg irons, and cruel treatment Madhouses, as they nere then called, were callous to the essential humanity and sensitivity of patients; in fact, it was often believed that mental patients lacked feeling. Custodial care and the protection of the public were paramount considerations. In 1793 Pinel, then head of the Paris Asylum for Men (Bicêtre), horrified his colleagues by removing restraints and shackles from his patients Contemporaneously. Tuke, in England, led the Quaker movement in the same direction, and this example was followed in America, uhere, at the Pennsylvania hospital in Philadelphia. Benjamin Rush took steps to eliminate restraints. In the early part of the 19th century the leadership in opposition to physical restraint of the mentally ill was assumed by John Connolly, an Englishman.

In the early days of the United States the mentally ill were dealt with by a variety of measures. Some were auctioned off for their care to farmers within the community. some were driven from tonn by court order and some were placed in almshouses. Serious abuses. of course, took place. The first state asylum for the mentally ill in the United States was established in Williamsburg, Va. in 1766, but the extension of this type of service to other states moved very slowly.

In the middle of the 19th century Dorothea Dix (*q.v.*) undertook a campaign to construct better-equipped asylums under state auspices. So vigorous was her effort that during her lifetime 32 asylums were established or enlarged in the United States and

abroad. These were still asylums, however, although many assumed the name of hospital, and many of the abuses that characterized earlier years continued. The movement away from community toward state responsibility, in fact, enhanced the isolation of the institution, and this became one of its most serious handicaps. Isolation caused the family to abandon the patient and made it harder for the patient to visit and eventually return home. It removed the institution from the sight of the citizens and public officials and clothed it in mystery and dread. It allowed many abuses to grow up unnoticed. Changing the name to hospital merely obscured the fact that internally there was very little change.

It was the sad experience of one inmate of several Connecticut institutions. Clifford W. Beers, at the beginning of the 20th century that finally brought about the organization of a citizens' organization for the elimination of abuses and the provision of care that would warrant the name hospital. Beers, having suffered the usual restraints and abuses, pledged, while recovering, to attack these problems. On his return home he wrote an autobiography entitled *A Mind That* Found *Itself* (1908), describing his own experience as a patient. While Beers was in spirit a crusader, he was still wise enough to seek and follow the best professional and scientific counsel. His book had an enormous sale.

Incomparably, the greatest contribution to the whole study of mental health in the 20th century came from Vienna at the time of Sigmund Freud. Carl Jung and Alfred Adler. All modern techniques of psychotherapy derive from Freud and his associates, whose nork led to a vastly increased understanding of the human mind. both in sickness and in health.

Organization and Agencies.—United States—With the counsel of such psychiatrists as Adolf Meyer. Beers founded in 1908 the Connecticut Society for Mental Hygiene and in 1909 the National Committee for Mental Hygiene. which later. in 1950, helped form the National Association for Mental Health After 1909, therefore there existed in the United States a body of citizens interested in the needs of the mentally ill and exerting an influence for improvement. Similar groups developed in many other countries. and nithin the United States a large number of state and local mental health associations were formed.

The National Xssociation for Mental Health in the United States consists of formal affiliation between national, state and local mental health associations. It conducts an annual national campaign for funds, 5% of the proceeds of ahich are devoted to research. The central concern of the association is mental illness, although many other activities bearing on mental health are also carried on.

In the beginning these organized mental health activities concentrated on improving hospitals for the mentally ill, and this continues to be their central concern. But within a decade of its beginning the National Committee for Mental Hygiene began to interest itself also in facilities for the mentally deficient, mentally disordered inmates of correctional institutions (jails and prisons), facilities of courts for the detection and handling of the mentally handicapped, and the handling of mental health problems among immigrants entering the United States. In the early 1920s it developed outpatient psychiatric clinics for children and adults. Steps were also taken to advance the teaching of psychiatry in medical schools, schools of social work and schools of nursing. in order to satisfy the increased need for personnel. It also promoted the mental health education of physicians, teachers, social workers. public health workers. police and clergy, all of whom are concerned with mental health problems.

The major governmental agency in the mental health field in the United States is the National Institute of Mental Health, in the United States public health service of the department of health, education and welfare. It operates a research centre in Bethesda, Md., and, in addition, makes grants to research centres and to university and other training centres for psychiatrists, psychologists. psychiatric social workers and psychiatric nurses. provides grants-in-aid for projects designed to facilitate the restoration of mentally ill patients to the community and makes direct grants to state governments on a matching basis to encourage mental health facilities in communities. Other federal agencies—notably the armed forces, the Veterans administration, the office of vocational rehabilitation and the office of education—also carry out certain functions in mental health.

Each state, except Alaska, operates one or more institutions for mental disorders. and many also provide outpatient services. State mental hospitals care for about 85% of the mentally ill in hospitals of the U.S. There are, in addition, in more populous places, county and municipal mental hospitals. Each state also has a mental health authority, usually in the state department, concerned with public health or nith mental hospitals. which receives the above-mentioned matching grants from the National Institute of Mental Health. A number of states, beginning in 1954 with New York, established laws providing state aid to communities for the operation of mental health services. Under these laws the community creates a local mental health authority to plan and contract for local services.

Many communities also provide agencies for the social rehabilitation of patients discharged from mental hospitals. A pioneer in this service is Fountain house in New York city. (G. STE.)

Great Britain and the *Commonwealth.*—After 1948 in Britain the hospital care of the mentally ill was almost entirely the responsibility of the central government. operating through regional hospital boards as agents for the minister of health. The boards were established under the National Health Service act of 1946. Prior to that date the mental hospitals had been administered for more than 100 years by the local health authorities of the counties and large cities. Until the early part of the 19th century, care of mental patients, mainly of a custodial nature. was in the hands of private asylums run either by charitable bodies or for profit Then a number of serious scandals came to light, which aroused the public conscience, and a small group of members of parliament kept up a continuous agitation and stirred the government to set up official inquiries into the administration of private asylums. Out of these inquiries came a series of disturbing reports, mhich led, often after setbacks and delays, to several important acts of parliament, such as the County Asylums acts, which placed a duty upon local authorities to make provision for the care and treatment of the mentally sick. The middle of the 19th century saw the building of large asylums in many parts of Britain and the establishment of the lunacy commissioners, appointed by the lord chancellor, who were charged with inspecting and licensing all places where mental patients were cared for. The commissioners' functions were later taken over by the board of control.

All patients in mental hospitals were, under the Lunacy act of 1890, subject to compulsion, until the 1930 Mental Treatment act made provision for such patients to accept hospital treatment voluntarily. The Mental Health act of 1959 swept away all previous legislation relating to mental illness and mental deficiency and made it possible for patients suffering from any form of mental disorder to be treated in a hospital on a completely informal basis. The 1959 act had two main objectives: first, to eliminate so far as possible all distinction, legal and social, between mental and physical illness; second, to provide community care for all those not ill enough to need continuous medical or nursing care. Such community care is the responsibility of the local health authorities. In certain parts of Britain, notably at Nottingham, York, Oldham (Lancashire) and Worthing (Sussex), community mental health services have existed for some years. Local authorities are encouraged to build hostels and training and occupation centres for the mentally disordered and to deploy a trained staff of mental welfare officers and psychiatric social workers to work in the community in close liaison with the hospital authorities. The hospitals provide a steadily increasing number of psychiatric outpatient clinics and day hospital facilities. In pursuance of the other objective of the new act, psychiatric inpatient units would be established in existing general hospitals and included in those planned for the future.

In 1946 the several voluntary organizations concerned with mental health were fused into the National Xssociation for Mental Health. The association operates homes for special types of mentally disordered persons, does a certain amount of aftercare

work, organizes training of workers in the mental health services and undertakes educational work both within the service and among the public at large. The Mental After-Care association provides hostels for patients discharged from mental hospitals who are unable to return directly to their own homes. Psychiatric research is mainly the responsibility of the government-financed Medical Research council, but a voluntary body, the Mental Health Research fund, also works in this field.

The mental health services of the commonwealth vary greatly both in character and in extent. By the 1960s they were most advanced in Canada. where the pattern resembles that of the United States perhaps more than that of Britain. Elsewhere there was a noticeable time lag before developments in Britain could be reproduced overseas; in most of Africa, for example, the services were still rudimentary. There were indications, however, that public awareness of mental health as a major social problem was beginning to be felt in parts of the commonwealth.

Europe. — The care and treatment of the mentally disordered and the promotion of mental health follow a broadly similar pattern in most of the countries of western Europe. In general, the state, either through the central or the provincial government, is responsible for the provision and maintenance of establishments for the treatment and care of mentally ill and mentally defective persons. In many countries. however — France, the Netherlands and western Germany, for example — this responsibility may be delegated in part to religious bodies or other voluntary organizations.

Hospital provision for the mentally disordered in western Europe is on a lesser scale proportionately than in Britain or the United States. There is a greater tendency for such patients to remain in the community. Despite this, fully developed community mental health services are rare in most countries, though the Netherlands was a pioneer in this respect In Amsterdam, A Querido, the city's director of public health, developed the type of integrated community services which embraces social-psychiatric advice and treatment in the patient's own home, liaison with other social services, hospital treatment when necessary and aftercare. The Amsterdam scheme became the model for similar developments in Rotterdam. The Hague, Utrecht and, indeed, other countries.

Communal care of a somewhat different type is exemplified in the Belgian state colony for mental patients at Geel. near Antwerp, the origin of which can be traced back to the 6th century. A record of miraculous cures, especially of persons thought to be possessed of devils, turned it into a place of pilgrimage, and the inhabitants grew accustomed over the centuries to mental patients in their midst. The colony, established by a religious order. was taken over by the state in 1852, and in the 1950s comprised about 1,500 patients, living in houses indistinguishable from those of the local population. The colony has a small infirmary for those who become too disturbed to live among the community.

Alongside the governmental agencies are the voluntary bodies, to whom in the main is entrusted the work of promoting mental health and of educating the public in its attitudes toward mental disorder, usually in co-operation with the ministry of health of the country concerned. The Netherlands has a National Federation for Mental Health; in France there is La Ligue Française d'Hygiène Mentale; and in Sweden, Svenska Foreningen for Psykisk Hälsovård. As in Britain and in the United States, there was in almost every country of western Europe the same remarkable growth, in the period after World War II, of public interest in and understanding of the problems of mental health.

(K. RN.)

International — In 1930 through Beers's efforts, an International Congress on Mental Hygiene was hcld in Washington, D.C., and concurrently with this an International Committee for Mental Hygiene was formed. This body, as a result of the Third International Congress on Mental Hygiene, was succeeded in 1948 by the World Federation for Mental Health. a federation chiefly of national, professional, voluntary citizens' and some governmental agencies, and which. by 1958, comprised more than 100 such associations in more than 40 countries. The federation enjoys a consultative relationship with several United Nations agencies and also carries on consultative services with various national groups. It conducts studies and provides education in mental health conditions and also provides education in mental health for professional groups.

UN agencies concerned with mental health are the World Health organization. the world counterpart of a national public health service; the Cnited Nations Educational, Scientific and Cultural organization, which carries on cultural interchange and education; and the United Nations Children's fund, which is concerned mith the health of children.

Approaches. — There are three types of approach to mental health: restoration, protection and elevation. Restoration of mental health is the function of clinical or psychiatric services, ranging from nonmedical services for those who are mildly or temporarily disturbed to hospital services for those with severe mental illnesses. In many cases, public hospitals in the United States have not been provided with the facilities to use modern knowledge of better ways of handling mental illnesses. Mental health associations strive to bring new treatment into use promptly. Many communities need such encouragement to provide local inpatient and outpatient services and nonmedical services, such as vocational and social rehabilitation. Many hospitals fail to follow up patients when they recover enough to leave the hospital, even though they still need psychiatric service.

The protection of mental health, **ie.,** the prevention of mental disorder, is essentially outside the field of psychiatry. falling more nithin the area of public health. However. some medical treatment, not involving mental disorder, may be considered as preventive nhen it forestalls involvement of the brain; *e.g.,* in pellagra and syphilis. Similarly, the correction of certain social problems and life crises may prevent serious mental disorder. Mental disorders are found in 100 or more different diseases, each with its own set of causes; hence it is not possible to depend upon any general measures to treat or prevent mental disorders. Much that is done in the name of prevention is an attempt to alter adverse conditions found repeatedly in the background of the mentally ill. Though application of such measures can be thoroughly justified, it must be remembered that such preventive effort has not been tested scientifically. and it is not knòwn how great a part adverse conditions play in the causation of mental illnesses.

The third aspect of mental health, *i* e., positive mental health, differs from restoration and prevention in that it is oriented toward talents and assets (positive) rather than illnesses (negative). It is concerned with facilities that identify and develop talents and capacities and, therefore, is more a matter of education, occupation and recreation.

These three aspects, of course, are not in practice separable, since all are concerned with the effective functioning of an integrated being. See also PSYCHIATRY; PSYCHOLOGY. APPLIED; PSYCHOTHERAPY; PUBLIC HEALTH; HOSPITAL; and articles on the various mental diseases. (G STE)

MENTAL TELEPATHY is the communication of two organisms without the use of the senses. See PARAPSYCHOLOGY.

(P. E. M.)

MENTAL TESTS: see PSYCHOLOGICAL TESTS AND MEASUREMENTS.

MENTAWAI, a group of islands off the west coast of Sumatra, Indon. They include Siberut, Sipora and Pagai (Pagi) of Nassau. They are volcanic, and sunken coral reefs render them dangerous to approach. The islands generally are covered with thick forests. There are a few small rivers in Siberut. Population 22,524. The people are considered to be of Caucasian origin, probably related to the very early indigenous peoples of Sumatra, and pre-Batak. The Mentawai islanders have golden-bronn skins. black hair, dark eyes and broad, flat noses, the men are of middle height, the women short and thickset. They tattoo and have a custom resembling one of Hawaii — wearing flowers in the hair and behind the ears. They have an inflexible moral code, knoning nothing of divorce and punishing adultery with death. The man is the head of his own family, and marriage is either endogamic or exogamic. Polygamy is not practised. Their religion is nature worship, oblations being made in the forest to nature spirits; they have no idols or temples but are known to set up a

bamboo cylinder in the forest and decorate it with scraps of cloth, leaves and flowers, a rite which may be phallic in origin. They are governed by village chiefs. Houses are of bamboo and *atap* on piles. They grow fruit, coconuts, sugar cane and tobacco. They are keen hunters and fishers and collect forest products. They are also good boatbuilders. (E. E. L.)

MENTEITH, a district of southwestern Perthshire, Scot., roughly comprising the Perthshire basin of the Forth west of the Ochils. On the northeast it extends to the Teith. The Menteith hills rise north of Aberfoyle. The village of PORT OF MENTEITH (pop. of civil parish, 1951. 721) is on the northern shore of the Lake of Menteith, 4 mi. E. of Aberfoyle. On Inchmahome (Gaelic, "the Isle of Rest") are ruins of an Augustinian priory founded in 1238 by Walter Comyn. The island was the residence of Mary Queen of Scots. when a child of five, for a few months before her departure to France in 1548. On Inch Talla stands the ruined tower of the earls of Menteith, dating from 1428.

Formerly Menteith was a stewartry and gave the title to an earldom. The title was first held by Gilchrist, a Celtic chief ennobled by Malcolm IV, and passed successively to Walter Comyn, to a branch of the Stewarts, and finally to the Grahams. becoming extinct in 1694.

MENTHA, a genus of the Labiatae family commonly known as mint (*q v*), containing about 25 species of strong-scented herbs mostly cultivated for the aromatic oil obtained from all parts of the plant, but a few grown in the garden for ornament and fragrance. (*See* MINT; PENNYROYAL; PEPPERMINT; SPEARMINT.)

(J. M. BL.)

MENTHOL: *see* CAMPHOR.

MENTON (Ital. MENTONE), a tomn in the *département* of the Alpes-Maritimes in southeast France, on the shore of the Mediterranean. about 15 mi. E. of Nice. Pop. (1954) 16,421. Menton was probably the Lumone of the Itineraries, but no Roman remains exist. After having belonged to the counts of Ventimiglia and a noble Genoese family, it was purchased about the middle of the 14th century by the Grimaldis, lords of Monaco. During the first republic and the first empire it belonged to France. but in 181j it reverted to the prince of Monaco, who subjected it to such exactions that in 1848 its inhabitants proclaimed the town (with Roquebrune on the west) independent. under the protection of Sardinia. In 1860 both Menton and Roquebrune were purchased by France from the prince of Monaco. and added to the *département* of the Alpes Maritimes then formed out of the county of Nice. ceded the same year to France by Sardinia. The town is built in the form of an amphitheatre on a rocky promontory, which divides its semicircular bay into two portions. Below, along the seashore. is the town of hotels and foreigners. while above. is that of the native Mentonese, with steep, narrow and dark streets, around the strong castle which was once its protection against pirates. Facing southeast. and sheltered on the north and west by mountains, the bay of Menton has a good climate and is frequented by invalids.

MENTOR, in Greek legend. the son of Alcimus and friend of Odysseus (*q.v.*), who makes him guardian of his household. In Fenelon's *Télémaque* he plays a prominent part. giving the hero much good advice; hence the modern use of mentor for adviser, sage counselor.

MENZEL, ADOLF FRIEDRICH ERDMANN VON (1815–1905), German lithographer and painter, known in his day for picturing the times of Frederick the Great, was born on Dec. 8, 1815, at Breslau. and moved to Berlin in 1830. In 1832 he took charge of his dead father's lithographic workshop, and, self-taught, rapidly became famous in this medium. In 1839–42 he illustrated F. Kugler's *Geschichte Friedrichs der Grosse* with 400 plates. decisive in their effect on German 19th-century graphic art; and this was followed by illustrations for similar publications such as a lavish edition of Frederick's works with 200 plates (1843–49) and E. Lange's *Die altpreussische Armee* (1852). In painting Menzel was soon famous for his glittering re-creations of such scenes as Frederick the Great's concerts at Sanssouci and "The Ball Supper" (1878) showing the court of William I vigorously refreshing itself. In later times he was most admired. however, for minor paintings and drauings dating from about 1840 onward. These interior, street and landscape scenes show an unorthodoxy of vision reminiscent of that of Menzel's contemporary Honoré Daumier. Subjects are viewed from high or low angles, there are departures from conventions of grouping and framing and excursions are made into railway and industrial subjects, the most famous of which is "The Foundry" (1875). Menzel died in Berlin, Feb. 9, 1905. (D. C. T. T.)

MENZEL, WOLFGANG (1798–1873), German poet. critic and literary historian. was born on June 21, 1798. at Waldenburg in Silesia, studied at Breslau. Jena and Bonn. and after residence in Aarau and Heidelberg finally settled in Stuttgart. where from 1830 to 1838, he had a seat in the Württemberg diet. His first work, a clever and original volume of poems, *Streckverse* (1823), was folloned in 1824–25 by a popular *Geschichte der Deutschen* in three volumes and in 1829 and 1830 by *Rübezahl* and *Narcissus,* the dramatized fairy stories upon which his reputation as a poet chiefly rests In 1851 he published the romance of *Furore,* a lively picture of the period of the Thirty Years' War; his other writings include *Geschtchte Europas,* 1789–1815 (2 vols., 1853), and histories of the German War of 1866 and of the Franco-German War of 1870–71

From 1826 to 1848 Menzel edited a *Literaturblatt* in connection with the *Morgenblatt,* revived it again in 1852. He died on April 23, 1873, at Stuttgart

MENZIES, ROBERT GORDON (1894–), Australian statesman, was born in the small wheat town of Jeparit. Victoria, on Dec. 20, 1894. His father owned a country store. After primary education at rural state schools. he non a series of scholarships and graduated with first class honours in law from Melbourne university.

In 1929, when he was 34, Menzies became the youngest king's counsel in Victoria; he had already established a practice yielding £A10,000 a year.

At the crest of his law career Menzies switched to politics. In 1928 he nas elected to the upper house in the Victorian state legislature; frustrated in a house which only had power to review legislation, in 1929 he successfully sought election to the lower house. In 1934 he resigned to contest the Melbourne suburban seat of Kooyong in the federal house of representatives nhich he won and held. He was prime minister of Australia from April 1939 to Aug 1941; elected again in Dec. 1949, he passed the previous record for cumulative occupancy of the office on Nov. 30, 1954. As parliamentary leader of the Liberal party (counterpart of the Conservatives in the United Kingdom), Menzies headed a government in the mid-1950s which was a coalition of the Liberal and Country parties.

Menzies' political creed was a blend of liberalism. conservatism and an Australian brand of antisocialism—a combatting of egalitar[i]an[i]sm. "I have a respect for the rights of the top dog," he once said. "There is no foolish doctrine of equality between the active and the idle, the intelligent and the dull and the frugal and the improvident." In foreign policy. he sought an Australian association with the United States as intimate as that with Great Britain and complementary to it.

The Liberal-Country party coalition with Menzies as prime minister again won the elections of Dec 10. 195j (R. J. GE.)

MEPHISTOPHELES (MEPHOSTOPHILES). Faust's familiar spirit. The first spelling is Goethe's, the second is the original form, and the name has undergone many other vowel shifts. Various etymologies have been suggested for the original version: Hebrew *mephis-tophel* ("destroyer-liar"), Greek *Mephos Phigein* ("not loving light"), etc.; also a faulty Greek translation of Lucifugum, a category of supernatural beings invented by the Byzantine scholar and philosopher Michael Constantine Psellus and described by Johannes Tritheim as ". . . a sort wandering in darkness, a mysterious kind of demon, dark through and through, malicious. restless, stormy." The presence of Lucifuge in the French *Grand Grimoire* (one of the chief medieval textbooks of necromancy) gives some plausibility to this theory. It is not recorded that the historical Faust ever named a familiar spirit, although he referred to the devil once or twice as his *Schwager*

("crony" or "brother-in-law"); and it seems probable that the anonymous author of the first *Faustbuch* (1587) invented the name. It is vain to seek in the many and various lists of fiends in magical manuals! except in the so-called Faustian *Höllenzwänge* ("harrowings of hell"), where it was introduced into existing ritual texts which the editors attributed to Faust in order to increase their sales value. In the interests of verisimilitude the great Faustian ritual classic *Magia Naturalis* et *Innaturalis* (in the Weimar Grand-Ducal library) placed Mephisto high in the infernal hierarchy, among the seven electors or planetary spirits. These derived ultimately from the *maskim* of the Akkadians, the seven adversaries of the planetary gods. *Magia* assigned Mephisto to Jupiter, gave variant spellings (Mephistophiel, Mephistophielus, Mephistophiles and Mephistophilus), brought him into prominence throughout as Faust's familiar and gave a portrait of him as a tubby little monk. But even in this manual Mephisto is completely overshadowed by the far mightier and more sinister Aciel (undoubtedly the black sun of the Akkadian cosmos); and he is chiefly conspicuous by his absence in other Faustian rituals, although he was allowed a minor part in some. A late-comer and a parvenu in the infernal hierarchy, he never became an integral part of a tradition which predated him by thousands of years. He belongs to legend and literature. Ritual magic rejected him.

In the first *Faustbuch,* Mephostophiles was represented as a formidable, remorseful, yet ruthless. fiend and realistically characterized. He gained considerably in stature in the Elizabethan prose version by P. F. Gent (1592) and attained to tragic proportions in Christopher Marlowe's drama (published 1604) as a fallen angel, torn between satanic pride and dark despair. Goethe's Mephistopheles is entirely different, perhaps a subtler but certainly a slighter creation. He is coldhearted. cynical, witty. malignant and destructive, the very spirit of denial, as he defines himself; but nevertheless

> A part of that same might
> Which wills the evil course and furthers right.

As such he is far from displeasing to the Almighty, with whom he is on easy terms; and his mission is foredoomed to failure because (unlike his predecessors in the *Faustbücher* and Marlowe's drama) he is incapable of satisfying Faust's desires. He is finally befooled, resembling in this the comic devil or poor devil of pre-Lutheran popular literature, for Faust's soul escapes him while he is making improper advances to the angels who have come to rescue it. In his great speech against the light (*Studierzimmer* I) there are traces of a different conception based on the ancient dualism between good and evil, darkness and light which harks back to Zoroastrianism; but Goethe's Mephisto is too strongly individualized and also too protean a character to fit readily into any abstract system. See also FAUST. (E. M. BR.)

MERANO, a town in southern Tirol in the Italian province of Bolzano. 20 mi. N.W. of it by the Val Venosta railway. Pop. (1951) 25,900. The town is at a height of 1,001 ft., at the foot of the vine-clad Kiichelberg. and on the right bank of the Passeria river, above its junction with the Adige. The name includes several adjacent villages, Maia Alta and Bassa being on the left bank of the Passeria, while Gratsch is on its right bank and northwest of the main town. The most noteworthy building is the parish church (14th to 15th centuries). but there are many handsome buildings and promenades. Merano, noted for its mild winter climate, is a health resort.

To the N.W., on the Kiichelberg, is the half-ruined castle of Tirolo (2,096 ft.), original seat of the family which gave its name to the county. Merano is first mentioned in 857. From the 12th century to about 1420 it was the capital of the Tirol. but then gave way to Innsbruck. It came under Italian rule in 1918.

MERCANTILE SYSTEM. The name given to the economic policy which developed in Europe at the close of the middle ages. The doctrine of the mercantile system, stated in its most extreme form, made wealth and money identical, and regarded it therefore as the great object of a community so to conduct its dealings with other nations as to attract to itself the largest possible share of the precious metals. Each country's interest was to export the utmost possible quantity of its own manufactures and to import as little as possible of those of other countries, receiving the difference of the two values in gold and silver. This difference is called the balance of trade, and the balance is favourable when more money is received than is paid. Governments might resort to all available expedients—prohibition of, or high duties on, the importation of foreign wares, bounties on the export of home manufactures, restrictions on the export of the precious metals—for the purpose of securing such a balance.

But this statement of the doctrine, though current in textbooks, does not represent correctly the views of all who belonged to the mercantile school. Many members of that school were much too clear-sighted to entertain the belief that wealth consists exclusively of gold and silver. The mercantilists may be best described, as W. G. F. Roscher remarked, not by any definite economic theorem which they held in common, but by a set of theoretic tendencies, commonly found in combination, though severally prevailing in different degrees in different minds. The underlying principles may be enumerated as follows: (1) the importance of possessing a large amount of the precious metals; (2) an exaltation (a) of foreign trade over domestic, and (b) of the industry which works up materials over that which provides them; (3) the value of a dense population as an element of national strength; and (4) the employment of state action in furthering artificially the attainment of the ends proposed.

The discoveries in the new world had led to a large development of the European currencies. The old feudal economy, founded principally on dealings in kind, had given way before the new "money economy," and the dimensions of the latter were everywhere expanding. Circulation was becoming more rapid, distant communications more frequent, city life and movable property more important. The mercantilists were impressed by the fact that money is wealth *sui generis,* that it is at all times in universal demand and that it puts into the hands of its possessor the power of acquiring all other commodities. The period, again, was marked by the formation of great states, with powerful governments at their head. These governments required men and money for the maintenance of permanent armies, which, especially for the religious and Italian wars, were kept up on a great scale. Court expenses, too, were more lavish than ever before and a larger number of civil officials was employed. The royal domains and dues were insufficient to meet these requirements, and taxation grew with the demands of the monarchies. Statesmen saw that for their own political ends industry must flourish. But manufactures make possible a denser population and a higher total value of exports than agriculture; they open a less limited and more promptly extensible field to enterprise. Therefore they became the object of special governmental favour and patronage, while agriculture fell comparatively into the background. The growth of manufactures reacted on commerce, to which a new and mighty arena had been opened by the establishment of colonies. These were then viewed simply as estates to be worked for the advantage of the mother countries and the aim of statesmen was to make the colonial trade a new source of public revenue. Each nation, as a whole, working for its own power and the greater ones for predominance, they entered into a competitive struggle in the economic no less than in the political field, success in the former being indeed, by the rulers, regarded as instrumental to pre-eminence in the latter. A national economic interest came to exist, of which the government made itself the representative head. States became a sort of artificial hothouse for the rearing of urban industries. Production was subjected to systematic regulation, with the object of securing the goodness and cheapness of the exported articles, and so maintaining the place of the nation in foreign markets. The-industrial control was exercised, in part directly by the state, but largely also through privileged corporations and trading companies. High duties on imports were resorted to, at first perhaps mainly for revenue, but afterward in the interest of national production. Commercial treaties were a principal object of diplomacy, the end in view being to exclude the competition of other nations in foreign markets, while in the home market as little room as possible was given for the introduction of anything but raw materials from

abroad. The colonies were prohibited from trading with other European nations than the parent country, to which they supplied either the precious metals or raw produce purchased with home manufactures. Under the mercantile system a colony was thus regarded as a hewer of wood and drawer of water for the mother country. For Britain, the loss of the North American colonies was a major consequence of the doctrine.

That the efforts of governments for the furtherance of manufactures and commerce under the mercantile system were really effective toward that end is admitted by Adam Smith, and cannot reasonably be doubted, though doctrinaire free traders have often denied it. Technical skill must have been promoted by their encouragements; while new forms of national production were fostered by attracting workmen from other countries, and by lightening the burden of taxation on struggling industries. Communication and transport by land and sea were more rapidly improved; and the social dignity of the industrialist was enhanced.

Such a mercantile policy had been already practised in the 14th and 15th centuries, thus preceding any formal exposition or defense of its speculative basis. At the commencement of the 16th century it began to exercise a widely extended influence. Charles V adopted it, and his example contributed much to its predominance. Henry VIII and Elizabeth I conformed their measures to it. The leading states soon entered on a uni ersal competition for manufacturing and commercial preponderance. Through almost the whole of the 17th century the prize, so far as commerce was concerned remained in the possession of the Netherlands, Italy having lost its former ascendancy by the opening of the new maritime routes, and Spain and Germany being depressed by protracted wars and internal dissensions. The admiring envy of the Netherlands felt by English politicians and economists appears in such writers as Raleigh, Mun, Child and Temple. Cromwell, by his Navigation act, which destroyed the carrying trade of the Netherlands and founded ilie British empire of the sea, and Colbert, by his whole economic policy, domestic and international, were the chief practical representatives of the mercantile system.

See G. Schmoller, *The Mercantile System* (Eng. trans., *1896)*; also the articles. INTERNATIONAL PAYMENTS; FREE TRADE; PROTECTION; PHYSIOCRATIC SCHOOL, etc.

MERCAPTANS are organic chemical compounds of similar type to the alcohols (*q.v.*) but containing sulfur in the place of oxygen. They are thus thioalcohols. or thiols. Their generic name is derived from *mercurium captans,* which refers to the formation of characteristic crystalline mercury salts by the interaction of the thiols with mercuric oxide.

Mercaptans may be either aliphatic or aromatic. Ethyl mercaptan. $C_2H_5.SH$, a typical aliphatic thiol, is a volatile liquid boiling at 36.2" C. and sparingly soluble in water; it has a disagreeable smell. It is made by warming sodium ethyl sulfate with aqueous potassium hydrogen sulfide. Ethyl mercaptan is used commercially in the production of the drugs sulfonal (*q.v.*), trional and tetronal. *n*-Butyl mercaptan, a liquid boiling at 98° C., is one of the important components of the scent of skunks.

Phenyl mercaptan, or thiophenol, $C_6H_5.SH$, the simplest aromatic thiol, is a liquid boiling at 169.5° C., and is prepared by acting on benzenediazonium chloride (*see* DIAZO COMPOUNDS) successively with potassium ethyl xanthate and caustic alkali or by reducing benzene sulfonyl chloride with zinc dust and sulfuric acid.

MERCATOR, GERARDUS (latinized form of GERHARD KREMER) (1j12–1594), the greatest of the Renaissance geographers, best known for the map projection which now bears his name, was born at Rupelmonde. in East Flanders, on March 5, 1512. He matriculated at the University of Louvain in Aug. 1530. He studied mathematics, astronomy and cosmography under the celebrated Gemma Frisius; and at Louvain he first practised as a maker of scientific instruments. In the pair of large globes completed by Gemma in 1537 Mercator collaborated, probably as engraver; and he prepared a set of field instruments for the emperor Charles V His earliest printed cartographic works. of each of which one copy only is now knonn, were a map of the holy land (1537); a world map (1538) on a double cordiform projection derived from that used by Oronce Finé in 1531; and a large map of Flanders completed in 1540 from a survey made in the three previous years. Mercator's terrestrial globe, 41 cm. in diameter, was published in 1541, the celestial in 1551; and in 1552 he presented them to Charles V at Brussels with an astronomical ring, or armillary sphere, and a manuscript *Declaratio* on the uses of all three instruments.

Mercator had early inclined toward Protestantism. and in 1544 he was arrested on a charge of heresy, although without serious consequences, Fear of religious persecution was doubtless the motive for his emigration in 1j52, at the invitation of the duke of Jülich, Cleves and Berg, to Duisburg, in the German Rhineland, where his workshop was established for the remainder of his life. In 1j64 he was appointed cosmographer to the duke, to whom some of his most important works were to be 'dedicated. Mercator's great map of Europe. in 15 sheets, which had been begun in Louvain, was published at Duisburg in 1554. This map illustrates Mercator's progressive emancipation from Ptolemy, whose excessive length of 62° for the Mediterranean was reduced to 58° in filercator's globe of 1541 and to 53° in his map of Europe. On Oct. 28. 1556, he observed a solar eclipse at Duisburg; in 1563 he surveyed Lorraine for Duke Charles II, but his map was apparently never published. In 1564 Mercator published the second of his large wall maps, that of the British Isles, 'in eight sheets. This was engraved from materials supplied to him by an English friend. who has not been identified.

In 1569 Mercator produced his memorable world chart drawn on the projection named after him and entitled *Nova et aucta orbis terrae descriptio ad usum navigantium accommodata.* Mercator was neither the inventor nor the first user of this projection (which is discussed in the article MAP); but he was the first to apply it (by an empirical method) in a nautical chart for the use of seamen. so that the pilot could lay off a compass course on the chart as a straight line making the same angle with all meridians.

In the little *Chronologia,* published at Cologne. also in 1569, Mercator described the majestic plan of the great cosmographical work which was to occupy the rest of his life, with its threefold division into modern maps, Ptolemy's maps, and maps of ancient geography. Apart from a revised edition of the Europe (1572), all Mercator's remaining output consisted wholly of atlas-size maps. His critical edition of the 27 Ptolemaic maps (with one added) was published at Cologne in 1578 under the title *Tabulae geographicae Cl. Ptolemaei ad mentem auctoris restitutae et emendatae* and reprinted in 1584, with the Latin text added. Helped by his sons and grandsons, Mercator drove forward the preparation of the modern maps for the atlas. Progress was delayed by lack of engravers; but in 1585 the first part. devoted to France. Belgium and Germany and containing 51 maps. was published. and four years later the second part, covering Italy, Slavonia and Greece in 23 maps, appeared. hlercator suffered strokes in 1590 and 1593 and died at Duisburg on Dec. 2. 1594. The third part of the atlas. devoted mainly to the British Isles. was dedicated to Queen Elizabeth I in 159j by Rumold Mercator (Gerardus' son), who, in the same year, published the complete work, *Atlas sive Cosmographicae meditationes de fabrica mundi et fabricati figura,* with 107 maps in all.

As a geographical consultant, Mercator had an international reputation. Among his correspondents were, in England, John Dee and Richard Hakluyt; in the Netherlands, Abraham Ortelius and the scholar-printer Christophe Plantin, whose account books testify to the sale of Mercator's maps and instruments throughout Europe. In their Duisburg workshop Mercator and his family practised all the cartographic processes from compilation and drawing to the engraving of the map. He was rightly described by a panegyrist as *ingenio dexter, dexter et ipse manu* ("cunning alike of mind and of hand").

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(R. A. SN.)

MERCEDES, the capital of Soriano, a ranching and wheat-growing department in southwest Uruguay, is on the Rio Negro river, about 186 mi. from Montevideo by rail. Founded in 1781, it has an active port; its beaches and river promenade attract tourists. During the summer season, regattas and a tennis tournament provide social and sporting attractions. Residents of Mercedes insist that their cathedral has the finest dome in Uruguay. They are also very proud of the city's airport. Mercedes has some industries in addition to tourism, but its principal function is as a departmental administrative, commercial, ranching and agricultural centre. The population of Mercedes is about 44,900 (1954 est.). (M. I. V.)

MERCENARY, one who serves or acts solely for motives of personal gain (Lat. mercenarius, from merces, "reward, gain"), particularly a soldier who offers himself for service in any army which may hire him. Probably, mercenaries are as old as war itself. They appeared in almost every highly organized society and played an important part in the ancient world. In European history they came to the fore in the 12th and 13th centuries. As, in the subsequent period, the feudal organization of warfare decayed and capitalism emerged, they became the nucleus of any army. With the full development of the bourgeois society, however, national armies took more and more the place of professional adventurers in search of gain.

The Swiss Wars produced a famous Swiss infantry which frequently sold its service where it was profitable. Other outstanding infantrists were the German Landsknechte of the 15th and 16th centuries, who, in some cases. also served as mercenaries abroad. A particularly significant part was played by the Italian mercenaries of the later middle ages, whose commanders often gained great power. See CONDOTTIERE. (H. HH.)

MERCERIZING. The term mercerizing is most commonly understood to refer to the treatment of cotton goods with caustic soda to impart a permanent high lustre, as in broadcloth shirting and lustrous embroidery cotton. In a more general sense mercerizing covers the treatment of almost any kind of cellulose with almost any agent which will swell cellulose, and thus includes the swelling of wood pulp by caustic, a step in the manufacture of viscose, as for rayon. Mercerizing was named after the Englishman, John Mercer, who first observed the effects in 1844 and patented their production in 1850. H. A. Lowe, also in England, discovered the effect of tension in producing lustre in 1889 while trying to prevent shrinkage. Extensive utilization of the process came still later, jo years after its discovery. Cotton is usually mercerized for lustre, but there are also increases in strength and in attraction for dyes.

Mercerized cotton is virtually a different fibre from the natural product, with different properties. The fundamental swelling of cotton normally causes shrinkage in length but in practice this is not allowed, or is overcome by stretching back to the required length. The result of tension while swollen is a rounding and smoothing of the fibre surfaces and a more nearly parallel arrangement, thus improving the lustre.

The most important methods of mercerizing are described below but are subject to many variations. In warp yarn mercerizing 50–60 warps, each of 378 parallel threads wound in "ball" form, are fed at once through a succession of compartments with guide rolls, and with squeeze rolls between. In a typical machine the compartments contain boiling out and cooling baths, caustic soda, caustic washes, dilute acid, acid washes and a finishing bath. The yarn emerges at approximately its original length.

In skein mercerizing the yarn is mounted dry on arms with rollers, which can move apart to stretch it taut. It is then immersed and rotated in caustic containing a wetting agent to promote thorough impregnation, lifted, and washed under tension. Stretching, or shrinking and stretching, while in the caustic or washes may be required to produce the desired result. Additional washing and neutralizing follow outside the machine.

For mercerizing piece goods the cloth goes through a caustic bath in a padder which consists essentially of guide and squeeze rolls. Then it enters a tenter and, still containing caustic of mercerizing strength, runs part way down the machine tightly stretched between chains of clips which hold it by its edges. It is next washed by water sprays while still under tension, and finally released for neutralizing, further washing, and drying.

The very best results in mercerization are obtained with the longest staple cottons such as Sea Island, but most mercerized goods are made from the better U.S. staples. Either yarn or cloth has a better lustre if gassed or singed to remove loose fibre ends. Knitting yarns are of moderate twist, made into two-ply by twisting together in the direction opposite to the singles twist, so that the outer fibres lie approximately parallel to the direction of the yarn Single ply yarns do not develop an acceptable lustre but are sometimes mercerized to increase their attraction for dyes.

If the goods are allowed to shrink, the results of mercerizing are quite different from those without shrinkage. Yarn or cloth treated in this way shows less (if any) added lustre and if dyed in the same bath comes out darker in shade, much darker if greatly shrunken. Cloth becomes more closed in structure and appears stronger. Such added strength, however, in the case of knitting yarn has been found to be just about proportional to the increase in cross section caused by shrinkage in length; it is not a true net gain of strength.

Caustic soda is the least expensive alkaline mercerizing agent and easier to control than most other swelling agents which have mercerizing effects. Operating conditions should be kept uniform, but the action of caustic cannot go as far as that of 62% sulfuric or 70% nitric acids, which disintegrate cotton if not held within a narrow range of conditions; or of Triton B, a tetra alkyl ammonium hydroxide, which can dissolve cotton as well as mercerize it. Water and dilute caustic soda swell cotton but mercerizing effects appear first at concentrations of about 13%–14%. Since cotton takes out caustic from a solution, leaving it weaker, and wet cotton dilutes it, mercerizing baths at ordinary temperatures are usually run at 20%–25% to ensure a sufficient and uniform concentration. Weaker caustic can he used at very low temperatures but usually any advantages in cost or quality do not justify the expense of extreme cooling. Absorbent goods may be mercerized in one-half minute; and a longer time than four minutes is seldom necessary

The properties of mercerized cotton are not actually new but are those of unmercerized cotton developed to a much greater degree. Absorptive properties are increased by 25%–50%, the values being highest when there has been a large amount of shrinkage. Drying sometimes interferes with absorption. Mercerized cotton which has been dried does not dye so dark when coloured in the same bath with similar material not dried after mercerizing.

The properties of mercerized cellulose have suggested other names for it. "Dispersed cellulose" does not seem appropriate for cotton because the fibres are not only still solid but may have become stronger. "Cellulose hydrate" implying actual hydrate combination with water is unsuitable because this idea is no longer widely accepted.

Ordinary cotton or other natural cellulose yields the "native" type of X-ray diffraction diagram. The change in the fibre produced by swelling with caustic or certain other reagents gives rise to a new "mercerized" diagram, as shown by viscose rayon or mercerized cotton. It is due to a different crystalline structure following the removal of the swelling agent. Any pronounced change such as a closer approach to parallel arrangement of the cellulose particles or crystallites, produced by tension, is also shown in the X-ray diagrams. There are various methods for detecting mercerization or estimating its "degree." All, except visual inspection, depend upon absorptive properties. Merely dyeing together with known similar mercerized and unmercerized materials will usually suffice as a test, the mercerized sample dyeing much darker. (C F. G ; X)

MERCHANDISE MARKS: see TRADE-MARKS AND NAMES.

MERCHANT ADVENTURERS, a famous early English trading company. (See CHARTERED COMPANIES.)

MERCHANT BANKERS, private banking firms which do not conduct an ordinary banking business but confine themselves chiefly to acceptance and loan- and share-issuing. In most cases they evolved out of merchant firms engaged in foreign commercial business whose foreign connections and activities caused large amounts of foreign exchange to pass through their hands. They were at one time the dominant figures in the London exchange market, though they had already left most of this business to smaller firms. Foreign exchange in the period before World War I was largely taken over by the London branches of the foreign banks, from whom it has since been again taken over by the English banks. Foreign trade connections also, by making their name and standing familiar to banks and merchants in all countries, made bills drawn on them universally acceptable and so developed the growth of their activity in acceptance, by which, on payment of a commission, they placed their names at the disposal of less eminent firms and allowed bills to be drawn on themselves for transactions in which they were not directly concerned.

The foreign connections of such firms and their high prestige also led to their being applied to by foreign governments. municipalities and other borrowers who desired to raise loans in the London market, and their wealth and high standing in the opinion of the investing public gave them exceptional qualifications for this task. By a gradual evolution they largely ceased to act as merchants and concentrated their attention on acceptance and

loan-issuing. When the United Kingdom abandoned the gold standard in 1931, foreign loan-issuing in London virtually ceased and many of the merchant banking firms entered the domestic capital-issue field, sponsoring and underwriting debenture and share issues on behalf of large industrial companies. As bankers in the ordinary sense of the word were not formerly admitted on the court of the Bank of England, that court was chiefly recruited from the ranks of the merchant bankers. After nationalization of the bank this was no longer the case, though there were still a number of merchant bankers on the court. (See MONEY MARKET.)

MERCHANT MARINE: *see* SHIPPING INDUSTRY; SHIPBUILDING (MERCHANT AND NAVAL); NAVAL ARCHITECTURE.

MERCHANT MARINE ACADEMY, UNITED STATES: *see* MILITARY! NAVAL AND AIR ACADEMIES.

MERCIA, one of the kingdoms of Anglo-Saxon England. The original kingdom seems to have lain in the upper basin of the Trent. comprising the greater part of Staffordshire, Derbyshire and Xottinghamshire and the northern parts of Warwickshire and Leicestershire. The name (*Merce*) seems to denote men of the March. and presumably was first applied when this district bordered upon the Welsh. Later Mercia successively absorbed all the other territories between the Humber and the Thames except East Anglia, and some districts even beyond the Thames.

The origin of the kingdom is obscure. The royal family, according to Felix, Life of St. Guthlac, were called Iclingas. Icel, their ancestor, may have been the founder of the kingdom, but nothing is known of him. The family, however, claimed descent from the ancient kings of Angle (cf. Offa I and Wermund). The first Mercian king of whom we have any record was Cearl, who apparently reigned about the beginning of the 7th century, and whose daughter Cwoenburg married Edwin, king of Deira. During Edwin's reign Mercia was subject to his supremacy, though it may have been governed throughout by princes of its own royal family. Its first prominent appearance in history may be dated in 633, when the Mercian prince Penda joined the Welsh king Cadwallon in overthrowing Edwin. According to the Anglo-Saxon Chronicle, Penda began to reign in 626, and fought against the West Saxons at Cirencester in 628. In the Mercian regnal tables, however, he is assigned a reign of only 21 years, which, as his death took place in 6j4 or 655, would give 634 as the date of his accession, presumably on the overthrow of Edwin, or perhaps on that of Cadwallon. During the reign of Oswald, Penda clearly reigned under the suzerainty of that king. In 642, however, Oswald was slain by Penda in a battle at a place called Maserfeld, which has not been identified with certainty. During the early part of Oswio's reign the Northumbrian kingdom was repeatedly ravaged by the Mercians, and on one occasion (before 651) Penda almost captured the Northumbrian royal castle at Bamborough. At the same time he extended his influence in other directions, and expelled Coenwalh, who had divorced his sister, from the throne of Wessex. Indeed, at this time nearly all the English kingdoms must have acknowledged his supremacy. The Middle Angles, whose territory included the counties of Northampton, Rutland, Huntingdon, and parts of Bedfordshire, Cambridgeshire, Leicestershire and Lincolnshire, formed a dependent principality under his son Peada. At this time also the territory corresponding to the modern counties of Cheshire, Shropshire and Herefordshire seems to have been occupied. The last of these counties is said some time later to have been under the government of another son of Penda, named Merewald. In 654 or 6jj Penda again invaded Northumbria, with a huge army divided into 30 legions, each under a royal prince, among whom were Xethelhere, king of East Anglia, and several Welsh kings. He was slain, however, by Oswio, at a river called the Winwaed. Mercia then came again under Northumbrian rule. Peada, the eldest son of Penda, was allowed to govern the part south of the Trent, while north Mercia was put in charge of Northumbrian officials. Penda, although he did not prohibit the preaching of Christianity, had remained a heathen to the end of his life. His death was followed by the conversion of his kingdom. Peada had embraced Christianity on his marriage with a daughter of Oswio, and under him the first Mercian bishopric was founded. Shortly afterward Peada was murdered, but in 6j8 the Mercians rose under his younger brother Wulihere and threw off the Northumbrian supremacy.

Wulfhere seems to have been a vigorous ruler, for he extended the power of Mercia as far as it had reached in the days of his father, and even farther. According to the Anglo-Saxon Chronicle he invaded Wessex as far as the Berkshire downs in 661. At the same time he conquered the Isle of Wight, which he gave to Aethelwalh, king of Sussex. Between 661 and 665 he was defeated by the Northumbrian king Ecgfrith and had to give up Lindsey. In 675 he again fought with the West Saxons under Aescwine, and shortly afterward died. His brother Aethelred, who succeeded him, invaded Kent in the following year, and in 679 fought a battle on the Trent against Ecgfrith, by which he recovered Lindsey. After this, however, me hear little of Mercian interference with the other kingdoms for some time; and since it is clear that during the last 15 years of the 7th century Wessex, Essex, Sussex and Kent were frequently involved in strife, it seems likely that the Mercian king had somewhat lost hold over the south of England. In 704 Aethelred resigned the crown and became a monk, leaving his kingdom to Coenred, the son of Wulfhere. Coenred also abdicated five years later and went to Rome. Ceolred, the son of Aethelred, who succeeded, fought against the West Saxon king Ine in 715. On his death in the following year Aethelbald, a distant relative, came to the throne, and under him Mercian supremacy was fully restored over all the English peoples south of the Humber. After his murder in 757 the Mercian throne was held for a short time by Beornred. He was expelled the same year by Offa, who soon restored the power of Mercia, which seems to have suffered some diminution during the later years of Aethelbald. Offa's policy was apparently the extinction of the dependent kingdoms. In his reign the dynasties of Kent, Sussex and the Hwicce seem to have disappeared, or at all events to have given up the kingly title. In 787 he associated his son Ecgfrith with him in the kingdom, and after his death (796) Ecgfrith reigned alone for a few months. On the death of Ecgfrith the throne passed to Coenwulf, a descendant of Pybba, father of Penda. In 821 Coenwulf was succeeded by his brother Ceolwulf, who was deprived of the throne in 823, being succeeded by Beornwulf. In 825 Beornwulf was defeated by Ecgberht, king of Wessex, and in the same year he was overthrown and slain by the East Angles. The supremacy now passed to Wessex.

In 827 Ludeca, the successor of Beornwulf, was slain in battle with five of his earls. Wiglaf, who succeeded him, was expelled two years later by Ecgberht, but regained the throne in the following year. He died, probably in 839, and was succeeded by Berhtwulf, who reigned until 852. Under these later kings Mercia seems to have extended from the Humber to the Thames, including London, though East Anglia was independent, and that part of Essex which corresponds to the modern county of that name had been annexed to Wessex after 825. Berhtwuli was succeeded in 852 by Burgred, who married Aethelswith, daughter of Aethelwulf. His power seems to have been more or less dependent on the West Saxons. In 853, with the assistance of Aethelwulf he reduced North Wales to subjection. Again in 868 he called upon the West Saxon king Aethelred for assistance against the Danes under Loobrok's sons, who at this time invaded Mercia after their overthrow of the Northumbrians at York. No battle took place, and the Merciansubsequently made peace with the Danes. In 872 the Danes occupied London on their return from invading Wessex, after which a truce was again made. In 873 the Danes encamped at Torksey, Lincolnshire, and although another truce ensued, they advanced in the following year to Repton, and Burgred was driven from the kingdom. He went to Rome, where he remained until his death. In 874 Ceolwulf, a king's thegn, was made king by the Danes, and definitely acknowledged their overlordship. In 877, after the second invasion of Wessex, the Danes seem to have taken the eastern part of Mercia into their own hands. How long Ceolwulf reigned over the western portion is unknown. About 884 the most important person in English Mercia was an earl, Aethelred, who accepted the suzerainty of Alfred, whose daughter Aethelflaed he married in or before 887. Aethelred and Aethelflaed appear to have had almost regal power, though they did not use the royal title. In 886 London, which had been recovered by Alfred from the Danes, was restored to Aethelred. During the invasion of 893–97 English Mercia was again repeatedly ravaged by the Danes; but in the last of these years, by the united efforts of Alfred and Aethelred, they were at length expelled. In the following years the government was carried on by Xethelred and Aethelflaed, who after her husband's death co-operated with her brother Edward the Elder in the great campaigns which led to the conquest of Danish Mercia. After her death in 918 her daughter, Aelfwyn was soon deprived of the government by Edward, and English Mercia was definitely annexed to Wessex.

From this time onward its existence as a separate kingdom was at an end, though during the last years of Eadwig's reign the Mercians and Northumbrians set up Eadgar as king. In the last century of the Saxon period the earls of Mercia frequently occupied a semiroyal position. The most important of these were Aelfhere under Eadgar, Edward and Aethelred, Eadric Streona and Leofric, under Edward the Confessor. (F. G. M. B.)

MERCIER, DÉSIRÉ JOSEPH (1851–1926), Belgian Roman Catholic philosopher and prelate, a leader in the 19th-century revival of Thomistic philosophy, was born Nov. 21, 1851, at Braine-l'Alleud, in the Walloon part of Brabant. He studied at Malines and Louvain, being ordained priest on April 4, 1874. He taught in the philosophy section of the Malines seminary (1877–82) and served as spiritual adviser. Meanwhile, Pope Leo XIII followed up his call for a revival of Christian philosophy with a letter of 1880 to Victor Auguste Cardinal Dechamps of Malines. The pope asked that Louvain university offer a program in Thomistic philosophy, and in 1882 Mercier was appointed

professor at Louvain for this purpose. After assuring the pope of his love for Aquinas, he attended J. M. Charcot's clinic in Paris for instruction in recent psychology.

Mercier's inaugural address at Louvain (1882) pledged modern Thomism to unite Christian faith with reason, empirical observation with speculation, and tradition with perpetual growth in thought. Lecturing publicly on the main parts of Thomism in relation to modern philosophy and science, he attracted lay and ecclesiastical students from many countries. Two papal briefs of 1888–89 urged the founding of an Institut Supérieur de Philosophie at Louvain, and in 1894 it started with Mercier as president. He published an influential course of philosophy and an account of contemporary psychology, while eminent colleagues worked in philosophy of science, sociology and medieval philosophy. The institute became a major centre of Thomism. published the *Revue Nkoscolastique* (now *Revue Philosophique de Louvain*) and evaluated contemporary philosophies.

Mercier, who had been made a domestic prelate in 1887, was appointed archbishop of Malines in 1906 and was created a cardinal in 1907. He energetically supported priests' retreats, workers' colleges and social improvements. During World War I his courageous stand against the Germans' burning of the Louvain library and deportation of workmen made him the moral leader and international spokesman of the Belgian people. He forthrightly insisted that might cannot permanently overcome right and that God's word cannot remain bound. Asked how he could remain serene even in wartime, Cardinal Mercier replied that his secret consisted in "giving oneself confidently to the goodness of God." During the Versailles meeting, Pres. Woodrow Wilson visited him at Malines and later invited him to the United States. The cardinal's tour of the United States and Canada in 1919 resulted in civic and academic honours, as well as financial support for rebuilding the Louvain library.

Mercier was actively interested in the ecumenical work of reuniting the Christian churches. Although aware that this mas a slow process, he sponsored the Malines conversations (1921–25), with Lord Halifax and other Anglicans, on interfaith problems. In the spring of 1924 Cardinal Mercier celebrated the jubilee of his ordination. He died in Brussels on Jan. 23, 1926. At the 1951 centenary, the Cardinal Mercier chair was endowed for lectures by visiting philosophers at Louvain university.

His works include *Retreats to His Priests,* Eng. trans. by J. M. O'Kavanagh (1912); *Manual of Modern Scholastic Philosophy,* by Mercier and professors of Louvain, trans. by T. L. and S. A. Parker, 2 vol. (1917–18); *Origins of Contemporary Psyckology,* trans. by W. H. Mitchell (1918); *Cardinal Mercier's Own Story,* Eng. trans. (1920).

See John A. Gade, *The Life of Cardinal Mercier* (1934); L. de Raeymaeker, *Le Cardinal Mercier et l'Institut Supérieur de Philosophie de Louvain* (1952). (J. D. C.)

MERCIER, HONORÉ (1840–1894), Canadian lawyer and statesman. was the son of Jean Baptiste Mercier, farmer, and of Marie Kimener, his wife. He was born at St. Xthanase d'lberville on Oct. 1j, 1840. Mercier was educated at the Jesuit college of St. Mary, Montreal. Afterward he was admitted to the bar of the province in April 1865. At the age of 22 he became the editor of the Conservative *Courrier de St. Hyacinthe,* in mhich he supported the policy of the Sicotte administration, which then represented the interests of Quebec, under the Act of Union (1840); but when Sicotte accepted a seat on the bench, Mercier joined the opposition and contributed largely to the defeat of the ministerial candidate. In 1864 he vigorously opposed the scheme of confederation, on the ground that it would prove fatal to the distinctive position held by the French Canadians. He resumed the editorship of the *Courrier* in 1866 but after a few months retired from journalism. In Aug. 1872 he was elected as member for the county of Rouville. and in May 1879 he became solicitor general in the Joly government, representing the county of St. Hyacinthe; and on the defeat of the ministry in October he passed, with his leader, into opposition. On the retirement of Joly from the leadership of the Liberal party in Quebec in 1883, hfercier was chosen as his successor. Mercier's attitude in the matter of the execution of Louis Riel, leader of the northwest rebellion, brought adherents to the Liberal minority in the legislative assembly, and at the general elections in Oct. 1886 the province was carried in the Liberal interest. In Jan. 1887 Mercier was sworn in as premier and attorney general. He succeeded in passing without opposition the Jesuit Estates act, a measure to compensate the order for the loss of property confiscated by the crown. When Mercier appealed to the electorate in 1890, his policy was endorsed. Early in 1891 he negotiated a loan in Europe for the province, and while on a visit to Rome he was created a count of the Roman empire by Leo XIII. For a few years he was the idol of the people of Quebec, but in 1891 it was alleged that subsidies voted for railways had been diverted to political use, and he was dismissed by the lieutenant governor. At the elections held in March 1892, his party was hopelessly defeated. On the formation of a new government he was brought to trial and declared not guilty: his health. however, gave way.

MERCIER, (LOUIS) SÉBASTIEN (1740–1814), French dramatist, born in Paris, June 6, 1740, was one of the first writers of *drames bourgeois.* His *Du Théâtre* (1773) emphasized the theatre's didactic function and criticized traditional French tragedy and comedy as artificial and sterile. He urote about 60 plays. including a social comedy, *La Brouette du vinaigrier* (1775); *Jenneval* (published 1767, performed 1781), adapted from George Lillo's *London Merchant* (1731); such *drames* as *Le Faux Ami* (1772) and the antimilitarist *Le Déserteur* (published 1770, performed 1782); and two historical dramas about the French religious wars, *Jean Hennuyer, évêque de Lisieux* (1772) and *La Destruction de la Ligue* (1782), so provocatively anticlerical and antimonarchical that they were not performed until after the Revolution Mercier was not a technical innovator; his best plays present a thesis forcefully, subordinating other dramatic considerations to the didactic end. As well as plays, he wrote *L'An 2440* (1770), a nork of prophetic imagination; and *Le Tableau de Paris* (2 vol. 1781; 12 vol. 1782–89), mhich foreshadows Honoré de Balzac's classification of social types.

Mercier, nicknamed *le singe de Jean-Jacques,* was a humanitarian idealist. who was strongly influenced by Rousseau and shared his viens of society, rejecting the *philosophes'* belief in progress. A member of the Convention, his moderate viens led him to oppose the death penalty for Louis XVI. He was imprisoned during the Terror but was released after Robespierre's death. He died in Paris, April 25, 1814.

See *Théâtre complet* (1778–84); L. Béclard, L. S. *Mercier, sa vie, son oeuvre* (1903). (W. D. HH.)

MERCK, JOHANN HEINRICH (1741–1791), German author and critic, was born at Darmstadt on April 11, 1741. He became paymaster at Darmstadt in 1768

Merck helped to found the *Frankfurter gelehrte Anzeigen* in 1772 and was one of the chief contributors to Nicolai's *Allgemeine Bibliothek.* In 1788 he nas involved in serious financial difficulties, and although friends. notably Goethe, were ready to come to his assistance, his losses and the death of five of his children preyed upon his mind.

He committed suicide on June 27, 1791. Merck influenced the *Sturm und Dvang* movement by his acute criticisms and was a mentor to the young poets of his day

Merck's *Ausgewählte Schriften zur schönen Literatur und Kunst* were published by A. Stahr in 1840. with a biography. *Briefe an J H Merck von Goethe, Herder, Wieland und andern bedeutenden Zeitgenossen* (1835), *Briefe an und von J. H Merck* (1838) and *Briefe aus dem Freundeskreise von Goethe, Herder, Höpner und Merck* (1847) were all edited by K Wagner. A selection of hlerck's writings and correspondence was edited by K. Wolff, 2 vol. (1909).

See G Zimmermann, *J.* H. *Merck, seine Umgebung und seine Zeit* (1871).

MERCOEUR, PHILIPPE EMMANUEL DE LORRAINE, DUC DE (1558–1602), French soldier. was born on Sept 9. 1jj8, and married Marie de Luxembourg, duchesse de Penthièvre

In 1582 he was made governor of Brittany by Henry III, who had married his sister. Mercoeur put himself at the head of the

League in Brittany and had himself proclaimed protector of the Roman Catholic Church in the province in 1588. Invoking the hereditary rights of his wife, who was a descendant of the dukes of Brittany, he endeavoured to make himself independent in that province and organized a government at Nantes, calling his son "prince and duke of Brittany."

With the aid of the Spaniards he defeated the duc de Montpensier, whom Henry IV had sent against him, at Craon in 1592, but the royal troops, reinforced by English contingents, soon recovered the advantage. The king marched against Mercoeur in person and received his submission at Angers on March 20, 1598. Mercoeur subsequently went to Hungary, where he entered the service of the emperor Rudolph II, and fought against the Turks, taking Stuhlweissenburg (Székes-Fehérvár) in 1599. Mercoeur died on Feb. 19, 1602.

See his *Correspondance,* ed. by Carné, 2 vol., (1899).

MERCURIC FULMINATE is an explosive once widely used in the manufacture of percussion caps. By the 1960s it had been very largely replaced by lead azide in this application because of the latter's greater stability, reduced sensitivity to water and greater convenience of manufacture. Also, the fulminate requires the use of a critical raw material—mercury. Diazodinitrophenol, called DDNP, is another important initial detonating agent. Mercuric fulminate, $Hg(ONC)_2$, was discovered by E. C. Howard in 1799; J. von Liebig isolated the free fulminic acid in 1823. Other salts of this acid had been known even earlier; *e.g.,* silver fulminate prepared by L. G. Brougnatelli in 1798.

Although the use of mercuric fulminate to ignite gunpowder was common considerably earlier, its use for detonation of high explosives originated with Alfred Nobel's invention of blasting caps, in 1867.

Mercuric fulminate is a gray, sandy, crystalline powder with a specific gravity 4.4. It is extremely sensitive to friction, percussion and flame. Ignition instantly changes into detonation, except when the granular material has been pressed to high density ("dead pressed"). Mercuric fulminate is not very stable to heat and deteriorates after protracted storage in tropical climates, particularly if not protected from humidity. Deterioration makes it less explosive and may easily result in misfires. Mercuric fulminate is exceedingly toxic. *See* DETONATOR; EXPLOSIVES; PROPELLANTS.

See A. Marshall, *Explosives,* 3 vol., 2nd ed. rev. (1917–32); T. L. Davis, *The Chemistry of Powder and Explosives,* 2 vol. (1941–43). (G. B. K.; X.)

MERCUROCHROME, a trade name of merbromin, the first of a series of antiseptic substances in which mercury was incorporated into an organic molecule in an attempt to obtain the bacteriostatic and bactericidal action of mercury without the irritant effects of mercuric chloride. Mercurochrome contains from 24% to 26.7% of mercury. Dilute water solutions, which are brilliant red with yellow-green fluorescence, exert a weak surface anti-infective action on skin, mucous membranes and wounds. Its activity is decreased in the presence of body fluids, and it penetrates poorly except in injured tissues.

It is used commonly in the home as a first-aid measure to prevent infection in small cuts and wounds, and to a lesser degree professionally as a general surface anti-infective. It has been largely replaced by more effective agents of the series or by antibiotics. (V. E.)

MERCURY (MERCURIUS, MERQURIUS, MIRQURIUS), the Roman god of merchandise and merchants, commonly considered identical with the Greek Hermes (*q.v.*), introduced at Rome with a name derived from a root related to merchandizing (*merx,* "merchandise," etc.; another view is given by F. Altheim in *Griechische Götter,* pp. 39 ff.). Although obviously not of primitive Italian cult, his worship was introduced rather early. His temple on the Aventine in Rome was dedicated in 495 B.C., and there he was associated with the goddess Maia (*q.v.*), identified as his mother through her association with the Greek Maia, mother of Hermes. Both Mercury and Maia were celebrated in a festival on May 15 (the month of Maia), the dedication day of the temple, a holiday of special importance for the guild of merchants (*mercatores, mercuriales*).

Near the Porta Capena there was a spring sacred to him, the water of which was used by merchants for a lustral rite on May 15 (Ovid, *Fasti, lege:* v, 673 ff.).

In Roman art Mercury is more purely represented as a standing, usually nude, figure holding a purse, symbolic of his business functions, but artists were free to borrow attributes of the Greek Hermes irrespective of their appropriateness to the Roman deity. Hence, he is found wearing winged sandals and winged cap and carrying the caduceus (*q.v.*).

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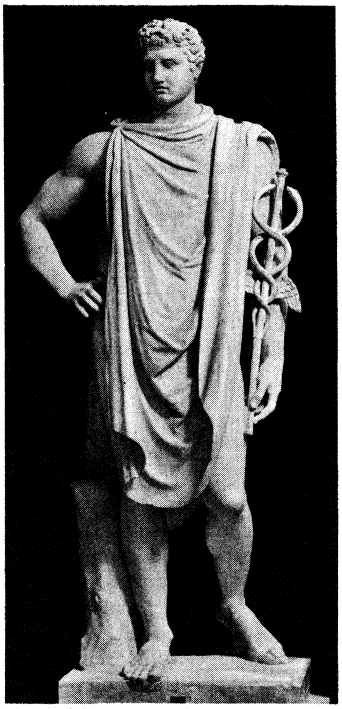


ALINARI

ROMAN STATUE OF MERCURY, CARRYING CADUCEUS. IN THE VATICAN MUSEUM, ROME

MERCURY is the smallest of the major planets and has a diameter of only about 3,000 mi. It is also the nearest to the sun, with a mean distance of 36,000,000 mi., or 0.39 of the earth's distance. But the eccentricity of its orbit, amounting to 0.206, is much greater than that of any other major planet, and its perihelion and aphelion distances (minimum and maximum distances from the sun) are respectively 28,500,000 and 43,350,000 mi., or approximately in the ratio of 2 to 3. Its period of revolution in its orbit is 88 days, but its synodical period, *i.e.,* the interval between, say, successive superior conjunctions with the sun, is 116 days. At its most favourable elongations it recedes only about 28° from the sun. After Pluto its orbit has a greater inclination (7°) to the ecliptic than that of any other major planet. The albedo (the percentage of sunlight reflected from the planet's surface) is low, but at a mean elongation its brightness is about equal to that of a star of zero magnitude; and although at a favourable elongation it can reach −1.2 magnitude, the planet is frequently dimmed or obscured by the haze and mists near the horizon.

As Mercury has no satellite it has been necessary to determine its mass from its attraction on another body; the minor planet Eros is the best for this measurement. On the basis of this measurement, Mercury's mass was found to be 0.054, or about one eighteenth that of the earth. The planet's density is almost six times that of water, higher than that of any other planet. Because the mass is comparatively small, the high density cannot be attributed to gravitational compression; instead, it implies a high percentage-abundance of iron, higher than of the earth.

Surface Features and Rotation.—As the angular diameter of Mercury varies from about 5 to 13 sec. of arc, its phases are easily observed by even a small telescope. But under the circumstances of observation (daytime or near the horizon) it is far from easy to define the surface features with accuracy.

Between 1881 and 1889 Giovanni Schiaparelli at Milan carried out a careful study of the planet. His conclusion was that the periods of axial rotation and orbital revolution are identical and that the axis of rotation is approximately normal to the orbit plane.

It would, of course, follow from such conditions that the planet always presents approximately the same face to the sun, as the moon does to the earth, though in consequence of the large eccentricity of the orbit, the effect of libration in longitude of the surface markings as seen from the sun would cause a displacement of nearly 24° on each side of a mean position. About 37% of the surface would be permanently sunlit; the same amount in perpetual night; and the remainder exposed alternately to sunlight and dark-

ness, with enormous changes of temperature during each revolution.

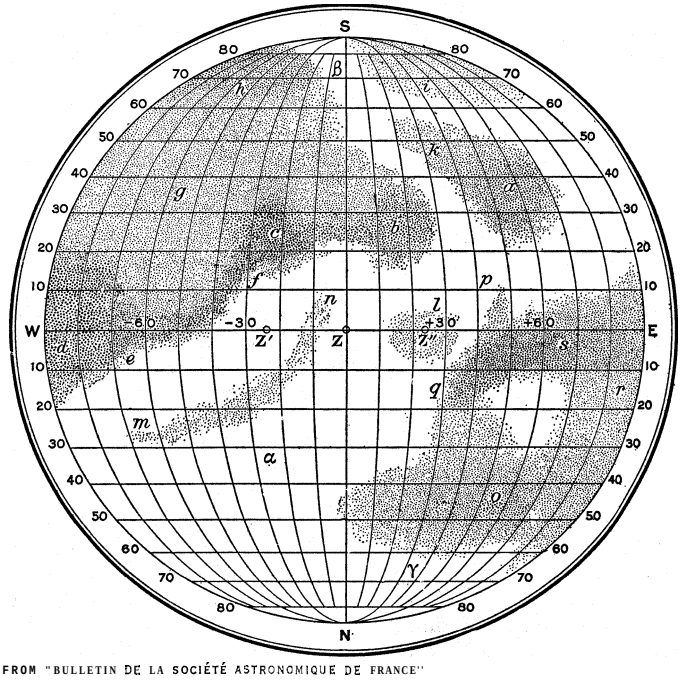
A fresh attack on the problem of Mercury's rotation was made from 1924 to 1929 by E. M. Antoniadi at Meudon with the help of the great 33-in. refractor, and the result was to establish Schiaparelli's deductions. The markings seemed to be somewhat variable in intensity, but—apart from the libration mentioned above—constant in position relative to the terminator, thus indicating the identity of the periods of rotation and revolution. The chart of Antoniadi is shown in the figure. Most of the objects shown can be identified with features recorded at various times by G. Schiaparelli, W. Denning, E. Barnard, R. Jarry-Desloges, G. Fournier, A. Danjon, B. Lyot and A. Dollfus *(see* E. Antoniadi, *La Planète Mercure* [1934] and *L'Astronomie* [Jan. 1955]).

Because the markings on Mercury appeared to be of variable intensity, Antoniadi suspected the presence of a tenuous atmosphere. Lyot and Dollfus observed the planet under better conditions (at the Pic du Midi) and found no evidence of such variation. However Dollfus' polarization measurements indicated .that there might be a trace of atmosphere, probably no more than 0.003 of the terrestrial atmosphere. And, in theory, this is what would be expected from a consideration of the high surface temperature on the sunlit side of the planet, about 340° C., or higher than the melting point of lead. The temperature of the dark side of the planet is probably about −253° C., which heat is obtained by conduction from the interior of the planet.

The surface of Mercury may be compared with that of the moon. Like that of the moon, Mercury's reflectivity is 7%. Similar patches, known as *maria* or seas (presumably lava fields): have been observed on the surfaces of both planets. And the microstructure of the surfaces of the two bodies (pulverized lava) is probably identical—a deduction from the fact that the polarization curves of the two bodies are indistinguishable.

Dollfus found the obliquity of the planetary equator to be 7°, about the same as the orbital inclination on the ecliptic.

Transits.—Since the inclination of Mercury's orbit to the ecliptic is 7°, it usually happens that at the time of inferior conjunction the planet passes north or south of the sun, but should conjunction occur when it is near one of its nodes, it crosses the sun's disk and is seen during transit projected on the sun as a small black spot. Since Earth passes the line of nodes about May 7 and Nov. 9, transits can take place only near those dates. The November transits, however, which occur with Mercury in the neighbourhood of perihelion and, consequently, more remote than usual from Earth, are more common than those in May, when the conditions are reversed, the limits of distance from the node within which the planet must be for a transit to take place being 4° 45′ and 2° 40′, respectively. The table gives the dates and Greenwich mean astronomical times of the middle of all the transits from 1677 (the date of the first one accurately observed) until the year 2003. The hours are in all cases reckoned from noon.



FROM "BULLETIN DE LA SOCIÉTÉ ASTRONOMIQUE DE FRANCE"

ANTONIADI'S CHART OF MERCURY SHOWING THE PORTION OF THE SURFACE TURNED TOWARD THE SUN AT THE PLANET'S PERIHELION AND APHELION; I.E., AT THE POINTS ON THE ORBIT AT WHICH MERCURY IS NEAREST TO AND FARTHEST FROM THE SUN, Z′ AND Z″ REPRESENTING EXTREME. ZENITH POINTS OF THE SUN

Transits of Mercury From 1677 to zoo3

Year	Mo. and Day	Hour	Year	Mo. and Day	Hour
1677	Nov. 7	0	1845	May 8	8
1690	Nov. 9	18	1848	Nov. 9	2
1697	Nov. 2	18	1861	Nov. 11	20
	May 5	11	1865	Nov. 4	19
	Nov. 6	11	1878	May 6	7
1723	Nov. 9	5	1881	Nov. 7	3
1736	Nov. 10	22	1891	May 9	14
1740	May 2	11	1894	Nov. 10	7
	Nov. 4	22	1907	Nov. 14	0
1743	May 5	18	1914	Nov. 7	0
1756	Nov. 6		1924	May 7	
	Nov. 9	16	1927	Nov. 9	14
	Nov. 2	10	1940	Nov. 11	19
	Nov. 12	18	1953	Nov. 14	5
1789	May 5	3	1957	May 7	13
1799	May 7	1	1960	Nov. 7	5
1802	Nov. 8	21	1970	May 8	20
	Nov. 11	15	1973	Nov. 9	23
1815			1986	Nov. 12	16
1822	Nov. 4	14	1993	Nov. 7	16
1835	May 5	0	1999*	Nov. 15	9
	Nov. 7	8	2003	May 6	19

*Mercury grazes the sun's limb.

Motion of Perihelion.—What was for a long time a perplexing problem was presented by the motion of Mercury's perihelion, the line of apsides—or the longer axis of the orbit—showing a greater advance in the direction of the planet's motion than could be accounted for by the gravitational action of all the other planets. Urbain Leverrier in 1845 concluded that the excess of motion was 35 sec. of arc per century, but this was increased by later investigations to over 40 sec. of arc per century. It was accordingly concluded that Mercury is disturbed by some unknown masses or that Newton's lam of gravitation is not rigidly true. Leverrier attributed the excess of motion to the action of a group of planets revolving inside the orbit of Mercury, and at first this explanation seemed to be confirmed by the occasional reports of dark objects seen in transit across the sun's face. But for very many years past, the sun has been photographed almost daily at some observatory or other, such as Greenwich or the Cape of Good Hope, without any such objects being detected, and photographs of the sky in the neighbourhood of the sun during total eclipses have likewise failed to disclose anything of the sort. If, then, such intra-Mercurial bodies exist, they must be extremely small. It was at one time suggested that the minute particles which produce the zodiacal light might be invoked to explain the observed motion, but the idea was shown on theoretical grounds to be untenable. Solution of the difficulty was supplied by Einstein's theory of generalized relativity, and the matter was regarded as satisfactorily cleared up. (G. P. K.)

MERCURY, a metallic element, is the only common metal that is liquid at ordinary temperatures. It was known to the ancient Chinese and Hindus and has been found in Egyptian tombs of 1500 B.C. The term *mercurius* was first employed about the 6th century by the alchemists, who used the symbol for the planet Mercury to represent the metal, which, because of its mobile form and its colour, was called quicksilver. Its symbol Hg derived from the Latin *hydrargyrum*, "liquid silver."

OCCURRENCE AND PRODUCTION

Mercury occurs free in nature, but the principal ore is cinnabar, the red sulfide, HgS. Other compounds, such as selenides, tellurides and chlorides, occur but are not of economic importance. The average percentage of mercury in igneous rocks is estimated at 10^{-7}, its abundance being less than one one-hundredth that of zinc or of lead.

The most important mercury mines in Europe are those of Almaden in Spain, Abbadia San Salvatore in Italy, and Idria in Yugoslavia. In the U.S. the mines of California, Nevada, Alaska and

Idaho lead the field. Among deposits in other countries are those of Turkey, Czechoslovakia, Chile and Canada. (See also CINNABAR.)

The extraction of mercury from the sulfide ore is accomplished either by roasting in air: $HgS + O_2 \longrightarrow Hg + SO_2$ or by roasting with lime: $4HgS + 4CaO \longrightarrow 4Hg + 3CaS + CaSO_4$

The metal is condensed from the furnace gases. usually with little difficulty, and is not readily oxidized by air. Much of it drops from the condensers in the form of soot (mercury in wet dust), and the metal is commonly separated from this by mechanical agitation with lime.

In small-scale laboratory work, mercury can be purified by filtration, followed first by mashing nith nitric acid or mercurous-nitrate solution to remove the less noble metals and then by distillation to separate the mercury from the more noble metals.

The production of mercury in the Cnited States follows the trend of demand and price and is affected by the volume of imports. After its wartime peak of 51 929 flasks (1 flask = 76½ lb. mercury) in 1943, U.S production dropped to 4,535 in 1950. It rose to more than 38,000 flasks in 1958 for the highest peacetime production since 1883. The guaranteed-price ($225) program expired at the end of 1958. World production (all figures approximate), which reached a modern high of 275,000 flasks in 1941 and dropped to 107,000 in 1948, fluctuated between 180,000 and 250,000 after 1950.

PROPERTIES AND USES

Properties. — The physical properties of the metal, atomic number 80, atomic weight 200 61, are listed in the table along with those of cadmium, zinc and copper for comparison.

The coefficient of cubical expansion of mercury is given by the equation: $\alpha = 1\,8006 \times 10^{-4} + 2 \times 10^{-8}\,t$ from 0° C. to 300° C. This linear expansion, together with the fact that mercury does not wet glass, makes the metal useful in thermometers. An alloy of mercury and thalium, 8.5% Tl has a lower melting point and can be used in thermometers down to −60° C. The high density and low vapour pressure of mercury make it useful in barometers, manometers and in vacuum gauges, such as the McLeod gauge. Its good electrical conductivity makes it exceptionally useful in electrical switches and relays of the sealed type. The value of the ohm is defined in terms of the conductivity of mercury.

Uses. — Mercury enjoys continued and typical use in agricultural and industrial fungicides; in mercury batteries (used as power packs for the transmission of temperature and other data from the first U.S satellites) and other electrical apparatus and in barometers, thermometers and other industrial and control instruments (as mentioned above); and in the electrolytic production of chlorine (see below) and caustic soda. Mercury also is used in the electrolytic purification of nuclear waste. Many of its compounds, particularly the oxide, chloride, sulfate, acetate and phosphate (see Chemistry, below), find extensive uses in industrial chemistry as catalysts, mercuric sulfate, for example, in making methyl styrene Mercury also is used in pigments called mercadium reds and in a frozen-mercury casting process (see METALLURGY: *Precision* Casting).

Rfercury is used in heat engines in three large installations in the Cnited States. The high boiling point allows a considerable increase in theoretical efficiency of such engines over that possible when using steam.

Gaseous mercury, like all gases, does not conduct electricity unless it is ionized. The first ionization potential of mercury is 10.39 v. The property makes it useful in rectifiers for alternating current and for lighting. The light emitted by electrical discharge through mercury vapour is rich in ultraviolet rays, and lamps of this kind in fused quartz envelopes are widely used as strong sources of ultraviolet light.

High-pressure mercury-vapour lamps. besides being used for general lighting and many special applications, were widely installed for street lighting and highway lighting in the second half of the 20th century (see also LIGHTING: Gaseous *Vapour* Lamps).

Amalgams (*q.v.*) are alloys of mercury with other metals. The easy amalgamation of gold and silver was once employed in extracting these metals from ores. The process is now rare.

Amalgams of sodium and of potassium are employed as reducing agents. In one technical method for producing chlorine a flowing mercury cathode is used in electrolyzing the sodium chloride solution. The sodium ions discharge at the mercury surface, forming sodium amalgam, which is continuously drained away and treated with water to form sodium hydroxide and hydrogen. (For details of the process, see CHLORINE: Commercial Preparation.) Two-phase amalgams of cadmium in the A'eston cell and of zinc in the Clark cell are used to give constant electromotive forces in these standard cells (see INSTRUMENTS, ELECTRICAL MEASURING: Primary Electrical Standards).

Amalgams are extensively used in dentistry for preparing fillings.

Pharmacology and Therapeutics. — Elemental mercury can be absorbed through the skin. The greatest source of danger in industrial and research laboratories lies in the inhalation of mercury vapour. The relative toxicity of various compounds toward organized tissue depends on their relative ease of formation of the mercuric ion Thus mercuric chloride is most toxic while some nonionizable organic mercurials are safe even on intravenous administration. The ionizable salts, particularly the bichloride. benzoate, cyanide, oxycyanide, salicylate, red mercuric iodide and potassium mercuric iodide, may be used as antiseptics. with great care. The popular organic mercurial antiseptics are not destructive to tissues and are less irritating than the simpler mercury salts. Ointments of metallic mercury and of its insoluble compounds also are employed. Yellow mercuric oxide ointment consists of 1% of the yellow oxide in wool fat and petrolatum. Ammoniated mercury ointment contains 5% of $HgNH_2Cl$ in wool fat and petrolatum; it is used as a skin antiseptic Several ointments of metallic mercury are made by triturating various amounts of metallic mercury into wool fat, white wax and petrolatum. Rfercurous chloride (calomel) once was widely used as a cathartic; it also has diuretic action.

Chronic mercury poisoning results from exposure to small amounts of mercury over extended periods of time, as may occur in industries which use mercury or its salts. The symptoms are loss of appetite. salivation, gingivitis, nutritional disturbances, increasing renal damage and anemia. The treatment consists of removal of the patient from all contact with mercury or its compounds, promotion of elimination and improvement of the patient's nutritive state. Response is sometimes very slow.

Acute mercury poisoning results from ingestion of soluble mercury salts. They are irritant poisons. Mercuric chloride precipitates all proteins nith which it comes in contact, thus causing an ashen-gray appearance of the mouth and pharynx. Vomiting usually occurs a few minutes after ingestion. The physician should know the length of time that elapsed before vomiting occurred and also its thoroughness. Administration of protein, in the form of milk or raw eggs, folloned by evacuation by emesis and washing of the stomach by means of a gastric tube will inactivate and remove the mercuric ions that have not yet been absorbed. This

Physical Properties of *Mercury Coinpared With Zinc, Cadmium and Copper*

	Mercury	Zinc	Cadmium	Copper
Melting point, ° C.	−38.87	419.4	320.9	1,083
Boiling point, ° C.	356.9	907	767	2,595
Density of liquid	13.546$^{20°}$			
Density of solid	14.17$^{-38.9°}$	7.14$^{20°}$	8.65$^{20°}$	8.95$^{20°}$
Vapour pressure	4.78 × 10^{-6} mm. at −30° C. 1.85 × 10^{-4} mm. at 0°C. 1.84 × 10^{-3} mm. at 25° C. 2.73 × 10^{-1} mm. at 100° C. 760 mm. (b.p.) at 356.9° C.			
Critical temperature	1.460° C.			
Critical pressure	1.586 atm			
Critical density	5 g. per c.c.			
Latent heat of vaporization at the boiling point, cal./g.	70.62	475	240	1,755
Resistivity, ohm cm. at 20° C.	95.8 × 10^{-6}	5.89 × 10^{-6}	7.6 × 10^{-6}	1.68 × 10^{-6}
at 0° C.	94.0766 × 10^{-6}	5.75 × 10^{-6}		

treatment must be followed by treatment to combat the systemic toxicity.

CHEMISTRY

The 'element is placed in group II of the periodic table of elements, in the same family with zinc and cadmium. It has seven stable isotopes, the mass numbers and percentage abundances of which are: 196, 0.15%; 198, 10.1%; 199, 17.0%; 200, 23.3%; 201, 13.2%; 202, 29.6%; 204, 6.7%. Isotope 204 is a good heat-exchange material and is of atomic interest because of its low-absorption cross section. In natural mercury the seven isotopes each emit the same spectral lines: with very slight differences in wave length because of the isotope shift. For use as a standard the wave length of a spectral line from a single isotope is preferred. The stable mercury isotope of mass 198 has been produced by neutron bombardment of gold. The green line of wave length 5,461 Å is recommended as a wave-length standard. Radioactive isotopes having mass numbers 197 and 205 have been produced by artificial transmutations. The isotope 197 has a half life of 64 hours and decays by k-electron capture to Au^{197}.

Isotope 205 has a half life of j.j minutes and decays by emission of a beta particle to Tl^{205}. Other radioactive isotopes have also been reported in studies on artificial radioactivity. These are useful as tracers in the study of many chemical problems. The element has two electrons in the 6s orbitals. which accounts for its being bivalent in the higher oxidation state, forming mercuric compounds. Mercury also can exist in the univalent state, forming a second \\.ell-defined series of compounds. In this state the remaining 6s electron is used in the association of two molecules. Thus, all mercurous salts exist as double molecules not only in solution but in the solid and gaseous states; *e.g.*, Hg_2Cl_2.

The soluble compounds of mercury are fairly easily reduced. Thus, metallic copper or silver will replace mercury from solution slowly; the more active metals, such as zinc and tin, rapidly. The oxidation-reduction potentials for the two reactions are:

$$2Hg = Hg_2^{++} + 2e^- \quad -0.799 \text{ v.}$$
$$Hg = Hg^{++} + 2e^- \quad -0.854 \text{ v.}$$

are so nearly alike that reducing agents which reduce the mercuric ion to the mercurous ion will. in excess, reduce the mercurous ion to mercury. This must be considered in all the applications of mercury compounds in analytical chemistry.

The common univalent compounds of mercury are the oxide. chloride, bromide, iodide, sulfide, nitrate, sulfate, phosphate and chromate. Mercurous oxide, Hg_2O, results from the action of alkalies on soluble, mercurous salts. It is unstable, slowly decomposing into mercury and mercuric oxide. Mercurous chloride, Hg_2Cl_2, commonly known as calomel (*q.v.*), is probably the most important mercurous salt. It is prepared by subliming a mixture of mercury and mercuric chloride: $HgCl_2 + Hg = Hg_2Cl_2$. It is formed as a white precipitate when mercuric chloride solutions are treated with reducing agents. The saturated solution of mercurous chloride in normal potassium chloride solution has a constant electromotive force against a mercury electrode. This electrode—mercurv-solid mercurous chloride-chloride ion—is used as a reference electrode in electrochemical measurements.

The most common bivalent compound of mercury is mercuric chloride, bichloride of mercury or 'corrosive sublimate. It is extensively used as an antiseptic. Mercuric bromide and iodide are less soluble. The iodide exists in two crystalline forms. yellow and red. The red form is the stable one at ordinary temperatures and transforms to the yellow modification at 128° C. It is soluble in solutions of iodides, forming a stable complex ion HgI_4^{--}. Nessler's reagent, a solution of potassium-mercuric iodide. K_2HgI_4, is used in the detection of small amounts of ammonia. With ammonia it becomes turbid because of the formation of a yellow precipitate. $Hg_2NI.H_2O$. Mercuric nitrate results from the action of excess nitric acid on mercury. It is easily hydrolyzed. yielding the basic salt $Hg(NO_3)_2.HgO$. The sulfate formed by the action of hot concentrated sulfuric acid on mercury is also stable only in the presence of excess acid. On dilution it yields the basic salt $HgSO_4.2HgO$. Mercuric cyanide and mercuric thiocyanate, like the halides of mercury, form complex ions in the presence of alkali cyanides or thiocyanates, forming such compounds as $K_2Hg(CN)_4$ and $K_2Hg(CNS)_4$. The latter compound is used as a reagent in chemical microscopy because it gives characteristic crystalline precipitates with a number of metal ions. Mercuric thiocyanate is used in making pyrotechnic novelties called Pharaoh's serpents, serpents or serpents' eggs. It burns to form a voluminous ash so that a small pellet quickly changes to a long, fragile serpentine form. Mercuric fulminate. $Hg(OCN)_2$, is formed when alcohol is added to a hot solution of mercuric nitrate. The dry powder explodes on impact and is used in percussion caps for detonating other explosives.

Mercury sulfide exists in two forms, the red cinnabar and black metacinnabar. It is formed when hydrogen sulfide is passed into solutions of mercuric salts, the black form being usually obtained.

Mercuric ammonia compounds result from the action of ammonia or ammonium hydroxide on compounds of mercury. Thus, mercuric chloride and ammonia yield the compound $HgCl_2.2NH_3$, containing ammonia of crystallization. From solution ammonium hydroxide precipitates the ammono-basic chloride $HgNH_2Cl$, known as infusible white precipitate. Mercurous chloride and ammonium hydroxide yield this same compound along with metallic mercury, the finely divided metal making the material appear black. When both ammonolysis and hydrolysis occur, derivatives of Millon's base. HOHgNHHgOH, are formed. The formula is also written $Hg_2NOH.H_2O$. The iodide $Hg_2NI.H_2O$ is the yellow precipitate formed by the action of ammonia on Nessler's reagent, mentioned above.

Analysis. — The mercurous ion is recognized by the formation of a white precipitate with chloride which blackens on treatment with ammonia. The mercuric ion is recognized by the formation of the same white precipitate when stannous chloride is added to a hydrochloric acid solution of the substance being tested, $2HgCl_2 + Sn^{++} = Hg_2Cl_2 + Sn^{++++} + 2Cl^-$. This precipitate is reduced by excess stannous chloride to a gray precipitate of mercury, $Hg_2Cl_2 + Sn^{++} = 2Hg + Sn^{++++} + 2Cl^-$. The mercurous ion may be determined quantitatively by precipitating and weighing mercurous chloride. The mercuric ion may be determined by precipitating and weighing the sulfide or by titration with iodide. Mercury may be determined electrolytically, using a platinum cathode. It may also be determined by decomposing the sample with lime in a combustion tube and passing the vapours through a weighing tube containing gold foil to absorb the mercury.

See Index references under "Mercury" in vol. 24.

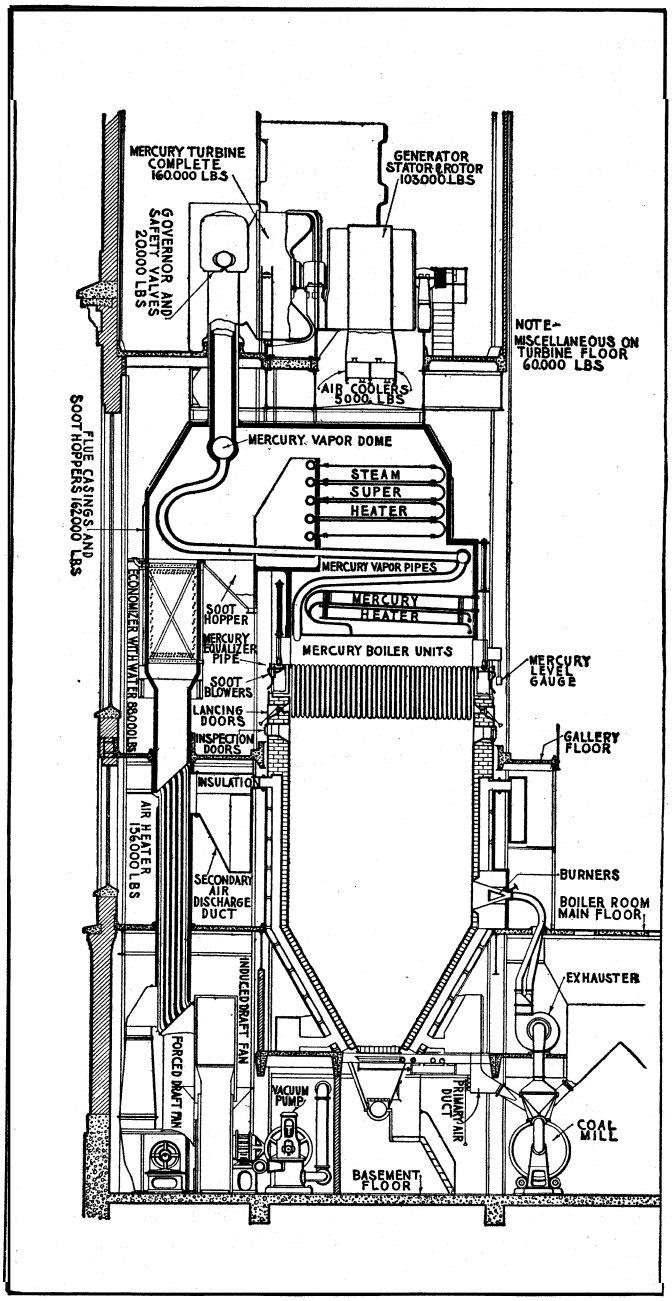
BIBLIOGRAPHY.—For the history of mercury, *see* B. Neumann, *Die Metalle* (1904); A. Rossing, *Geschichte der Metalle* (1901). The general chemistry is given in J. W. Mellor, *A Comprehensive Treatise on Inorganic and Theoretical Chemistry,* 16 vol. (1922–37) and *Supplement,* ed. by *H. 6'.* A. Briscoe *et al.* (1956). A concise treatment is given in W. M. Latimer and J. H. Hildebrand, *Reference Book of Inorganic Chemistry,* 3rd ed. (1951). For physical data on the metal, *see* A. E. van Arkel, *Reine Metalle* (1939); on the metal and its compounds, *see* International Critical Tables; New York Academy of Sciences, *Mercury aizd Its Compounds* (1957). For mercury poisoning, *see* L. Goodman and A. Gilman, *The Pharmacological Basis of Therapeutics,* 2nd ed. (1955). For production and consumption *see* U.S. Bureau of Mines, *Minerals Yearbook* (annual). (I. B. J.; WN. B.)

MERCURY-VAPOUR BOILER, a process of power generation which uses mercury instead of water in a boiler.

The highest pressure at which saturated water vapour can exist is 3.200 lb. pressure per square inch. and at that pressure the temperature is only 706° F. In the mercury cycle, mercury is boiled in a specially designed boiler at whatever pressure is desirable. The vapour is then carried through a turbine where it does useful work. The exhaust pressure is kept at whatever vacuum is desirable to obtain the proper steam pressure.

In the mercury cycle all the latent heat of the mercury vapour is turned into steam at any steam pressure desirable, and this steam can be used either for power or for heating purposes.

A Typical Installation. — Figs. 1 and 2 give side and end elevation of the 10.000 kw. mercury turbine installation at Hartford. Conn., by the Hartford Electric Lighting Company. and a description of the same will give a clear view of the great gain in efficiency obtained by this installation. The equipment is de-



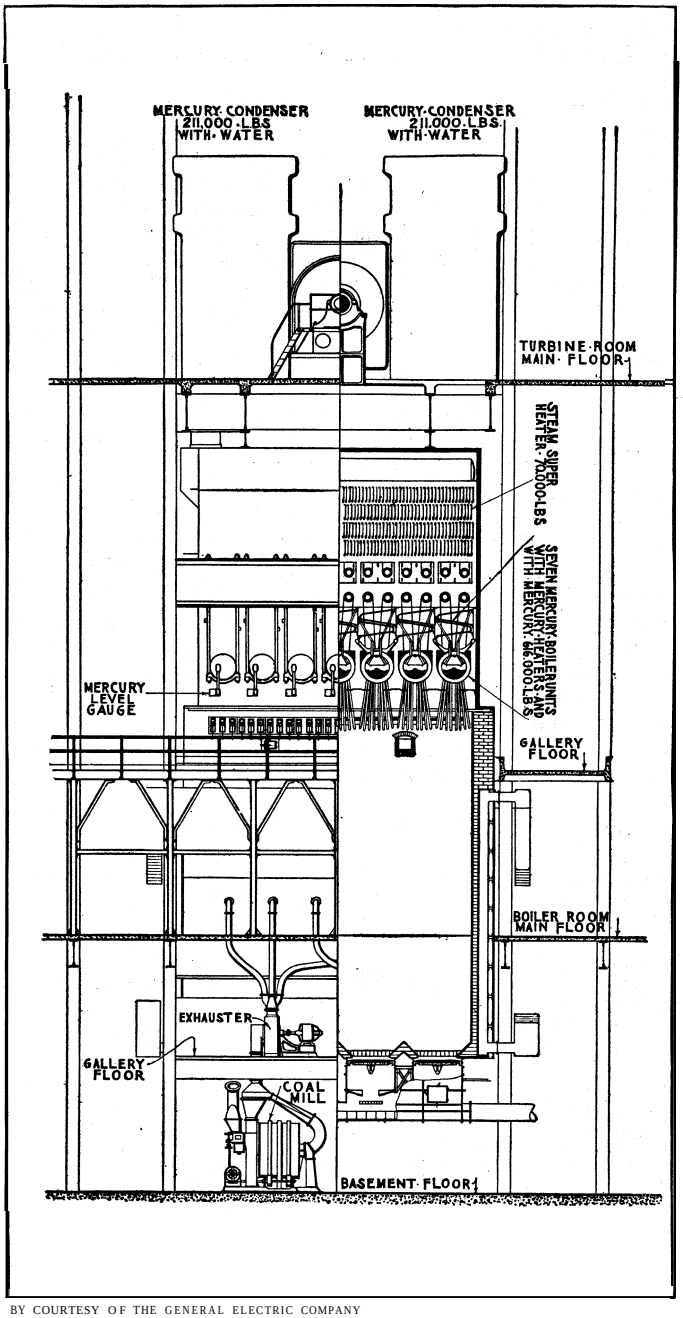
BY COURTESY OF THE GENERAL ELECTRIC COMPANY

FIG. 1.—ARRANGEMENT FOR MERCURY-VAPOUR BOILER AND TURBINE EQUIPMENT, SIDE ELEVATION

signed for the following results: Full-load output of mercury turbine, 10,000 kw.; coal burned per hour, 14,500 lb.; steam produced per hour, 350 lb. gauge, 700° F, 125,000 pounds. The fuel is burned in the furnace, as in a steam boiler, and the products of combustion pass successively through a mercury boiler, a mercury liquid heater, a steam superheater, a feed water heating economizer and an air preheater. The first two of these give heat to the mercury. The others give it to the steam or return it to the furnace.

The mercury vapour made in the boiler passes first through a turbine driving at 10,000 kw. generator at 720 rpm. and then exhausts into a pair of surface condensers. The tubes of these condensers contain water, so that the heat delivered to them by the condensation of the exhaust mercury vapour causes them to make steam which collects in drums above the tubes at which point it is available for use. In the equipment being described, this steam passes from these drums through the superheater mentioned. The condensed mercury is drained through a cleaning sump and then runs by gravity through the liquid heater and into the boiler. By mounting the condenser high enough above the boiler, the weight of the descending column of mercury overcomes the boiler pressure so that no feed pump is required.

Basis of Design.—The following list gives data as to designed conditions for the 10,000 kw. unit and its substantial accuracy is fully established by experience with apparatus now operating: Output of mercury turbine, 10,000 kw.; speed of mercury turbine, 720 r.p.m.; steam produced per hour, 125,000 lb.; steam pressure, 350 lb. gauge; steam temperature, 700° F; mercury vapourized per hour, 1,150,000 lb.; temperature mercury vapour, 884° F; pressure vapour at mercury turbine, 70 lb. gauge; vacuum in mercury condenser, 28 in.; temperature mercury exhaust, 458° F; gas temperature beyond mercury liquid heater, 950° F; gas temperature beyond steam superheater, 650° F; gas temperature beyond water economizer, 480° F; gas temperature to stack, 280° F; air temperature entering furnace, 390° F; coal burned per hour, 14,500 lb.; heat in coal per pound 14,500 B.T.U. It will thus be seen that when 14,500 lb. of coal (with a heat value of 14,500 B.T.U. per pound) is burned under the mercury boiler



BY COURTESY OF THE GENERAL ELECTRIC COMPANY

FIG. 2.—ARRANGEMENT FOR MERCURY-VAPOUR BOILER AND TURBINE EQUIPMENT. END ELEVATION

per hour, 10,000 kw. are generated by the mercury boiler and 125,000 lb, of steam are generated at 350 lb. gauge pressure and with a temperature of 700° F (264° F superheat).

What this amount of steam can accomplish in combination with the mercury turbine in existing power plants is shown by the table below:

Fuel Rates in B.T.U. per Kilowatt Hour

	Steam alone	Steam with mercury	Per cent gain
A . . .	14,000	9,400	33
B . . .	17,000	10,500	38
C . . .	22,000	11,600	47
D . . .	35,000	13,800	60·5

Case *A* represents the best development of modern plants with 350 lb. pressure, high superheat and the most effective auxiliary and feed heating arrangements. Case B represents a station that was considered very good a short time ago with about 200 lb. steam pressure, less perfect firing and auxiliary arrangements and less superheat. Case *C* represents a station in which conditions of size, load factor or efficiency are even less favourable. Case D represents what might be done in a good non-condensing station. The ratios here shown are not much affected by the usual causes of relative inefficiency such as load factor, turbine efficiency or condensing facilities.

The mercury cycle lends itself particularly to the increasing of station capacity of existing plants. By burning approximately 20% more fuel, the same amount of steam as before can be produced, the power from the mercury turbine will be almost equal that produced by the steam turbines, the fuel rate of the mercury turbine will be at approximately 4,000 B.T.U. per kilowatt hour, and the fuel rate of the steam turbine wili remain as before. If this rate was 17,000 B.T.U. per kilowatt hour, the combined rate would be at about 10,500 B.T.U.—a gain of 38%.

Heating Plants.—From the figures that have been given, it will be seen that the gain in economy is incident to the production of steam by a method which gives a valuable by-product in the form of power. A very striking case of profitable use is found in a city heating plant. If, in such a plant, this unit were used in connection with a suitable steam turbine unit which would take steam at 350 lb gauge pressure, superheated and exhausted into the street mains at 100 lb. per square inch and saturated, the results with the best coal burned efficiently would be about as follows: Fuel burned per hour, 14,500 lb.; steam delivered per hour, 125,000 lb; power produced by mercury turbine, 10,000 kw.; power produced by steam, 3,400 kw.; total power produced, 13,400 kilowatts. From these figures it will be seen that the power is produced at a rate of about 16,000 B.T.U. in fuel per kilowatt hour, which is comparable with very good condensing steam stations, and that all this 100 lb. heating steam is produced in addition.

A careful investigation in regard to the probable mercury supply of the world indicates that it is sufficient to take care of this process for practically an indefinite time. The present mercury mines in operation could easily double their output which would take care of 1,000,000 kw. per year, in addition to the present uses of mercury.

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MERCY, compassion, pardon, pity, or forgiveness. The Latin word *merces* was used in the early Christian ages for the reward that is given in heaven to those who have shown kindness without hope of return. In the mediaeval Church there were seven "corporeal" and seven "spiritual works of mercy" *(opera misericordiae)*. The order of the Sisters of Mercy is a religious sisterhood of the Roman Church, founded in 1827.

MERCY, FRANZ, FREIHERR VON, lord of Mandre and Collenburg (d. 1645), German general in the Thirty Years' War, who came of a noble family of Lorraine, was born at Longwy between 1590 and 1598. From 1606 to 1630 he was engaged in the imperial service. After distinguishing himself at the first battle of Breitenfeld (1631) he commanded a regiment of foot on the Rhine and defended Rheinfelden against the Swedes with the utmost bravery, surrendering only after enduring a five-months' siege. He now became a general officer of cavalry, and in 1635, 1636 and 1637 took part in further campaigns on the Rhine and Doubs. In September 1638 he was made master-general of ordnance in the army of Bavaria, then the second largest army in Germany. In the next campaign he was practically commander-in-chief of the Bavarians, and at times also of an allied army of Imperialists and Bavarians. He was made general field marshal in 1643, when he won his great victory over the French marshal Rantzau at Tuttlingen (Nov 24–25), capturing the marshal and seven thousand men. In the following year Mercy opposed the French armies, now under Enghien (afterwards the great Condé) and Turenne. He fought, and in the end lost, the desperate battle of Freiburg, but revenged himself next year by inflicting upon Turenne the defeat of Mergentheim (Marienthal). Later in 1645, fighting once more against Enghien and Turenne, Mercy was killed at the battle of Nördlingen (or Allerheim) as the crisis of the engagement, which, even without Mercy's guiding hand, was almost a drawn battle. He died on Aug. 3, 1645. On the spot where he fell, Enghien erected a memorial, with the inscription Sta *viator, heroem calcas.*

CLAUDIUS FLORIMOND, COUNT MERCY DE VILLETS (1666–1734), Imperial field marshal, was born in Lorraine, and entered the Austrian army as a volunteer in 1682. After seven years of service in Hungary and five years in Italy, he displayed great daring in the first campaigns of the Spanish Succession War in Italy, twice fell into the hands of the enemy in fights at close quarters and for his conduct at the surprise of Cremona (Jan. 31, 1702) received the emperor's thanks. With this he took part in the Rhine campaign of 1703, and the battle of Friedlingen, and his success as an intrepid leader of raids and forays became well known to friend and foe. He was on that account selected early in 1704 to harry the elector of Bavaria's dominions. His resolute leadership was conspicuous at the battle of Petenvardein (1716) and he was soon afterwards made commander of the Banat of Temesvár. At the battle of Belgrade (1717) he led the second line of left wing cavalry in a brilliant and decisive charge which drove the Turks to their trenches. After the peace he resumed the administration of the Banat, which after more than 150 years of Turkish rule needed a humane and capable governor. But he was called away to southern Italy, where he fought the battle of Francavilla (June 20, 1719), took Messina and besieged Palermo. For eleven years more he administered the Banat, reorganizing the country as a prosperous and civilized community. In 1734 he was made a field marshal, but on June 29, was killed at the battle of Parma while personally leading his troops. He left no children, and his name passed to the Mercy-Argenteau family.

MERCY-ARGENTEAU, FLORIMOND CLAUDE, COMTE DE (1727–1794), Austrian diplomatist, son of Antoine, comte de Mercy-Argenteau, entered the diplomatic service of Austria, going to Paris in the train of Prince Kaunitz. He became Austrian minister at Turin, at St. Petersburg, and in 1766 at Paris, where his first work was to strengthen the alliance between France and Austria, which was cemented in 1770 by the marriage of the dauphin, afterwards Louis XVI., with Marie Antoinette, daughter of the empress Maria Theresa. Mercy-Argenteau was in Paris during the years which heralded the Revolution, and supported first Loménie de Brienne, and then Necker. In 1792 he became Austrian governor-general of the Belgian provinces. In July 1794 he was appointed Austrian ambassador to Great Britain, but he died a few days after his arrival in London.

See T. Juste, *Le Comte de Mercy-Argenteau* (Brussels, **1863**); **A.** von Arneth and A. Geoffroy, *Correspondances secrbtes de Marie Thérèse avec le comte de Mercy* (1874); and A. von Arneth and J. Flammermont, *Correspondance secrbte de Mercy avec Joseph II. et Kaunitz* (1889–91). Mercy-Argenteau's *Correspondances secrbtes de Marie Thérèse* has been condensed and translated into English by Lilian Smythe as *A Guardian of Marie Antoinette* (2 vols., 1902).

MER DE GLACE. A glacier 16 sq.m. in area on the northern slope of Mt. Blanc, near Chamonix. During the summer months the rate of flow is estimated at two feet a day. It is a favourite tourist resort.

MERE. (1) An adjective primarily indicating something pure and unmixed (Lat. *merus,* pure).

(2) An arm of the sea, or estuary; a lake or any shallow stretch of inland water. In the Fen countries "mere" is applied to marshland, *cf.* Lat. *mare,* Fr. *mer,* Ger. *meer.*

(3) A landmark or boundary; an object indicating the extent of a property without actually enclosing it; a road which forms a dividing line between two places (O.E. *maere,* Lat. *murus, a* wall). A "meresman" is an official appointed by parochial authorities to ascertain the boundaries of a parish and to report upon the roads, bridges, waterways, etc. In the mining districts of Derbyshire a mere is a certain measurement of land in which lead-ore is found.

MEREDITH, GEORGE (1828–1909), British novelist and poet, was born at Portsmouth, Hants., on Feb. 12, 1828. About his early life little is recorded, but there is a good deal of quasi-autobiography, derived apparently from early associations and possibly antipathies, in some of his own novels, notably *Evan Harrington* and *Harry Richmond.* He had, as he said, both Welsh (from his father) and Irish blood (from his mother) in his veins. His father, Augustus Armstrong Meredith, was a naval outfitter at Portsmouth (mentioned as such in Marryat's *Peter Simple);* and his grandfather, Melchisedek Meredith, clearly suggested the "Old Mel" of *Evan Harrington.* Melchisedek was 35 when, in 1796, he was initiated as a freemason at Portsmouth; and he appears to have been known locally as "the count," because of a romantic story as to an adventure at Bath; he was church warden in 1801 and 1804; and some of the church plate bears his name.

Meredith's mother died when he was three years old, and he was made a ward in chancery. He was sent to school at Neuwied on the Rhine, and remained in Germany till he was 16. During these impressionable years he imbibed a good deal of the German spirit; and German influence, especially through the media of poetry and music, can often be traced in the cast of his thought and sentiment, as well as in some of the intricacies of his literary style. Returning to England he was at first articled to a solicitor in London, but he had little inclination for the law, and soon abandoned it for the more congenial sphere of letters, of which he had become an eager student. At the age of 21 he began to contribute poetry to the magazines, and he eked out a livelihood for some years by journalism, on the *Daily News* and other London papers, and for the *Ipswich Journal,* for which he wrote leaders; a certain number of his more characteristic fugitive writings are collected in the memorial edition of his works (1909–11). In London he became one of the leading spirits in the group of young philosophical and positivistic Radicals, among whom were John (afterwards Lord) Morley, Frederic Harrison, Cotter Morison and Admiral Maxse. But during the years when he was producing his finest novels he was practically unknown to the public. In 1849 he married Mrs. Nicholls, daughter of Thomas Love Peacock, the novelist, a widow, eight years his senior, whose husband had been accidentally drowned a few months after her first marriage (1844), and who had one child, a daughter; but their married life was broken by separation; she died in 1861, and in 1864 Meredith married Miss Vulliamy, by whom he had a son and daughter. His second wife died in 1885. Up to that time there is little to record in the incidents of his life; he had not been "discovered" except by an "honourable minority" of readers and critics. It must suffice to note that during the Austro-Italian War of 1866 he acted as special correspondent for the *Morning Post;* and though he saw no actual fighting, he enjoyed, particularly at Venice, opportunities for a study of the Italian people which he turned to account in several of his novels. Towards the close of 1867, when his friend John Morley paid a visit to America, Meredith undertook in his absence the editorship of the *Fortnightly Review* for Messrs. Chapman and Hall. They were not only the publishers of his books, but he acted for many years as their literary adviser, in which capacity he left a reputation for being not only eminently wise in his selection of the books to be published, but both critical and encouraging to authors of promise whose works he found himself obliged to reject. Thomas Hardy and George Gissing were among those who expressed their grateful sense of his assistance. He was indeed one of the last of the old school of "publishers' readers." In his early married life he lived near Weybridge, and later at Copsham between Esher and Leatherhead, while soon after his second marriage he settled at Flint cottage, Mickleham, near Dorking, where he remained for the rest of his life.

EARLY WORK

Meredith's first appearance in print was in the character of a poet, and his first published poem "Chillian Wallah," may be found in *Chambers's Journal* for July 7, 1849. Two years later he put forth a small volume of *Poems* (1851), which was at least fortunate in eliciting the praise of two judges whose opinion was of the first importance to a beginner. Tennyson was at once struck by the individual flavour of the verse, and declared of one poem, "Love in the Valley," that he could not get the lines out of his head. Charles Kingsley's eulogy was at once more public and more particular. In *Fraser's Magazine* he subjected the volume to careful consideration, praising it for richness and quaintness of tone that reminded him of Herrick, for completeness and coherence in each separate poem, and for the animating sweetness and health of the general atmosphere. At the same time he censured the laxity of rhythm, the occasional lack of polish, and the tendency to overload the description with objective details to the confusion of the principal effect. No doubt as a result of Kingsley's introduction, two poems by Meredith appeared in *Fraser's Magazine* shortly afterwards; but apart from these, and a sonnet in the *Leader,* he published nothing for five years.

In the meanwhile he was busy upon his first essay in prose fiction. It was on Dec. 19, 1855, that the *Shaving of Shagpat, a* work of singular imagination, humour and romance, made its appearance. Modelled upon the stories of the *Arabian Nights,* it catches with wonderful ardour the magical atmosphere of Orientalism, and in this genre it remains a unique triumph in modern letters. Though unappreciated by the multitude, its genius was at once recognized by such contemporaries as George Eliot and Dante Gabriel Rossetti, the latter of whom was one of Meredith's intimate friends. For his next story it occurred to Meredith to turn his familiarity with the life and legendary tradition of the Rhinelander into a sort of imitation of the grotesquerie of the German romanticists, and in 1857 he put forth *Farina, a Legend of Cologne,* which sought to transfer to English sympathies the spirit of German romance in the same way that *Shagpat* had handled oriental fairy-lore. The result was less successful. The plot of *Farina* lacks fibre, its motive is insufficient, and the diverse elements of humour, serious narrative, and romance scarcely stand in proportion to one another. But the *Ordeal of Richard Feverel,* which followed in 1859, transferred Meredith at once to a new sphere and to the altitude of his accomplishment. With this novel Meredith deserted the realm of fancy for that of the philosophical and psychological study of human nature, and *Richard Feverel* was the first, as it is perhaps the favourite, of those wonderful studies of motive and action which placed him among the literary demigods. It depicts the abortive attempt of an opinionated father to bring up his son to a perfect state of manhood through a "system" which controls his circumstances and represses the natural instincts of adolescence. The love scenes in *Richard Feverel* are gloriously natural and the book marked a revolution in the English treatment of manly passion. Certain chapters were omitted from later editions. In the following year Meredith contributed to *Once a Week,* and published in America (1860; 1st English edition 1861) as a book the second of his novels of modern life, *Evan Harrington,* originally with the subtitle "He Would be a Gentleman"—in allusion to the hero being the son of "Old Mel," the tailor—which contains a richly humorous—in its unrevised form, splendidly farcical—plot, with some magnificent studies of character. Afterwards revised, a certain amount of the farcical element was cut out, with the result

that, considered as comedy, it has weak spots; but the countess de Saldar remains a genuine creation. In 1862 he produced his finest volume of poems, entitled Modern Love, and Poems of the English Roadside, *with* Poems and Ballads. An attack upon the dramatic poem which gives the volume its title appeared in the Spectator, and is memorable for the fact that Meredith's friend, the poet Swinburne, with one of his characteristically generous impulses, replied (Spectator, June 7, 1862), in a spirit of fervent eulogy. Some of the "sonnets" (of 16 lines) into which Modern Love is divided rank with the most subtle and intense poetic work of the 19th century.

Returning to fiction, Meredith next published *Emilia* in England (1864), afterwards renamed Sandra *Belloni* (1886). His powerful story Rhoda Fleming (1865) followed soon afterwards. Vittoria, published in the Fortnightly Review in 1866, and in book form in 1867, is a sequel to *Emilia* in *England*. Four years later appeared The Adventures of Harry Richmond in the pages of *Cornhill* (1870–71). Its successor was *Beauchamp's* Career (Fortnightly Review, 1874–75), the novel which Meredith usually described as his own favourite. Its hero's character is supposed to have been founded upon that of Admiral Maxse. Sandra Belloni, Rhoda Fleming, Vittoria and *Beauchamp* are all masterpieces of his finest period, rich in incident, character and workmanship. "The House on the Beach" and "The Case of General Opie and Lady Camper" (New Quarterly Magazine, 1877) were slight but glittering exercises in comedy; the next important novel was The Egoist (1879), which shows an increase in Meredith's twistedness of literary style and is admittedly hard to read for those who merely want a "story," but which for concentrated analysis and the real drama of the human spirit is an astounding production. In an interesting series of lectures which Meredith delivered at the London Institution in 1877, his main thesis was that a man without a sense of comedy is dead to the finer issues of the spirit, and the conception of Sir Willoughby Patterne, the central figure of The Egoist, is an embodiment of this idea in the flesh. The Tragic Comedians (1880), the next of Meredith's novels, slighter in texture than his others, combines the spirits of comedy and tragedy in the story of the life of Ferdinand Lassalle, the German Socialist. The appearance of Diana of the Crossways (1885), a brilliant book, full of his ripest character-drawing, though here and there tormenting the casual reader by the novelist's mannerisms of expression, marks an epoch in Meredith's career, since it was the first of his stories to strike the general public. Its heroine was popularly identified with Sheridan's granddaughter, Mrs. Norton, and the use made in it of the contemporary story of that lady's communication to The Times of the cabinet secret of Peel's conversion to Free Trade had the effect of producing explicit evidence of its inaccuracy from Lord Dufferin and others. As a matter of historical fact it was Lord Aberdeen who himself gave Delane the information.

Meanwhile further instalments of poems—Poems and Lyrics of the Joy of Earth (1883)—had struck anew the full, rich note of natural realism which is Meredith's chief poetic characteristic. "The Woods of Westermain," in particular, has that sense of the mysterious communion of man with nature which is found in the poetry of Wordsworth and Shelley. Ballads and Poems of Tragic Life (1887) and A Reading of Earth (1888) gave further evidence of the wealth of thought and vigour of expression which Meredith brought to the making of verse. His readers, of the verse even more than of the prose, must be prepared to meet him on a common intellectual footing. When once that is granted, however, the music and magic of such poems as "Seed-time," "Hard Weather," "The Thrush in February," "The South-Wester," "The Lark Ascending," "Love in the Valley," "Melampus," "A Faith on Trial," are very real, amid all their occasional obscurities of diction.

Meredith had now completed his 60th year, and with his advancing years the angles of his individuality began to grow sharper, while the difficulties of his style became accentuated. The increase in mannerism was marked in One of Our Conquerors (1891), otherwise a magnificent rendering of a theme full of both tragedy and comedy, in the poem of "The Empty Purse" (1892) and in Lord *Ormont* and His *Aminta* (1894). In The Amazing Marriage (1895) he seemed to catch an afterglow of genius. In 1898 appeared his Odes in Contribution to the Song of French History, consisting of one ode ("France, Dec. 1870") reprinted from Ballads and Poems (1871), and three other previously unpublished; a fine example of his lofty thought, and magnificent—if often difficult—and individual diction. In 1901 another volume of verse, A Reading of Life, appeared. In later years, too, he contributed occasional poems to newspapers and reviews and similar publications, which were collected after his death (Last Poems, 1910). His comedy, The Sentimentalists, was performed on March 1, 1910; his early but unfinished novel, Celt and Saxon, was also posthumously published in that summer.

Now famous, Meredith was chosen to succeed Tennyson as president of the Authors' Society; on his 70th birthday (1898) he was presented with a congratulatory address by 30 prominent men of letters; he received the Order of Merit; and new editions of his books (bath prose and verse), for which there had long been but scanty demand, were called for. One of the results was that Meredith, with very doubtful wisdom, recast some of his earlier novels; and in the sumptuous "authorized edition" of 1897 (published by the firm of Constable, of which his son, William Maxse Meredith, was a member) very large alterations are made in some of them. It meant the excision in old age of some of the most virile passages of books that were written in the full glow and vigour of his prime. In Constable's memorial edition (1910) of his complete works the excisions were published separately.

HIS STYLE AND PHILOSOPHY

Meredith's literary quality must always be considered in the light of the Celtic side of his temperament and the peculiarities of his mental equipment. His nature was intuitive rather than ratiocinative; his mental processes were abrupt and far-reaching; and the suppression of connecting associations frequently gives his language, as it gave Browning's, but even to a greater extent, the air of an impenetrably nebulous obscurity. This criticism applies mainly to his verse, but is also true of his prose in many places, though there is much exaggeration about the difficulties of his novels. When once, however, his manner has been properly understood, it is seen to be inseparable from his method of intellection, and to add to the narrative of description both vividness of delineation and intensity of realization. But when Meredith is at his best he is only involved with the involution of his subject; the aphorisms that decorate his style are simple when the idea they convey is simple, elaborate only in its elaboration. Pregnant, vividly graphic, capable of infinite ahades and gradations, his style is a much finer and subtler instrument than at first appears, and must be judged finally by what it conveys to the mind, and not by its superficial sound upon the conventional ear. It owes something to Jean Paul Richter; something, too, to Carlyle, with whose methods of narrative and indebtedness to the apparatus of German metaphysics it has a good deal in common. To the novelist Richardson, too, a careful reader will find that Meredith, both in manner and matter (notably in The Egoist and in Richard Feverel), owes a good deal; in "Mrs. Grandison" in Richard *Feverel* he even recalls "Sir Charles Grandison" by name; and nobody can doubt that Sir Willoughby Patterne, both in idea and often in expression, was modelled on Richardson's creation. Careful students of the early 19th century English novel will find curious echoes again in Meredith of Bulwer-Lytton's (Baron Lytton's) literary manner and romantic outlook.

The philosophy which represents Meredith's "criticism of life," is broadly speaking a belief in the rightness and wholesomeness of Nature, when Nature—"Sacred Reality"—is lovingly and faithfully and trustfully sought and known by the pure use of reason. Man must be "obedient to Nature, not her slave." Mystical as this philosophy occasionally becomes, it is yet an inspiring one, clean, austere and practical; and it is always dominated by the categorical imperative of self-knowledge and the striving after honesty of purpose and thought. A strong vein of political Radicalism runs through Meredith's creed. It is, how-

ever, a Radicalism allied to that of the French *philosophes,* rather than to the contemporary developments of British party politics, though in later life he gave his open support to the Liberal Party. In spite of his German upbringing Meredith was always strongly French in his sympathies, and his appreciation of French character at its best and at its worst is finely shown in his Napoleon odes.

Meredith died at Flint cottage, Box hill, Surrey, on May 18, 1909. A strong feeling existed that he should be buried in Westminster Abbey, and a petition to that effect, which was approved by the prime minister, H. H. Asquith, was signed by many men of letters. But this was not to be. A memorial service was held in the abbey, but Meredith's own remains, after cremation, were interred at Dorking by the grave of his second wife. He died just after his old friend Swinburne. (H. C.)

BIBLIOGRAPHY.—The first edition of Meredith's collected works was published by Messrs. Chapman and Hall (1885–95); other editions are the edition de luxe (39 vols., 1896–1912), the library edition (18 vols., 1897–1910), the memorial edition (27 vols., 1909–11), and the standard edition (1914, etc.), all published by Messrs. Constable. *The Poetical Works of George Meredith* were published with notes by G. M. Trevelyan (1912). *See* M. B. Forman, *Bibliography of the Writings in Prose and Verse of George Meredith* (1922) and *Meredithiana* (1924). *The Letters of George Meredith* were collected and edited by his son, W. M. Meredith (2 vols., 1912); *see* also *Letters to Edward Clodd and Clement K. Shorter* (1913); *Letters to Richard Henry Horne* (Cape Town, 1919); *Letters to Swinburne and Watts-Dunton* (Cape Town, 1922); *Letters to Various Correspondents* (Pretoria, 1924); *Letters to Alice Meynell, . . . 1896–1907* (Nonesuch Press, 1923). For biography and criticism *see* R. Le Gallienne, *George Meredith: Some Characteristics* (1890), which includes a bibliography by John Lane; M. Sturge Henderson. *George Meredith, Novelist, Poet, Reformer* (1907); G. M. Trevelyan, *The Poetry and Philosophy of George Meredith* (1912); C. Photiades, *George Meredith sa vie* (1910, Eng. trans. 1913); Lady Alice M. Butcher, *Memories of George Meredith* (1919); *R.* Galland, *George Meredith and British Criticism* (1923); *J.* B. Priestley, *George Meredith* (1926); Robert E. Sencourt, *The Life of George Meredith* (1929); *R.* E. G. George, *Life of George Meredith* (1929).

MERENGUE, a Caribbean dance, variously attributed to the Haitian and Dominican republics. Although there are several varieties of the dance, the Dominican merengue is probably the most popular.

In dancing the merengue a step-close is taken to the side and repeated with a slight dipping of the knee or dragging of the foot. The accent occurs on the first and third beats of a 4-4 measure. The basic step may be done from side to side, forward and backward, turning and rocking forward or backward. The dance, usually performed in closed position, occasionally is done in an open-break position. (B. WE.)

MERES, FRANCIS (1565–1647), English writer, author of *Palladis Tamia: Wits Treasury* (1598; edited by D. C. Allen, 1938), a commonplace book containing uninspired comments on religion, music, painting, etc., and a section on poetry. Here, among other information valuable to scholars, Meres gives a list of the plays Shakespeare had produced by 1598 and mentions the deaths of Marlowe, Peele and Greene. He also quotes what is evidently general opinion on contemporary poets, calling Shakespeare "the most excellent in both kinds" (comedy and tragedy) "for the stage"; and Chaucer, "the God of English poets." Born at Kirton, Holland, Lincolnshire, and educated at Pembroke college, Cambridge, in 1602 Meres became rector of Wing, Rutlandshire, and died on Jan. 29, 1647.

See G. Gregory Smith, *Elizabethan Critical Essays* for part reprint and introduction (1904); and J. W. H. Atkins, *English Literary Criticism: the Renascence* (critical) (1947).

MEREZHKOVSKY, DMITRI SERGEIEVICH (1865–1941), Russian novelist and critic, was born in St. Petersburg (Leningrad) on Aug. 2, 1865, the son of a court official, and graduated from St. Petersburg university. He married Zinaida Hippius, the poet (*q.v.*). His first volume of poetry, published in 1588, was followed by more poetry, *Vera, Sakya Muni, Avakum, Black Angel,* etc., by translations from Euripides and other Greek classics, by literary essays on Russian and foreign writers, *Eternal Companions* (1897), and by a trilogy of historical romances collectiveiy entitled *Christ and Antichrist* and consisting of *Smert Bogov* (1895, Eng. trans. *The Death of the Gods,* 1901, popular ed. 1926), the central figure of which is Julian the Apostate; *Voskresenie Bogi* (1902, Eng. trans. *The Forerunner,* 1902; repr. 1924), which described the life and times of Leonardo da Vinci; and *Antikhrist: Petr i Aleksei* (1905, Eng. trans. *Peter and Alexis,* 1905), based on the story of the relations between Peter the Great and his son. After the "trilogy" came the novels *Alexander I.* (1911, French trans. 5th ed. 1922), *December 14* (1920, Eng. trans. 1923), and in connection with the Tutenkhamon excavations, *The Birth of the Gods* (Eng. trans. 1925), followed by *Akhnaton* (Eng. trans. 1927).

About 1900–02 Merezhkovsky evolved a mystic, neo-Christian or apocalyptic teaching, based on the equal sanctity of flesh and spirit as opposed to the cult of the flesh as represented by paganism, and the cult of the spirit as revealed by ecclesiastical Christianity. The influence of Sienkiewicz can be traced in many of Merezhkovsky's writings, which include critical studies such as *Tolstoi and Dostoievsky* (2 vols., 1901–02). He also wrote on religious, political and social questions, and published several plays, including *Paul I.* (1908) and *Carewicz Aleksy* (Warsaw, 1921), a tragedy in five acts. After the revolution he left Russia and went to live in Paris, where he continued to write, notably such biographies as *Napoleon, A Study* (1929); *The Romance of Leonardo da Vinci* (1931); *Jesus the Unknown* (1933). His death in Paris was reported from Vichy Dec. 9, 1941.

See also J. Chuzeville, *Dmitri Merezhkovsky* (1922).

MERGANSER, the name for fish-eating ducks constituting the subfamily Merginae in the family Anatidae. Skilful divers, they pursue prey under water by the drive of the powerful feet set far back, capturing it with the long, slender, cylindrical, serrate bill. Largest is the goosander or common merganser *(Mergus merganser),* 25 in., green-black head with short simple crest, black back, white on wings and below and pale buffy breast; the nostril is near the middle of the bill; it breeds in northern Europe, Asia and America, the latter known as the American merganser *(M. m. americanus).* The same general range is inhabited by the red-breasted merganser (M. *serrator),* 22 in., long double crest, white collar, broad reddish chest-band and nostril nearer base of bill. Bill and feet in both species are red. *M. squamatus* occurs in extreme northeastern China, M. *australis* on the Auckland islands south of New Zealand, M. *octosetaceus* from southern Brazil to northeastern Argentina. The smew *(Mergellus albellus),* smallest of mergansers, 17 in., of northern Europe and Asia, is largely white, with black on back, wing coverts, under eye and in large white crest. The hooded merganser *(Lophodytes cucullatus),* 18 in., wooded regions from southern Canada to Oregon, Nebraska, Louisiana and Florida, is the most beautiful species, with black head, neck and back, white below, cinnamon flanks and a high, erectile white crest edged black. The nest is on the ground or in hollow trees. with 6 to 18 buff or ivory eggs, incubated about a month. The smaller South American torrent duck (*Merganetta armata*), of rushing mountain streams in the Andes from Colombia to Chile, with spurred wings and longer spiny tail but without serrations on the mandible, constitutes the subfamily Merganettinae. (G. F. Ss.)

MERGENTHALER, OTTMAR (1854–1899), U.S. inventor of the Linotype machine, was born May 11, 1854, at Hachtel, Ger. A precocious boy, he was ambitious to study engineering, but his father, burdened with the higher education of older sons, found the expense .beyond his means. Ottmar was apprenticed to a watchmaker at the age of 14, later attended technical classes at night, and in 1872 emigrated to the United States. In 1878 he became a naturalized U.S. citizen. While employed in the Baltimore machine shop of August Hahl, a relation, he was assigned to work on an inventor's plans for a device to make type molds of papier-mâché. This device proved impracticable, but Mergenthaler became dedicated to the problem involved: the mechanization of the tedious work of typesetting. In 1886 .he produced his Linotype which, by bringing copper matrices into brief contact with a molten, but fast-cooling, alloy, rapidly molded column-widths of type. The machine, by speeding the printing process and reducing its cost, fostered a dramatic expansion of all publishing fields and a rapid increase in literacy.

Mergenthaler later patented other successful inventions, but the Linotype remained his life interest. He was a compulsive worker who often overtaxed his strength. At 45 he contracted tuberculosis: he died in Baltimore, Md., Oct. 28. 1899. (M. Sv.)

MERGUI, the southernmost district of Burma, in the Tenasserim division, bounded on the west by the Andaman sea of the Bay of Bengal and on the east by Thailand. Area 10,906 sq.mi. Of its timber trees the most valuable are the teak (Tectona grandis), thin-gan (*Hopea odorata*), *kanyin* (*Dipterocarpus laevis*), etc. Gold, copper, iron, tin and coal are found in the district. Mergui, before it passed to the Burmese. was a densely populated country. On its occupation by the British in 1824–1825 it was found to be almost depopulated — the result of border warfare and of the cruelties of the Burmese conquerors. At that time the inhabitants numbered only 10,000. Pop. (1941) 180,827. The chief exports consist of rubber, tin ore, rice. rattans, dried fish, areca nuts and edible birds' nests. The staple imports are piece goods, tobacco, cotton, earthenware, tea and sugar.

Mergui town became the centre of the rubber and tin ore exporting trade, which. eclipsed its earlier importance as the centre of the prarling trade in the neighbouring archipelago. Pop. (1953) 33.697.

MERGUI ARCHIPELAGO, a cluster of islands in the Andaman sea, near the southern coast of Lower Burma. They are chiefly noted for their picturesque beauty, some rising to 3,000 ft. The archipelago is only sparsely inhabited by the island race of Selungs and by Burmans engaged in pearl-oyster fishing.

MERIAN, MATTHÄUS (1593–1650), Swiss engraver and etcher, was born in Rasel. In 1609 he was placed under Dietrich Meyer, a painter and engraver of Ziirich, and in 1613 went to Nancy. After studying in Paris, Stuttgart (1616) and the Low Countries. he went to Frankfurt. where in 1618 he married the eldest daughter of J. T. de Bry, publisher and engraver. He worked with his father-in-law at Oppenheim, returned to Basel; but went back to Frankfurt after De Bry's death (1623) to take over his business.

Merian completed in 1623 the great record of discovery and travel *Collectiones Peregrinationum* in *Indiam,* which had been begun by the De Brys in 1590. De Bry's business remained in Merian's family until 1726, when a great fire destroyed it. Between 1627 and 1629 Wenceslaus Hollar was in Merian's studio in Frankfurt. Between 1625 and 1630 Merian published illustrations to the Bible; in 1635 he began the series *Theatrum Europaeum,* and in 1642 published Martin Zeiller's *Topographia,* the plates etched and engraved by himself and his sons Matthäus and Caspar. Among his last works was a "Dance of Death" (1649). He died in Frankfurt. (C. H. C. B.)

MÉRIDA, capital city of the state of Yucatan in Mexico. Pop. (1960) 177,405. Mérida stands at the northern end of a porous limestone plain which is ideal for growing the cactuslike agaves from which henequen or sisal hemp fibres are taken. Henequen and other products are shipped from Progreso, its Gulf of Mexico port. 23 mi. away. Most of the drinking water is obtained from underground pools, formed by rain seeping through the limestone, and is pumped to the surface by windmills. Mérida was founded in 1542 by Don Francisco Montejo (the younger) on the site of an ancient Mayan city called T'ho. A famous landmark in Mérida is the House of Rlontejo (La *Casa Solariega* or *Adelantado*), built in 1549. Called the "white city" for its cleanliness, it is a tourist base for trips to nearby ruined Mayan cities, such as Chichén-Itzá, Uxmal, Labná and Kabah. The magnificent Mayan architecture caused the Spaniards to name Mérida after the Spanish city of the same name, which was known as the Rome of Spain. Most of the Mayas speak their own language, and the women still wear the huipil, a straight white dress with colourful embroidery at the neck and hem. For sale in Mérida's market are handsome objects of henequen, fine linen hammocks, filigree gold jewelry, tropical fruits, and venison the year round. Yucatán's locally developed railway system from Campeche to Progreso is connected to trunk lines of the National railways of Mexico, linking the peninsula with the rest of Mexico. Mérida has a 16th-century cathedral, an archaeological museum and is the seat of a university (Universidad Nacional del Sureste de Mexico).

(H. R. Hy.)

MÉRIDA (anc. Augusta Emerita, capital of Lusitania), a town of western Spain, in the province of Badajoz, on the right bank of the river Guadiana. 30 mi. E, of Badajoz. Pop. (1950) 22.134 (mun.). Augusta Emerita was founded in 25 B.C. As the capital of Lusitania it soon became one of the most splendid cities in Iberia and was large enough to contain a garrison of 90.000 men. In 1129 its archbishopric was formally transferred to Santiago de Compostela, and in 1228, when Alfonso IX of León expelled the Moors. Mérida was entrusted to the order of Santiago. in whose keeping it soon sank into decadence. Chief among the Roman remains is the bridge, constructed of granite under Trajan, or Augustus, and restored by the Visigoths in 686 and by Philip III in 1610. It comprised 81 arches. 17 of which were destroyed during the siege of Badajoz (1812), and measured 2,575 ft. in length. There are a few remnants of Roman temples and of the colossal wall which encircled the city, besides a Roman triumphal arch. commonly called the Arco de Santiago, and a second Roman bridge. by which the road to Salamanca was carried across the small river Albarregas (alba Regia). The Moorish alcazar or citadel was originally the chief Roman fort. From the Lago de Proserpina, or Charca de la Albuera, a large Roman reservoir. 3 mi. N., water was conveyed to Mérida by an aqueduct, of which there are extensive remains. The Roman theatre is in good preservation; there are also vestiges of an amphitheatre and of a cjrcus, 485 by 120 yd.

MERIDA, capital of Mérida state in western Venezuela, lies ón a terrace near the Chama river. It is on the trans-Andean highway (not to be confused with the Pan-American highway, which follows a far more direct and a shorter route between Caracas and the Venezuela-Colombia border) at the north foot of the Sierra Nevada de Mérida, the country's only mountain chain to have permanent snow at the higher elevations. Mérida, founded in 1558, for a long time suffered because of the difficulties of accessibility; it was not until coffee became commercially important that the people of Mérida found a product of sufficient value per unit of bulk to support the high cost of transportation. In the second half of the 20th century the Sierra Nevada de Mérida was the principal coffee-producing area of Venezuela. The city is 300 mi. southwest of Caracas and 145 mi. southeast of Maracaibo. The city enjoys one of the pleasantest climates in the country; it has two distinct rainy seasons. Mérida resembles a town from Castile with its narrow cobbled streets, flowers. convents, shuttered houses and neat plaza. It was 'destroyed by earthquakes in 1812 and again in 1894. It is a small manufacturing centre, making textiles, cordage goods, tobacco products, vegetable oil and furniture. The cathedral, convents and university serve to make it the religious and academic centre of the region. Pop. (1961) 40.404. (L. We.)

MERIDEN, a city in Connecticut, U.S., midway between New Haven and Hartford. It was named in a deed in 1664 from "Meriden Farms" in Dorking, Surrey. England; the word means "pleasant valley." The town was incorporated in 1806; the city was chartered in 1867 and the town and city were consolidated in 1922.

Meriden is a highly industrialized community. Its principal industries are the manufacture of sterling silver, gold, silver and nickel-plated ware, britannia ware, ball bearings, cut glass, cabinet hardware, casters, lighting fixtures, electrical accessories, cutlery, hardware and household utensils. The pewter and silverware industry is an old one. Samuel Yale began the manufacture of pewter in 1794. The famous trade mark "1847 Rogers Brothers" indicates the year in which Rogers brothers began the manufacture of silverware there.

The city is the site of a state school for delinquent boys and a state tuberculosis sanitorium. It occupies an area traversed by the Quinnipiac river and Harbor brook. The countryside is dominated by the Hanging hills of which West Peak. Mt. Lamentation and Mt. Higby are the most prominent. A state park has been established in the hills in the northwest part of the city.

Meriden lies on the perimeter of the great urbanized belt that extends across Connecticut from New York city to Boston. Trav-

elers who cross the area are likely to have difficulty in distinguishing the city as an independent community. Pop. (1960) 51.850; for comparative population figures see table in CONNECTICUT: Population. (E. E. SR.)

MERIDIAN, a city of eastern Mississippi, U.S., 136 mi. N. of Mobile and 247 mi. S.W. of Memphis; the seat of Lauderdale county. Meridian sprouted in 1854 at the planned junction site of two rail lines 20 mi. from the Alabama boundary, the name having been chosen by a pioneer railroad man who thought the word meant the same thing as "junction." As other railroads moved in, the village developed as a railroad town. Meridian was incorporated in 1860. In 1948 it adopted a council-manager government, the first city in the state to do so.

As the city's population grew its economy became diversified. Manufactures include garments, metal windows, dump truck bodies, furniture, sewer tile, roofing, boxes, brick and cement, hosiery, shirts, lumber, fertilizer, brush handles and insulation board. Stockyards, cotton and cottonseed-oil mills and compresses are a part of the industrial pattern. A naval auxiliary air station is located 12 mi. north.

Excellent recreational facilities are available in the city and surrounding area. 4 public junior college was opened in 1956. The city is also served by more than 50 physicians, 100 churches and over 25 modern hotels and motels.

For comparative population figures see table in MISSISSIPPI: Population. (E. H. Hs.)

MERIDIAN, in general a direction toward the south or toward the position of the sun at midday. Geographical meridians are the great circles drawn on the earth's surface which pass through the poles, and thus pass through all places having the same longitude. The meridian of Greenwich (the great circle passing through Greenwich observatory and the two poles) is the zero from which terrestrial longitudes are reckoned.

In astronomy the meridian is the great circle through the pole and the zenith; it intersects the horizon in the north and south points.

MERIKANTO, OSKAR (1868–1924), Finnish composer, was born at Helsingfors on Aug. 5, 1868. He received his musical education in Leipzig and Berlin. Returning to Finland he began to write operas, drawing his subjects from the legends of his country. In 1911 he was appointed conductor of the opera at Helsingfors. Outside Finland he is best known for his very beautiful Finnish songs. Besides the three operas, Daughter of Pohja, The Death of Elina, *Queen* of *Emmeritz,* he wrote organ music and some choral works.

Merikanto died at Helsingfors on Feb. 17, 1924.

MÉRIMÉE, PROSPER (1803–1870), French novelist, archaeologist, essayist, and in all these capacities one of the greatest masters of French style during the 19th century, was born at Paris on Sept. 28, 1803. His grandfather, of Norman extraction, had been a lawyer and steward to the maréchal de Broglie. His father, Jean François Léonor Mérimée (1757–1836), was a painter of repute. Mérimée had English blood in his veins on the mother's side, and had English proclivities in many ways. He was educated for the bar, but entered the public service instead. A young man at the time of the Romantic movement, he felt its influence strongly, though his peculiar temperament prevented him from joining any of the coteries of the period. Nothing was more prominent among the romantics than the fancy, as Mérimée himself puts it, for "local colour," the more unfamiliar the better. He exhibited this in an unusual way. In 1825 he published what purported to be the dramatic works of a Spanish lady, Clara Gazul, with a preface stating circumstantially how the supposed translator, one Joseph L'Estrange, had met the gifted poetess at Gibraltar. This was followed by a still more audacious and still more successful *supercherie.* In 1827 appeared a small book entitled la Guzla (the anagram of Gazul), and giving itself out as translated from the Illyrian of Hyacinthe Maglanovich.

The book, which has greater formal merit than Clara Gazul, is said to have taken in Sir John Bowring, a competent Slav scholar, and the Russian poet Pushkin, but, as Mérimée declares, a few words of Illyrian and a book or two of travels and topography were the author's only materials. In the next year appeared a short dramatic romance, La Jacquerie, in which is visible Mérimée's faculty of local and historical colour. This was followed by the Chronique de Charles IX. (1829).

He had already obtained a considerable position in the civil service, and after the revolution of July he was chef *de* cabinet to two different ministers. He was then appointed to the more congenial post of inspector-general of historical monuments. He did not, however, neglect novel writing during this period, and numerous short tales appeared, chiefly in the Revue de Paris. The best of all, Colomba, a Corsican story of extraordinary power, appeared in 1840. He travelled a good deal; and in one of his journeys to Spain, about the middle of Louis Philippe's reign, he made an acquaintance destined to influence his future life not a little—that of Mme. de Montijo, mother of the future empress Eugénie.

Mérimée, though in manner and language the most cynical of men, was a devoted friend, and shortly before the accession of Napoleon III. he had occasion to show this. His friend, Libri Carucci dalla Sommaja, was accused of having stolen valuable manuscripts and books from French libraries, and Mérimée took his part so warmly that he was actually sentenced too, and underwent fine and imprisonment. Between 1840 and 1850 he wrote more tales, the chief of which were *Arsène Guillot* and Carmen (1847), this last, on a Spanish subject, hardly ranking below Colomba.

The marriage of Napoleon III. with the daughter of Mme. de Montijo at once enlisted what was always strongest with Mérimée—the sympathy of personal friendshipon the emperor's side. He was made a senator, but his most important rôle was that of a constant and valued private friend of both the "master and mistress of the house," as he calls the emperor and empress in his letters. He was occasionally charged with a kind of irregular diplomacy, and once, in the matter of the emperor's Caesar, he had to give literary assistance to Napoleon.

At this time he wrote the letters which have been published as Lettres *à* une inconnue, and also the letters addressed to Sir Anthony Panizzi, librarian of the British Museum. After various conjectures it seems that the inconnue just mentioned was a certain Mlle. Jenny Daqin of Boulogne. The acquaintance extended over many years.

Both series, and others since published, abound in gossip, in amusing anecdotes, in sharp literary criticism, while both contain evidences of a cynical and Rabelaisian or Swiftian humour which was very strong in Mérimée. This characteristic is said to be so prominent in a correspondence with another friend, which now lies in the library at Avignon, that there is but little chance of its ever being printed. A fourth collection of letters, of much inferior extent and interest, has been printed by Blaze de Bury under the title of Lettres *à une* autre inconnue (1873), and others still by d'Haussonville (1888), and in the Revue des Deux Mondes (1896). In the latter years of his life Mérimée suffered very much from ill-health. He died at Cannes September 23, 1870.

Mérimée's character was a peculiar and in some respects an unfortunate one, but by no means unintelligible. Partly by temperament, partly it is said owing to some childish experience, when he discovered that he had been duped and determined never to be so again, not least owing to the example of Henri Beyle (Stendhal), who was a friend of his family, Mérimée appears at an early age to have imposed upon himself as a duty the maintenance of an attitude of sceptical indifference and sarcastic criticism.

All his literary work has the Renaissance character. It is tolerably extensive, amounting to some seventeen or eighteen volumes, but its bulk is not great for a life which was not short, and which was occupied, at least nominally, in little else. About a third of it consists of the letters already mentioned. Rather more than another third consists of the official work which has been already alluded to—reports, essays, short historical sketches, the chief of which latter is a history of Pedro the Cruel (1843), and another of the curious pretender known in Russian story as the false Demetrius (1852). Some of the literary essays, such as

those on Beyle, on Turgeniev, etc., where a personal element enters, are excellent. Against others and against the larger historical sketches — admirable as they are — Taine's criticism that they want life has some force. In purely archaeological matters his *Description des peintures de Saint-Savin* is noteworthy.

It is, however, in the remaining third of his work, consisting entirely of tales either in narrative or in dramatic form, and especially in the former, that his full power is perceived. He translated a certain number of things (chiefly from the Russian); but his fame does not rest on these, on his already-mentioned youthful *superchéries* or on his later semidramatic works. There remain about a score of tales, extending in point of composition over exactly 40 years and in length from that of *Colomba,* the longest, which fills about 150 pages, to that of *L'Enlèvement de la redoute* (1829), which fills just half a dozen. They are unquestionably the best things of their kind written during the century, the only *nouvelles* that can challenge comparison with them being the very best of Gautier, and one or two of Balzac. The motives are sufficiently different. In *Colomba* and *Mateo Falcone* (1829) the Corsican point of honour is drawn on; in *Carmen* (written apparently after reading Borrow's Spanish books), the gypsy character; in *La Venus d'Ille* (1837) and *Lokis* (two of the finest of all), certain grisly superstitions.

Arsène Guillot is a singular satire, full of sarcastic pathos, on popular morality and religion; *La Chambre bleue,* an 18th-century *conte,* worthy of *C.* P. J. Crébillon for grace and wit and superior to him in delicacy; *The Capture of the Redoubt* just mentioned is a perfect piece of description; *L'Abbé Aubain* is again satirical; *La Double méprise* (the authorship of which raised objections to Mérimée when he was elected to the academy) is an exercise in analysis strongly impregnated with the spirit of Stendhal, but better written than anything of that writer's. These stories, with his letters, assure Mérimée's place in literature at the very head of the French prose writers of the century. He had undertaken an edition of Brantôme for the Bibliothèque Elzévirienne, but it was never completed. (G. SA.)

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MERINA, the name applied to the inhabitants, sometimes called Hova, of the central part (Imerina) of the interior plateau of Madagascar (*q.v.*). Strictly speaking. the term Hova designates the Merina caste of freemen. as distinct from the castes of nobles (Andriana), serfs (Mainty) and slaves (Andevo). The Andriana are thought to have migrated from Indonesia more recently than other Indonesian elements of the population, being lighter in skin colour and more Malayan in appearance, differences preserved through caste endogamy. Originally organized in a group of small independent kingdoms, each ruled from a hilltop fortress and often at war among themselves, the Merina achieved lasting political unity under the ruler Andrianampoinimerina (1787–1810!, and in the reign of Radama I (1810–28) subjugated over two-thirds of the island. Later rulers claimed the whole of Madagascar as their domain, a claim not generally recognized by foreign powers. Antananarivo (*q.v.*), the present capital of the Malagasy Republic. was first established by Merina rulers as their seat of government. This royalty was abolished by Gen. J. S. Gallieni in the French conquest of Imerina. the last queen. Ranavalona III. being exiled in 1897. The present Merina population is over 1,000,000.

See A. Dandousu and G. S. Chapus, *Histoire des Populations de Madagascar (1952).* (R. *F. G.)*

MERING, BARON JOSEPH VON (1849–1908). German physician, physiologist, pharmacologist and experimental pathologist who did important pioneer work in the control of diabetes and the development of barbiturates. was born in Cologne, Feb. 28, 1819, the son of Baron Friedrich Everhard von Mering. His early medical career was spent in Strasbourg, where he engaged in private medical practice; laboratory research, teaching clinical medicine, forensic medicine and laryngology. In 1890 he moved to Halle, where in 1900 he became director of the medical clinic. He served in that position with distinction until his death on Jan. 5, 1908.

Yon Mering was a pioneer investigator in many fields. He was noted for the discovery of phlorizin diabetes, the experimental production of diabetes by removal of the pancreas. his studies on gastrointestinal physiology and the introduction of new sedative and hypnotic drugs: among the latter was veronal, developed in collaboration with Emil Fischer.

The experimental production of pancreatic diabetes (shared with Oscar Minkowski) must be ranked among his greatest achievements since it became a landmark in the modern investigation of diabetes mellitus leading. in 1921. to the discovery of an extract of pancreas. insulin, as a remedy for the condition. (F. N. A.)

MERINO: *see* SHEEP; WOOL.

MERIONETH (Welsh MEIRIONYDD), a county of north Wales bounded north by Caernarvon and Denbigh. east by Denbigh and Montgomery, southeast by Montgomery, south by the Dovey estuary, dividing it from Cardigan, and west by Cardigan bay. It is nearly triangular, its greatest length from northeast to southwest being about 45 mi. and its greatest breadth about 30 mi. Area 660 sq.mi. Pop. (1951) 41,46j. It is situated in the Snowdonia National park. 64% of the park being in the county. It has been described as a paradise of botanists and geologists. In 1955 an area round Cader Idris was declared a nature reserve.

Physical Features. — The outstanding geological feature is the Harlech dome, a mountain tract about 15 mi. from north to south by 10 mi. from east to west, from the coast inland. It is roughly oval. with Barmouth and Dolgelley. Harlech and Maentwrog around its edges. It is of Cambrian age and composed of grits, quartzites and slates. forming a large anticline. Its central portion is occupied mainly by Harlech grits and Menevian beds. Around the dome on the north, east and south. from Towyn to Caernarvonshire. great volcanic masses. mostly greenstone, stand out in a sweeping curve. The igneous material is intruded into Lingula, Tremadoc and Arenig beds. This belt of high ground surrounding the dome includes Rhobell Fawr (2.408 ft.), composed of andesitic rock, while in the Arenig beds (interstratified with and overlaid by accumulations of volcanic ashes. feldspathic traps or lava flows) are the rugged heights of Cader Idris (*q.v.*), Aran Fawddwy (2,970 ft.) and, Xrenig Fawr (2,800 ft.). The rough grits of the Harlech dome are separated from the grits and lavas farther east by the valley of the Eden and Mawddach. The Ordovician volcanic rocks are. in turn, overlaid by the Llandeilo and Bala beds, the latter including the Bala limestone. South of Rhobell Fawr the great ring of volcanic mountains is broken across by the deep. straight Bala cleft — one of the sharpest geological fault lines in Britain. The great fault line has many branches; the Mawddach estuary line. with its beautiful sands, represents a section which has sunk seaward. Here and there along the eastern boundary of the county. Llandovery and Wenlock strata are included. The structure of the Silurian tract is synclinal; in the Berwyn mountains the Ordovician rocks again appear n-ith associated andesitic and felsitic lavas and tuffs. West of Llangar, near Corwen, is a small patch of Carboniferous Limestone. Glacial drift with boulder clay is prominent in the valleys and on the mountainsides. while a good deal of blown sand fringes the coast north and south of Harlech. The southern section of the county is bordered in some parts by the river Dyfi (Dovey), which rises in a small lake near Xran Fawddwy, passes Machynlleth and expands into an estuary on Cardigan bay. the origin of n-hich is probably associated with the Llyfnant fault zone of northern Cardiganshire and southern Montgomeryshire.

History. — The Ardudwy coast between Barmouth and Harlech

seems to have been important in Megalithic times, while finds of flat axes of bronze to the northeast of Bala lake indicate early attempts to reach the coast from England by way of the Bala cleft. The finds of gold and late Bronze Age hoards on the northwest coast near Harlech indicate contact with Ireland. The upper Dee valley as well as other strategic sites in the county have hilltop camps of Romano-British age. A Roman trackway ran from the military site at Pennal, in the south of the county, northward to Tomen y Mur and thence to Segontium and Kanovium in the north. Somewhere to the east of Dolgelley this trackway was met by another following the Bala cleft from Caergai. In the post-Roman centuries, the remoteness and isolation of the county became more pronounced. Shut off by hills on all sides, it experienced little Saxon, Scandinavian or early Norman influence. In this respect it bears a striking contrast with the neighbouring county of Montgomery, which had easier connections with England. In Saxon times the county was under the princes of Gwynedd, although some parts of what later became Merionethshire were under the princes of Powys. A Norman attempt to enter the county was repulsed in 1096. During the next 300 years there were many fights in the neighbourhood of Corwen, which commanded the entrance to the county via the Bala cleft. There Owain Gwynedd was posted to repel Henry II, and thither Owen Glendower (Owain Glyndwr) retired before Henry IV. The remoteness of the region made it a gathering ground of the Welsh resistance to the English, and in the county and over its borders, at Dolgelley and Machynlleth, there are traditions of Glendower's parliaments. In this sheep-rearing county the Cistercian abbey of Cymmer (Y Fanner), near Dolgelley, was founded about 1200. It was dissolved by Henry VIII, though some interesting ruins remain. The county was still inaccessible in Elizabethan times, and its remoteness is mentioned by Thomas Churchyard (1587). About that time may be traced the beginnings of the slate industry, though it did not come into prominence until the 18th century. There were quarries in the 19th century at Ffestiniog, Corris, Aberllefenni, Pennal, Abergynolwyn and Arthog, though the depression in the slate industry after 1914 seriously diminished the output. There are records of gold mines in the Mawddach valley from early times, and copper has been mined in the Ardudwy and lead in the Dyfi valleys. The flannel and woollen industries were formerly important in the county. In the 18th century Dolgelley was famous for its production of a Welsh tweed cloth, and Bala made stockings and woollen caps. The county is now almost entirely a region of pastoral farming, and many young men and women are forced to seek employment in the large cities over the border in England. Aberdovey, Barmouth and Harlech have many summer visitors. (X.)

Agriculture, Communications and Administration.—The climate varies much with the elevation. Grain crops cover a small area only; oats and mixed corn are the most important cereal crops. Potatoes and turnips are also grown, but more than half the land area of the county is in rough grazings. While the soil is generally thin, there are fertile tracts in the valleys, and there is some reclaimed land. The chief features of the farming are beef cattle rearing and sheep farming, but at mid-20th century there was an increase in milk production. The county is noted for its hardy Welsh Mountain sheep, and the Welsh Mountain ram from Merioneth is in great demand in other counties. The Welsh Black cattle are noted and are exported to midland pastures. The Forestry commission acquired large areas of rough land for the planting of coniferous trees, and forestry is one of the major industries of the county. The railway (Western Region) skirts the coast from Portmadoc to Aberdovey. The coast is almost unnavigable, because of sandbanks; the only havens are Barmouth and Aberdovey. The National trust owned 1,387 ac. in Merioneth in 1956.

The county returns one member to parliament. There are no municipal boroughs. The urban districts are: Bala (pop., 1951, 1,508), Barmouth (2,472), Dolgelley (2,246), Ffestiniog (6,920) and Towyn (4,491). The shire is in the Wales and Chester circuit, and assizes are held at Dolgelley, the county town. Merionethshire is in the dioceses of St. Asaph and Bangor.

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MERISTEM, a botanical term for tissue which has the power of developing new forms of tissue, such as the cambium from which new wood is developed or the tissue at the apex which is responsible for the growth in length of the stem or root.

MERIVALE, CHARLES (1808–1893), English historian and dean of Ely, the second son of John Herman Merivale, was born on March 8, 1808. He was at Harrow (1818–24) and St. John's college, Cambridge (1826), where he was elected fellow in 1833. He declined the professorship of modern history at Cambridge in 1869, but in the same year accepted from Gladstone the deanery of Ely, which he held until his death on Dec. 27, 1893. His principal work was *A History of the Romans Under the Empire* (7 vol., 1850–62), but he wrote several smaller historical works and published sermons, lectures and Latin verses.

See *Autobiography of Dean Merivale,* ed. by his daughter, Judith A. Merivale (1899); *Family Memorials,* by Anna W. Merivale (1884).

MERLE, a name sometimes applied to the European blackbird (*Turdus merula*), especially in association with the word mavis in Scottish poetry. (*See* BLACKBIRD.)

MERLIN, ANTOINE CHRISTOPHE (1762–1833), French revolutionary, called "of Thionville," was born at Thionville on Sept. 13, 1762. After studying theology, he devoted himself to law. Deputy for Moselle in the legislative assembly (1791), he moved and carried the institution of a committee of surveillance and proposed the law sequestrating the property of the *émigrés.* Elected to the Convention (1792), he pressed for the execution of Louis XVI. He was with the army at Mainz, in the Vendée (1793) and on the Rhine again (1794). A supporter of the reaction against Robespierre, he sat in the council of the Five Hundred and, at the coup d'état of 18 Fructidor (Sept. 4, 1797), demanded the deportation of certain republican members. In 1798 he was appointed administrator of posts, being sent to organize the army of Italy.

Merlin lived in retirement under the consulate and the empire. He died in Paris on Sept. 14, 1833.

See J. Reynaud, *Vie et correspondance de Merlin de Thionville* (Paris, 1860).

MERLIN, PHILIPPE ANTOINE, COUNT (1754–1838), French politician and lawyer, known as Merlin "of Douai," was born at Arleux (Nord) on Oct. 30, 1754, and was called to the Flemish bar in 1775. As deputy for Douai in the Constituent Assembly he carried important legislation abolishing the feudal and seignorial rights. On the dissolution of the Assembly he became judge of the criminal court at Douai. As a member of the council of legislation he presented to the Convention on Sept. 17, 1793 the law permitting the detention of *suspects.* He was closely allied with his namesake Merlin "of Thionville," and, after the counter-revolution which brought about the fall of Robespierre, he became president of the Convention and a member of the Committee of Public Safety. He persuaded the Committee of Safety to close the Jacobin club. He recommended the readmission of the survivors of the Girondin party to the Convention, and drew up a law limiting the right of insurrection. With Cambacérès he had been commissioned in April 1794 to report on the civil and criminal legislation of France, and produced his *Rapport et projet de code des délits et des peines* (10 Vendémiaire, an. IV.). Merlin's code abolished confiscation, branding and imprisonment for life. He was made minister of justice (Oct. 30, 1795) under the Directory. After the *coup d'état* of the 18th Fructidor he became (Sept. 5, 1797) one of the five directors, and, being accused of the various failures of the government, retired into private life on June 18, 1799. Under the consulate he became procureur-général in the court of cassation, and did more than any other lawyer to fix the interpretation of the Napoleonic Code. He became a member of the council of state, count of the empire, and grand officer of the Legion of Honour; but was banished on the second restoration. The years of his exile were devoted to his *Répertoire de jurisprudence* (5th ed., 18 vols., 1827–1828) and to his *Recueil alphabétique des questions de droit* (4th ed., 8 vols., 1827–28). At the revolution of 1830 he returned to France, and

re-entered the Institute of France. He died in Paris on Dec. 26, 1838.

See M. Mignet, *Portraits et notices historiques* (1852), vol. i.

MERLIN, the famous bard of Welsh tradition, enchanter and counsellor of Arthurian romance. The personality of Merlin, on one side of demoniac, on the other of human, parentage, is now generally recognized as a combination of diverse traditions. Geoffrey of Monmouth, to whom we owe the conception of the romantic Merlin, probably knew more than one tradition, Nennius' story of the boy Ambrosius, "child without a father," who revealed to Vortigern the secret of the insecure foundations of his tower, being the starting point of his combination. Into this framework were introduced elements derived from the much older story of the demon Asmodeus (Aschmedai), who acted as familiar spirit to Solomon—the feats of divination with which the boy astonishes the messengers of the king, derive directly from this source. Later on a Vita Merlini, long attributed to Geoffrey—an attribution on which modern scholarship has thrown doubts—incorporated features from the Scotch tradition of a certain Lailoken, a "wild man of the woods," gifted with powers of divination. This led to the idea that there had been two Merlins, Merlin-Ambrosius and Merlin-Sylvestris, a view now very generally rejected. The second part of Robert de Borron's trilogy, which was the starting point of the Arthurian cyclic development, dealt with the birth of the seer and his relations with Uther Pendragon. This, originally in verse form, was later worked over in prose, and expanded, first with additions dealing with the wars incident to the opening of Arthur's reign, then with a medley of romantic incidents connected with Arthur's court.' The two elements are combined in a unique ms., No. 337 (Fonds *Français)* of the Bibliothèque Nationale. Finally, a fantastic romance, entitled Les *Prophécies de* Merlin, belonging to a late period of Arthurian evolution, completed the cycle. Merlin is a strange and interesting personality, and his story may quite possibly have been inspired by popular tradition connected with an actual Welsh bard and sooth sayer.

BIBLIOGRAPHY.—For the life of Merlin *see* Geoffrey of Monmouth's *Historia* and the *Vita Merlini* (ed. *J. J.* Parry, University of Illinois, *Studies in Language and Literature,* vol. x, *1925).* For the romantic Merlin see *Merlin,* ed. H. O. Sommer *(1894)* and vol. ii of Sommer's *Vulgate Version of the Arthurian Romances* (1908–16); *Merlin,* ed. G. Paris and *J.* Ulrich (*Société des anc. textes fr.* 1886), an edition of the unique Huth ms., the version contained in which was utilized by Malory; *Les Prophécies de Merlin,* ed. *L. A.* Paton (1926–27). *See* also F. Lot, *Annales* de *Bretagne,* vol. xv. For the oriental parallels *see* M. Gaster, *The Exempla of the Rabbis* (1925) and *E.* Seymour, *Tales of King Solomon* (1925). *J. D.* Bruce, *The Evolution* of *Arthurian Romance,* vol. ii (1923), gives a bibliography of the scattered *Merlin* studies. (*J. L. W.*)

MERLIN (*Falco columbarius*), a small falcon (*q.v.*) of both old and new worlds, usually called pigeon hawk (*q.v.*) in America Its range includes most of Eurasia, Africa, most of North America and some islands. It is migratory over much of its range, in the new world going south as far as Peru.

Length is about 10–13 in., varying somewhat over its range; the female is larger than the male. The male has slaty upper parts with a wide black band on the distal part of the tail; under parts are buffy, streaked with dark brownish; there are no dark facial stripes. Wings are long and pointed. The female is nearer dark brownish above, whitish or creamy below with very heavy streaks of dusky brownish, and the tail has alternating whitish and dark bands (whitish ones narrower). Young during the first summer and winter closely resemble the female. Colours are pale or dilute in populations dwelling in dry areas (as in deserts), darker in humid areas (as in British Columbia).

The merlin builds no nest. In forests it uses old nests of other birds, such as crows, or even squirrel nests; in much of its range it lays its eggs on the ground or in a niche in a cliff. A small depression is lined with bits of plant material and there the three to seven (usually four) eggs are laid. Incubation, mostly by the female, requires 28–32 days. The male brings food to a nearby place and the female comes for it; later he feeds both mate and brood till the latter are nearly ready to depart. Young attain flight in 28 days. One brood is reared yearly.

The merlin is a dashing bird with buoyant flight, usually flying near the ground or among trees. Most of its food consists of birds up to about starling size (rarely to size of plover), some insects and numerous small mammals. There are known instances of its capturing the young of several game-bird species. The merlin was once much used in falconry (*q.v.*). (R. S. PR.)

MERLIN0 COCCAJO: see FOLENGO, TEOFILO.

MERMAIDS AND MERMEN, in the folklore of England and Scotland. semihuman beings who dwell in the sea, but can live on land and enter into social relations with humans.

The typical mermaid has the head and body of a lovely woman, but below the waist is fashioned like a fish. with scales and fins. For a time a mermaid may become to all appearance an ordinary human being; an Irish legend ("The Overflowing of Lough Neagh and Liban the Mermaid," in Joyce's Old Celtic Romances) represents the reverse case.

The mermaid legends of all countries may be grouped as follows: (a) "A mermaid or mermaids either voluntarily or under compulsion reveal things that are about to happen." Thus in the *Nibelungenlied.* (See also Kong Frederichs den *andens* Kronike, Copenhagen, 1680. p. 302.) (b) "A mermaid imparts supernatural powers to a human being." (See "The Old Man of Cury," in Hunt's *Popular* Romances of the *West of* England, 1871.) (*c*) "A mermaid has some one under her protection and for wrong done to her ward exacts a terrible penalty." (See the "Mermaid's Vengeance" in Hunt's book already cited.) (d) "A mermaid falls in love with a human being, lives with him as his lawful wife for a time, and then, some compact being unwittingly or intentionally broken by him, departs to her true home in the sea." Here the typical legend is that of *Mélusine* (*q.v.*), made the subject of a romance by Jean d'Arras. (e) "A mermaid falls in love with a man. and entices him to go to live with her below the sea; or a merman wins the affection or captures the person of an earthborn maiden." This form of legend is very common, and has been a favourite with poets. Danish ballads are full of the theme; as "Agnete and the Merman," an antecedent of Matthew Arnold's "Forsaken Merman"; the "Deceitful Merman, or Marstig's Daughter"; and the story of Rosmer Hafmand (No. 49 in Grimm). The mermaid has generally to be bribed or compelled to utter her prophecy or bestow her gifts, and whether as wife or paramour brings disaster in her train. The fishtail is really of secondary importance. for the true Teutonic mermaid—probably a remnant of the great cult of the Vanir—had no fishtail. The Tritons, the Sirens of classical antiquity, the Phoenician Dagon. and the Chaldaean Oannes are well-known examples. (See also Jones. Traditions of the *North* American Indians, 1830; Dennis. Folklore of China, 1875.)

Quasi-historical instances of the appearance or capture of mermaids are common enough. and serve, with the frequent use of the figure on signboards and coat of arms. to show how thoroughly the myth had taken hold of the popular imagination.

The best account of the mermaid-myth is in S. Baring-Gould's *Myths of the Middle Ages. See* also *E.* Pontoppidan, who has collected much matter to prove the existence of mermaids; Maillet, *Tellianzed* (1755); J. and W. Grimm, *Deutsche Mythologie,* i, 404, and *Altdän. Heldenlieder* (1811); Waldron's *Description of the Isle of Man.*

MERMILLOD, GASPARD (1824–1892), Swiss bishop of Lausanne and Geneva, cardinal, preacher and formulator of Roman Catholic social doctrine, was born at Carouge, near Geneva, on Sept. 22, 1824. He was ordained in 1847 and worked in Geneva for ten years before establishing the first Roman Catholic parish there since Calvin's time; in the same year, 1857, he was made the vicar-general of the bishop of Lausanne for the canton of Geneva. He was made titular bishop of Hebron and auxiliary for the canton in 1864 and administrator in 1871; the canton protested, and what is known as the Swiss *Kulturkampf* ensued (see SWITZERLAND: History). Mermillod was forbidden to exercise first his episcopal and then his priestly functions. In 1873 on his appointment as vicar apostolic he was at once expelled from Switzerland. He then administered his vicariate from Ferney, on the French side of the border. until in 1883 he returned as bishop of Lausanne and Geneva, though the latter city only withdrew its objections to him in 1890, when he was made a curial cardinal.

In 1882 Pope Leo XIII made him chairman of a commission of theologians appointed to elaborate Catholic social doctrine; in 1885 he founded the Union Catholique d'Études Sociales et Économiques. and these bodies exercised a major influence on *Rerum Novarum* (1891), the classic encyclical on social questions. Cardinal Mermillod died in Rome on Feb. 23, 1892. His works were published in a three-volume edition in 1893–94.

See L. Jeantet, *Le Cardinal Mermillod* (1906). (M. DK.)

MEROE, the southern capital of the Ethiopian kings of Napata, 700–300 B.C., becoming eventually the sole capital of the Meroitic kingdom which lasted till about A.D. 350; now an extensive field of ruins, found on the east bank of the Nile near Kabushia railway station in the Egyptian Sudan, lat. 15° 30′ N. The whole site was surveyed by K. R. Lepsius in 1844. A quarter of a mile from the river is an enclosure containing royal palaces and other important buildings, reaching back to Aspaluta, *c.* 590 B.C., in the lower levels. Here was found a bronze head of Augustus now in the British Museum, and many remnants of building and sculpture of Netekaman, *c.* A.D. 100, who built a temple of Ammon outside, backed against the east face of the enclosure. Baths were attached to the later palaces. Northward from the enclosure was a little temple of Isis (temp. Akinirar, etc.); eastward was another, rather earlier, of the lion god Apiremak with stelae down to Taqeriramane, A.D. 250, and a kilometre beyond a larger temple of the sun (?), containing a monument of Aspaluta but mostly built by Teriteqas, Candace and Akinirar, a trio of *c.* 30 B.C. All the above temples face the east; but southwards about 2 mi. was a shrine facing westwards. with great stelae at the entrance of Candace and Akinirar containing a reference to Augustus.

The nearest necropolis eastward is Meroitic at the north end, post-Meroitic toward the south end, the latter part with burials on wooden beds and remarkable pottery. Our kno ledge up to this point is due to J. Garstang's excavations, 1909–14; the more distant cemeteries and the pyramids were completely excavated by G. A. Reisner in 1921–23. On the hills about 2 mi. away are two groups of pyramids. In the southern group were buried three kings of the early part of the 3rd century B.C. surrounded by various tombs of the 8th to the 3rd century; the northern group was almost entirely royal with pyramids of 30 later kings and queens, the earliest being that of Ergamenes in the early part of the 3rd century B.C.

Westward of these and about 1 mi. from the city was a great cemetery of nobles and others of the Ethiopian and Meroitic periods. A fragment of the Greek inscription of a heathen invader from Axum was picked up by A. H. Sayce, and an Axumite graffito exists in one of the pyramid shrines.

See J. Garstang, *Meroë* (1911) and *reports* in "Annals of Archaeology and Anthropology," vols. iii–vii (Liverpool, 1910–14); G. A. Reisner, articles in *Boston Museum of Fine Arts Bulletin* xx, xxi, xxiii, and *The Journal of Egyptian Archaeology,* vol. ix. (F. LL. G.)

MEROITIC LANGUAGE AND WRITING. The Ethiopian kings of Napata, and afterward of Meroe, employed the Egyptian language in hieroglyphic writing for their formal inscriptions and presumably for other records. There are found in Nubia, however, monumental records. tombstones, funerary altars, and graffiti, dating from the first century B.C. to near the end of the third century A.D. inscribed in a native language and in a special script which is called Meroitic, since Nubia was then ruled from Meroe.

The same writing is found also on potsherds, and the use of it on prepared skins and writing tablets of wood can be certified from small fragments. For the decoration of temples and other objects, there were employed the original hieroglyphic (pictorial) forms of the Meroitic writing symbols, but modified hieroglyphic Egyptian was also used for the same purpose.

The symbols of Meroitic writing were modeled on Egyptian, but were employed on an entirely different system. Like Egyptian, the Meroitic writing was from right to left; the signs, unlike Egyptian, face backward. The elaborate Egyptian writing does not express vowels, whereas the simple Meroitic system aimed at recording syllables each consisting of a consonant followed by a vowel.

The Meroitic alphabet consisted of 17 consonantal signs and four rather vague vowel signs together with two syllabics te and *tē* or *tō,* making 23 characters in all.

Besides the alphabet there were special symbols for numerals and perhaps in rare cases resort could be had to special picture signs to symbolize special words. The words were usually separated by double points so that the writing was admirably clear except in regard to the distinction of vowel sounds and the probability that a certain kind of vowel (a?) was not marked and had to be surmised from the context.

Meroitic writing was deciphered in 1910 after the discovery of a large number of new inscriptions in lower Nubia and at Meroe; the language. however. is still almost entirely a sealed book, though names of persons, deities and places, also certain titles borrowed from Egyptian and Meroitic titles which occur in Egyptian demotic, are readily found.

It can only be stated as yet that the Meroitic language shows agglutinative formation, absence of gender and some degree of connection with Nubian.

See F. Ll. Griffith, *Karanòg, The Meroitic Inscriptions of Shablûl and Karanòg* (University of Pennsylvania, Eckley B. Coxe, Jr., Expedition to Nubia, vol. vi, 1911) and articles in *The Journal of Egyptian Archaeology; E.* Zylharz, *Das meroïtische Sprachproblem* in *Anthropos* xxv, with bibliography (1930). (F. LL. G.; C. T. HE.)

MEROPE, name of: (1) The daughter of Cypselus, king of Xrcadia, and wife of Cresphontes, ruler of Messenia. Cresphontes and two of his sons were murdered and the throne seized by Polyphontes, who forced Merope to marry him. A third son, Aepytus escaped; he returned later, killed Polyphontes and recovered the kingdom. (Xpollodorus ii, 180; Pausanias iv, 3, 6.)

(2) The daughter of Atlas and wife of Sisyphus. She was one of the seven Pleiades, but remained invisible, hiding her light for shame at having become the wife of a mortal.

MEROVINGIANS, the name given to the first dynasty which reigned over the kingdom of the Franks. The name is taken from Merovech, an early king of the Salian Franks, who succeeded to Clodio in the middle of the 5th century, and soon became a legendary figure. At the great battle of Mauriac (the Catalaunian fields), in which Aetius checked the invasion of the Huns (451), there were present in the Roman army a number of Frankish foederati, and a later authority states that Merovech (Merovaeus) was their leader. Merovech was the father of Childeric I (457–481), and grandfather of Clovis (481–511). See FRANCE: History.

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MERRIAM, CLINTON HART (1855–1942), U.S. biologist, who first described many genera and species of North American mammals and plants, was born in New York on Dec. 5, 1855, and was educated at Yale and Columbia universities. In 1872 he accompanied the Hayden geological surveys in Utah, Idaho, Montana and Wyoming as naturalist; in 1875 he was assistant to the U.S. fish commission at Woods Hole, Mass.; in 1876 he collected marine invertebrates in the Bay of Fundy; in 1881 he visited the Bermudas; in 1881 and 1882 he studied the life of the St. Lawrence river; and in 1883 he sailed to the arctic seal fisheries as surgeon on the ship "Proteus." In 1885 he took charge of the newly established division of ornithology and mammalogy in the U.S. department of agriculture, later called the U.S. biological survey, in 1896. He had charge of the Death valley expedition in 1890–91 and served as Bering sea commissioner to investigate seal fisheries off the Pribilof Islands in 1891.

In 1910 he became a research associate of the Smithsonian institution and conducted biological and ethnological investigations under the E. H. Harriman trust fund until 1939. He was also chairman of the U.S. geographic board, 1917–25. In later years he devoted himself to the distribution, linguistics and mythology of Pacific coast Indians. Merriam published a number of books and some 400 scientific papers. He died March 19, 1942.

MERRILL, ELMER DREW, (1876–1956), U.S. botanist,

who specialized in the classification of Asiatic and Philippine plants, was born in East Auburn. Me., Oct. 15, 1876. His principal positions were, successively, director of the Philippine bureau of science (1919–23); dean of the college of agriculture of the University of California (1923–29); director of the New York Botanical garden (1930–35); and, finally, Arnold professor of botany (1935–48) and director of the Arnold arboretum (1935–46) of Harvard university. He published numerous articles in the field of systematic botany, mostly concerned with plants of southeastern Asia and the western Pacific islands. Book-length works are: *A Flora of Manila; Enumeration of Philippine Flowering Plants; Index Rafinesquianus; Plant Life of the Pacific World; The Botany of Cook's Voyages;* and *Bibliography of Eastern Asiatic Botany* (with E. H. Walker). (R. C. R.)

MERRILL, FRANK DOW (1903–1955), U.S. army officer, leader of the specially trained jungle fighters known as "Merrill's Marauders" in Burma during World War II, was born at Hopkinton, Mass., on Dec. 4, 1903. He enlisted in the regular army and graduated from the U.S. military academy in 1929. Assigned to the U.S. embassy in Tokyo in 1938 and to the China-Burma-India theatre in 1941, he eventually became operations officer for Gen. Joseph W. Stilwell (*q.v.*). To retake north Burma from the Japanese, Merrill organized and led a regimental-sized group of American volunteers brought to India for training in guerrilla tactics. The Marauders in Feb. 1944 left Ledo, in Assam, and marched several hundred miles through mountainous Burmese jungle to outflank the enemy, harass his lines of communication and defeat him in a series of sharp engagements. Undernourished, feverridden and near exhaustion, the Marauders elimaxed their campaign in May by capturing. with the aid of Chinese reinforcements, the Myitkyina airfield. The city fell in August, making possible the extension of the Ledo road from India to juncture with the Burma road into China and thereby providing an overland supply route to supplement the air route over the so-called Hump.

After duty as deputy commander of U.S. forces in the India-Burma theatre, Merrill in 1945 served as chief of staff of the 10th army, Okinawa. In 1947 he was with the U.S. military advisory group to the Republic of the Philippines. He retired from the army in 1948 as a major general and died on Dec. 11, 1955, at Fernandina Beach, Fla. (MN. BN.)

MERRIMACK, a stream formed in the White mountains of central New Hampshire. U.S., by the confluence of the Pemigewasset river, which originates in Profile lake in Franconia Notch State reservation, and the R'innipesaukee, which flows from Lake Winnepesaukee, New Hampshire's largest lake. The Merrimack flows south through the cities of Concord, Llanchester and Nashua in New Hampshire before crossing the state line into Massachusetts where it turns northeast at Lowell and continues past Haverhill to its mouth on the Atlantic ocean near Newburyport. Of its total length of 110 mi., the lower 22 mi. of the Merrimack are tidal.

The cities along its banks used the water power of the Merrimack to produce a large portion of the cotton and woolen textiles and hosiery of New England from about 1850 to the 1930s. These industries were still active in the second half of the 20th century. but the boot and shoe industry. plus miscellaneous industries characteristic of New England. employed a majority of the norkers. The Merrimack valley is the central artery for tourist travel to many vacation centres in New Hampshire. (A. S. CN.)

MERRIMAN HENRY SETON (d. 1903), the pen-name of Hugh Stowell Scott, English novelist. He was a member of the firm of Henry Scott and Sons, and was for some years an underwriter at Lloyd's. His literary career began in 1889 with *The Phantom Future,* and he made his first decided hit with his Russian story, *The Sowers* (1896), which was followed by many other well-constructed novels. He was an enthusiastic traveller, many of his journeys being undertaken with his friend Stanley Weyman. He was about 40 when he died near Ipswich, on Nov. 19, 1903.

Among his most successful books were *Roden's* Corner (1898); *The Isle of Unrest* (1899); *In Kedar's Tents* (1897); *The Velvet Glove* (1901); *The Vultures* (1902); *Barlasch* of *the Guard* (1903); and *The Last Hope* (1904).

MERRIMAN, JOHN XAVIER (1841–1926), South African statesman, was born on March 15, 1841 at Street, Somerset, England, the son of a clergyman who afterwards became bishop of Grahamstown, South Africa. His family moved to South Africa in 1849, and he was educated at the Diocesan College, Rondebosch, and later at Radley College, England, returning to the Cape in 1861. He entered politics in 1869. In 1875 he joined the Molteno Ministry as commissioner of public works, and was virtually Secretary for War during the Galeka war of 1877. In the Scanlen Ministry (1881–4) he was commissioner of public works. The Afrikander Bond caused the fall of the Scanlen administration because the Ministry opposed the attempt of the Transvaal Boers to seize Bechuanaland; and when Rhodes formed a Ministry in 1890 Merriman, alienated by the extreme policy of the Bond, joined it as treasurer-general. Meanwhile the Bond had adopted a constitutional programme, and 1890 saw a drawing together of the Dutch and British elements at the Cape. But the Uitlander troubles in the Transvaal became acute, and in 1893 Merriman resigned. He was chairman of the Cape parliamentary committee which inquired into the Jameson raid of 189j, and drew up its report. The general election in Cape Colony in 1898 gave the Bond a very narrow victory, and W. P. Schreiner became Prime Minister, with Merriman treasurer-general again, though he was not a member of the Bond. Merriman was among the ministers who in 1900 opposed the measure to disfranchise the Cape rebels, causing the cabinet to resign. At the general election of 1904 Merriman was defeated, but was returned shortly afterwards at a by-election. In Jan. 1908 he succeeded Dr. Jameson as Prime Minister and treasurcr-general *(see* SOUTH AFRICA: *History).* Merriman was now head of the Afrikander Bond party, renamed the South African party. He was a member of the national convention which hammered out the new constitution. He supported the unitary as against the federal principle in South African policy. It was expected in some quarters that Merriman would be the first prime minister of the Cnion. The position fell to Botha. Merriman remained outside the ministry, though he gave the government steady support. He died Aug. 2, 1926.

MERRITT, WESLEY (1836-I~IO), U.S. soldier, was born in New York city on June 16, 1836, graduating at West Point. He won distinction in the Virginian campaigns of 1864–65 and in Sheridan's Shenandoah valley campaign; in 1895 he became major general. He was superintendent at West Point (1882–87), commanded the military department of Missouri (1887–95) and that of the Atlantic (1897–98). In May 1898 he commanded the U.S. forces sent to the Philippines after Admiral Dewey's victory; stormed Manila on Aug. 13, and was military governor of the islands until Aug. 30. At Paris, he was on the peace commission. He died at Natural Bridge, Va., Dec. 3, 1910.

MERRY DEL VAL, RAFAEL (1865–1930), Spanish ecclesiastic and diplomat, was born on Oct. 10, 1865 in London, where his father was secretary to the Spanish legation. Educated at Baylis house near Slough and at Ushaw college near Durham, he took up diplomacy at the Vatican and in 1892 became master of the robes and acting private chamberlain to Pope Leo XIII. In 1897 he was sent to Canada to report on the difficult Manitoba schools question, and in 1900 he became archbishop of Nicea. He was secretary of the Sacred College of Cardinals during the election of Pius X (July 1903), under whom he became cardinal and secretary of state. On Jan. 12, 1913, he succeeded Cardinal Rampolla as archpriest of the Vatican basilica; in the following October he was appointed secretary of the Holy Office, and in Dec. 1920 he became camarlengo of the Holy Roman Church. He died in Vatican City on Feb. 26, 1930.

MERSEBURG, in the district of Halle, Ger., on the Saale. Pop. (1950) 38,441. From 968 until the Reformation it was the seat of a bishop, the residence of the margraves of Meissen and a favourite residence of the German kings. Fifteen diets were held there; when its fairs enjoyed an importance anticipating Leipzig. From 1657 to 1738 it was the residence of the dukes of Saxe-Merseburg. It consists of an irregularly built old town, a new quarter and two suburbs, Altenburg and Neumarkt. The cathedral, restored 1884–86, has a choir, crypt and two towers of the

11th, a transept of the 13th and a late Gothic nave of the 16th century. It contains a great organ dating from the 17th century. The Gothic palace, formerly the residence of the bishops of Merseburg, was later used as public offices. Industries include machinery and paper, metal founding, tanning and brewing.

MERSEN (MEERSSEN), **TREATY OF,** concluded on Aug. 8, 870, at Mersen, Holland, between Charles the Bald and his half-brother Louis the German, by which the kingdom of their nephew Lothair II (d. 869) was divided between them. Charles received a portion of the kingdom of Lothair, afterward called Lorraine, extending from the mouths of the Rhine to Toul, together with the town of Besançon, the Lyonnais, the Viennais, the Vivarais and the Uzège, while Louis had the cities of Cologne, Trier and Metz, together with Alsace, the Escuens and the Varais; *i.e.,* the greater part of the diocese of Bescançon. The boundary between the two realms was marked approximately by the valleys of the Meuse and Moselle and by the Jura.

MERSENNE, MARIN (1588–1648), French mathematician and theologian, the closest friend of Descartes and the savant in whom, according to Thomas Hobbes, "there was more than in all the universities together," was born near Oizé in Maine on Sept. 8, 1588. He was a fellow pupil of Descartes at La Flèche. Having joined the Minim friars (1611), he settled in 1620 at the convent of L'Annonciade in Paris.

For many years Mersenne acted as intermediary between Descartes and other philosophers. It was he who collected the various "objections" appended, with Descartes' "replies" to them, to the 2nd edition of the *Meditations* (1642); and he also secured criticisms of the *Dioptric.* His own *Quaestiones in Genesim* (1623) included an attack on Robert Fludd (*q.v.*); when Fludd retorted, Mersenne was supported by Pierre Gassendi. Further books were *L'Impiété des déistes* (1624); *La Vérité dans les sciences* (1625); *Harmonie universelle* (1636–37), on music and musical instruments; and a number of works on mathematics and on the physical sciences. For "Mersenne numbers" *see* NUMBERS, THEORY OF. In geometry his name is particularly associated with research on cycloid curves. He died in Paris on Sept. 1, 1648.

See his *Correspondence,* ed. by Mme. Paul Tannery, Cornélis de Waard and R. Pintard (Paris, 1932 ff.). (S. V. K.)

MERSEY, a river in Cheshire. Eng., 70 mi. long. formed by the Goyt, from Axe Edge southwest of Buxton, and the Etherow, from between Penistone and Glossop. The Mersey drains a large part of the Peak district. Its chief tributary, the Irwell, flows south from Rossendale forest through Manchester and joins it near Irlam. Other tributaries are the Tame from the north and the Bollin from the southeast. The main river expands into an estuary which narrows to less than three-quarters of a mile at Liverpool and forms an important harbour. (*See* LIVERPOOL and BIRKENHEAD.) The Manchester Ship canal (*q.v.*) joins the estuary through Eastham locks, skirts its southern shore up to Runcorn and crosses the river several times. (T. HER.)

MERSIN (ICEL), a seaport of Turkey, and capital of the province of Içel. Pop. (1960) 68,574. It began with the silting up of Tarsus and Pompeiopolis, east and west, id the early middle ages; but it grew with the Egyptian occupation of Cilicia (1832). It is the busiest port on the south coast, being the terminus of the railway from Adana and Tarsus, by which (but still more by road) the produce of the rich "Aleian" plain comes down. The anchorage is good, but the bay shoals for a long way out, and is exposed to swell from southwest and south. The low coastal section has a bad summer climate.

MERSWIN, RULMAN (1307–1382), German mystic, was born at Strasbourg in 1307, and became a banker. At the age of 40, he came into touch with Tauler and the group of 14th century mystics known as the Friends of God. In *Story of the First Four Years of a New Life,* he writes: "Of all the wonderful works which God had wrought in me I was not allowed to tell a single word to anybody until the time when it should please God to reveal to a man in the Oberland to come to me. When he came to me God gave me the power to tell him everything."

Merswin claimed that certain books were written by this "Friend of God," who has been identified with various people by ditierent scholars, and that other books were written by himself. As all the writings bear the marks of a single authorship it has been assumed, especially by Denifle, that "the Friend of God" is a literary creation of Merswin just as William Langland in England about the same time drew the figure of Piers Plowman. Karl Rieder (*Der Gottesfreund von Oberland,* Innsbruck, 1905) attributes the authorship to Merswin's secretary and associate Nicholas of Löwen, head of the House of St. John at Grünenwörth.

See also Karl Schmidt, *Nicolaus von Basel* (Vienna, 1866); Denifle, *Der Gottesfreund im Oberland und Nikolaus von Basel* (1876); Rufus M. Jones, *Studies in Mystical Religion,* ch. xiii (1909).

MERTENSIA, a genus of perennial herbs of the family Boraginaceae (*q.v.*), comprising about 40 species found in cool regions of the northern hemisphere and especially abundant in western North America. Many are very smooth plants, of pleasing habit. with brightly coloured usually blue or white flowers. Well-known representatives are the sea lungwort (*M.* maritime) and the Virginia cowslip (*qq.v.*), which is not to be confused with the yellow cowslip of Europe.

MERTHYR TYDFIL, a municipal, county and parliamentary borough of Glamorgan, Wales, on the Taff river, 24 mi. N.N.W. of Cardiff by road. Pop. (1951) 61,142. Area 27.8 sq.mi. It was named after St. Tydfil. a Christian princess slain by raiding Picts in the 5th century. At Penydarren park remains can be seen of a Roman camp. The town is irregularly built and the early industrial prosperity resulted from the iron and coal of the district. Four ironworks were established there (Dowlais, Cyfarthfa, Penydarren and Pentrebach) between 1757 and 1783. The Guest family was associated with Dowlais and in 1759 a furnace was started for the smelting of iron ore. In about 1780 export of iron to America began and in 1856, also at Dowlais, Bessemer steel was first rolled into rails, but the use of puddled iron was not wholly abandoned at the works till 1882. A canal had been built from Merthyr to Cardiff to carry iron; from Merthyr, too, the first steam locomotive, built by Richard Trevithick in 1804, set forth to Abercynon; and there Adrian Stephens invented the whistle in case of explosions. Isambard Brunel built the main line railway from Merthyr to Cardiff: opened in 1841. The mining of local coal for smelting gave a great impetus to the iron industry and many more collieries and ironworks were opened. Cyfarthfa was converted into steelworks in 1883. The trade depression of the 1920s–1930s caused the closing of the huge Dowlais works, which moved in great part to Cardifi in 1930, and by 1932 Merthyr was one of the places in the country most severely affected by unemployment. Merthyr was left dependent mainly on the collieries of Treharris which. together with those at Merthyr Vale, were the only deep mines being worked in the mid 1950s. But by that time relief from unemployment had been brought by the advent of new light industries which included engineering, chemicals, stockings, washing machines and joinery.

Cyfarthfa castle (1825) standing in a fine park (160 ac.), houses a grammar school, museum and art gallery and Merthyr has a technical institute and a college of further education (begun in 1950). Merthyr Tydfil was incorporated in 1905 and became a county borough in 1908.

MERTON AND MORDEN, an urban district (1911) and parliamentary division (1948) of Surrey, Eng., 10 mi. S.S.W. of Charing Cross, London, to which it is linked by underground railway. Pop. (1961) 67,974. Area 5.1 sq.mi. Merton parish church (12th-century) contains the seat used by Lord Nelson when he lived at Merton place (now demolished). At Merton priory, a rich Augustinian house demolished by Henry VIII, Thomas à Becket and Walter de Merton, founder of hlerton college, Oxford, were educated. The John Innes Horticultural institution at Merton was moved to Hertfordshire in 1949. By Stane street many Roman relics have been found.

The Wandle river flows through Morden park which, with its deer park, bird sanctuary and 18th-century house, was bequeathed to the National Trust in 1942. Largely residential, the district has a variety of light industries.

MERULA, GEORGIUS, the Latinized name of GIORGIO MIRLANI (c. 1430–1494), Italian humanist and classical scholar, was born at Alessandria in Piedmont. He taught at Venice and Milan. where he held a professorship until his death. His works include the editio princeps of Plautus (1472), of the *Scriptores rei rusticae,* Cato, Varro, Columella and Palladius (1472). He also published commentaries on portions of Cicero.

MERV (MERU, MAUR or MARY), an ancient oasis and town of

central Asia in the Turkmen S.S.R. The oasis covers 51,892 sq.mi. and has about 90,000 inhabitants. mainly Turkomans (Turkmens) of the Tekke tribe. The great chain of mountains which, as the Paropamisus and Hindu Kush, extends from the Caspian to the Pamirs, is interrupted about 180 mi. south of the oasis. where the Hari-Rud (Tejend) and Murghab rivers force their way through and then flow in parallel courses until they are lost in the Kara-Kum desert. The loess oasis of Merv depends on the Murghab for its life. Cotton is the chief source of wealth; grain and fruit are also grown. The railway from Krasnovodsk on the Caspian, linking with the Chkalov (Orenburg)-Tashkent lines, passes through the oasis, from which a branch runs southward to Kushk, on the Afghan frontier.

Summer heat is oppressive, about 97° F., and the least wind raises clouds of dust uhich darken the air and make respiration difficult. In winter the temperature drops to 19° F., but snow rarely falls and never lies. The rainfall is about five inches a year; the dry period is usually from June to October.

History. — In the Hindu *Puranas* and in Persian tradition Merv is looked upon as the ancient paradise, the cradle of the Aryan families of mankind and so of the human race. Under the name of Mouru it is mentioned with Bakhdi (Balkh) in the geography of the *Zend-Avesta (Vendidad)* which dates at least from 1200 B.C. It occurs as Margu in the cuneiform inscriptions of the Achaemenid monarch Darius I, where it is mentioned as part of one of the satrapies of the Persian empire. It afterward became a province (Margiana) of the Graeco-Syrian (Seleucid), Parthian and Sassanian kingdoms. When the Greeks under Alexander the Great passed through the oasis they found cultivation by irrigation, but they made no mention of any large town. It is uncertain whether Alexander founded a city there, but 60 years later the Seleucid Antiochus Soter (280–261 B.C.) built Antiochia Margiana on the Margus (the Epardus of Arrian and the modern Murghab), near the site of the modern Bairam 'Ali. After the battle of Carrhae in 53 B.C. the Parthian victors settled many of their Roman prisoners in Margiana. Under the later Sassanian kings Merv was the residence of the *marzuban* or "warden of the marches," as well as the seat of a Christian archbishopric.

The Moslem Arabs conquered the oasis in A.D. 651, rebuilt the city slightly to the west of the original site and made it the capital of Khurasan. Using Merv as his base, Qotaiba ibn Muslim, early in the 8th century, conquered Balkh, Bukhara, Ferghana and Kashgaria; and other Moslem leaders later penetrated into China. The 'Abbasid movement, which resulted in the overthrow of the Umayyad caliphate and the substitution of the house of 'Abbas, began in Merv in the middle of the 8th century. Later in that century Merv became notorious as the centre of heretical propaganda preached by Mokanna (*q.v.*), "the veiled prophet of Khurasan."

Under the Abbasid caliphs Merv, like Bukhara and Samarkand, was one of the great centres of Islamic learning: the celebrated Yaqut spent three years studying in its libraries, collecting material for his geographical dictionary. In those days silk, as well as cotton, was cultivated; the land taxes were levied on the amount of land irrigated. In the 11th century the Seljuk Turks took possession of the oasis; and Sultan Sanjar (1118–57) made Merv his capital. It was under the able rulers of this dynasty that Merv attained the zenith of its glory, though a temporary setback occurred in 1153, when the Ghuzz Turks overran the oasis.

In 1221 the Mongols conquered the oasis, destroyed the town of Merv and demolished the dam on which all the irrigation depended; and Merv never fully recovered from this disaster. In 1409 the Timurid ruler Shah Rukh repaired the dam and built a new city immediately south of the ruins of the old town, but it never prospered as its predecessor had done. Shah Isma'il, the first Safavi ruler of Persia, incorporated Merv in his domains in 1510, but neither he nor his successors could prevent the Uzbegs from beyond the Oxus from carrying out repeated raids. In 1787 Shah Murad, the amir of Bukhara, conquered the oasis, despite the heroic resistance of Bairam 'Ali Khan, a local chief. Shah Murad destroyed the dam again and dispersed most of the inhabitants. Early in the 19th century Merv came under the rule of Khiva, but the Tekke Turkomens drove the Khivans out in 1856 and remained supreme until the Russians occupied the oasis in 1884. Under Russian rule the dam was at length repaired and real progress toward recovery was made. The soviet government took further steps to restore prosperity, and it was planned to supplement the water supply by a canal from the Oxus.

Towns. — The capital of the oasis, New Merv, founded early in the 19th century, is 30 mi. W. by S. of the ruins of its predecessors. It stands on both banks of the Murghab and is 735 ft. above sea level. In 1939 the population was 50,000. Merv has the largest wool-cleaning plant in central Asia, as well as a number of cotton mills, carpet factories, motor-repair works and a brewery. The town of Bairam 'Ali (called after the 18th-century hero) has about 30,000 inhabitants; it has a large cotton-oil extraction plant, where cotton from the adjacent collective farm is treated.

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MERX, ADALBERT (1838–1909), German theologian and orientalist, was born at Bleicherode, Prussian Saxony, on Nov. 2, 1838, and became (1875) professor of theology of Heidelberg. He elucidated the Sinaitic palimpsest discovered in 1892 by Mrs. Agnes Smith Lewis (*see* BIBLE), the results being embodied in *Die vier kanonischen Evangelien nach ihrem ältesten bekannten Texte* (1897–1905).

Merx died at Heidelberg on Aug. 6, 1909.

MÉRYON, CHARLES (1821–1868), French etcher, one of the first of the great French artists to use the life of a modern city as the material of expression, was born in Paris on Nov. 24, 1821. His father was an English physician, his mother a French dancer. Méryon's childhood was spent with his mother, but she died when he was still young. He, entered the French navy, and in the corvette "Le Rhin" made a voyage around the world. On the coast of New Zealand he made drawings which he employed years afterward as studies for etchings of those regions. Méryon left the navy as a lieutenant. He entered the studio of Bléry, who taught him the technique of etching. Although very poor, Méryon would not ask for assistance from his relatives and earned his living by hack work. For practice he made studies after Dutch etchers, such as Zeeman and Adriaen van de Velde. He then began the series "Eaux-fortes sur Paris," executed from 1850 to 1854, and although Méryon always considered these plates as a set, they were never published as such. Besides these 22 etchings, Méryon produced about 70 others, including all the work of apprenticeship and decline.

Although Méryon was a great master of his medium, he was appreciated by only a few artists and critics. His prints sold for almost nothing. His life was one of great disappointments and terrible hardships; he became subject to hallucinations and shortly after the completion of the Paris series, he was committed to the mental institution at Charenton. A partial cure was effected, but he was returned to the asylum in 1867 and died there the following year.

The etchings of Méryon complement the poems of Baudelaire, in their similar subject matter and in that both made use of traditional forms, with no innovation other than personal genius, to produce works that remain striking for their originality and modernity. It is evident that architecture must enter largely into any representation of a city, however visionary the representation. Generally speaking, Méryon's figures are incidental, like those of a landscape painter, but sometimes, as in his "La Morgue," they tell the story of the picture, or, as in "La Rue des Mavais Garcons," with the two women secretly conversing, at least suggest it. In "L'Abside de Notre-Dame," by many considered to be Méryon's masterpiece, how empty would have been the scene, even with its miraculous effects of light and atmosphere, without the few human figures. Perhaps the lesson was learned from Giovanni Battista Piranesi, who brought to life the ruins of Rome and Paestum with a few beggars and vagabonds, but in MCryon's work it is extended into the poetry of a later time.

See Loÿs Delteil, *Catalogue raisonne of the Etchings of Charles Méryon,* ed. by H. J. L. Wright (1925); G. Geffroy, *Méryon* (1926),

the best and most comprehensive biography of the artist. (H. Es.)

MESA, a flat-topped tableland with steep sides, common in the Colorado regions of the United States; a butte is similar, but smaller. Both are formed by erosion; during denudation areas of harder rock in a plateau act as flat protective caps for portions of land situated between such places as stream valleys, where erosion is especially active. This results in table mountains or fortress hills. The term is borrowed from Spanish and derives from the Latin *mensa,* "table."

MESA VERDE NATIONAL PARK, covering more than 51,000 ac. in the southwestern corner of Colorado, contains the most notable prehistoric cliff dwellings in the United States and also provides some of the most striking scenery to be found in the national parks. From the north end there is a sweeping view of mountains, mesas and river valleys in Colorado, Utah, Arizona and New Mexico. Hundreds of prehistoric pueblo (village) ruins are to be seen on the high tableland and in the rugged canyons that dissect it. The visitor may view there the development of Pueblo culture from subterranean lodges of the 7th and 8th centuries A.D. to the adobe and stone surface pueblos and cliff dwellings which were occupied from the 9th to the 13th centuries, when they were deserted for some unknown reason.

The most striking' ruins are the multistoried apartments built under overhanging cliffs. The largest of these is Cliff palace (excavated in 1909) in which 223 rooms can still be counted, including numerous kivas, the circular ceremonial chambers of the Pueblo Indians.

Although early Spanish explorers gave the great mesa its name (meaning "green table"), there is no evidence that they discovered the large cliff dwellings hidden in the many canyons. Small cliff houses in the lower reaches of the canyons were discovered by W. H. Jackson and W. H. Holmes of the Hayden survey in the 1870s. On Dec. 18, 1888, two cowboys, Richard Wetherill and Charles Mason, discovered Cliff palace. In 1891, Gustav Nordenskiöld excavated in the major ruins on the mesa and published a report which is one of the outstanding books on North American archaeology. The national park, which is provided with a museum, camping facilities and overnight accommodations, was established in 1906. See also CLIFF DWELLERS; PUEBLO; INDIAN, NORTH AMERICAN: Culture Provinces: *The* Southwest; NATIONAL PARK SYSTEM. THE. (J. 0. Bw.)

MESDAG, HENDRIK WILLEM (1831–1915), Dutch marine painter, was born at Groningen on Feb. 23, 1831. He entered the family banking firm of Mesdag. but about 1866, owing to the influence of Josef Israels, took up the study of art. His sea pieces became famous and earned him the gold medal of the Paris Salon, among them being "Effet du soir à Scheveningen" (1872); "Après l'Orage" (189j); "Rentrée des bateaux de pêche" (1900); and "Une Soirée sur la plage de Scheveningen" (1911). He presented his fine collection of pictures and objets *d'art* to the nation, and they are housed in the Mesdag museum at The Hague.

Mesdag died at The Hague on July 7, 1915.

MESHED (properly *Mash-had,* the place of martyrdom), capital of Khurasan in Iran, is situated at an elevation of 3,197 ft., in the valley of the Ah-i-Meshed or Kashaf Rud, a tributary of the Hari Rud. The town, in 37° 16′ N., 59° 36′ E., is 460 mi. by air from Tehran (566 mi. by road), 200 mi. from Herat, and 472 mi. by road from Zahidan near the frontier of India. The population (1956) was 241.989, of which about 10,000 were pilgrims. Meshed Jews number about 4.000.

The city is about 6 mi. in circumference. There are unusually large numbers of caravanserais. The main street forms a fine avenue planted with plane and mulberry trees and having a stream running down the centre. A great hospital, well organized and equipped. is located in a park in the outskirts. Meshed, the most sacred place in Iran, the "Mecca" of all Shiahs, has grown up around the tomb of the Imam Riza and has supplanted Tus, the ancient capital, now in ruins, about 1j mi. northwest. It is visited annually by about 100,000 pilgrims. Riza (770–819) was the eighth of the 12 Imams in line of succession after Mohammed's cousin and son-in-law Ali, whose particular followers —as Shiahs—the Iranians are. To the Shiahs, Imam Riza is a martyr, being believed to have been poisoned by the caliph Mamun.

The buildings of the shrine—"the Glory of the Shiah World"—together with a space extending to about 100 yd. beyond the gates of the shrine on each side, are bast, *i.e.,* sanctuary. The shrine consists of a magnificent assemblage of buildings in addition to the sacred tomb itself: mosques, theological colleges. oratories, libraries, assembly halls. administrative offices. Of the mosques the most important was built by the queen Gowhar Shad and dedicated in 1418; for intensity and beauty of colour it is wholly unrivaled.

Meshed is important politically as well as commercially and religiously. The transit trade of Meshed to central Asia is not so great as before the construction of the Trans-Caspian railway. It is the centre of the northern wool trade and of an important rug industry. It is a nucleus of trunk roads, being joined with Tehran (566 mi.) by a good motor road; with Ashkhabad on the Trans-Caspian railway; and south with Zahidan (600 mi.) and the road to railhead of the Indian system.

Chief items of export were carpets, hides and skins, opium, timber and cotton tissues; imports were sugar, skins and hides, cotton stuffs, carpets, minerals and metals.

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MESMER, FRANZ (FRIEDRICH) **ANTON** (1734–1815), Austrian mystic and physician, inventor of the method of treatment called after him mesmerism, forerunner of the modern hypnosis (*q.v.*), was born on May 23, 1734, at Iznang, a village near Lake Constance. He studied theology and medicine at the universities of Ingolstadt (Germany) and Vienna. His interest in the teachings of Paracelsus caused Mesmer to believe that the stars influence the health and general condition of human beings by way of a subtle and invisible fluid. He became convinced that there was a healing and magnetic power in his own hands, and in 1775 he first called this force emanating from his body "animal magnetism" nhich, he believed. permeated the universe.

Mesmer had striking successes especially with hysterical patients. but he consistently believed and emphasized that his remarkable cures nere entirely natural phenomena. Conventional medical men in Vienna. honever, accused him of practising magic. and in 1778 he was finally ordered to leave Austria. He then settled in Paris. His popularity continued for several years, but doctors called Mesmer an impostor and a charlatan, and in 1784 the French government appointed a commission of physicians and scientists to investigate his activities. Benjamin Franklin was a member of this commission, nhich reported that Mesmer had indeed effected many cures but attributed them not to animal magnetism but to some as yet unknown physiological causes. The report as a whole was unsympathetic to Mesmer; he lost his flourishing practice and retired to private life in Versailles.

He lived for a time in Switzerland, but early in 1814 he moved to a village near his native Iznang. He died in 1815.

Mesmer's faith in his own cures was undoubtedly sincere. He himself never grasped the psychological and physiological implications of his treatment by animal magnetism and could not foresee the therapeutic benefits to be derived by later generations from suggestion or hypnosis. (M. Go)

MESOLITHIC. The concept of a Mesolithic period in European prehistory was first proposed by archaeologists to fill the

gap between the Paleolithic, with its chipped stone tools, and the Neolithic, which had polished stone tools. The varied tool kits assigned to the Mesolithic are based on chipped stone, often including characteristic microlithic elements which occurred only rarely in Upper (late) Paleolithic contexts. In some Mesolithic assemblages, ho ever, pecked or polished stone tools also occur. In addition a variety of antler, bone and wooden equipment such as harpoons, hafts, fish spears, dug-out canoes, bows, arrows and other implements for hunting, fowling and fishing are found.

In northwestern Europe, the type locality, the Mesolithic began with the retreat of the fourth European glacier about 8000 B.C. and lasted until about 2700 B.C. As the continent gradually warmed, the big-game animals disappeared and the people began to exploit new sources of food in the postglacial environment. Although culturally and technologically they were continuations of the earlier Paleolithic inhabitants, Mesolithic peoples developed diverse local adaptations to special environments. There was greater isolation of people because they were more settled and progress seems less spectacular than in the Upper Paleolithic, but the increasing efficiency in obtaining food from a restricted environment was of importance in cultural evolution. By 3000 B.C. the Mesolithic peoples were rapidly being absorbed by cultivators moving into Europe from the south and east.

Outside northwestern Europe there is no direct counterpart to the Mesolithic. Even in northwestern Europe there is a clearer difference between Mesolithic and Neolithic than between Upper Paleolithic and Mesolithic. Thus the term is not, as once was thought, a reflection of a world-wide sequence of events in man's past.

See also ARCHAEOLOGY: *Prehistory.* (F. A. HE.)

MESONERO ROMANOS, RAMON DE (1803–1882), Spanish prose writer, who was born in Madrid and died there, wrote the *Panorama matritense* (1835–38; title changed to *Escenas matritenses* in enlarged edition of 1842), a collection of interesting pen pictures of old-time and contemporary Madrid, and an autobiography, *Memorias de un setentón, natural y vecino de Madrid* (1880).

MESONS: *see* PARTICLES, ELEMENTARY.

MESOPOTAMIA, "the land between the rivers." namely. the Euphrates and the Tigris in western Asia. The upper courses of the two rivers, which lie in the mountains of eastern Turkey, are not included. From the foot of the mountains to the Persian gulf the term Mesopotamia is sometimes used in a wide sense to include the plain of southeastern Turkey and all. of the kingdom of Iraq (*q.v.*); sometimes it is used in a narrow sense for the northern part only. The region of Baghdad. where the two rivers come closest to each other, marks the border between the northern part. called Mesopotamia by the Romans. Al Jazirah ("the Island") by the Arabs, and the southern alluvial plain, called Babylonia by the Romans and Iraq Arabi by the Arabs. Mesopotamia in the wider sense is bordered in the north by the Turkish mountains, in the southeast by the Persian gulf, extending eastward beyond the Tigris to the Zagros range on the border of Iran and westward beyond the Euphrates to the escarpment of the Syrian desert. Mesopotamia in the narrow, or Roman, sense is "the island" between the rivers from the foot of the mountains to Baghdad only. In this article the term is used in the wide sense in the sections dealing with geography, geology and medieval and recent history; especially for the last periods of Ottoman rule no other term offers itself for the territory that later became the kingdom of Iraq. In the sections dealing with ancient history. however, the term. is used in the narrow sense, while the history of the alluvial plain is treated in the article BABYLONIA AND ASSYRIA.

(H. G. GK.)

Geography. — The northern part of Mesopotamia is a belt of stony country varying between 40 mi. and 100 mi. broad which extends as far as Hit, which stands on the site of the old coast line before the formation of the alluvial plain of the twin rivers. This alluvial plain extends southward, falling nearly 100 ft. between Baghdad and Basra. and forms the fertile basin in which grew up the ancient civilizations of Sumer and Akkad. The plain is everywhere extremely flat and has a transverse slope away from the rivers and from the Persian hills to the Tigris. This flatness and the form of the slope combined to allow perennial irrigation on a large scale and so made the ancient civilizations possible. The alluvial plain itself is of comparatively small extent, about 35,000 sq.mi., more than one-sixth the whole area of hlesopotamia.

Geology.—Mesopotamia is one of a series of great depressions which lie on the southern side of the Alpine-Himalayan mountain system and along the northern edge of the ancient plateau blocks of Africa, Arabia and India. The margins of the depression show striking contrasts. The southwestern boundary toward Syria and Arabia is marked by the emergence of basement rocks of Archean age. It is frequently faulted but slopes are normally gentle. To the north and east the surface rises abruptly to parallel ridges. the "Persian Ladder" of some early writers. These are composed of rocks mainly of Secondary and Tertiary age. On the floor of the depression are found exposures of beds from the Lower Cretaceous onward to recent alluvium which is still accumulating.

The mountain system and the depression have developed out of a geosynclinal belt as the result of pressure from central Persia toward the stable massif of Arabia. The Arabian plateau consists of an ancient crystalline rock basement (part of the old Gondwanaland continent), now largely covered by horizontally disposed sediments of later age and less resistant in character. Along the northern edge of the block there lay for a very long period, certainly from Permian times, part of the great Tethys sea. In this sea were laid down the marine sediments. largely calcareous, that were later to form the fold mountains and the floor of the Mesopotamian depression.

Pressures from the Persian side, particularly in Late Pliocene times, compressed these weakly resistant deposits and uplifted them to form the fold ranges. Since their formation and extending into Recent (geological) times they have been subject to intermittent uplift while the forward zone of subsidence (Mesopotamia) has been further depressed. The accumulation in this zone of material eroded from the adjacent mountains has probably contributed to this mo ement. Evidence of the repeated uplift of the folded zone is seen in the terraces along the river valleys leading down to the plain. Some abandoned irrigation canals show that uplift along minor anticlines within the plain is still going on and investigations in the 20th century seem to prove that general subsidence within the trough continued well into historical times. Over most of Mesopotamia the rock series rest horizontally one upon another and appear to have been little disturbed. The Jabal Sinjar and Jabal Makhul in the north are a continuation of the Syrian folds. The Jabal Hamrin and other minor folds along the eastern edge of the plain mark the approach to the mountain belt.

The succession of events leading to the present condition seems to have been as follows: the ancient Archean continent spread across the whole area from Arabia to Persia and Armenia and suffered little change throughout the Lower Paleozoic period. Downwarping in Carboniferous times led to minor transgression to the west of Iraq. Continuing during the Permian epoch this led to the formation of the Tethys sea and its extension across the whole Mesopotamian region and far beyond it. Its southern shoreline lap on the Arabian block and by the early Mesozoic its deepest waters were along a line somewhat to the east of the present Zagros ranges. Folding in the Zagros began in Rliddle Cretaceous times hut had little effect in Iraq. Thick Upper Cretaceous limestones are exposed near Anah on the Euphrates. Heavy sedimentation went on with little disturbance during the early Tertiary. The Middle Eocene saw further marine transgression followed by the deposition of a nummulitic limestone. The Oligocene was at first a period of marine retreat during which some terrestrial deposits were laid down. Soon, however, the sea spread once more and subsidence in the Mesopotamian zone accompanied heavy folding to the east. The 1.000-it.-thick Asmari limestone. the main oil-hearing series in the southeast of the plain, is of Oligocene-Miocene age. The Lower Fars series, including shales with salt and anhydrite beds all of Miocene age, forms the cap rock above the Asmari series. Folding continued with increasing severity during the Pliocene, creating the main eastern ranges and

leaving the Mesopotamian region as a zone of weakness between them and the Arabian block. Later, widespread uplifts raised the mountain belt still higher and caused the retreat of the sea far to the southeast. The last great event in the history of the region was probably an advance northward of the head of the gulf as a result of the rise in oceanic levels following the melting of the northern ice fields as the Ice Age came to an end.

Mesopotamia today includes two strongly contrasting regions with their dividing line running approximately northeast and southwest through Baghdad. Upper Mesopotamia is mainly dry steppe country across which the Euphrates and the Tigris flow in deeply incised channels, evidently the result of rejuvenation caused by repeated subsidence in the lower plain. The area between the two rivers, known as the Jazirah, is a low undulating plateau with many enclosed basins of which the Wadi Tharthar is the most notable. Surface rocks are mainly Miocene with some Cretaceous to the west along the Euphrates. The Jabal Sinjar has a capping of basalt over gently folded Miocene. The Jabal Hamrin east of the Tigris separates the Jazirah from Assyria, an area of enclosed valleys separated by fold ridges which increase in height to the east. Pliocene conglomerates and sandstones are common and some of the more northwesterly ridges are basalt capped. Lava beds occur widely along the Tigris north of Mosul.

Lower Mesopotamia is an area of marshes interspersed with occasional areas of dried mud or sandy desert. Lake and marsh together cover about 1,500 sq.mi. The western boundary of this vast alluvium-covered area runs roughly parallel to the Euphrates course from Ramadi to Hawr al Hammar at 10 to 20 mi. W. of the river. Along the Tigris it reaches to more than 100 mi. N. of Baghdad and to 75 mi. E. of that city. Thicknesses of more than 90 ft. have been proved near Basra. All this material must have been derived from the erosion of neighbouring land surfaces—a little as wind-blown sand and dust from the deserts to the west, much of a coarser kind washed down from the eastern hills, but most brought by the Euphrates and Tigris during their frequent floods. At Ramadi the Euphrates has an average silt content of jj3 g. per cubic metre, the Tigris at Baghdad 787 g., while the Karun is estimated to bring down more than 1,000,000 cu.yd. each year.

Perhaps the most interesting geological question concerning the alluvial plain is the supposed growth of the delta region. It was long believed that the head of the Persian gulf near the beginning of historical times lay northwest of Baghdad and that it had retreated to its present position as the result of normal delta growth at the mouths of the inflowing rivers. Supposed identifications of places mentioned in early historical documents seemed to support this idea of the simple infilling of the upper gulf. The French geologist J. de Morgan in 1900 suggested that the delta of the Karkheh and Karun grew across the gulf and thus cut off a lagoon into which the Euphrates and Tigris flowed. The Hawr al Hammar would thus be a relic of this lagoon. Sir A. T. Wilson later suggested that heavy material brought down from the Arabian plateau by the Batin during a rainy interval in the Ice Age combined nith the silt of the Karun to form the barrier which created the lacustrine area.

Boring and other investigations in the search for oil in the coastal areas have produced much new evidence which led G. M. Lees and N. L. Falcon to point out in 1952 that "the older archaeological theories are based on an unjustifiably simple assumption." This was that the rivers were building their deltas on a stable platform. Had this been so they should have filled the lakes and marshes long ago and the coasts should have advanced far more rapidly than they have. The new evidence suggests rather that the floor of the geosynclinal trough has continued to subside intermittently, though in recent times sedimentation has just about kept pace with its sinking. (T. HER.)

Ancient Geography.— In most countries there is little change in the position of inhabited sites: which continue over long periods either on the same spot or on one nearby. In Mesopotamia, on the other hand. much of the desert is strewn with the ruins of ancient cities where now only an occasional shepherd is to be found. The reason for these changes is not always apparent, but usually three causes appear to have operated. There may have been a change of climate, the rivers may have altered their positions or their mouths, or in some cases political events may have triumphed over geographical situation. Whether or not there has been a change in climate in Mesopotamia since ancient times has been disputed. There is no doubt that in Upper Paleolithic times the Syrian desert was sufficiently humid for permanent settlement, and L. H. D. Buxton found numerous traces of Paleolithic implements in districts now inhabited only by wandering Bedouins. There were even some traces of Neolithic peoples. In Mesopotamia itself we have no evidence before Sumerian times, since when, most writers maintain, there is no evidence of any change of climate. Sir William Willcocks thought the ancient canals were not in use at the same time and that the presence of all these waterways is not therefore evidence of a progressive desiccation. In the neighbourhood of Babylon and Kish where canals are particularly numerous a study of levels showed that there at least Willcocks' statement was abundantly justified. Thus, the change in the siting of ancient cities was not caused by a change in climate. Second, there can be no reasonable doubt regarding the change in the position of the rivers, for both the Tigris and Euphrates have shifted their courses since ancient times. All the cities of Babylonia have therefore been left without water. Apart from Borsippa, the only ancient city on the river is Babylon, itself a relatively modern town which took the place of Kish, 1j mi. away, when a change in the river made that site no longer usable. It may seem difficult to understand, if there has been no change in the climate, how regions which are now desolate could once have been the site of prosperous cities. A study of the hydrography of ancient Mesopotamia will, however, explain this change. First, the course of the old bed of the Euphrates, the river on which ancient Mesopotamia depended chiefly for its water supply, has changed its place very considerably. The modern stream runs 10 mi. E. of its ancient course, and in places more. Ancient Babylonia was therefore much smaller than modern Iraq. Apart from minor divergencies that have not yet been fully explored, the Euphrates divided into two branches almost due west of where Baghdad now stands. One branch ran past Sippar and Kutha and the other followed the course of the present stream as far as Babylon, where it turned east and ran slightly north of but in the same general direction as the modern Shakah al Hadith past Kish and Nippur. Lower it divided again, the western branch being in the general direction of the modern Shatt al Kar past the cities of Kisurra and Shuruppak and the more easterly branch running past the modern Bismayah, the ancient Adab, in a southeasterly direction till it was joined by the Shatt al Gharraf, which communicates with the Tigris. From this point onward its general direction was south, past the ancient city of Lagash. The true Mesopotamia, therefore, the region between the rivers as opposed to the lower marshes of both streams, was much narrower. Of all the ancient cities in Akkad, the northern part of the alluvial plain, only Borsippa lay away from this narron- strip and Borsippa was close at hand. In these circumstances it is clear that to a large extent the alteration in Mesopotamia has been the conversion of fertile land into desert and poor steppe in the central region, while on the western boundary the converse has taken place. But this movement of the rivers is not sufficient to explain the whole of the changes. In ancient times, when the strip was narrower, irrigation was comparatively easy. The normal method has always been to dig canals from one river to the other. When the Tigris was nearer at hand it mas easier to ensure a more ready flow of water through the canals. It is also abundantly clear from an examination of the ancient canals that great difficulty nas found in keeping them in proper condition. Further, unless conditions are very favourable and the water used for irrigation is kept very dilute from certain salt solutions. the irrigated land becomes very hard and impermeable. By itself the mere hardening of the land may not have been sufficient in ancient times to have converted cultivated land into desert. but it probably played its part. The increasing distance of the rivers and the consequent difficulty of irrigation has aluays been felt. Ancient Akkad consisted of a narrow strip of cultivated soil, bounded throughout much of its

length by a river or canal on both sides, not. as today, a narrow strip along the Euphrates with desert to the west and a further strip of desert to the east, between the fertile lands and the Tigris.

In Sumer, as the southern part of the alluvial plain was called. the changes were even greater. There also the country was much smaller. Pliny, writing in the 1st century A.D., says that the Euphrates had in ancient times its own mouth, but that the men of Erech dammed it up, possibly, as Sir A. T. Wilson suggests, to irrigate the rich land near Suq ash Shuyukh. Before the time of Rim-Sin the Euphrates ran west of Ur, reaching open water near Eridu. This region is the only part of its course which in ancient times was more westerly than at present. but Ur is today only a little way from the stream. Rim-Sin straightened the course of the river so that it passed by Ur and left Eridu a waterless city. There in ancient times Mesopotamia ended. It seems probable that both Eridu and Lagash were in ancient times on the edge of the sea and that they were closely connected because of the ease of communications. The progressive silting up of this region and the action of Rim-Sin and his successors left both cities in the desert, and today the river runs east of Ur. while Erech, which, in the opinion of ancient geographers was the cause of all the trouble, lies away in the waterless desert. Southeast all the lands to Basra and the rich palm groves and marshes of modern Iraq were as yet to be. We do not know exactly where the true coast line was in ancient times. but for all practical purposes Eridu marked the southernmost extension.

All these changes have been progressive; the Euphrates had ceased to flow past Kutha and Kish long before our era. Eridu was an inland city nearly 4.000 years ago, and unless steps are taken the Euphrates threatens to run still farther to the west. The changing course of the rivers is the result partly of natural causes and partly of methods of irrigation.

In spite of these progressive changes. however. most of the ancient sites do show evidence of continued occupation, at or near the spot where the ancient city stood. The Mongol invasion probably accomplished more in a few years than the hand of nature or the irrigation projects of ancient kings did in many centuries. In 1258 Hulagu Khan, a grandson of the great Jenghiz, sacked Baghdad, and the invasion of the Mongols destroyed all the ancient irrigation systems and converted Mesopotamia into a desert. Many of the old towns had long ago ceased to exist but on many of the sites there are traces of continued occupation. The towns which gre up after the Mongol invasion have survived until today and mark the contrast between ancient and modern Mesopotamia.

The distribution of ancient cities in Mesopotamia is therefore extremely different from that of modern times. They fall into four groups: those of the northern foothills, the Assyrian group and the cities of Akkad and Sumer; all except the last two groups are widely separated from one another. In ancient times there were hardly any cities of importance on the middle Euphrates and, as today, few of any note on the lower Tigris. The foothill towns of the north, including such cities as Samosata. Edessa and Nisibis, were never of any great political importance except for their strategic value as border forts. Gsually small in size, they commanded various entrances between the plains and the mountains and passed from one hand to another, being used against the plain or against the mountains according to the position of the dominant power. This line of towns was also of value as it still is because of the fact that it commands the upper and easier route from east to west. Edessa and Nisibis, therefore. have played for a long time the dual role of forts in times of war and of entrepôts on a main caravan route in times of peace. The second group of cities lies within the fertile triangle of land between the Tigris and the Greater Zab. It has always been a region of red earth and great fertility and is remarkable for the closeness of occupation in ancient times. To the north of the triangle, just below the mountains, lay the city of Khorsabad. which has been generally accepted as being the site of Dur-Sharrukin, Sargon's city. Nineveh itself lay on the Tigris opposite the modern city of Mosul and about 40 mi. above the confluence of the Greater Zab. Farther south, but still in the triangle, lay Calah (Kalakh), the modern Nimrud. The other cities of the group are more isolated. Ashur or Assur lies down the Tigris. about 60 mi. from Nineveh and separated from it by desert, an easy journey downstream but more difficult upstream. The last city is Arbela, today Irbil. This is a foothill town of considerable importance lying almost due east of Calah and south of the Zab river. Of these cities it is interesting to note that three, Nineveh, Assur and Arbela, are close to if not on the same site as a modern town. The foothill towns also have not moved. In lower Mesopotamia the towns are practically all on different sites.

Down the Tigris from Assur there are no important ancient towns till the old glacial shoreline is reached and the true alluvial valley begins. There are the first traces of ancient irrigation. The site of Opis. Upe, is probably on the Tigris close to its juncture with the Uzaym. Apart from the site of Baghdad, which has always been an important centre, and Ctesiphon, a little lower down the river, the ancient cities from this point onward lay on the old bed of the Euphrates. The most northerly of these cities is Sippar, probably on the actual edge of the glacial shoreline and 5 mi. from the present bed of the Euphrates. From this point onward the traveler who abandons the modern river and passes along the old bed of the stream and the canals which have succeeded it will find a continuous string of imposing mounds in what is today a bare and monotonous plain, fringed along the western horizon by the palm trees which mark the course of the Euphrates. South of Sippar lay Agade, the city whose name is associated with that of Sargon. Kutha lay on the canal of Kutha, which may in ancient times have been one of the branches of the river. Below Kutha again, on what is today the Shakah al Hadith, but which in ancient times was certainly the main stream, lay the great city of Kish. Fifteen miles westward of Kish are the ruins of Babylon. These are today close to the Hillah branch of the Euphrates, and since the foundation of the city it has always been on the river. It is from this point onward that the main contrasts between ancient and modern Mesopotamia begin. When the river changed its course and flowed south past Babylon it deserted a whole line of ancient riparian cities, and today there are only two ancient cities west of the modern course of the Euphrates, Borsippa, close to Babylon, and Ur, far to the south. The modern Shakah al Hadith and the Shatt al Kar follow more or less the course of the ancient stream. Nippur lay south of Kish on the main river. Below Eridu there is only one ancient site, near Suq ash Shuyukh, and all the modern marshland was nonexistent. It is probable that southern Sumer consisted of a series of lakes and that much of what is now marshland was open water, although higher up the stream it is probable that marshes were still in existence. Otherwise the scenery of ancient Mesopotamia was probably not very different from what it is today, except for the alteration in position of the cities. Akkad, the northern alluvial plain, had the ,same steppe, the same fringing gallery of palms along the river, but this fringing gallery was at Kish and Nippur not at Hillah and Diwaniyah. Where there are modern towns on the river there was desert or steppe, just as today the ancient cities are mere mounds, waterless and bare. Southern Mesopotamia, Sumer, has altered considerably; most of the lakes have filled up, though they may recall their ancient form in floodtime. The lakes have been succeeded by marshes and though some of these survive many have been transformed into steppe and desert. In each of the three areas there has always been a dominant town, shifting under the change of the rivers; in Assyria, Mosul is the direct descendant of ancient Nineveh and the site is almost the same. In Akkad the changes have been greater; the oldest paramount town is Kish. Agade was only temporarily important, and the hegemony shifted to Babylon and across the narrow neck of land to Seleucia and Ctesiphon on the Tigris, and later to Baghdad, itself on an ancient site. In the south the changes have been greater. Larsa and Ur have ceased to hold dominating geographical positions, and the outlet of southern Mesopotamia passed under the caliphs to Basra nearer to the Persian gulf. The true geographical history of Mesopotamia has a clear cut at the invasion of the Mongols, and from this point begins the study of the modern cities. (L. H. D. B.; X.)

HISTORY

PRECLASSICAL TIMES

The great political powers that determined the history of Mesopotamia were Babylonia in the south and Assyria in the north *(see* BABYLONIA AND ASSYRIA: *History).* Therefore most of the sources for the history of Mesopotamia (in the narrow sense) come from Babylonian and Assyrian centres.

Prehistoric Periods.—In the 4th millennium B.C. the village cultures of the Hassuna and Tall Halaf periods extended over all of northern Mesopotamia *(see* ARCHAEOLOGY: *Prehistory: Civilization; Egypt and Western Asia: Mesopotamia).* The culture named after the type site of Samarra, on the Tigris north of Baghdad, which overlaps in time with the Hassuna and Tall Halaf periods, was restricted to the middle Tigris and middle Euphrates regions. Both the Samarra and the Tall Halaf cultures excelled in their elaborately painted pottery.

In the period following Tall Halaf, *i.e.,* in the latter part of the 4th millennium B.C., Mesopotamia shared with Babylonia the culture known as Ubaid, though local differences between northern and southern Ubaid existed. Northern Ubaid furnished the first example of the type of temple that remained dominant through the ages: a temple excavated at Tepe Gawra, northeast of Mosul, is the oldest known building whose walls were decorated with pilasters and recesses.

The great step from village culture to high civilization was made in Babylonia in the period called Protoliterate, when the Sumerians arrived toward the end of the 4th millennium. In north Mesopotamia, however, the culture called Gawran, which in time corresponds to the southern Protoliterate period, shows little change, although the so-called Eye temple of Tall Brak (northwest of Mosul) is similar to southern buildings.

Ancient Ethnography.—Nothing is known of the ethnic background of the prehistoric cultures of the Hassuna. Samarra, Tall Halaf and Ubaid periods. Whether the Eye temple of Tall Brak testifies to the presence of Sumerians that far north, or may be explained by cultural influence from the south, is an open question. In historical times Mesopotamia. which is open to the Syrian desert, saw a constant influx of Semitic-speaking nomads from the Arabian peninsula: the earliest inscriptions in the Semitic Akkadian language found at Mari (Tall Hariri on the middle Euphrates) belong to the Early Dynastic period (middle of 3rd millennium B.C.). About the same time Semites were also present in Babylonia, where they soon (about 2350 B.C.) established the dynasty of Akkad. During the early part of the 2nd millennium a new group of tribes, speaking a language of the western Semitic type known as Canaanite. is found all over Mesopotamia. In the 12th century it is the Aramaeans who constitute a new Semitic element, and beginning with the 9th century Arabs appear on the scene.

The Assyrians, who centred around the Mosul region, spoke a dialect of Akkadian and shared in the high civilization of Babylonia. How early they settled in Assyria and adopted a sedentary way of life is unknown; from before 2000 to 600 B.C. the Assyrians were clearly distinct from the above-mentioned Semitic nomads. although their Akkadian language belongs to the Semitic family of languages.

Apart from these Semites, a non-Semitic people is found in Mesopotamia from the late 3rd to the middle of the 2nd millennium B.C., the Hurrians. Their language is not related to any known linguistic group. Around 1500 Hurrians under Aryan dynasties established kingdoms in north Mesopotamia, the most important of which was the kingdom of Mitanni. After 1200 the Hurrians were either absorbed by the Aramaeans or retreated into the Armenian mountains, where a language akin to Hurrian was then spoken in the kingdom of Urartu.

Early History.—After the Sumerian king Lugalzaggesi, who founded the first empire including Mesopotamia by marching along the Tigris and Euphrates to the "upper sea" (the Mediterranean), it was Sargon of Akkad (about 2350 B.C.) who extended his own empire over the same area. Sargon's grandson. Naramsin, built a palace at Tall Brak, and a stele of his was found near Diyarbekir. The empire of the 3rd dynasty of Ur (about 2130–2030) included Assyria, where governors of the kings of Ur were installed. When the kingdom of Ur collapsed, Assur seems to have become independent. The earliest historical kings of Assyria fall roughly into the middle of the period of the dynasties of Isin and Larsa (about 1900). When in the 19th century B.C. Assyrian trade colonies flourished in Anatolia, the trade routes from Assur along the upper Tigris and across Mesopotamia to the upper Euphrates must have been safe.

Western Semites.—Before 1800 B.C. Assyria suffered a setback. and the Anatolian trade came to an end. About that time speakers of a west Semitic language were established on the middle Euphrates. Most information comes from Mari (Tall Hariri). There ruled a dynasty of local kings with west Semitic names such as Yagit-Lim and Yakhdun-Lim. The records were written in Akkadian, but many west Semitic idioms in the texts, as well as the proper names of individuals. show that the majority of the people belonged to the newcomers. People of the same stock entered Babylonia somewhat earlier (about 1900), where they seized power in Isin and Larsa and founded the new kingdom of Babylon.

Around 1820 B.C. Shamshi-Adad, a man of west Semitic origin, was able to build up a large kingdom in Mesopotamia. Early in his career he spent some time in Babylon. He then turned north, conquered Assur, where he made himself king, and Mari, where he installed his second son. Yasmakh-Adad, as viceroy. Although Shamshi-Adad ruled over Assur and erected some buildings there, he had other residences beside it; one of them, called Shubat-Enlil, may be the site of Tall Chagar Bazar in the Khabur region of northern Mesopotamia. The last ten years of Shamshi-Adad coincide with the first ten of the great Hammurabi of Babylon, who began his northward expansion immediately after Shamshi-Adad's death. In Mari, Yasmakh-Adad was driven out and replaced by Zimri-Lim, an offspring of the old local dynasty. Hammurabi used Zimri-Lim as a figure in his political game which ended by the conquest of Mari (about 1770). The bulk of the Mari archives belongs to the reign of Zimri-Lim. In these documents various small kingdoms of Mesopotamia are mentioned in connection with campaigns of Hammurabi of Babylon, Ishme-Dagan of Assur and others. Not enough was known by the late 1950s to give a detailed historical account. It seems clear, however, that Ishme-Dagan himself finally came under the overlordship of Hammurabi, so that toward the end of latter's reign the kingdom of Babel held not only all of Babylonia proper but also the middle Euphrates valley and Assyria.

From the Mari documents something is learned also about the nomadic tribes with whom Zimri-Lim and his officials had to deal. Repeated inroads of nomads upon the cultivated land occurred. Some tribes were already sedentary at the time. others were leading a nomadic life, and the king of Mari tried various methods of pacifying them and. occasionally, of securing their military help. Several tribal names appear. The Hanaeans seem to have been settled around the town of Hana upstream from Mari. The names Amorites and Sutaeans (*Amurrû, Sutû*) seem to be more general designations for nomads, but there is no clear evidence that *Amurrû* was a general term for all western Semites, as the name "Amorites," introduced for them by some writers, would imply. A large nomadic tribe, divided into several subtribes, is called "the sons of the south," written with the word sign for "sons" followed by the Canaanite word *yamina* "south." If the sign for "sons" is also read in Canaanite, the name is *Banu-yamina,* and the similarity of this name with that of the Israelite tribe of Benjamin has been much discussed. The question as to whether the biblical Benjaminites are part of the same tribe as the *Banu-yamina* of Mari, or whether different tribes were only called "southerners" by their neighbours, is still unsolved, though caution would argue in favour of the second alternative. Parts of the large tribe of the "sons of the south" actually appeared in the south; *i.e.,* in Babylonia; the majority of the tribe. however, must have kept the name "southerners" as a tribal name in spite of wide wanderings, since the king of Mari had to deal with them not only around his capital but also in the northern part of Mesopotamia.

Kassites.—During the reigns of Hammurabi's successors the Babylonian kingdom lost its power and many of its territories.

Assyria became an independent kingdom again, and a new people, the Kassites (*Kashshû*) appeared on the scene. Several of the Babylonian kings after Hammurabi had to fight the Kassites in Mesopotamia. Toward the end of the Babylonian dynasty the Kassites ruled over Hana on the middle Euphrates. In Babylonia proper, the Kassites seized power after the downfall of the Babylonian dynasty (about 1600 B.C. according to the chronology adopted here; see BABYLONIA AND ASSYRIA: History: Middle Period: Chronology).

Hurrians and Aryans. — Already in the latter part of the Akkad period (about 2200 B.C.) a Hurrian ruler, Tish-Adal of Urkish, is known from north Mesopotamia. In the Mari archives some Hurrian texts were found, which show that this language mas spoken there in the Hammurabi period. About two generations before the fall of Babylon (about 1650) Hurrians lived in the plain of Antioch and other parts of north Syria. After the dark period following the fall of Babylon. they had spread all over Syria and Mesopotamia. At this time, about 1500, a small number of Aryans were associated vith them. These Aryans, speaking the language known from India and venerating some Vedic gods (Indra, Varuna, Mitra and the Nasatyas) must be regarded as members of those Aryan tribes that later settled in India. but they must have left the main tribes on the way and settled in Mesopotamia instead. They soon became the ruling class among the Hurrians; individual Aryans became kings of small states in Syria. and in Mesopotamia they founded several kingdoms. one of which was called Hurri. while another was known as Mitanni.

The Mitanni kingdom, which existed from about 1500 to about 1360 B.C., had its centre in the Khabur region of north Mesopotamia. It extended westward to the Mediterranean sea where Mukish with its capital Alalakh (Atshana) in the plain of Antioch was one of its vassals. Eastward it reached as far as Kirkuk near the Persian border; Kirkuk itself, called Arrapkha in antiquity. was the centre of a vassal kingdom which included Nuzi (Uorghan Tepe). Assyria. which lay between the Khabur and Kirkuk. must also have been part of the Mitanni empire, and there are some indications that it was under Mitannian suzerainty indeed, although the Assyrians themselves only kept the memory of an unbroken sequence of Assyrian kings. The Mitanni kingdom was organized on the basis of feudalism. Under the Aryan dynasty there existed vassals and a class of noblemen, called *mariannu,* who were chariot warriors. According to their proper names, both Aryans and Hurrians belonged to this nobility

Since Washukanni, the capital of the Mitanni kingdom, had not been found by the late 1950s, the sources for the history of that kingdom come either from such peripheral sites as Alalakh and Nuzi or from neighbouring countries, mainly Egypt and the Hittite kingdom. Several generations of Mitanni kings are knonn. The most outstanding ruler was Saushatar (about 1480 B.C.). He was the overlord of both Nuzi and Alalakh and is said to have looted the palace in Assur. The Syrian campaigns of the Egyptian king Tuthmosis III, who crossed the Euphrates and conquered part of Naharina "(the land of) the two rivers." should be dated after the reign of Saushatar. Thereafter, however. the two countries were on friendly terms. as is shown by the fact that several Mitanni princesses were married to Egyptian kings: a daughter of Saushatar's successor, Artatama, to Tuthmosis IV; Gilu-Khepa, the daughter of the next king, Shutarna II, to Amenhotep III; and Tadu-khepa, daughter of Tushratta, became the wife first of the same Pharaoh and later of his son, Amenhotep IV (Ikhnaton), from whose archive, the so-called Tall al Amarna letters, this information comes.

Tushratta was the last independent king of Mitanni. In the north, the Hittite king Suppiluliuma, who led his country to new power after a period of weakness, became his most formidable enemy. Suppiluliuma took advantage of the rivalry between Tushratta of Mitanni and Artatama of Hurri by allying himself with the latter. A first campaign against Tushratta was unsuccessful. In a second campaign, Suppiluliuma descended to the Khabur region from the north, looted Washukanni, while Tushratta avoided a battle, and conquered most of Syria as far as Damascus and the Lebanon. When Tushratta was killed by one of his sons shortly after the accession of Amenhotep IV. dynastic struggles broke out between Hurri and Mitanni and went on for some time.

In the year (1362) of the death of Tutenkhamon of Egypt. Suppiluliuma conquered Carchemish on the Euphrates and installed his son Piyassili as viceroy of that country. Thereafter he was approached by Mattiwaza, a son of Tushratta, to help him against Shutarna of Hurri, who had driven him from his country. Suppiluliuma sent Piyassili of Carchemish to lead him back to his capital. and after a victory over Shutarna. Mattiwaza was married to Suppiluliuma's daughter and made a Hittite vassal as ruler of Mitanni. From then on the region which had been Mitanni was part of the Hittite empire; it was now mostly called Hanigalbat.

Soon. however, Assyria rose to power and became a dangerous neighbour of the Hittites. Adadnirari I of Assyria (about 1305–1273 B.C.) twice conquered Hanigalbat: at first he made the local ruler, Shatuara I, tributary. Shatuara's son, Wasashata, revolted and turned to the Hittites, but lost his life when Adadnirari reconquered his country and laid it waste. After the death of Adadnirari, Hanigalbat was lost to the Assyrians once more, so that Shalmaneser I (about 1273–43) had to reconquer it. He defeated not only Shatuara II of Hanigalbat but also the Hittites who helped the latter; he turned the whole territory east of the Euphrates into an Assyrian province. Also under his son, Tukulti-Ninurta I (about 1243–06), Mesopotamia remained part of the Assyrian empire.

Aramaeans.—Under Tukulti-Ninurta's successors, Assyria suffered a setback, while in Mesopotamia Aramaeans appeared for the first time. Tiglath-pileser I (about 1114–1074 B.C.), who restored Assyria to its old power, defeated some Aramaean tribes in Mesopotamia and extended his campaigns into southeastern Turkey and to the Mediterranean coast. After him, however, Assyria declined again, and during this period the Aramaeans must have established themselves firmly in Mesopotamia and parts of Syria. During the 10th century B.C. they occupied many of the formerly Hittite small states of Syria, and when, around 900, Assyrian kings began a new expansion, they had to fight Aramaeans on the western border of Assyria and on the middle Euphrates, where they conquered the Xramaean kingdom of Laqê. The site of Tall Halaf, near the sources of the Khabur, then called Guzana (Gozan), was the seat of another Aramaean kingdom, one of whose rulers, Kapara, decorated his palace with elaborate reliefs and statues (10th or 9th century B.C.). Afterward Guzana became an Assyrian province. Still another Aramaean state. Bit Adini with the capital Til Barsib (Tall Ahmar) on the Euphrates south of Carchemish, was conquered and turned into an Assyrian province by Shalmaneser III in 856.

Assyrian and Neo-Babylonian Periods. — Mesopotamia remained part of the Assyrian empire until its end. The policy of deporting the entire population of conquered territories must have affected Mesopotamia as well as other parts of the near east. An Aramaean element also entered Assyria proper, where Aramaean writing appeared during the period of the Assyrian empire. The rise to power of the Chaldeans. an Aramaean tribe that had settled in southern Babylonia and in 626 established the Neo-Babylonian dynasty. contributed to the downfall of Assyria. When Nineveh was conquered in 612 by Nabopolassar of Babylon and Cyaxares of Media, the last Assyrian king tried to hold out in Harran in Mesopotamia but was defeated there too, despite the help he got from Egypt. The battle of Carchemish (605 B.C.), in which the Babylonian crown prince, Nebuchadnezzar, defeated Pharaoh Nechoh (or Niku), put an end to the Egyptian attempt at controlling Mesopotamia. The Assyrian empire was divided between Media and Babylonia. but the exact frontier between the two kingdoms in Mesopotamia is not known. Harran was held by the Medes at first. When Cyrus the Great by his victory over Astyages put an end to the Median kingdom, Nabonidus of Babylon was able to seize Harran, where he built a new temple to the moon-god. The cult of this god flourished in Harran from at least the 9th century B.C. into the Christian era. With the conquest of Babylon in 539 Cyrus gained all of the Neo-Babylonian kingdom, and Mesopotamia became part of the Persian empire. Little is known about Mesopotamia under Achaemenid rule, not

even to which of the satrapies of the kingdom it belonged. It remained in the Persian empire until the time of Alexander the Great. (H. G. GK.)

SELEUCIDS, PARTHIANS AND ROMANS

Hellenism.—What would have happened had Alexander lived we can only guess. Under the Seleucids Babylon was moved across the plain to Seleucia, but before long the central authority was transferred to the other side of Mesopotamia, Antioch or elsewhere. It is improbable that cuneiform and the Babylonian language continued to be used in Mesopotamia during the Hellenistic period, as it did in Babylonia, where it was certainly written as late as the last century B.C., and was still used as a learned language till the first Christian century. Unfortunately there are no native documents from the pre-Christian Hellenistic period. That the Hellenizing process went as far as it did in Syria is unlikely, and even there Aramaic remained the language of the people, even in the towns (cf. EDESSA). Still, Greek influence was considerable. This would be mainly in the towns, the growth of which was quite a feature of the Macedonian rule in Mesopotamia (Pliny vi, 30, § 117). This is seen in the Greek names which now appear: such are Seleucia opposite Samosata, Apamea (=Birijik) opposite Zeugma, Hierapolis (=Membij), Europus, Nicatoris, Amphipolis (=Thapsacus, or near it), Nicephorium (Rakkah), Zenodotium (stormed by Crassus), all on or by the Euphrates; Edessa on the upper waters of the Balikh, Ichnae (perhaps Khnes, above the junction of the Qaramuch with the Balikh). These are all in the Osroene district; but Nisibis (Nasibin) became an Antioch, and as its district was known as Mygdonia (from Macedon) there were doubtless many other Greek settlements. To a lesser extent the same influences would be at work in towns called even by western writers by their real names, such as Batnae, Carrhae (Harran) and Resaena.

Mesopotamia naturally had its share of suffering in the struggles that disturbed the time, when Eumenes or Seleucus traversed it or wintered there. It was invaded and temporarily annexed in 24j by Ptolemy III Euergetes in his rapid expedition to beyond the Tigris. When Molon revolted on the accession of the youthful Antiochus III (224 B.C.) he entered Mesopotamia from the south. Antiochus skirted the northern highlands by way of Nisibis. In Mesopotamia a large part of the army of Antiochus VII Sidetes was destroyed in 130 B.C., and the Syrian kings did not again seriously attempt to assert their rule beyond the Euphrates. When Phraates II turned the Scythians against himself. however, even Mesopotamia suffered from the plunderers (*Joh.* Antioch., in Miiller iv, 561). The immigration of Arabs must have been going on for long. About this time they even founded a dynasty in Aramaean Osroene (see EDESSA).

Parthian Period.—Under Mithridates II Mesopotamia was a definite part of the Parthian empire, of which the Euphrates became the western boundary; but in 92 B.C. on that river his ambassador met Sulla, though the long duel did not begin immediatelv.

It was perhaps a Parthian governor of Mesopotamia who was called in to help Straton of Beroea against Demetrius III; but before long Mesopotamia (especially the district of Nisibis) was attached to the growing dominions of Armenia under its ambitious king Tigranes, perhaps with the consent of Sanatruces (Sinatruces). The lost territory, however, was recovered by Phraates III, and Mesopotamia was guaranteed to Parthia by the treaties of Lucullus and Pompey (66 B.C.). It was traversed. however, several times by Roman troops crossing from Armenia to Syria, and Parthia's declaration of war against Armenia involved it with Rome. Gabinius crossed the Euphrates (54); but the command was assumed by Crassus, who. though he seized Ichnae, etc., and Nicephorium, fell near Carrhae (53), and the Parthian dominion was confirmed. The tragedy of the ides of March saved Mesopotamia and the east from a great campaign by Julius Caesar. and it was at the hands of Ventidius Bassus, and west of the Euphrates, at Gindarus (northeast of Antioch), that the Parthians received the check that put an end to any real rivalry with Rome. Mesopotamia narrowly escaped being the scene of the struggle when Marcus Antonius in 36 finally decided to make his disastrous attempt against Phraates IV by way of Armenia. In A.D. 36 Tiridates found support in his attempt to secure the throne of Artabanus III in Mesopotamia, and it was there that he saw his army melt away. The expedition against Rome of Vologaeses I (*q.v.*) of A.D. 62 reached no farther westward than Nisibis, and in 66 a peaceable arrangement was made. Of the half-century that preceded Trajan's great oriental undertaking not much is known. When in 11j Trajan entered Mesopotamia from the north no serious resistance was offered, and it became a province as far as Singara. The woods at Nisibis, the headquarters, provided material for the boats with which in 116 he crossed the Tigris. Hatra, an interesting fortress uhich seems to have been Aramaean, fell, and the army advanced to Hit, where it found the fleet that was subsequently transferred to the Tigris. For the revolt that occurred while Trajan was on the Persian gulf, in which the Jews had an important hand, Nisibis and Edessa suffered capture and destruction. Hatra successfully withstood siege, however, and Hadrian abandoned Mesopotamia, setting the boundary at the Euphrates. Again for half a century there is not much to relate. Then, mhen Vologaeses III, yielding to his growing discontent, took advantage of the death of Antoninus to invade Armenia, the Romans were victorious (164), and after the storming of places such as Nicephorium, Edessa and Nisibis, western Mesopotamia was once more Roinan as far as the Khabur, Carrhae becoming a free city and Osroene a dependency.

By this time Christianity had secured a foothold, perhaps first among the Jews, and we enter upon the earliest period from which documents in the Edessan dialect of Aramaic, known as Syriac, have been preserved. Unfortunately they contain practically nothing that is not of Christian origin [1] On the death of Aurelius, Hatra aided Niger against Septimius Severus in 194; Osroene rose against Rome, and Nisibis was besieged and other Roman places taken; but Septimius Severus appeared in person (195), and from Nisibis as headquarters subdued the whole country. of which he made Nisibis metropolis, raising it to the rank of a colony, the Sinjar district, where Arabs from Yemen had settled, being incorporated. On his retiring, everything was undone, only Nisibis holding out, but on his reappearance in 198 the Parthians withdrew. Again the Euphrates bore a Roman fleet. Hatra. however, was besieged twice in vain. Peace then prevailed till Caracalla's unprovoked attack on Parthia in 216, after he had reduced Osroene to a province. On his assassination near Carrhae (217), Macrinus was defeated at Nisibis and had to purchase peace, though he retained Roman Mesopotamia, reinstating the princely house in Osroene.

THE SASSANIAN PERIOD

Ardashir's power was rising when the Parthian Artabanus died in 224 (227), and Ardashir proposed to prove himself the successor of the Achaemenids. Hatra resisted the first Persian attack as it had resisted Rome, but Mesopotamia mas overrun, Nisibis and Carrhae being taken (233). It was immediately, indeed, recovered by Alexander Severus, and retained, whatever was the precise success of the war; but Nisibis and Carrhae were retaken by the Persians in the reign of Maximin. Under Gordian III in 242 Mesopotamia was entered by a great Roman army which recovered Carrhae and Nisibis and defeated the Persians at Resaena; but when Gordian after a difficult march down the Khabur was murdered at Zaitha below Circesium, Philip the Arabian (244) made the best terms he could with Shapur I. Whatever they were, the Roman garrisons seem not to have been really withdrawn. A rest for Mesopotamia seems to have followed; but in 258 Shapur, tempted by the troubles in the Roman empire, overran the country, taking Nisibis and Carrhae and investing Edessa. and when Valerian invaded Mesopotamia he was eventually made prisoner near Edessa (260). After Shapur's cruel victories in Syria, however, he was defeated by Odaenathus, who relieved Edessa, and Mesopotamia became for ten years practically part of an Arabian empire (see PALMYRA), as it was to be

[1] The earliest inscription in Syriac yet known dates from A.D. 77, and was found at Serrin (opposite Kal'at en-Najm) by M. A. S. von Oppenheim.

four centuries later. In consequence of the revolt of Zenobia, Mesopotamia was lost to Rome and the Euphrates became the frontier. Aurelian overthrew the Palmyrene rule, but he was assassinated before he could carry out his intended expedition against Persia; Probus was assassinated before he was able to do anything (or much), and although Carus easily overran Mesopotamia. which became Roman again, and even took Ctesiphon, the Romans retreated on his death (283–284). The next incident is the defeat of Galerius, between Carrhae and Callinicus, where he had entered Mesopotamia (about 296), in the war provoked by Narses in consequence of his relations with Armenia. When it was retrieved by a signal victory, Diocletian advanced to Nisibis and thence dictated terms of peace by which Mesopotamia to the Tigris mas definitely ceded to Rome (298).

After about 40 years' peace the struggle was resumed by Shapur II. Nisibis thrice endured unsuccessful siege (338, 346, 350), although meanwhile Constantine had suffered defeat at Singara (348). Then hlesopotamia enjoyed two short rests (separated by a sharp struggle) while the rivals were engaged elsewhere, uhen in 363 Julian (*q.v.*) made his disastrous attempt, and Jovian bought peace at the price, among other things, of Singara and Nisibis; *i.e.*, practically all eastern Mesopotamia. The surrender of Nisibis, which had been in the possession of Rome for so many generations, caused consternation among the Christians, and Ephraem Syrus (*q* v) moved to Edessa, where his "school of the Persians" soon became famous (see EDESSA) In the war of 421 in which the northeast of Mesopotamia mas chiefly concerned, the Romans failed to take Nisibis, and it became a natural rallying point for the Nestorians after the decision of Ephesus (431). hlatters were still more complicated nhen the western Christians of Edessa found themselves unable to accept the ruling of Chalcedon against Monophysitism in 451 (see MONOPHYSITES), and there came to be three parties: Nestorians (*q.v*). Jacobites (see ANTIOCH. SYRIAN ORTHODOX PATRIARCHATE OF) and Melchites (*q.v.*).

In the beginning of the 6th century there was another severe struggle in Mesopotamia, which found an anonymous Syriac historian (see EDESSA), and in infringement of agreement the Romans strongly fortified Dara against Nisibis. The Persian invasion of Syria under Kavadh I (*q.v.*) was driven back by Belisarius, but the latter was defeated in his pursuit at Rakkah (531). The peace begun by Chosroes I (532) was not long kept. and Roman Mesopotamia, except the pagan Harran. suffered severely (540). Edessa undergoing a trying siege (544). The 50 years' peace also (562) was short-lived; the Romans again failed in an attempt to recover Nisibis (573). while Chosroes' siege of Dara was successful. Mesopotamia naturally suffered during the time of confusion that preceded and followed the accession of Chosroes II, and the Romans recovered their old frontier (591).

With the accession of Phocas (602) began the great war nhich shook the two kingdoms. The loss of Edessa, nhere Narses revolted, was temporary, but the Roman fortress of Dara fell after nine months' siege (c. 605); Harran, Ras al-'Ain and Edessa followed in 607, many of the Christian inhabitants being transported to the far east. and Chosroes carried the victorious arms of Persia far into the Roman empire. Finally Heraclius turned the tide, and Kavadh II gave up the conquests of his predecessor. The Syrian Christians, however, found that they had only exchanged the domination of a Zoroastrian monarch for an unsympathetic ecclesiastical despotism. In the confusion that folloned, when men of letters had to live and work in exile, Nisibis set up for a time (631–632) a grandson of Chosroes II. Finally all agreed on Yazdegerd III, but while Chosroes II and I-Ieraclius had been at death grips with each other a great invasion had been preparing in Arabia. (X.)

MEDIEVAL AND MODERN TIMES

The Arab Conquest. — The Moslem Arab conquest both of Iraq (southern Mesopotamia) and of Jazirah (northern Mesopotamia) was rapid and complete. By 640 Heraclius had lost the northern cities. Conversion to Islam became general. The invaders were tolerant by comparison with the Byzantines, and the rapid spread of Islam among the conquered was as much the result of its simplicity and fashionableness as of the disabilities which it imposed on non-Moslems. An effect of the Arab conquest was the gradual ousting of Syriac by the kindred Arab speech, the language of religion and government, already well established in parts of Mesopotamia by the Christian Arab tribes.

The Caliphate. — The religious and political history of Mesopotamia during the next six centuries is given elsewhere. (See CALIPHATE; ISLAM; PERSIA.) Here it need only be said that the people of Mesopotamia could not escape the consequences of their geographical position and of the wealth of their country and were involved in the sectarian and political disputes of their Arab lords. The Omayyad caliph Marwan III abandoned Damascus for a Mesopotamian capital at Harran, and the Abbasids, whose power was based as much on Persian as on Arab support, ruled Islam from Iraq.

Karbala in Iraq was the scene of the tragedy (680) which made the great schism of Islam permanent. Karbala and Najaf are still the great Shi'ah holy cities and southern Iraq is predominantly Shi'ah to this day, while the north and the Jazirah are Sunni. Aramaean Christian influences, emanating from Harran, are thought to have contributed to the development of the Mu'tazilite heresy, and the revolutionary Kharijite sect found militant supporters in the Jazirah. But there is no evidence that these occasional civil and religious wars of the first two Moslem centuries seriously damaged the prosperity of the region. The irrigation system of Iraq was preserved by the Arabs; the centre of Islam attracted wealth from the outlying provinces, and at the beginning of the 9th century no region in the world was wealthier.

Decay set in rapidly. The introduction of black slaves from east Africa resulted in the long servile "War of the Zanj" (869–883). More fatal was the introduction of the Turkish soldiery, as hardy as Arabs and more amenable to discipline, first as slaves who received a veneer of Mohammedanism in barracks, and later, when Islam had established itself in southern Turan. as professional soldiers coming singly or in war bands to play the part which the Teutonic *foederati* had played during the Roman decline. Mutasim (833–847), son of Harun al-Rashid, first formed a Turkish bodyguard and, when his people murmured, transferred his capital to Samarra.

Ambitious or rebellious governors could hire Turks as well as the caliphs, and political disintegration had begun before the 9th century ended. The Saffarids revolted in Persia; Ahmad ibn-Tulun of Egypt seized part of the Jazirah and Arab Hamdanids and Oqailids followed him. A Byzantine revival under the Macedonian dynasty threatened the northern borders in the last half of the 10th century, and the caliphs, terrorized by their Buwaihid amirs (practically "mayors of the palace"), their sovereignty restricted to little more than the Euphrates valley, were reduced to the defensive. The Seljuk invasion of western Asia in the middle of the 11th century rallied Islam, but the Seljuk power waned quickly. Their Anatolian satrapy separated itself from Persia, and the intervening Jazirah became a hunting ground for Turkish princelets (atabegs) and crusaders till Zengi expelled the latter from Edessa (1144). But for a generation after him the north remained a mosaic of warring Turkish states. The great Kurd Saladin, having checkmated the Franks in Syria, established Egyptian supremacy in northern Mesopotamia, but with his death polyarchy revived. In spite of earlier Karmathian devastations the south was fairly prosperous while the caliph Nasir (1180–1242) intrigued against the decaying Seljuks with the more vigorous and barbarous rulers of Khwarezm, and, when these rude warriors threatened him, called in the Mongols of Jenghiz Khan to destroy the Moslem buffer between him and the disciplined heathen of the north.

The kingdom of Khwarezm went down in 1219. In 1258 Mesopotamia paid for the policy of Nasir. Hulagu Khan, grandson of Jenghiz and ruler of Persia, inspired by his queen and by his general Kitbugha (both Nestorian Christians), picked a quarrel with the last caliph, Mustasim, killed him, sacked Baghdad and made Iraq into a wilderness. Next year it was the turn of the north. Two murderous campaigns wiped out the principalities and most of their populations, and the Mongol flood rolled on into Syria.

The Decadence (1258–1534).—The conquest was unprece-

dentedly ruinous. By ordering the destruction of the embankments and headworks of the rivers and canals, Hulagu converted vast areas of Iraq into steppe or swamp. The cultivators, thinned first by massacre and then by malaria and famine, were too weak to rebuild the canal system and prevent the nomads of Arabia from terrorizing the countryside and encroaching on the remnants of cultivation. Henceforth the internal history of Iraq is that of an unending struggle betneen a few towns and the pastoral tribes —Arabs in most of the region, Kurds and Turkomans in the north —who regarded farmer and to nsman as inferiors to be blackmailed and robbed.

For 80 years after the conquest Iraq was a poor province of the empire of the Ilkhans, the house of Hulagu. When their empire broke up. Hasan Jalair, a Moslem Mongol noble, seized its western provinces and made Baghdad his winter capital. His successors ruled the eastern Jazirah. The Ortoqids, the only atabeg dynasty to survive the Mongols, mere more or less independent on its western flank. In 1393 Timur the Tatar took Baghdad, but the Jalair expelled his governor. He returned in 1401 and sacked the city only less barbarously than Hulagu. On his death the Jalair returned but were soon overthrown by their rivals, the Turkomans of the Black Sheep (Qara-Qoyunly), whose capital was at Van. But their unstable power was challenged by the Turkomans of the White Sheep (Aq-Qoyunly). nhose power was based on Diyarbekir. Their chief, Uzun Hasan, conquered Iraq and the Jazirah, but the new empire was distracted by rebellion and threatened by the growing ambition of the Osmanli Turks and of the new Persian dynasty of the Safawids. In 1508 Shah Ismail's general, Lala Hussein, took Baghdad and soon added Mosul to his master's empire.

Turco-Persian Rivalry.— In 1512 Selim the Grim girt on the sword of Osman and promptly made war on the Safawids. Shah Ismail's defeat at Chaldiran gave the Turk Ardalan, Mosul, Amadia and Rakkah, but Kirkuk and Baghdad remained Persian until 1534, when Suleiman I the Magnificent took Baghdad. Basra was taken 12 years later by the Turks.

Unfortunately. frequent wars with Persia and the turbulence of the tribes prevented the Turks from organizing an anarchical country as they had organized their more central conquests. Their hold on Basra was precarious and the province was practically independent during most of the 17th century under a local dynasty. Shahrizor (the Kirkuk region) was constantly disputed by the Persians. sometimes aided, sometimes opposed, by local Kurdish chiefs. Local treachery brought the Persians into Baghdad in 1623. After 15 years Murad IV retook the city and massacred many Persian prisoners. For three generations there was peace between Persian and Turk. From 1724, when war broke out again, to 1747 fighting was almost continuous, and the exploits of Nadir Kuli, who became Nadir Shah, and of his opponent Topal Osman Pasha gave an epic grandeur to an indecisive struggle. The wars of 1774–79 and of 1820–23 were less destructive and equally indecisive.

The Tribal Problem.—Wars with the Arab tribes were constant from 1638 to the middle of the 19th century. The names of the tribes or confederacies changed. but there was no change in their politics. The close proximity of Arabia and of the vast Syrian steppe gave rebels a sure refuge. In 1641 the Shammar from Nejd reached the Euphrates and long controlled the towns of Anah and Dair uz-Zor.

The central government was at its weakest between 1760 and 1820 because of foreign war and the ambitions of provincial pashas. In Mesopotamia it tolerated a succession of "slave pashas," mostly Georgian freedmen, who ruled as independent satraps of Iraq, though they never renounced their allegiance to the sultan.

The Last Phase.— The period of direct Ottoman rule began in 1831 when Ali Riza Pasha deposed Daud, the last slave pasha of Iraq. The Jalili mere folloned into exile or retirement by the ruling families of the Kurdish hill states. blohammed "the Blind" of Ruwanduz had a brief period of rebellious success but was captured and made away with, and the last and best of the Kurdish princes disappeared when the Babans of Sulaymaniyah (Suleimaniye) ceased to rule (1850). In the south Karbala was sternly disciplined (1842 and 1852). But until Midhat Pasha no Mesopotamian governor made any attempt to solve the tribal problem by other means than striking, often feebly, at the elusive nomads in the hope that they would be compelled to obedience. Midhat (see MIDHAT PASHA) won his reputation as a reformer in Baghdad (1869–72) by imposing conscription and founding municipalities and administrative councils and by inaugurating a policy of land settlement. His aim was to wean the tribes from nomadism by selling state lands to their sheikhs upon easy terms, giving security of tenure; where the sheikhs became landlords, as among the Muntafiq, their power over their followers waned, and by the beginning of the 20th century the nomad Arabs, though by no means tamed, were less. powerful and dangerous.

Meanwhile, the development of international communications had brought Mesopotamia and especially Iraq into the sphere of European politics. Great Britain sought a rapid route to India through a country where its Indian traders prospered and its consuls at Baghdad had been almost ambassadors since 1807. Capt. Francis R. Chesney brought the first steamer down the Euphrates from Birijik in 1836. A Turkish steamship company for river navigation was formed in 1855, and in 1861 the Lynch company obtained a concession for the maintenance of two steamships on the Tigris. though the idea of the Euphrates line as a mail route to India had been abandoned. The telegraph was introduced between 1861 and 1864; railway schemes, first mooted in 1842 and temporarily abandoned because of the opening of the Suez canal, were revived by the Germans, who in 1899 obtained the original concession for a railway to the Persian gulf. The subsequent effect of this great scheme upon international politics and particularly upon the relations of Great Britain, Germany and Turkey is described elsewhere (see BAGHDAD RAILWAY; TURKEY). The section from Baghdad to Samarra mas completed on the eve of World War I. Schemes for the revival of prosperity by the repair of the old irrigation works began to interest the Turks, and the Hindiyah barrage was completed by Sir W. Willcocks in 1913. But though the latest Turkish rulers were more efficient in some respects than those of the 19th century, they were equally unpopular. Their ideas on education went no further than the conversion of Arabs and Kurds into indifferent copies of the Turkish *effendi;* their justice was still venal; their customs officials were still corrupt and the accessible taxpayer still paid for those whom the tax collector dared not assess or was bribed not to see. Hopes disappointed by the Turkish revolutionaries of 1908 began to turn to Arab nationalism and the outbreak of World War I found the Arabs of Mesopotamia, with few exceptions, either hostile to the Turk or, more often, indifferent to what might befall him. For subsequent history see IRAQ. See also Index references under "Mesopotamia" in the Index volume. (P. GR.; P. W. I.)

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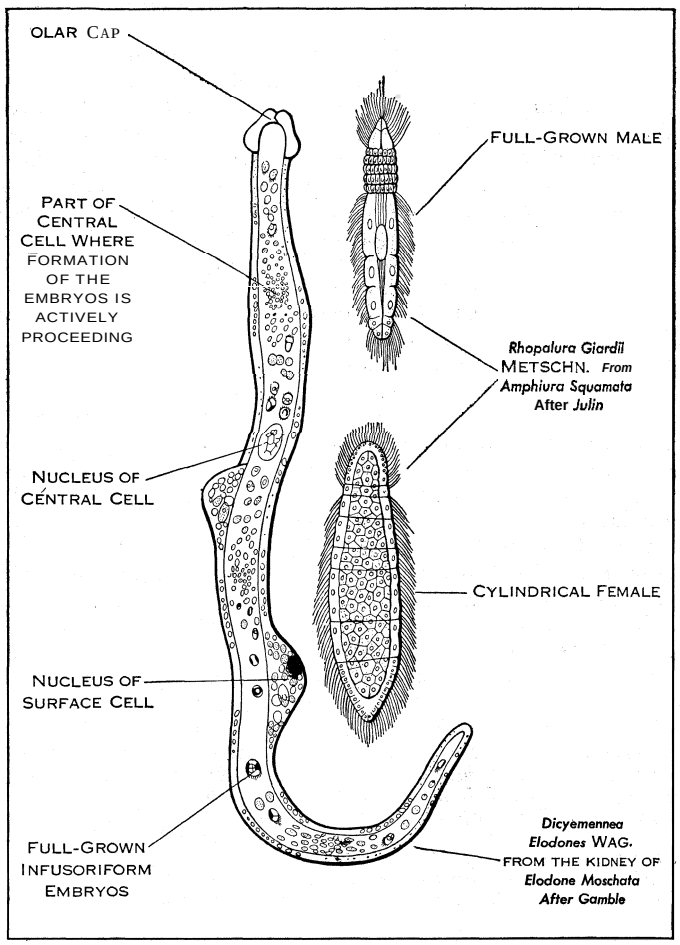
MESOZOA, a small group of minute parasitic animals, com-

prising two classes: (1) the *Rhombozoa,* which are found only in the kidneys of cephalopods, and (2) the *Orthonectida,* which infest ophiurids, polychaets, nemertines, Turbellaria and possibly other groups.

Class I. RHOMBOZOA.—These animals consist of a central cell from which certain reproductive cells arise, enclosed in a single layer of flattened and for the most part ciliated cells; some of them are modified at the anterior end and form the polar cap. There are two orders, the *Dicyemida,* with a definite number of surface cells and a polar cap, by which they are fixed in the renal cells of their host; and the *Heterocyemida* of less definite construction. There are two phases. The "Nematogen" gives rise to vermiform larvae like itself which never leave their host. The "Rhombogen" gives origin to infusoriform larvae, which escape from their original host and probably infect new ones.

Class II. ORTHONECTIDA.—The Orthonectida contain animals with a central mass destined to form male and female reproductive cells surrounded by a single layer of ciliated surface cells arranged in regular rings. The sexes are separate and unlike, the females being much larger than the males. These sexual



FROM "THE CAMBRIDGE NATURAL HISTORY" (MACMILLAN)

THE TWO CLASSES OF MESOZOA. AS ILLUSTRATED BY DICYEMENNEA ELODONES. ON LEFT. AND RHOPALURA GIARDII, ON RIGHT. THESE PARASITES INHABIT. RESPECTIVELY. THE KIDNEY OF CEPHALOPQDS AND BODY CAVITIES OF AMPHIURA

are free-living; the fertilized eggs develop inside the female to ciliated larvae that infect new hosts where they transform to an ameboid syncytium; this forms agametes that develop into the sexual adults.

(See L. H. Hyman, *The Invertebrates: Protozoa through Ctenophora.)*

MESOZOIC ERA, the major division of geologic time that began about 200,000,000 years ago. following the Paleozoic era (*q.v.*), and ended about 70,000,000 years ago with the start of the Cenozoic era (*q.v.*). Rocks that record Mesozoic history, widespread on continents in both hemispheres, originated chiefly as sedimentary deposits on lowlands and on subsiding sea floors. These rocks, laid down in three geologic periods represented by the Triassic, Jurassic and Cretaceous systems. have been much deformed and are exposed in high parts of the Alps. Himalayas, American cordilleras and other uplifted areas. The rock formations record not only great changes in physical geography, but also major developments in organisms. Reptiles, which had a lowly beginning late in the Paleozoic era, evolved rapidly in Triassic time when forms known as phytosaurs, resembling the crocodilian gavial (*q.v.*) of northern India, attained a length of 25 ft. The quadrupedal dinosaurs, with lengths of 10 to 15 ft. in the Triassic period, developed into Jurassic monsters up to 70 ft. Iong and had large representatives until their extinction late in the Cretaceous period. Marine reptiles were abundant and diverse through the era, attaining lengths of 30 ft. or more. Birds, feathered but with anatomical features suggestive of reptiles, appeared during the Jurassic period, as did the flying reptiles (pterosaurs) and small. primitive mammals. Radical changes in living forms near the close of the era may be related to physical developments. such as the closing of seaways and the rise of mountain belts, with attendant climatic changes. For detailed information *see* CRETACEOUS SYSTEM; JURASSIC SYSTEM; TRIASSIC SYSTEM. See also GEOLOGY; PALAEOBOTANY; PALAEONTOLOGY. (C. R. L.)

Geologic Time Chart

System and Period	Series and Epoch	Distinctive Records of Life	1,000 Years
	CENOZOIC ERA		
Quaternary	Recent	Modern man	11
	Pleistocene	Early man	1,000
Tertiary	Pliocene	Large carnivores	
	Miocene	Whales, apes, grazing forms	
	Oligocene	Large browsing mammals	
	Eocene	Rise of flowering plants	
	Paleocene	First placental mammals	70,000
	MESOZOIC ERA		
Cretaceous		Extinction of dinosaurs	130,000
Jurassic		Dinosaurs' zenith, primitive birds, first small mammals	160,000
Triassic		Appearance of dinosaurs	200,000
	PALEOZOIC ERA		
Permian		Reptiles developed, conifers abundant	235,000
Carboniferous (Upper Pennsylvanian)		First reptiles, coal forests	260,000
Carboniferous (Lower Mississippian)		Sharks abundant	285,000
Devonian		Amphibians appeared, fishes abundant	320,000
Silurian		Earliest land plants and animals	350,000
Ordovician		First primitive fishes	400,000
Cambrian		Marine invertebrates	500,000
	PRE-CAMBRIAN TIME		
		Few fossils	3,500,000–4,000,000

MESQUITE is a common name for shrubs or small trees of the genus *Prosopis* in the Leguminosae family, ranging from South America into the southwestern U.S. Two races occur, one low—called running mesquite—and the other often growing into trees 30 ft. tall. Roots penetrate depths of as much as 70 ft. Trunks may be 18 in. in diameter, but more commonly are smaller or shrublike. In warmer parts of the U.S. the mesquite is considered a pest and is eradicated. The leaf is divided into numerous narrow, olive green leaflets about one-eighth inch wide and an inch long. The foliage is lacy and shadeless. The flowers occur in dense, cream-coloured catkins about three inches long. followed by clusters of long beans. The beans are pale yellow, flecked with purple or red, about three-eighths of an inch wide, as much as six to eight inches long, filled with a sweet pulp. The seeds are lens shaped with a hard cover and may lie dormant in soils as long as 44 years, or germinate the next season. A gummy sap, resembling gum arabic, exuded from the stem is commercially valueless. The wood of the mesquite. formerly used in railroad ties. is without economic value other than for unusual furniture and trinkets.

A related species, the screw bean mesquite, *Strombocarpa odorata,* bears a tightly spiraled bean and occurs from Texas to California and southward into Mexico. The term mesquite is also applied to certain unrelated grasses of the genus *Muhlenbergia.* The present range of the mesquite in the U.S. is believed

to have resulted from seeds scattering during the early cattle drives. The northern range of the mesquite is limited by cold and the eastern range by excessive soil water. (EN. R. B.)

MESSAGER, ANDRÉ CHARLES PROSPER (1853–1929). French conductor and composer of operettas who achieved fame both in France and England. Born at Montluçon, Dec. 30, 1853, he was a pupil of Saint-Saens. After composing a symphony (1876) and a cantata, he completed Firmin Bernicat's comic opera *François les Bas-bleus* (1883). His reputation became established with his operetta, *La Béarnaise* (Paris, 1885; London, 1886). He married the Irish composer, Hope Temple, (Dotie Davies; 1859–1938), and between 1890 and 1926 he produced 14 operettas, including *Madame Chrysanthème*, based on the novel by Pierre Loti (Paris, 1893), *Mirette* (London, 1894), *Véronique* (Paris, 1898), *Fortunio*, based on Alfred de Musset's *Le Chandelier* (Paris, 1907). and *Monsieur Beazrcaire*, based on the novel by Booth Tarkington (Birmingham. Eng.. 1919). Messager wrote in a light style, but he brought to the operetta a melodic elegance which made it acceptable to the more serious-minded musical public. He wrote three ballets of which the best known was *Les Deux Pigeons* (1886). In 1898 he was appointed director of the Paris Opéra-Comique where, in 1902, he conducted the first performance of Debussy's *Pelléas et Mélisande*. He was artistic director of Covent Garden (1901–06) and later associate director of the Paris Opéra, where he conducted Wagner's *Der Ring des Nibelungen*. He died in Paris, Feb. 24, 1929.

See H Février, *Andre' Messager* (1948); *M*. Auge-Laribe, *Messager, musicien de théâtre* (1951). (E LR.)

MESSAGE STICKS. Among the natives of Australia, a branch of a tree is taken and notches made upon it in the presence of the messenger, who receives his instructions while they are being made. The messenger carries the message stick in a net bag, and on arriving at the camp to which he has been sent he hands it to the headman at some place apart from the others, saying to him, "So-and-so sent you this," and he then gives his message, referring as he does so to the notches on the stick.

The American Indians used a notched stick to record various incidents, such as the number of days spent on an expedition, the number of enemies slain and the like.

See B. Spencer and F. J. Gillen, *Native Tribes of Northern Australia* (1914).

MESSALLA CORVINUS, MARCUS VALERIUS (64 B.C.–A.D. 8), Roman general, author and patron of literature and art. He was educated partly at Athens, together with Horace and the younger Cicero. In 43 B.C. he was proscribed. but escaped to the camp of Brutus and Cassius. After the battle of Philippi (42) he went over to Antony, and later supported Octavian. In 31 Messalla was appointed consul in place of Antony, and took part in the battle of Actium. He subsequently held commands in the east, and suppressed the revolted Aquitanians; for this he celebrated a triumph in 27.

Messalla restored the road between Tusculum and Alba, and many handsome buildings were the result of his initiative. He was a patron of letters after the model of Maecenas, and his immediate circle included Tibullus and the poetess Sulpicia. He was a friend of Tibullus and a patron of Ovid.

The two panegyrics by unknown authors (one printed among the poems of Tibullus as iv, 1, the other included in the *Catalepton*, the collection of small poems attributed to Virgil) indicate the esteem in which he was held. Messalla was himself the author of various works; all of which are lost. They included *Memoirs* of the civil wars after the death of Caesar, used by Suetonius and Plutarch; bucolic poems in Greek; translations of Greek speeches; occasional satirical and erotic verses; essays on the minutiae of grammar. As an orator, he followed Cicero instead of the Atticizing school, but his style was affected and artificial. Later critics considered him superior to Cicero, and Tiberius adopted him as a model. Late in life he wrote a work on the great Roman families, wrongly identified with an extant poem *De progenie Augusti Caesaris* bearing the name of Messalla, but really a 15th-century production.

Two other members of this distinguished family of the Valerian gens may be mentioned:

MARCUS VALERIUS MESSALLA, father of the preceding, consul in 53 B.C. He was twice accused of illegal practices in connection with the elections, and on the second occasion was condemned. He took the side of Caesar in the civil war. He was augur for 55 years and wrote a work on the science of divination.

MANIUS VALERIUS MAXIMUS CORVINUS MESSALLA, consul 263 B.C. In that year he gained a brilliant victory over the Carthaginians and Syracusans. His relief of Messana obtained him the cognomen Messalla, which remained in the family for nearly 800 years. To commemorate his Sicilian victory, he caused it to be pictorially represented on the wall of the Curia Hostilia, the first example of a historical fresco at Rome.

MESSALLINA, VALERIA the third wife of the Roman emperor Claudius (*q.v.*). She was notorious for her profligacy, avarice and ambition, and exercised a complete ascendancy over her weak-minded husband, with the help of his all-powerful freedmen. During the absence of Claudius from the city, Messallina forced a handsome youth named Gaius Silius to divorce his wife and go through a regular form of marriage with her. The freedman Narcissus, warned by the fate of another freedman Polybius, who had been put to death by Messallina, informed Claudius of what had taken place, and persuaded him to consent to the removal of his wife. She was executed in the gardens of Lucullus, which she had obtained on the death of Valerius Asiaticus, who through her machinations had been condemned on a charge of treason. She was only 26 years of age. By Claudius she was the mother of the unfortunate Britannicus, and of Octavia, wife of Nero.

MESSAPIC is the name given to the language of the Messapii, Iappges and Calabri who occupied the southeastern part of Italy (Calabria and Apulia) in ancient times. These tribes appear to have invaded Italy about 1000 B.C from the opposite coast of the Adriatic (Illyricum), bringing their language with them. With the foundation of Greek colonies about 500 years later, they adopted the Greek alphabet, the Tarentine-Ionic variety, having previously been illiterate.

Over 250 brief inscriptions, and three longer ones, are known and (since J. Whatmough's edition of 1934) interpreted with reasonable certainty. The longer texts are public documents, the rest votive and funerary. In addition there are about 12 ancient glosses (words quoted and explained in authors), and a large number of proper names, local, ethnic, divine and personal, that must have been Messapic.

The more important features of the dialect are: *ă* from Indo-European *ŏ*, b from *bh*, *d* from *dh*, *-n* from *-m*, consonant gemination before *i*, a genitive singular ending in *-ī* (written *-ihi*), a system of personal names similar to the Italic (praenomen, nomen, cognomen), local names ending in *-oa* (pronounced *-ua*, and comparable to names like *Capua* elsewhere in Italy), the preservation of the Indo-European subjunctive and optative moods, and a sigmatic aorist.

An example of continuous text is the following inscription from Ceglie Messapico, *c.* 250 B.C., on a small square stone pillar:

anaaproditalahona*θ*eotoriddahipaka*θ*i
*θ*eotoridda*θ*aotoraskeo*χ*orrihibiliva
("To the lady Aphrodita, goddess of birth, Tutoridia
gave [this]. Tutoridia daughter of Tutor Cucorius.")

Here the first three words (*aprodita* being borrowed from Greek) have *-ā*, dat. sing. fem. (older *-āi*); *Oeotorridda* is nom. sing. fem., a patronymic, with *-idda* from older *-idia; Oaotoras* and *keo*χ*orrihi* are gen. sing. masc., *-ăs* from *-ŏs*, and *-ihi* written for *-i*, *-rr-* from *-ri-*; *biliva* (*cf.* Albanian *bil'ϵ*, "daughter"), nom. sing. fem.; *hipaka*θ*i* is a verb, 3rd sing., with *-*θ*i* written for *-ti*, and v is *u̯*.

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MESSENE, an ancient Greek city, capital of Messenia,

founded in 369 B.C., after the battle of Leuctra and the first Theban invasion of the Peloponnesos, by the combined Theban and Argive armies and exiled Messenians. invited to found a state independent of Sparta. The site, chosen by Epameinondas, lay on the western slope of the mountain which dominates the Messenian plain. The peak Ithome (2,618 ft.) served as acropolis. Messene remained important under the Romans, but we hear nothing of it in medieval times. The hamlet of Mavromati occupies a small part of the site.

Pausanias describes the city, its temples and statues, its springs, its market place and gymnasium. its place of sacrifice, the tomb of Aristomenes (*q.v.*) and the temple of Zeus Ithomatas on the summit of the acropolis. What chiefly excited wonder were the fortifications of Messene, which excelled all others of the Greek world. Of the wall, some 5½ mi. in extent, considerable portions remain. Almost the entire circuit can still be traced. The wall is flanked by towers about 31 ft. high; these have two stories and are entered by doors on a level with the top of the wall reached by flights of steps. Of the gates only two can be located, the eastern or Laconian, and the northern or Arcadian gate. The theatre, the stadium, the council chamber or bouleuterion, and the propylaeum of the market also remain, while on the shoulder of the mountain are the foundations of a small temple, probably that of Artemis Laphria.

MESSENIA, the southwestern district of the Peloponnese (Peloponnesos), bounded on the east by Mt. Taÿgetus (Tavgetos), on the north by the river Neda and the Arcadian mountains, on the south and west by the sea. Its area is 1.119 sq.mi. Historically and economically important is the great plain, watered by the river Pamisus (mod. Pirnatza), the most fertile tract in Greece, producing oranges, citrons, almonds, figs, grapes and olives. The plain is bounded north by the Nomian mountains (mod. Tetrási, 4,554 ft.); west by the mountains of Cyparissia (3.996 ft.), which attain 3,146 ft. in Mt. Mathia (mod. Lykódimo). Off the south coast of the southwest peninsula lie the three Oenussae Islands and the islet of Theganussa (Venetikó).

Messenia forms a department with its capital at Kalamata (Kalamai) (pop. 37,781) and a population numbering (according to the census of 1951) 227,871. The district was occupied by Germany in 1941.

HISTORY

The earliest inhabitants of hlessenia are said to have been Pelasgians and Leleges (*qq.v.*). Then came an Aeolo-Minyan immigration. In the Homeric poems eastern Messenia is represented as under the rule of Menelaus of Sparta, while the western coast is under the Neleids of Pylos. Dorians under Cresphontes invaded the country from Arcadia and extended their rule over the whole district. The Dorians blending with the previous inhabitants produced a single Messenian race with a strong national feeling. But the fertility of the soil, the warm and genial climate, the mingling of races and the absence of opposition, combined to render the hlessenians no match for their hardy and warlike neighbours of Sparta. War broke out which ended in the subjection of Messenia to Sparta (c. 720 B.C.). Two generations later the Messenians revolted, and under the leadership of Aristomenes (*q.v.*) kept the Spartans at bay for about 17 years. When Sparta again won out those Messenians who did not leave the country were reduced to the condition of helots.

Revolt broke out again in 464 B.C.; the insurgents defended themselves for some years on the rock-citadel of Ithome, but eventually they had to leave the Peloponnese and were settled by the Athenians at Naupactus. After the battle of Leuctra (371 B.C.) Epameinondas invited the exiled Messenians to return to their country. The city of Messene (*q.v.*) was founded in 369 B.C. to be the capital of the country and, like Megalopolis in Arcadia, a check on Sparta. A great part of the land remained very sparsely peopled, and Messenia never again became really powerful. After the fall of the Theban power it became an ally of Philip II of Macedon. Subsequently it joined the Achaean League, and we find Messenian troops fighting at Sellasia. The Spartan tyrant, Nabis, succeeded in taking the city but was forced to retire by Philopoemen and the Megalopolitans. It again joined the Achaean league, though much weakened by the loss of Abia, Thuria and Pherae, which entered the league as independent members. In 146 B.C. the Messenians were brought under Roman sway by L. Mummius.

In the Middle Ages Messenia shared the fortunes of the rest of the Peloponnese. It was overrun by Slavic hordes, and was one of the battlefields of Byzantines, Franks, Venetians and Turks, who struggled for the possession of the Morea, as recalled by the ruins of the mediaeval strongholds of Kalamata, Coron (anc. *Asine*, mod. Korone), Modon (*Methone*) and Pylos.

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MESSERSCHMITT, WILLY (1898–), German aircraft designer and businessman, was born at Frankfurt am Main, Ger., on June 26, 1898, and educated at the Munich Institute of Technology. He designed gliders and sailplanes from 1912 to 1923 and then turned his attention to sport and transport aircraft, which he built in his factory at Bamberg. The outstanding characteristic of his aircraft was the single wing-spar. In 1927 he became chief designer to the Bayerische Flugzeugmerke at Augsburg, which was later renamed Messerschmitt-Aktien-Gesellschaft, and remained at the head of this firm until the end of World War II. A large proportion of all German fighter aircraft during the war were of Messerschmitt design, including the Me-109 (which flew for the first time in 1934) and the jet-propelled Me-262, which, early in 1944. became the first jet plane to be flown in combat. In 1939 the Me-109 won the absolute world speed record with a 435-m.p.h. flight. Messerschmitt's Me-163, called the Komet, was the first airplane specifically designed for a liquid-fuel rocket motor. After World War II, Messerschmitt again set up an engineering works at Munich for design and production in various engineering fields. (D. CR.)

MESSIAH (MESSIAS), a term, meaning "anointed one." which was used in the Judaism of New Testament times to designate the expected king of the Davidic line who was soon to appear, deliver Israel from foreign bondage and restore the glories of her golden age. In its original Semitic form. "Messiah," the word is found in the New Testament only in John i, 41 and iv, 25 (where the King James and Douay versions render it, by transliteration from the Greek, as "Messias"). Elsewhere in the New Testament it is translated into Greek (and then into English) as *christos* (Christ), a word literally equivalent to it, but with quite different associations.

The change from the Semitic "Messiah" to the Greek "Christ" was theologically significant since the Greek word was politically neutral and could be more easily charged with the specifically religious content of the unique messianic conceptions associated with Jesus and his followers. In the English Old Testament. the word Messiah appears only in the King James Version of Dan. ix, 25 et *seq.*—but erroneously, since the passage is obviously not concerned with the future ideal king, but with a historical high priest of the postexilic period, and the Hebrew word is therefore more correctly translated by the revised versions as "anointed one."

The Hebrew *mashiah*, of which "messiah" is merely a transliteration. is an adjective or substantive of passive formation derived from the verb *mashah*, meaning "to anoint." It can be used of a material object (*e.g.*, the shield of Saul, II Sam. i, 21), but more commonly is used of persons. Aaron and his descendants in the high priesthood, for example, are called "the anointed priest" (Lev. iv, 3; cf. Ex. xxix, 7), and Isa. lxi, 1 (cf. I Kings xix, 16) might suggest that sometimes prophets were anointed. In most instances, however. the ceremony of anointing is connected with the commissioning of kings. It was the act by which the essential power of kingship was conferred. Notable examples are the anointing of Saul (I Sam. x, 1), David (I Sam. xvi, 13; II Sam. v. 3). Solomon (I Kings i, 39) and Jehu (II Kings ix. 6). Kings therefore could be called simply "the Lord's anointed" (*mashiah Yhwh;* II Sam. i, 14), the title implying not only that the king exercised the authority conferred on him by deity, but also in some way shared the

divine nature.

Among neighbouring peoples. notably the Egyptians. kings were regarded as gods in the proper sense or' the term. Although the Hebrew view of the dignity and uniqueness of deity made impossible any such simple identification of God and king in Israel. it was nevertheless true that the king had so close a relationship to God that he could he called God's son (II Sam. vii, 14; Ps. ii, 7; lxxxix. 27); and it was presumably through the ceremony of anointing that this character was conferred upon him. Because of the supernatural aura that surrounded royalty. even the king's enemies hesitated to lay hands upon him, as is illustrated by David's expression of horror when a cornpanion suggested the possibility of ,assassinating Saul (I Sam. xxvi, 8–11; *cf.* xxiv. 6). Without an understanding of the quasi-divine character of Israel's kings, it is impossible to understand fully the later development of Messianism.

The ideas connected with the future, ideal, messianic king most likely originated in the hopes to which court poets gave form on the accession of a new monarch (Ps. ii, 8 *et seq.;* Ixxii, 2–17) or at the birth of a child in the royal family (so. according to a probable interpretation. Isa. ix. 6 *e: seq.).* With the passage of time and the failure of such grandiose dreams to be realized in the careers of particular historical kings. there developed a tendency to transfer them to an ideal figure of the more remote future. Such tendencies were accelerated by the declining fortunes of Israel during the last century and a half of her national existence.

Thus the hope of a future Messiah was born of disappointment with the realities of kingship in the present, accompanied by a firm faith in God's power to fulfill the ideal of kingship, through a figure of His own choosing. in the future. The pattern of this ideal king of the future was naturally David. the founder of the dynasty and the most successful and admired of previous kings. Among the important messianic passages of the Old Testament are to be noted especially Isa. xi. 1 *et seq.;* Ezek. xxxiv, 23 *et seq.;* Mic. v, 2–4; and Zech. ix. 9 *et seq.*

Two other figures who appear in the Old Testament are often considered "messianic" in the broad' sense, and are so regarded in the New Testament. viz., the Suffering Servant of Isa. lii, 13–liii. 12 and the Son of Man of Dan, vii. 13 *et seq.* Neither of these figures is identified with the kingly Messiah in the literature of the pre-Christian period. but both are used in early Christian thought to interpret the Messiahship of Jesus of Nazareth. The mysterious servant of the Lord in the Isaiah passage is not apparently a royal personage (although some scholars have attempted to connect his sufferings n-ith the annual ritual humiliation of the Babylonian kings); he is rather a prophet or teacher who suffers, dies and then through his dying achieves. in some unspecified a victory that brings forgiveness and new life to others.

The "son of man" in the Daniel passage is merely a symbol of the kingdom that "shall be given to the people of the saints of the Most High" (*cf.* Dan. vii, 13 *et seq.* with vii. 27; the term "son of man" being merely an Aramaic idiom meaning "a man"). Since the passage has a mythological flavour, and "a son of man" is easily misunderstood to be a particular individual who descends from heaven to save his people. there seems to have grown up a kind of son-of-man Messianism that finds classical expression in the "Similitudes" of the pseudepigraphic book of Enoch *(see* ENOCH, BOOKS OF). The three conceptions—royal Messiah, son of man, suffering servant—are typically combined in such passages as Mark viii. 29–31. Whether this combination was originally made by Jesus himself, or was the creation of the later church, is a question much disputed among scholars, but the balance of evidence favours the former of these views.

It should also be noted that the term messianic is sometimes used simply to describe the glories of the future age. even in passages where there seems to be no thought of a human. or quasi-human. deliverer of any kind (so notably with reference to many parts of Isa. xl–lxvi).

See also Index references under "Messiah" in the Index volume.

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MESSIER, CHARLES (1730–1817) French astronomer. regarded in his day as the foremost astronomical observer in France. after N. L. de Lacaille, nas born at Badonviller, Lorraine. on June 26. 1730. While at Paris in 1751, he was hired by the astronomer J. N. Delisle as a draitsman and recorder of astronomical observations. Becoming adept at handling astronomical instruments, he was appointed clerk at the Marine observatory in 1; j3 He was the first in France to observe the anticipated return of Halley's comet in 1759 and from that time on searched for new comets and nebulae. Called the "comet ferret" by Louis XV, Messier independently discovered 15 of them. He nas elected a foreign member of the Royal society in 1764 and obtained a seat in the Paris Academy of Sciences in 1770. He published a catalogue of nebulae in 1771 and another in 1781. These nebulae, which include many of the most prominent, are still known by his name. He died on April 12, 1817. (O.J.E.)

MESSINA, city. Sicily. 7 mi. south-southwest of the promontory of Faro (anc. *Promontorium Pelorum)* which forms the northeast angle of the island, capital of the province of blessina and seat of an archbishop. Pop. (1951) 168.497 (town); (1957 est.) 241.614 (commune). The site curves round the harbour. between it and the strongly fortified hills of Antennamare (highest point 3.707 ft.). The straits. which take their name from the town. are here about 33 mi. wide (over 2 mi. at Faro). The passage through them is extraordinarily beautiful. It was a flourishing and beautiful city when in 1908 early in the morning of December 28 one of the most disastrous earthquakes ever recorded destroyed it totally. At Messina about 84,000 lives were lost; the damage was done chiefly by the shock and by the fires which broke out afterwards. The seismic wave which followed did vast damage elsewhere along the strait, notably at Reggio di Calabria, which was also totally destroyed.

The façades of buildings at Messina in great part withstood the earthquake, but the remainder of the buildings was destroyed. The cathedral, begun in 1098, had a fine Gothic façade: theinterior had mosaics in the apses dating from 1330, and the nave contained 26 granite columns, and a fine wooden roof of 1260. The rest was in the baroque style; the high altar (containing the supposed letter of the Virgin Mary to the people of Messina), richly decorated with marbles, lapis lazuli, etc., was begun in 1628 and completed in 1726. The building was carefully restored after the earthquake. The new residential quarters, occupying a far larger space to the south of the old town, have very wide streets and low buildings: while the public buildings are being re-erected rapidly on the old site. A museum has also been formed containing the works of art that were saved. The importance of Messina is due to its harbour, a circular basin open on the north only, formed by a strip of land curving round like a sickle, from which it took its original name, Zancle (ζάγκλον, or rather δάγκλον, the Sicilian equivalent of the Greek δρέπανον, from which Trapani is derived).

Zancle was first founded by pirates from Cumae, and resettled from Cumae under Perieres, and from Chalcis under Crataemenes, in the first quarter of the 8th century B.C. Mylae was occupied very soon afterwards, but the first regular colony of Zancle was Himera (648 B.C.). After the capture of Miletus by the Persians in 494 B.C. Milesians and Samians joined Anaxilas of Regium in occupying Zancle in the absence of its king Skythes, and the name was changed to Messene, which is found on coins of the Samian type. About 480 Anaxilas established his authority at Messene. In 426 the Athenians gained the alliance of Zancle, but failed to obtain it in 415.

Messina fell into the hands of the Carthaginians (397 B.C.). They destroyed the city, but Dionysius recaptured and rebuilt it. Timoleon finally expelled the Carthaginians in 343 B.C. In the wars between Agathocles of Syracuse and Carthage, Messina supported the latter. After Agathocles' death, his mercenaries, the Mamertines, treacherously seized the town about 289 B.C. They came to war with Hiero II. of Syracuse and obtained help from Rome. This led to the first Punic War. At its close (241 B.C.), Messina became a free and allied city. During the civil wars Messina held with Sextus Pompeius; and in 35 B.C. it was sacked

by Octavian's troops, but it continued to flourish as a trading port, as the discovery of a large Roman necropolis (1st–3rd cent. A.D.) shows. In the division of the Roman empire it belonged to the East; and in A.D. 547 Belisarius collected his fleet here before crossing into Calabria. The Saracens took it (831), and it was the first permanent conquest of the Normans (1061).

In 1190 Richard I. of England, with his crusaders, passed six months in Messina. He quarrelled with Tancred, the last of the Hauteville dynasty, and sacked it. In 1194, with Sicily it passed to the Hohenstaufen under Henry VI., who died there in 1197; and after their fall was contended for by Peter I., of Aragon, and Charles I., of Anjou. At the time of the Sicilian Vespers (1282), Messina defended itself against Charles; Ruggiero di Loria defeated the French off the Faro; and from 1282 to 1713 Messina remained a possession of the Spanish royal house. In 1571 the fleet fitted out by the Holy League against the Turk assembled at Messina, and in the same year its commander, Don John of Austria, celebrated a triumph in the city for his victory at Lepanto (statue in the Piazza dell' Annunziata). Internal quarrels between the Merli, or aristocratic faction, and the Malvezzi, or democratic faction, fomented by the Spaniards, helped to ruin the city (1671–1678). The French at first came to its aid, but then abandoned it. In 1743 the plague carried off 40,000 inhabitants. The city was partially destroyed by earthquake in 1783. During the revolution of 1848 against the Bourbons of Naples, Messina was bombarded for three consecutive days. In 1854 the deaths from cholera numbered about 15,000. Garibaldi landed in Sicily in 1860, and Messina was the last city in the island taken from the Bourbons and made a part of united Italy under Victor Emmanuel. It was heavily bombed by British and U.S. air forces in World War II.

Messina was the birthplace of Dicaearchus, the historian (*c.* 322 B.C.); Aristocles, the Peripatetic; Euhemerus, the rationalist (*c.* 316 B.C.); Stefano Protonotario, Mazzeo di Ricco and Tommaso di Sasso, poets of the court of Frederick II. (A.D. 1250); and Antonello da Messina, the painter (1447–1499). (T. A.; X.)

MESSINA, STRAITS OF. The straits between Sicily and Italy, about 2 mi. wide at the north extremity and 10 mi. at the south, while the line taken by the trainferry between Reggio di Calabria Villa S. Giovanni and Messina is 5 mi. long. At the north end a lowering of the water level of about 300 ft. would produce a small isthmus; and the origin of the separation of Sicily and Italy may be post-palaeolithic. (*See* MALTA.) The straits were much feared by sailors in antiquity, especially owing to the rocks and whirlpools known as Scylla and Charybdis (*q.v.*); and the currents do, as a fact, present considerable difficulties, especially in a strong wind. The main current runs from south to north, and the subsidiary current in the reverse direction. They generally alternate every six hours, and are affected by the sun, the moon, and the winds. When the current runs from south to north, the level of the water in the straits falls from 6 to 8 in. and rises as much with the other current: when they are specially strong, they tear seaward from the bottom, and sometimes throw up fish with atrophied or abnormal eyes, and with organs for the production of phosphorescence. Some 140 kinds of fish are caught in the straits, and they are especially rich in plankton. There is an Institute of Marine Biology at Messina, the straits being naturally a very favourable spot for such studies, as so many fish must pass through when migrating. Much damage was done on both sides of the straits by the sea movement produced by the earthquake of Dec. 28, 1908.

MESTIZO, a term originally meaning a half-breed, one of whose parents was Spanish, and now used occasionally of any half-breed, but especially to denote persons of mixed Spanish (or Portuguese) and American Indian blood (Span. from Port. *Mestiço,* Lat. *miscere,* to mix). See also INDIAN, LATIN-AMERICAN.

MESTROVIC, NAN (IVAN MEŠTROVIĆ) (1883–1962), Yugoslav-U.S. sculptor, whose works are characterized by bold cutting and great powers of design, was born on Aug. 15, 1883, at Vrpolje in Slavonia, the son of Croatian peasants. The rudiments of his art were taught him by his father. At the age of 13 he was apprenticed to a marble cutter at Split (Spalato), and three years later entered the Vienna academy, where he studied under Edmund von Hellmer until 1904. He exhibited at the Vienna Secession exhibitions, at the Austrian exhibition at Earl's Court, London (1906), at Munich, Venice and Paris, where he attracted the notice of Auguste Rodin. Mestrovic was largely responsible for a nationalist artistic movement that included the sculptors Rosanditch and Dujan Penitch, the painter Racki and the architect Plecnik, and that culminated in the exhibition at Zagreb in 1910. Mestrovic was appointed rector of the academy at Zagreb in 1922. He moved to the United States in Jan. 1947 and joined the faculty of Syracuse (N.Y.) university, becoming a U.S. citizen in 1954. In 1955 he became professor of fine arts at Notre Dame university. He died on Jan. 16, 1962, in South Bend.

Mestrovic's works include a large number of religious reliefs and figures in walnut; the Pieta relief in the National Gallery of British Art is typical. His portraits include those of his mother (1908), Madame Banac (1913 and 1915), his wife (1915), Sir Thomas Beecham (1915, in the National Gallery of British Art) and Lady Cunard (1915). Among later works are figures of St. Francis of Assisi and "The Artist's Mother in Prayer" (1925); portraits of Herbert Hoover and Pope Pius XI; and two equestrian bronze statues of American Indians set up in Grant park in Chicago, Ill. At a one-man exhibition in 1947 at the Metropolitan Museum of Art, New York city, Mestrovic's works included a Pieta figure weighing more than five tons and the symbolic figures "Job" and "Despair."

META, a western tributary of the Orinoco (*q.v.*). It rises in the eastern cordillera of the Andes and empties into the Orinoco at Puerto Carreño (Puerto Páez, Venez.). It flows approximately southwest-northeast and forms part of the Colombia-Venezuela boundary for about 150 mi. in the lower course. The Meta is about 621 mi. long and at its junction with the Orinoco, is about 1 mi. wide. Its main headwaters rise in the high Andes east and south of Bogotá and meet to form the main river about 60 mi. out in the llanos (*q.v.*). In its course across the vast plains it receives a number of small tributaries from the northwest, chief of which is the Casanare. During the rainy season from May to October the whole river system overflows and large areas of that terrain are inundated. The drainage basin covers an area of approximately 35,000 sq.mi. almost entirely in eastern Colombia.

The river is navigable by shallow-draft boats throughout most of its course. It is little used, however, because the region through which it flows is sparsely populated, largely undeveloped and a great distance from markets. The largest towns are Villavicencio (elevation, 1,490 ft.) near the base of the Andes, 75 mi. southeast of Bogotá, and Puerto Carreño (elevation, 298 ft.) at the mouth of the Meta. (D. R. D.)

METABOLIC DISEASES. Metabolism is an inclusive term that applies to virtually all the active processes in living organisms. It thus encompasses the chemical reactions and physical phenomena involved in the organization, maintenance and growth of living matter. Cellular metabolism defines these activities in the single-celled organism or in a cell of a multicellular plant or animal. Tissue and organ metabolism refer to the physiological activities of the highly organized conglomerates of cells in an organ or tissue of animals or man; *e.g.,* brain, liver or connective tissue.

The metabolism of tissues involves nutrition, tissue synthesis (anabolism), tissue breakdown (catabolism), respiration and energy exchange and the functional activity or work, such as muscular contraction or glandular secretion. performed by the cells or organ. In the intact man or animal metabolism obviously includes the sum of the metabolic activities of all the organs and tissues. It is possible to determine various aspects of total body metabolism such as the metabolic rate. which is a measure of total energy expenditure under standard conditions, and by more discriminating procedures to secure estimates of activity in such limited areas as the rate of hormone secretion by a gland.

In the healthy individual the many metabolic activities of the body are maintained in an optimum state by a multitude of regulatory mechanisms. This stability of the organism has been termed homeostasis. A disease is the morbid state resulting from a dis-

turbance in homeostasis. In this sense any disease can be regarded as a metabolic disease. Infections and injuries induce illness by disturbing metabolic processes. The term metabolic diseases, however. is conventionally restricted to those disorders that are ascribable to primary disturbances in metabolic processes. This distinction cannot always be made with ease, and the decision to include or exclude certain diseases may be arbitrary. In this article a broad inclusive definition of metabolic disease has been accepted. The number of diseases involved is so great as to prohibit much more than tabulations and definitions. Many are extremely rare.

Nutritional Deficiency Diseases. — Cndernutrition is the result of a deficiency in calories and/or dietary protein. A severe chronic restriction in calories ultimately results in the depletion of vital structural protein. Inanition is readily detected and may be complicated by evidences of malnutrition. Extreme undernutrition in infants and children due primarily to a dietary protein deficiency has been termed kwashiorkor. It is also important to appreciate that protein deficiency may develop acutely from the extreme protein wasting that is a portion of the body's normal response to severe acute illnesses or injuries.

A chronic deficiency of any of the vital chemical substances (vitamins) that the body is incapable of synthesizing may lead to one or a combination of any of the several malnutrition syndromes. Deficiencies in thiamine, niacin and ascorbic acid, which are water-soluble vitamins, will induce beriberi, pellagra and scurvy respectively. The fat-soluble vitamins A and D in adequate amounts prevent the development of night blindness and rickets or osteomalacia. Malnutrition as well as undernutrition may also develop as a result of defects in gastrointestinal absorption such as that which is seen in sprue. In a sense pernicious anemia may also be regarded as a deficiency disease. The basic defect here is the absence of gastric intrinsic factor, without which vitamin B_{12} cannot be absorbed.

Inborn Errors of Metabolism. — Inborn errors of metabolism is a term generally applied to a group of diseases characterized by the fact that their basic etiology is a highly specific. genetically determined. biochemical or metabolic abnormality. At the present time most of the diseases in this category are rare; more are continually being discovered. As a matter of fact it is already difficult to draw a sharp line between those metabolic disturbances that are inherited and those that are acquired.

Gout is probably the most common disease in this classification. It is characterized by acute recurrent attacks of arthritis that are apparently due to the accumulation of urates in body fluids and in local deposits. The hereditary factor responsible for the inherent susceptibility to gout seems to be transmitted by a single autosomal dominant gene.

A number of defects in the body's ability to handle carbohydrates can be diagnosed. In glycogen storage disease (von Gierke's disease) gross excesses of this polysaccharide are stored in tissues, especially the liver and kidneys, and normal blood glucose levels are not maintained. In galactosemia the milk sugars. lactose and galactose, are not converted to glucose because of an enzymatic defect. Infants with this disease develop mental retardation, liver disease and cataracts, but all these manifestations can be prevented if the baby is not fed galactose during the first three years of life.

Renal glycosuria is a harmless "laboratory disease" in which small amounts of glucose escape in the urine at normal blood sugar (glucose) concentrations. Fructose and some pentoses rarely appear in the urine in other inborn metabolic disturbances of little medical consequence.

The defective handling of various amino acids, which are the building blocks of tissue protein, has also been defined as the cause of some metabolic disorders. Cystinuria results in the formation of cystine stones in the urinary excretory tract. Excessive urinary wasting of other amino acids may not be medically important but such cases have been detected. On the other hand the hereditary inability of the kidneys to conserve amino acids may be associated with a parallel wasting of inorganic phosphate, potassium and even glucose in the urine (Fanconi's syndrome). This often results in a relative acidosis and a form of rickets or osteomalacia that is resistant to treatment with vitamin D. Renal acidosis is a rare condition in which the kidneys are incapable of excreting acid urine. There occurs an excessive excretion of calcium, phosphate and potassium. The clinical manifestations are frequent renal stone formation, osteomalacia and muscular weakness. Phenylpyruvic oligophrenia is a condition in which the amino acid phenylalanine cannot be converted to tyrosine with the result that phenylpyruvic acid accumulates. Mental deficiency is uniformly present.

Familial periodic paralysis is characterized by periodic attacks of flaccid paralysis or extreme weakness of most of the voluntary muscles of the body, but particularly those of the limbs. The paralytic condition may last from a few hours to a few days, and betneen attacks the patient is usually normal. It is apparently due to a deficiency in the potassium content of the muscle cells. Porphyria is a constitutional disease in nhich the metabolism of porphyrins. which are blood pigments, is disturbed and unusual porphyrin compounds can be detected in the urine. In one form there is extreme photosensitivity of the skin. In the more common form. the symptoms and signs are often bizarre and in the early stages simulate severe neurotic states. Severe colic abdotninal pains suggesting acute surgical emergencies and profound neurological manifestations such as paralyses and convulsions are seen in some cases.

Xanthomatosis is a condition in which there occurs unusual deposits of fatty material in various tissues of the body and associated elevated levels of lipides in circulating plasma. Cholesterol and/or neutral fats are the lipides involved. Arteriosclerotic vascular disease occurs early in the life of persons with familial hypercholesteremia. As a matter of fact it is appropriate to include arteriosclerosis, which is the deposition of these fatty plaques in arteries. among the very important metabolic diseases.

Endocrine Disturbances. — The hormones are among the most important regulators of metabolic processes. Pathologic alterations in the rate of their secretion by the endocrine glands will produce significant metabolic disturbances. Hypersecretory states may be due to functioning tumors or hyperplasic glands that have somehow escaped from their usual controlling systems. Destructive tumors, infections or vascular occlusions may lead to endocrine deficiency states; the glands may also atrophy as a result of genetic or other unknown factors. Deficiency and hypersecretory states of the anterior pituitary, thyroid, adrenal cortex, pancreatic islets, parathyroids, ovaries and testes have been described. With respect to the posterior pituitary gland only a deficiency disease has been described — diabetes insipzdus, which is characterized by the failure of the kidneys to conserve body water in a normal fashion. No disease due to a deficiency of adrenal medullary secretions, epinephrine and norepinephrine, has been described, but secretory tumors of the adrenal medulla induce a syndrome that includes hypertension and diabetes *mellitus*.

Diabetes *mellitus* is the most common and probably the most complex of the endocrine diseases. It is a syndrome characterized essentially by pathologically high blood glucose concentrations and the spillage of glucose in the urine. The syndrome may be the result of any of several basic disturbances; more often than not the true cause is not ascertainable. Whatever the etiology, hou-ever, it may be looked upon from the practical viewpoint as a disease in which the endogenous insulin available is insufficient to meet the demands of the body. In addition to the dominating metabolic defect. which is the inability to utilize carbohydrates in an effective manner, there are abnormalities in fat and protein metabolism and more subtle disturbances that predispose the patient to the development of arteriosclerotic and other special types of vascular, renal and ocular disturbances.

Liver and Renal Disease. — Normal renal function is the key to the maintenance of optimum extracellular and intracellular fluid and electrolyte concentrations and is vitally concerned with the elimination of metabolites of all sorts. In renal insufficiency, from whatever cause, profound metabolic disturbances develop. Clinical signs and the biochemical changes differ somewhat from case to case depending upon the type of renal lesion, the severity

of the defect and the duration of the disease. In general, it can be said that the syndrome that results can be ascribed at least in part to the retention of inorganic and organic compounds, some of which are metabolic end products normally excreted in the urine. In some instances, however, electrolytes that should be sparingly excreted for the maintenance of homeostasis cannot be retained when the need dictates, as in the sodium wasting form of nephritis. In the nephrotic syndrome plasma protein is lost in the urine, and hypoproteinemia with attendant edema and other complications develops.

The liver is probably actively involved in the performance of more functions than any other organ in the body. It has a vital role in carbohydrate, protein and fat metabolism and is active in the conjugation and excretion of bile and other pigments, steroids, etc. Disturbances in liver function such as cirrhosis thus result in widespread metabolic derangements.

Miscellaneous Metabolic Diseases.—Obesity is probably the most common metabolic abnormality in the U.S. and other portions of the world where there is an abundance of food. It is of considerable medical importance in that its presence subjects the patient to significantly greater health hazards. Diabetes *mellitus*, hypertensive vascular disease and cardiac disease either occur with greater frequency or are adversely influenced by obesity. It is always due to overeating; appetite regulation is impaired. The basic etiology of most cases is obscure. The most frequently suggested causes are an occult metabolic disturbance, chronic anxiety or merely bad eating habits. True endocrine obesity is rare.

Hemochromatosis is a chronic disease in which iron is deposited in the various tissues of the body. The iron deposits induce fibrosis, impaired function and pigmentation of the skin. The liver, pancreas and heart are the most severely involved organs. The apparent cause of the disease is the excessive absorption of iron from the gastrointestinal tract or its parenteral introduction in huge amounts through multiple transfusions.

Hepatolenticular degeneration (Wilson's disease) is characterized by degenerative lesions in the basal ganglia of the brain with resulting rigidity, dysarthria and tremor, and by cirrhosis of the liver and a brownish pigmentation of the outer margins of the cornea (Kayser-Fleischer rings). Pathologic processes have been attributed to the accumulation of excesses of copper in the body. Treatment designed to enhance copper excretion in the urine has led to considerable clinical improvement.

Myasthenia *gravis* is characterized by weakness of voluntary muscles, especially after exercise. It is often associated nith enlargement of the thymus gland. Present evidence indicates that the weakness is due to blockage of the acetylcholine activating mechanism at the neuromuscular junctions.

See MALNUTRITION; HEREDITY: Heredity of Biochemical Characters; ENDOCRINOLOGY; EXCRETION (KIDNEY); LIVER; OBESITY; ARTERIES, DISEASES OF.

See also R. L. Cecil and R. F. Loeb (eds.), ***A Textbook*** of *Medicine* (1959). (R. L. L.)

METABOLISM: see DIET AND DIETETICS; ENDOCRINOLOGY; HORMONES; METABOLIC DISEASES; NUTRITION; RESPIRATION; VITAMINS.

METABUS, in Roman mythology, the father of Camilla, a legendary Volscian maiden who became a warrior and was a favourite of the goddess Diana. According to Virgil in the Aeneid, Metabus, pursued by his enemies, was fleeing from his city with the infant Camilla when he encountered the Amisenus (Amazenus) river, which was at a high level. Fastening the child to a javelin with bark, he declared that he was dedicating her to the goddess of the woods and hurled her across the river. He then escaped from his enemies by swimming to the other bank, where he found Camilla.

Living among shepherds and in the woods, Metabus taught Camilla the rustic arts, and she became a skilled hunter and resolute warrior. She mastered the techniques of war and handled the two-edged ax, javelin and bow with facility. It was said that she could run so fast that the plants in a cornfield or the surface of a body of water would not be disturbed when she passed over them.

Camilla never married. She became the leader of a band of warriors, including a number of maidens, and fought with Turnus in a battle against Aeneas. She was killed in battle by Arruns, an Etruscan, as she was chasing a retreating soldier. Arruns in turn was killed by an arrow dispatched by one of Diana's nymphs,

METAL. Metals are distinguished from nonmetallic substances by their high conductivity for electricity and heat, by their high reflectivity for light—their metallic lustre—and by their resistance to electric current increasing (not decreasing) with increasing temperature. Their widespread use in industrial civilization is due not only to these properties but to the fact that the common metals can be shaped into objects of commerce and art by deformation and by casting into molds, and to the fact that their properties can be greatly altered by alloying with other metals, so as to increase their strength or improve other properties. Not only alloying, but also deformation and heat treatment (*q.v.*) are used to control their mechanical properties such as hardness, strength, ability to resist repeated stressing (fatigue strength), ability to be drawn into wires (ductility) and ability to be forged into desired shapes (malleability). (See also METALLURGY.)

Metals occur with a great range of characteristics (these are given in detail under the names of each metal, some of which are listed in the accompanying table. The metals differ from the nonmetals in their chemical characteristics since the hydroxides of the metals (at least those of lower valence) are bases rather than acids.

There are several important groupings of the metals, and of the alloys of which they form the major constituent. The common metals (iron, aluminum, magnesium, copper, zinc, nickel, lead and tin) are produced in tremendous quantities, particularly those used in the building of large structures (iron in the form of steel, aluminum and its alloys and magnesium and its alloys). The so-called precious metals include the coinage metals, silver and gold, together with platinum, palladium and iridium which are used for jewelry. The light metals (aluminum, beryllium, magnesium and titanium) are important in the transportation industry, particularly in airplane construction. The platinum metals (ruthenium, rhodium, palladium, osmium, iridium and platinum) are in group VIII of the periodic table. The noble metals are those most resistant to high temperature oxidation; the commonest of these are gold, silver, palladium, platinum and rhodium. Contrasting with these are the chemically reactive base metals. The alkali metals are those of group Ia of the periodic table (lithium, sodium, potassium. rubidium and cesium) and are soft, low melting and rapidly oxidizing. The alkaline earth metals are those of group IIa of the periodic table (calcium, strontium, barium and radium); these elements are employed principally in the form of compounds. Some of the rare-earth metals, refined in very small quantities before 1945, have become commercially available; the rare-earth metals are the elements from atomic number 58, cerium, to 71, lutetium, (cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium). The transition metals are those in which an inner shell of electrons is only partially filled despite the presence of one or more electrons in an outer shell of higher quantum number. These are the metals from atomic number 21 (scandium) to 28 (nickel), from 39 (yttrium) to 46 (palladium), from 57 (lanthanum) to 78 (platinum) and from 89 (actinium) on. The refractory metals, possessing high melting points, have received increasing attention with the coming of high temperature applications such as turbines, jets and high-speed aircraft (tungsten, molybdenum, rhenium, tantalum, niobium, osmium, iridium and rubidium). Their melting points range from 3,387° C. for tungsten down to about 2,500° C. for iridium and ruthenium (see table). At the other extreme the low-melting metals (rubidium, cesium and gallium) melt just above room temperature and mercury melts at −38.87° C., so is normally a liquid and most commonly seen in thermometers and manometers.

Many elements are classed as semimetals (arsenic, antimony and bismuth of group Va, for example) because they possess much poorer conductivities than the true metals, and may be classed with the semiconductors, which differ from metals in that their conductivity increases with increasing temperature. The semicon-

*The Metals and Semimetals, With Some of Their Properties**

	Chemical symbol	Atomic number	Density at 20°C. in g. per c.c.	Melting point °C.	Electrical resistivity at 20°C. in 10^{-6} ohm-cm.	Coefficient of expansion†	Crystal structure‡
Actinium	Ac	89	10.07	1,050	—	—	FCC
Silver	Ag	47	10.49	960.5	1.59	19.1	FCC
Aluminum	Al	13	2.70	660	2.83	23.86	FCC
Americium	Am	95	—	—	—	—	—
Arsenic	As	33	5.73	817	33.3	5.59	Rhomb.
Astatine	At	85	—	—	—	—	—
Gold	Au	79	19.3	1,063	2.44	13.9	FCC
Barium	Ba	56	3.5	710	50	18	RCC
Beryllium	Be	4	1.84	1,284	5.88	9.9	HCP
Bismuth	Bi	83	9.8	271.3	106.86(0°)	13.45	Rhomb.
Calcium	Ca	20	1.55	850	4.24	22.5	FCC‡
Cadmium	Cd	48	8.65	321	6.83	29.8	HCP
Cerium	Ce	58	6.78	793	60 to 89	8.5	FCC‡
Cobalt	Co	27	8.92	1,493	5.68(0°)	13.8	HCP‡
Chromium	Cr	24	7.14	1,550	13.0	8.2	BCCS
Cesium	Cs	55	1.90	28.45	21	97	BCC
Copper	Cu	29	8.96	1,083	1.72	16.5	FCC
Dysprosium	Dy	66	8.764	1,407	91	8.6	IICP
Erbium	Er	68	9.16	1,497	86	9.2	HCP
Europium	Eu	63	5.24	826	81	32	BCC
Iron	Fe	26	7.87	1,540	10	11.7	BCCS
Francium	Fr	87	—	—	—	—	—
Gallium	Ga	31	5.97	29.75	56.8	18.3	Orth.
Gadolinium	Gd	64	7.95	1,312	134	6.4	HCP
Germanium	Ge	32	5.32	958	60x10⁶	5.92	DC
Hafnium	Hf	72	13.09	2,130	32.4	6	HCP‡
Mercury	Hg	80	13.55	-38.9	95.8	61	Rhomb.
Holmium	Ho	67	8.799	1,461	94	9.5	HCP
Indium	In	49	7.31	156.4	9.0	33	FCT
Iridium	Ir	77	22.42	2,454	4.9(0°)	618	FCC
Potassium	K	19	0.862	63.5	7	83	BCC
Lanthanum	La	57	6.19	920	56.8	4.9	HCP‡
Lithium	Li	3	0.53	186	11.7	45	BCC
Lutetium	Lu	71	9.74	1,652	68	12.5	—
Magnesium	Mg	12	1.74	650	4.6	27.3	HCP
Manganese	Mn	25	7.44	1,245	185	23	Cubic‡
Molybdenum	Mo	42	10.2	2,622	5.78	5.2	BCC
Sodium	Na	11	0.97	97.5	4.2	71	BCC
Niobium (Columbium)	Nb	41	8.57	2,415	13 2	7.2	BCC
Neodymium	Nd	60	7.00	1,024	64.3	6.7	HCP
Nickel	Ni	28		1,455	7.8	12.9	FCC
Osmium	Os	76		2,700	9.5(0°)	4.8	HCP
Protactinium	Pa	91	7.05	—	—	—	BCT
Lead	Pb	82	8.9	327	22	29.3	FCC
Palladium	Pd	46	12.02	1,551	10.8	11.6	FCC
Promethium	Pm	61	15.37	—	—	—	—
Polonium	Po	84	11.34	246	—	—	SC‡
Praseodymium	Pr	59	6.8	935	68	4.8	HCP‡
Platinum	Pt	78	21.45	1,773	10.6	9.0	FCC
Plutonium	Pu	94	19.737	639.5	145	50.8	Monocl.‡
Radium	Ra	88	5	700	—	—	—
Rubidium	Rb	37	1.53	38.5	12.5	66	BCC
Rhenium	Re	75	21.2	3,167	21	6.6	HCP
Rhodium	Rh	45	12.44	1,966	4.5(0°)	8.4	FCC
Ruthenium	Ru	44	12.2	2,400	7.16 to 7.6(0°)	9.6	HCP
Antimony	Sb	51	6.68	630.5	41.7	10.9	Rhomb.
Scandium	Sc	21	3.016	1,539	26	11.4	HCP‡
Selenium	Se	34	4.81	217	12(0°)		Rhomb.‡
Silicon	Si	14	2.32	1,410	15x10⁶(300°)	48	DC
Samarium	Sm	62	6.93	1,072	92	7.6	Rhomb.
Tin	Sn	50	7.3	232	11.5	23.5	BCT‡
Strontium	Sr	38	2.6	770	23		FCC‡
Tantalum	Ta	73	16.6	2,996	12.4(18°)	6.55	BCC
Terbium	Tb	65	8.253	1,356	116	7.0	HCP
Technetium	Tc	43	11.49	—	—	—	HCP
Tellurium	Te	52	6.24	452	200,000	—	Hex.
Thorium	Th	90	11.7	1,842	18.6	11.2	FCC:
Titanium	Ti	22	4.5	1,690	55	8.24	HCP‡
Thallium	Tl	81	11.85	303	18(0°)	29.4	HCP‡
Thulium	Tm	69	9.372	1,545	90	11.6	HCP
Uranium	U	92	19.05	1,133	29(0°)	13	Orth.‡
Vanadium	V	23	6.11	1,900	24.8	7.79	BCC
Tungsten	W	74	19.3	3,410	5.48(0°)	4.1	BCC
Yttrium	Y	39	4.34	1,509	53	10.8	HCP
Ytterbium	Yb	70	6.959	824	28	25.0	FCC
Zinc	Zn	30	7.14	419.5	5.8	31	HCP
Zirconium	Zr	40	6.5	1,830	45	7.2	HCP‡

*The properties of metals and semimetals are affected by the nature of impurities that may be present, variations in crystal structure and orientation and the thermal and mechanical history of the samples used to determine values; therefore the values for any two or more different samples may vary.

†Average linear coefficient of expansion near 20° C. per degree C. times 10^{-6}.

‡Crystal structure normally found at 20° C.; ‡ indicates that other forms are known; abbreviations: FCC=face-centred cubic (cubic close-packing!; BCC=body-centred cubic; HCP=hexagonal close-packed; DC=diamond cubic, like the diamond structure; SC=simple cubic; Rhomb.=rhombohedral (trigonal); BCT=body-centred tetragonal; Orth.=orthorhombic; Hex.=hexagonal; Tetrag.=tetragonal; Monocl.=monoclinic.

ductors are boron, carbon, silicon, germanium, tin (gray form), phosphorus, arsenic, antimony, bismuth, sulfur, selenium, tellurium and iodine.

With regard to crystal structure, the most common metallic types are (1) the face-centred cubic, such as copper, silver, gold, nickle, iron above 910° C. and lead which have a structure in which atoms are in cubic close-packing in positions at the corners of the unit cubes of the lattice and at the centres of the cube faces (these are very ductile metals); (2) hexagonal close-packed metals such as magnesium and most of the rare-earth metals with a different kind of close-packing normally described by using hexagonal axes (see CRYSTALLOGRAPHY); and (3) body-centred cubic such as tungsten, molybdenum, sodium and iron below 910" C. with atoms at the corners and at the centres of the unit cubes. Other types are also found, as well as examples of polymorphism (see table).

A piece of metal consisting of a single crystal will show a dependence of properties on direction in the crystal that reflects the symmetry of the atomic arrangement within the crystal. In metals with non-cubic structures there may be a wide variation of certain properties with crystallographic direction. The accompanying table gives average values that are encountered in the common polycrystalline form in which each piece of metal is composed of many individual crystals in more or less random orientation with respect to its neighbours.

The presence of "conduction'! electrons that are free to move about within a metal, not being bound to specific atoms, accounts for many of the metallic properties; the presence of defects in the crystal structure accounts for some of the mechanical properties (see CRYSTALS, DISLOCATIONS OF).

See ELEMENTS. CHEMICAL; METALLOGRAPHY; NATURAL RESOURCES; see also Index references under "Metal" in the Index volume.

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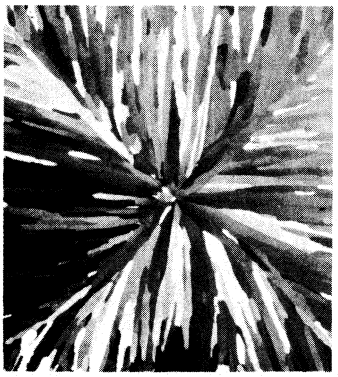
METALLOGRAPHY, the study of the structural characteristics or constitution of a metal or an alloy in relation to its physical and mechanical properties. In a broad sense, this includes: (1) the examination and interpretation of gross structural details of a metallurgical specimen, generally with the unaided eye; (2) the study of metallographic structures with the optical and electronic microscopes; (3) experimental derivation of the equilibria of alloy systems (see *Metals and Alloy Structure,* below); and (4) X-ray metallography—the study of the atomic arrangements in metals and alloys. To a large extent, the major difference between the observation techniques is a matter of resolution, or the separation of detail for observation.

MACROSCOPIC EXAMINATION

Valuable information can be secured through examination of metal fractures and metal surfaces, either before or after appropriate surface preparation. Such observations are usually conducted with the unaided eye. with a magnifying glass, or with a metallurgical or binocular microscope at image magnifications less than about ten diameters. In macroscopic examination the interest is generally confined to the gross structural details and defects arising from fabrication, etc., of the metal, and in consequence relatively large areas of the piece may be involved.

Depending upon the nature of the specimen, preparation prior to examination may or may not be required or desirable. When preparation is necessary, it is accomplished by first sectioning the object, and grinding or machining the exposed surface of interest to achieve reasonable smoothness. In the "as smoothed" condition, a variety of defects may be visible if present, such as



BY COURTESY OF G. L. KEHL

FIG. 1.—TRANSVERSE CROSS SECTION OF CAST-COPPER INGOT AFTER SURFACE PREPARATION AND MACROETCHING. MAGNIFIED ½ TIME

cracks, porosity, rolling seams, and others that are associated with the presence of voids or local separation of the piece. However, by subjecting the prepared surface to macroetching, additional details, if present, may be revealed, particularly details pertaining to crystalline, chemical and mechanical heterogeneities. Reagents for macroetching have been formulated for a variety of metals and alloys, a solution containing hydrochloric acid and water, for example, often being used to etch iron and steel *(see* also IRON AND STEEL: *Metallography and Heat-Treatment).*

Crystalline heterogeneity refers to the macroscopic appearance and arrangement of the crystals, known metallographically as grains, of a cast metal as related to the manner of solidification and attendant growth of the grains. As illustrated in fig. 1, macroetching has reavealed the presence of long columnar shaped grains that originated at the side walls of the mold at the onset of solidification and which, during the solidification process, grew predominantly toward the centre of the ingot, perpendicular to the surfaces of the mold walls.

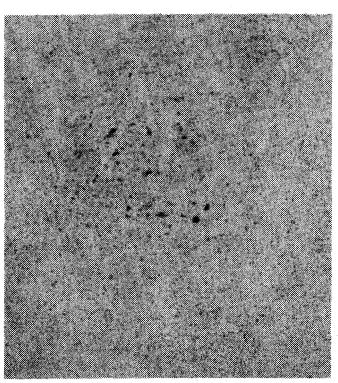
Chemical heterogeneity arises from the presence of impurities and nonmetallic inclusions, and from segregation of chemical elements. As illustrated in fig. 2, macroetching has revealed the location of segregated nonmetallic inclusions in a steel bar. The inclusions have been dissolved by the macroetching reagent, leaving voids which define the locations.

Mechanical heterogeneity arises from cold fabrication processes that plastically deform a metal. Such heterogeneity may be manifested by local deformation of the structure and attendant elongation or distortion of nonmetallic inclusions and regions of persistent chemical segregation in the direction of working.

OPTICAL METALLOGRAPHY

Compared to macroscopic examination, a greater abundance of structural knowledge of a metal may be secured through microscopic examination of prepared surfaces at magnification ranging from about 100 to 1,500 diameters. In particular, optical metallography will reveal such pertinent information as size and shape of grains *(see* fig. 3), the size, shape, and distribution of structural phases and nonmetallic inclusions, microsegregation and other structural conditions of interest.

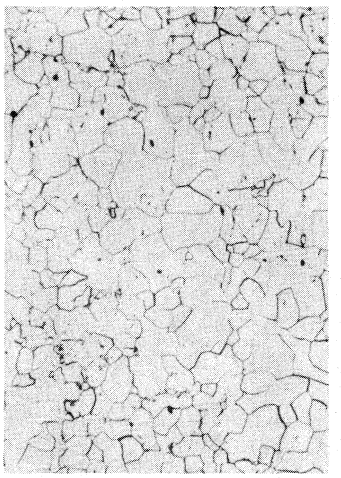
Specimen Preparation.— Inasmuch as microscopic examination of metals cannot be made on thin sections as in tissue microscopy, it is made on a prepared surface of a small specimen. In principle, the purpose of specimen preparation is to achieve a flat, scratch-free, mirror-polished surface having a minimum of surface distortion attending the preparational operations. In general, the procedure consists of grinding the specimen surface on a series of emery papers of decreasing grit size, either by hand manipulations or on a series of horizontally mounted rotating laps. Later the grinding scratches are removed by polishing on one or more cloth-covered laps onto which is charged an appropriately sized abrasive, such as levigated alumina or chromic oxide.



BY COURTESY OF G. L. KEHL

FIG. 2.—TRANSVERSE SECTION OF STEEL BAR MACROETCHED TO REVEAL SEGREGATION OF NONMETALLIC INCLUSIONS NEAR THE CENTRE. NO MAGNIFICATION

Electrolytic polishing is often advantageous, particularly in the case of metals that readily work-harden and those that are relatively soft. Electrolytic polishing consists of making the specimen the anode in an electrolytic cell, and some inert material, such as platinum or stainless steel as the cathode. Using a suitable electrolyte and with current flowing through the cell, metal comprising the hills of the grinding scratches will be preferentially dissolved with respect to the valleys, finally producing a nearly plane and scratch-free surface.



FROM GEORGE L. KEHL, "PRINCIPLES OF METALLOGRAPHIC LABORATORY PRACTICE" (1949); REPRODUCED BY PERMISSION W MCGRAW-HILL BOOK CO., INC.

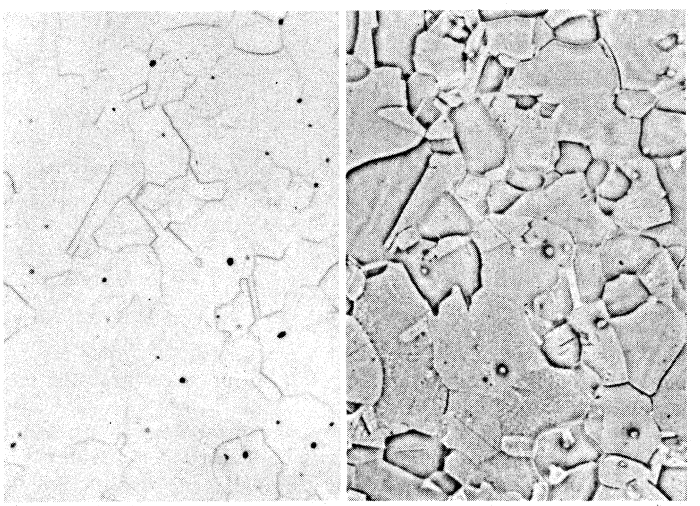
FIG. 3.— METALLOGRAPHIC APPEARANCE OF NOMINALLY PURE IRON. MAGNIFIED 100 TIMES

Metallographic Etching.— When a specimen in the "as polished" condition is examined microscopically it will usually appear homogeneous except for inclusions, voids, and surface defects, with no suggestion of the existence of a complex internal structure. However, by subjecting the polished surface to the action of a selected etching reagent, the structure is revealed by a selective and controlled solution, or unbuilding, of the structure inwardly from the polished surface.

In principle the selective attack of the etching reagent is attendant upon structural heterogeneities which differ in their rates of dissolution. Such heterogeneities may be associated with the presence of more than one phase in the structure, strained regions, or other discrete parts of the structure having higher energy than the surrounding material. The latter circumstance is illustrated in fig. 3, wherein the regions of the grain boundaries (the thin, dark lines) have been selectively attacked by the etching reagent owing to their higher energy compared to that of the grains proper which the boundaries surround. This selective attack gives rise to steep sloping valleys in the grain boundary regions, which appear dark (see *Metallurgical Optical Microscope,* below).

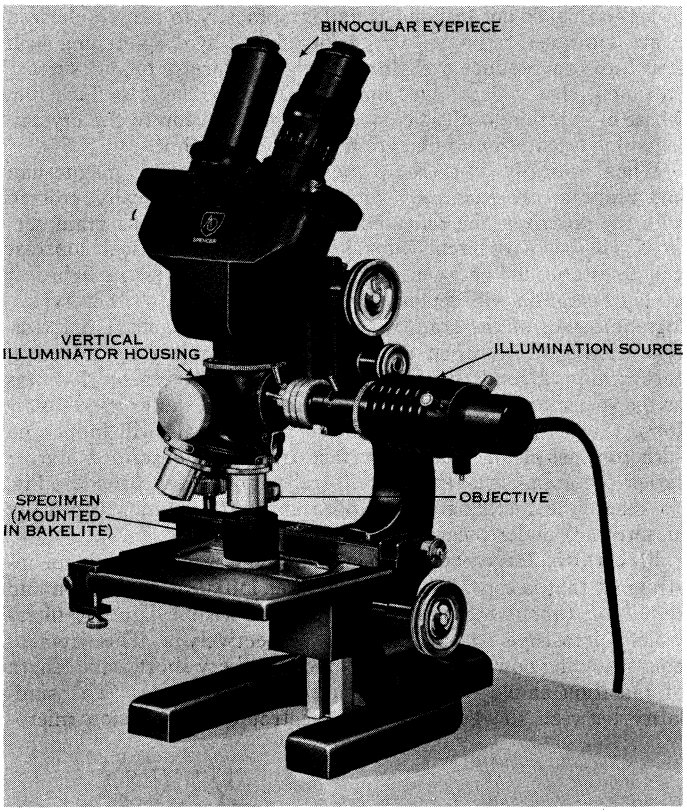
Metallographic etching reagents are generally composed of aqueous or alcoholic solutions of acids or mixtures thereof, alkalis, or other corrosive reagents. The reagents are applied to the polished surface by immersion or swabbing techniques, and the times of etching are usually the order of seconds.

Some metals and alloys, particularly corrosion resistant alloys, are difficult if not impossible to etch satisfactorily by immersion etching. In such cases, electrolytic etching is advantageous. and is readily carried out in the electrolytic cell arrangement for pol-



FROM GEORGE L. KEHL'S "OPTICAL MICROSCOPY" IN "MODERN RESEARCH TECHNIQUES IN PHYSICAL METALLURGY', REPRODUCED BY PERMISSION OF AMERICAN SOCIETY FOR METALS

FIG. 4.— NOMINALLY PURE NICKEL. CATHODICALLY ETCHED IN AN ARGON ATMOSPHERE (MAGNIFIED 250 TIMES)
(Left) metallographic appearance under bright-fleld illumination; (right) structural appearance under phase contrast



BY COURTESY OF AMERICAN OPTICAL CO.

FIG. 5.— BENCH TYPE OF METALLURGICAL MICROSCOPE

ishing. Specific electrolytes for this purpose, and appropriate cell conditions, have been formulated for a variety of metals and alloys.

Cathodic vacuum etching is ideally suited to the revelation of structure in bimetallic couples, and may also be used for etching of regular metallographic specimens and macrosections. It is, however, a specialized method and more troublesome to carry out than is immersion or electrolytic etching. The process consists of bombarding the polished specimen surface (cathode) with ions of a heavy gas at low pressure, accelerated to high velocities by a potential of 1,000 to 5,000 volts D.C. The metal atoms on the surface are ejected selectively, depending upon the microstructure and the comparative ease (sputtering rate) by which atoms can be removed from the various components of the structure. Pure nickel, as cathodically vacuum etched, is shown in fig. 4, and is similar in appearance to the structure revealed by more conventional etching methods.

Metallurgical Optical Microscope.—The metallurgical microscope, illustrated in fig. 5, differs from the more familiar biological type in several respects. The microscope objectives, and the optical system in general, are designed for use without a specimen cover glass, and the optical errors are minimized when used with green-yellow illumination of an approximate mean wave length of 5,700Å (1Å = 0.1mμ = 10^{-4} μ = 10^{-8} cm.). Owing to the optical opacity of metal specimens, illumination is accomplished by means of a vertical illuminator, shown schematically in fig. 6. A beam of light from an external source is directed into the microscope body tube and is deflected vertically downward by means of a thin plane glass reflector (fig. 6[A]) or less preferably by a mirror or total reflecting prism so positioned to cover about one-half the aperture of the objective system (fig. 6[B]). The illumination upon passing downward through the objective is focused upon a small area of the specimen surface. Much of the light upon reflection from the surface again passes through the objective and plane glass reflector (or through the unobstructed portion of the aperture in the case of the mirror or prism), to form the primary real image of enlarged proportions in the vicinity of the eyepiece. The eyepiece lens system, in conjunction with the cornea lens of the human eye, then forms a virtual image which, to a normal sighted observer, will appear to exist in space at about ten inches from the eye.

Owing to the method of illuminating a metallographic specimen, a surface perfectly plane and smooth will reflect all of the incident light into the microscope objective. However. if the surface is selectively made irregular by etching, the illumination incident upon discrete elements of structure (as between [A] and [B], fig. 7) may be reflected at low angles and thus be lost to the microscope objective system. Similarly, light losses may occur by multiple reflections within local surface depressions. In consequence, grain boundaries and interfaces, cavities, surface porosity, etc., will appear dark in the [illegible] as seen in fig. 3 for the case of grain boundaries. After appropriate etching the metallographic appearance of the grains proper in a pure metal or in solid solution alloys may vary in tone value from dark to light. This is known as oriented grain lustre and is illustrated macroscopically in fig. 1. The phenomenon is simply a manifestation of varying degrees of reflected light losses to the objective system as related to the orientation of minute facets produced on grain sections during etching. On any one grain section the facets are similarly oriented, but differ in orientation from those on adjacent grain sections. The principle is illustrated in fig. 7, and from the direction of the reflected light from grain (C), it will appear dark in the final image.

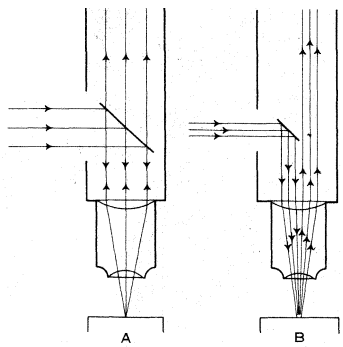
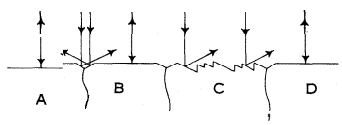


FIG. 6.—PRINCIPLE OF VERTICAL ILLUMINATION: (A) WITH PLANE GLASS REFLECTOR: (B) MIRROR (OR PRISM) REFLECTOR



BY COURTESY OF [illegible] KEHL

FIG 7.—LIGHT SCATTER AT GRAIN BOUNDARIES AND GRAIN PROPER

The purpose of microscopic examination is to resolve or separate fine detail of the structure. Total magnification is secondary provided the image is sufficiently enlarged for the observation of details. Resolution of fine detail in the object is directly dependent upon the numerical aperture (light-gathering ability) of the objective system and inversely dependent upon the wave length of light employed to illuminate the specimen. As illustrated in fig. 8, the resolution of structural detail at the same total magnification and wave length of illumination (5,700Å) is considerably improved through the use of a higher numerical objective. How-

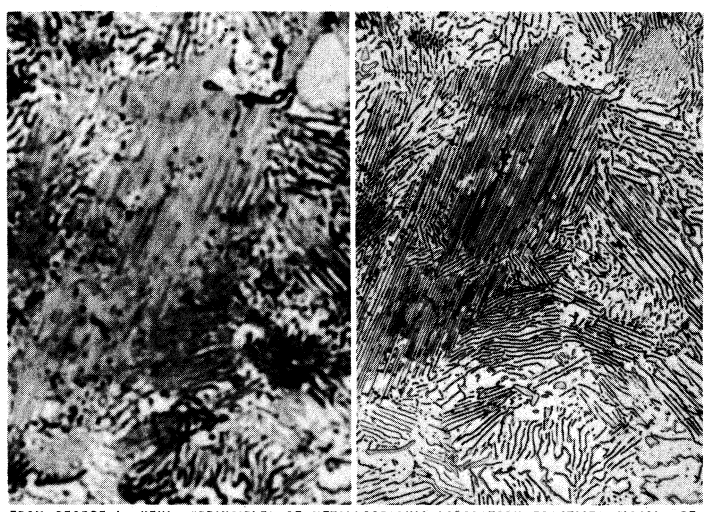


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FIG. 8.— LAMELLAR STRUCTURE (PEARLITE) PHOTOGRAPHED WITH AN OBJECTIVE OF (LEFT) 0.25 NUMERICAL APERTURE AND (RIGHT) 0.95 NUMERICAL APERTURE. BOTH MAGNIFIED 600 TIMES

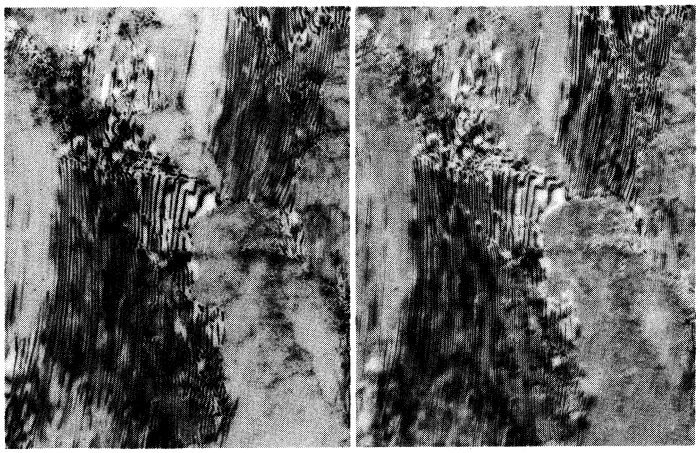

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FIG. 9.— LAMELLARSTRUCTURE (PEARLITE) PHOTOGRAPHED WITH (LEFT? GREEN-YELLOW ILLUMINATION OF 5,700Å AND (RIGHT) ULTRAVIOLET RADIATION OF 3,650Å. BOTH MAGNIFIED 500 TIMES

ever, an increase in magnification of the image of fig. 8 (left) would in no way be accompanied by improved resolution. Similarly, although not as striking, fig. 9 shows the influence of wave length of radiation on resolution at the same total magnification and with the same numerical aperture objective.

Phase Contrast.—With regard to a metallographic specimen, alteration in the phase of the reflected light may originate locally from vertical displacements of an element of structure with respect to the surroundings, from phases of different composition and attending surface optical activity, and from the normal consequence of metallographic etching and the selective formation of surface reaction films differing in thickness and perhaps refractive index. The differences existing in phase of the reflective light will in no way contribute to image contrast, and will in fact incite no response by the human eye. However, in phase-contrast metallography, through the use of auxiliary optical parts, differences in phase of the reflected light are transformed into corresponding differences in light intensity in the image plane, thus producing optical contrast in the image to which the eye is sensitive. A comparison between fig. 4 (left) and 4 (right) clearly illustrates the improvement in image contrast attending phase-contrast observations.

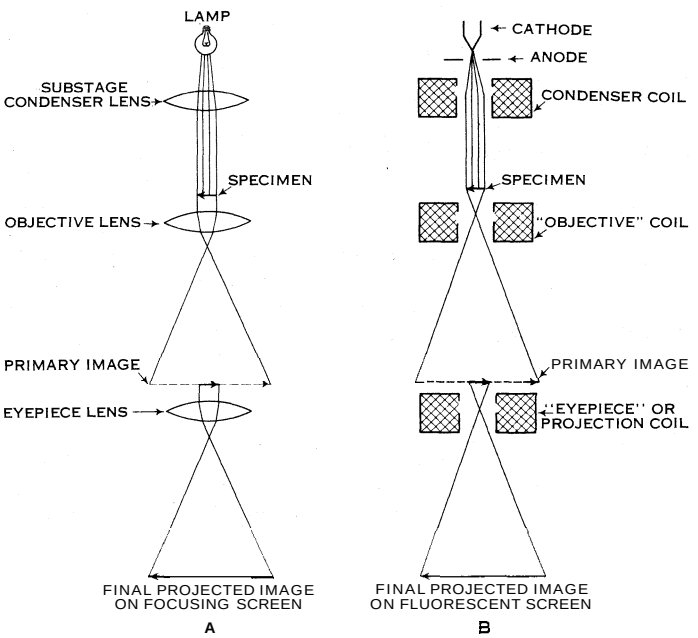
Polarized Light.— Polarized light metallography is useful for revealing grain structure, detection of preferred orientation, examination of oxide surface films, identification of phases in multiple-phase structures, and others. In simple form, a metallurgical microscope can be converted for use with polarized light by insertion of a Polaroid screen in the path of the illumination beam (known as the polarizer) to produce plane-polarized light incident on the specimen surface. A second component, consisting of a Polaroid screen fitted into a cap (known as the analyzer) is placed loosely over the eyepiece of the microscope to permit rotation. As related to the crystallographic structure of the specimen, metals may be classified as being optically anisotropic wherein the optical properties are different in different directions or as being optically isotropic wherein the optical properties are identical in all directions. Polycrystalline metals which possess a cubic structure such as copper, aluminum and gold, are optically isotropic, and owing to this, do not respond metallographically to plane-polarized light. However, response may be introduced by deep etching such structures to produce well-formed etched facets, or by surface treatment that will produce an optically anisotropic surface film whose orientation locally bears a direct relationship to the crystallographic orientation of the grain section beneath it.

BY COURTESY OF G L KEHL

FIG. 10.— ANNEALED URANIUM UNDER POLARIZED LIGHT. MAGNIFIED 150 TIMES

When optically anisotropic metals, such as zinc, magnesium and uranium are examined with the analyzer optically crossed with the polarizer, the reflected light from the various grain sections will be of different intensities, and hence optical contrast will be established between the grains. The darkness or lightness of any one grain will depend upon the orientation of the crystallographic axes of the grain with respect to the plane of polarization. Particularly, when examined with a strain-free objective, each grain will undergo four changes of brightness or darkness as the specimen is rotated 360° with respect to the crossed polarizers. Such rotation of optically isotropic metals will induce no such contrast changes unless surface treated as described above; rather the grains will remain uniformly dark in appearance. Fig. 10 shows the metallographic appearance of uranium (optically anisotropic) under polarized light.

Electronic Microscope.— The electronic microscope is an instrument that is capable of much greater initial magnification and resolution (about 0.002μ) than either the visible light or ultraviolet microscope (0.25μ and 0.1μ, respectively). This tremendous resolving power is attendant upon the very short wave length of radiation employed in the electronic microscope. The similarity between the light and the electronic transmission microscopes is illustrated in fig. 11. It is to be noted that each has similar components, differing only in the precise nature of the components. The "illumination" consists of a stream of electrons in vacuo that are accelerated to very high velocities by a potential of about 50,000 volts, giving the electron beam an equivalent wave length of about 0.05Å.



FROM GEORGE L KEHL, "PRINCIPLES OF METALLOBRAPHIC LABORATORY PRACTICI" (1949); REPRODUCED BY PERMISSION OF MCGRAW-HILL BOOK CO., INC

FIG. 11.— ANALOGY BETWEEN (A) LIGHT MICROSCOPE AND (B) ELECTRONIC MICROSCOPE

Because the electron beam will not pass through metal films of greater thickness than about 0.05μ, it is necessary in the case of metallographic specimens to form a replica of the surface, and to use the replica as the microscope specimen. This is accomplished in the general case by flowing over the etched surface a dilute solution of an appropriate plastic that will faithfully reproduce the topography of the surface. Upon hardening, the film is stripped and contains on one side a reverse impression of the specimen surface contour. Owing to variations in thickness of the film

and attendant dependency of electron scattering on thickness, contrast is established in the final image. An electron photomicrograph of pearlite (the lamellar structure of fig, 9) is shown in fig. 12.

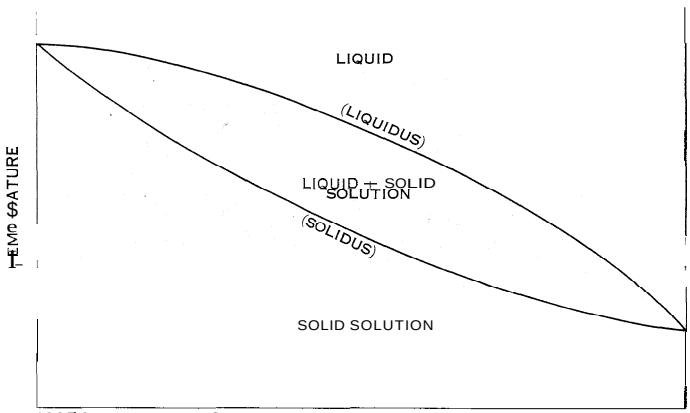
METALS AND ALLOY STRUCTURE

A pure metal, as illustrated in fig. 1 and 3, is composed metallographically of grains and grain boundaries. The grains proper possess internal symmetry, *i.e.*, the metallic ions are positioned with precise regularity in space, and are therefore true crystals even though they do not possess external symmetry. The orientations of the grains differ and give rise to grain boundaries in the structure which define the regions where the mutually adjacent grains have met. Owing to the atomic disorganization existing in the grain boundary regions, the free energy is higher than the crystalline grains proper, and in consequence, is more vigorously attacked by the etching reagent to produce optical manifestation of their location (see *Optical Metallography: Metallographic Etching,* above).

The metallographic structure of an alloy can be understood completely only with the aid of an equilibrium diagram pertaining to the alloy system of interest. Not only will such a diagram give a clue to the microstructures, but also to the thermal behaviour of the alloys, and their attendant properties.

An equilibrium diagram is determined experimentally, and consists of securing information on a variety of specific compositions with regard to equilibrium solidification temperatures. reactions occurring in the solid state, identification of phases in equilibrium and their limits of composition. Experimental techniques employed in obtaining such data consist of thermal analysis, electrical resistivity measurements, X-ray diffraction analysis, dilatometry, metallographic observations, and others. Particular attention is paid experimentally to isolating the system from extraneous outside influences, and to ensuring as far as possible the attainment of equilibrium conditions. These are necessary conditions in order to establish a reproducible, scientific basis for the study even though, in practice, alloys may exist in an intermediate or metastable condition. However, the constitutions of alloys tend to approach closely equilibrium conditions when cooled very slowly, or after prolonged heating at suitable temperatures.

The data so obtained in the case of a binary alloy system (a system of two components) are plotted on co-ordinates of weight or atomic per cent of the components as abscissa and temperature as ordinate. The equilibrium diagram illustrated in fig. 13 for two hypothetical component metals, A and B, is typical of an alloy system, such as copper-nickel, that exhibits mutual solubility of the components in both the liquid and solid states. In the solid state. a "solid solution" is formed. The liquidus line defines the locus of temperatures at which solidification begins upon very slow cooling; the solidus line the locus of temperature where solidification is completed. It is therefore possible to note for any specific alloy composition on the diagram the equilibrium temperature of beginning and ending of solidification. the phase or phases in equilibrium at any temperature of interest and, through simple calculations, the compositions and

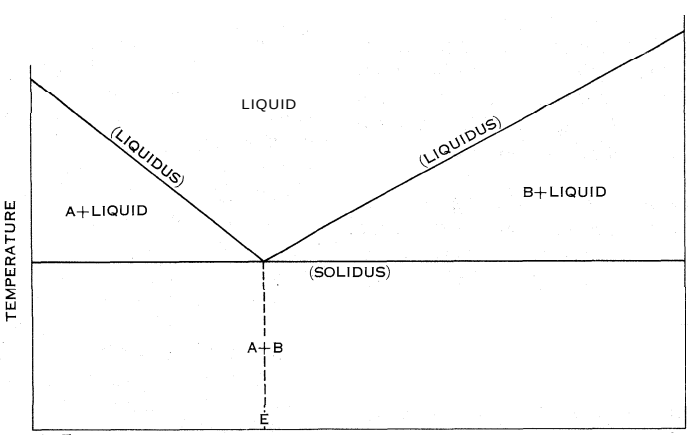


BY COURTESY OF G L KEHL

FIG. 13.— EQUILIBRIUM DIAGRAM OF AN ALLOY SYSTEM EXHIBITING COMPLETE MUTUAL SOLUBILITY OF THE COMPONENTS IN THE LIQUID AND SOLID STATES

BY COURTESY OF G. L. KEHL

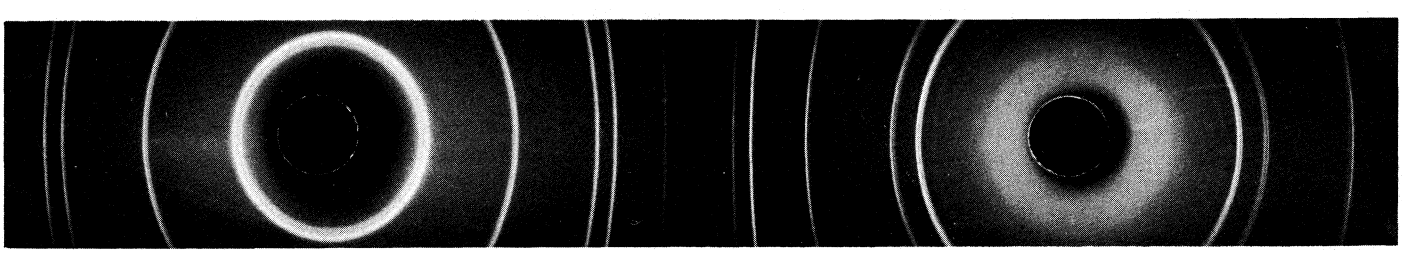
FIG. 12.— ELECTRON PHOTOMICROGRAPH OF PEARLITE. MAGNIFIED 10.000 TIMES



BY COURTESY OF G. L REHL

FIG. 14.— EQUILIBRIUMDIAGRAM OF AN ALLOY SYSTEM EXHIBITING MUTUAL SOLUBILITY OF THE COMPONENTS IN THE LIQUID STATE, NO DETECTABLE MUTUAL SOLUBILITY IN THE SOLID STATE

FIG. 15.— LAMELLAR FORM OF EUTECTIC. CORRESPONDING TO ALLOY COMPOSITION E, FIG. 14



BY COURTESY OF G. L. KEHL

FIG. 16.— X-RAY DIFFRACTION POWDER PATTERN OF PURE SILVER USING COPPER RADIATION

relative amounts of the two phases present. Metallographically, the diagram indicates the equilibrium structures to be a single-phase solid solution, which appear like that of a pure metal or one of the alloy components, although the alloys may differ greatly in physical and mechanical properties. colour, etc.

The equilibrium diagram of fig. 14 is of an alloy system in which the components are completely soluble in the liquid state, but insoluble in the solid state. Systems of this type exhibit the formation of a low melting temperature "eutectic," consisting of components A and B, that forms at the solidus temperature level from a part, or from all, of the liquid, depending precisely upon the alloy composition. The eutectic may assume various structural forms although the lamellar form (fig. 1j) is one of the most common. The equilibrium diagram further indicates that alloy compositions lying to the left of composition E will exhibit structures of primary A crystals and eutectic; those lying to the right, primary B crystals and eutectic; and composition E, known as the eutectic composition, will exhibit only a eutectic structure. Owing to the specific properties of A and B components, and their relative amounts and distribution in the various alloy compositions, the overall properties of the alloys may be quite different. Equilibrium diagrams of a variety of binary and ternary alloy systems have been compiled. *See* ALLOYS; HEAT-TREATMENT; IRON AND STEEL: *Austentite: Solid Solutions.*

X-RAY METALLOGRAPHY

The application of X-ray diffraction techniques to metallurgical problems has contributed much to the basic knowledge of metals and alloys. The technique is principally employed to study phenomena that are related to grouping of atoms themselves, and is capable of resolution of structure between 0.1μ (the lower limit of the optical microscope) and about 0.0001mμ.

The principle of X-ray diffraction analysis depends upon the impingement of an X-ray beam of appropriate wave length (or group of wave lengths) upon a suitable specimen (thin foils. metal powders. massive pieces for reflection of X-ray, etc.), and the subsequent diffraction of the beam from regularly spaced planes of atoms when certain geometrical conditions are satisfied, expressed in Bragg's law or by Laue's equations. *(See* SPECTROSCOPY, ***X-RAY.)***

The diffracted X-rays are generally recorded on photographic film. From measurements of the lines or spots on the diffraction pattern, and by analysis of intensity of the reflected rays, much basic information may be learned about the specimen. A typical diffraction pattern of pure silver (the specimen in the form of silver powder) is shown in fig. 16.

Among the important applications of X-ray metallography is the identification of phases in alloy structures through determining atom positions and spacing and hence the crystallography of the phases, in elucidating the mode of phase changes in solid state reactions involving movement of atoms, detection of preferred orientation and directionality attending cold working well in advance of gross observations by the optical microscope. the presences of internal strains, measurement of lattice parameter changes attending changes in temperature or the presence of solute atoms as in solid solutions, and many others.

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(G. L. KL.)

METALLURGY is the science and technology of metals. It includes the processes of producing metals by extracting them from their ores, refining or purifying them, and working them mechanically or otherwise adapting them to use. It includes also study of the chemical and physical properties of the metals, of their structure, both atomic and crystalline, the principles of combining them to form alloys, means of improving or enhancing their properties for particular applications, and the relations between properties, structures and uses. It includes the thermal and mechanical processing of metals as raw materials of manufacture, but not the design and manufacture of the multitude of things made of metals, except with regard to the manner in which these are affected by the metallic properties and structures.

This article traces the history and prehistory of metallurgy and discusses the various processes and techniques that have been developed and their applications. including those in nuclear engineering.

Following are the main divisions of this article:

I. History
II. Ores and Ore Treatment
  1. The Flotation Process
  2. Extraction of Metal
  3. Refining
III. Cast and Wrought Metal
  A. Iron and Steel
    1. Contraction
    2. Gas Liberation
    3. Segregation
    4. Contraction Stresses
  B. Nonferrous Ingots and Castings
  C. Die-Casting
  D. Precision Casting
IV. Mechanical Working
  1. Forging and Rolling
  2. Extrusion
V. Powder Metallurgy
VI. Heat-Treatment
  1. Annealing
  2. Hardening and Tempering
  3. Surface Hardening
  4. Age Hardening
VII. The Effect of Structure
VIII. Alloy Steels
IX. Other Developments
  1. Welding
  2. Heat-Resistant Alloys
  3. Furnaces
X. Metallurgy in Nuclear Engineering

I. HISTORY

It is generally agreed that the first metals known to man were those which occur in the native, *i.e.,* the metallic, state, of which the very earliest would in all probability be the nuggets of gold found in the sands and gravels of river beds. Such gold, even when naturally alloyed with silver to form electrum. is too soft to find application as tools or weapons and was employed merely for jewelry or other decorative purposes. Copper is another metal which occurs in the native state in many parts of the world, sometimes in large masses and usually, as indicated in Table I (analysis 1) in a state of very high purity. Such copper, though soft, is hardened appreciably when it is hammered, and sickles or daggers capable of cutting corn or flesh could thus be produced.

About the early 3rd millennium B.C., in a manner which must have been accidental, it was discovered that copper could also be produced by heating certain bright-blue stones in a charcoal fire to a good red heat. When the ore cropped out at the surface and weathering had occurred, the ordinary wooden shovels and antler picks used by the flint miner were adequate. Further, the air and rain had washed out much of the impurities in the ore and before the middle of the 3rd millennium copper containing around 0.5% of impurities was being produced in the near east in this way (analysis 2).

As time went on and the weathered surface ore was used up, the ore body became harder and, as is demonstrated in old mines in the Tyrol, the ore was won from mines, often of considerable depth, by "fire setting." Against the ore face a fire was built up and when the rocks had become sufficiently hot they were quenched with water, splitting off fragments of ore. This process is illustrated in G. Agricola's remarkable book *De Re Metallica* of A.D. 1556 (English trans. 1912; 1950). a typical example of the remarkable persistence of primitive metallurgical techniques almost down to modern times.

Ore bodies, however, are not normally composed of the pure minerals but are admixed with waste matter or gangue, and as a preliminary to the smelting process itself some sort of purification such as hand-picking, crushing and washing is generally reauired. There is definite evidence that the advantages of these were soon appreciated, and it is not, perhaps, out of place here

TABLE *I.* — *Analyses*

Analysis No.	Material	Age B.C.	Composition per cent								
			Copper	Tin	Iron	Kickel	Lead	Arsenic	Bismuth	Antimony	Silver
1	Native copper	—	99.96	—	—	—	—	—	—	—	—
2	Copper from weathered ore	Early 3rd millennium	99.43	0.02	0.3	0.005	0.002	0.1	0.0005	0.03	0.1
3	Copper from pyritic ore (unweathered)	Middle 3rd millennium	97.41	0.87	0.02	0.16	0.56	0.2	—	—	—
4	Arsenical bronze	Later 3rd millennium	95.0	Trace	0.3	0.1	0.3	4.2	Trace	—	—
5	Low-tin bronze	Later 3rd millennium	93.84	5.0	0.5	0.05	0.2	0.2	0.002	0.2	0.005
6	Typical bronze	Late 3rd millennium	86.93	10.62	0.25	0.49	0.68	0.77	—	0.32	—
7	Bronze made from refined copper	Early(?) 2nd millennium	89.47	10.0	0.1	0.3	0.03	0.05	Trace	0.03	0.01

to observe that in these primitive days the distinction between the miner, the engineer and the metallurgist had not yet arisen.

As the depth below the surface increases the ore not only tends to become harder, but it may also change radically in composition. A fundamental step in the whole history of civilization was taken when some early genius realized that copper may also occur in unweathered chalcopyrites. It may have been that the golden colour misled him into the belief that such ores were rich in the precious metal, but they were undoubtedly worked, and processes involving quite advanced metallurgical knowledge were gradually devised. These ores were less pure than the weathered surface material and the copper produced was correspondingly impure. By the latter half of the 3rd millennium B.C. copper was being produced from such sulfide ores and the impurities had risen to 2% to 3% (analysis 3).

Such impure coppers — the term "bronze" for them is a complete misnomer — possessed two advantages. In the first place they were distinctly harder than the purer metal, while secondly there was a very distinct improvement so far as the ease of casting was concerned. As these improvements became associated with the sort of ore used, the first step was taken toward the deliberate mixing of ores to obtain a still better product. In this way arose the curious alloys which contain several per cent of arsenic, antimony, iron or lead which bridge the gap, in central Europe at any rate, between the copper and true bronze ages and which can only be adequately explained as the result of deliberate additions (analysis 4).

Such alloys possess marked advantages when compared with copper itself, but they tend to be brittle and the superiority of tin as an alloying material was soon appreciated. Starting with a tin content of 5% or less (analysis 3) these bronzes quickly settled down to a value normally about 10% to 12% (analysis 6). If the full analyses of these bronzes are compared, they will be found to fall into two groups of which one (analysis 6), is far more impure than the other (analysis 7). There is reason to believe that the gradual deterioration in the purity of the copper produced (compare analyses 1, 2 and 3) was reversed due to the discovery of fire-refining. This process merely involves the melting of the crude copper under oxidizing conditions whereby the impurities are preferentially oxidized and can be skimmed off as a scum. The true Bronze Age had arrived. It must not be overlooked, however, that since the tin had often to be transported over relatively great distances bronze was inevitably a more expensive material, and there are good grounds to believe that the impure copper was still being produced and used for agricultural and other less exacting purposes.

The former belief that the history of metals can be divided into clear-cut periods is oversimplified. While the development of the bronze had been going on, the initial work on the production of iron had also been proceeding and copper, bronze and iron were made and used simultaneously, as indicated in Table II.

Concerning the absolute dating of prehistoric metals, then, as now, progress proceeded from discovery, and later experiment, to exploitation. Very early isolated finds are well known which date back to a period long before knowledge of that particular material had become sufficiently widely dispersed as to have any influence on the civilization of the time. How slow such dispersion was is well shown in the spread of the Hallstatt (*q.v.*) ironworking culture which took over 500 years to travel from the Austrian Tyrol to England, a distance not much more than 500 miles in a straight line. Thus it would appear reasonable to date the Early Bronze Age to a time when this metal first became of real use as weapons or tools rather than to that of the earliest isolated, and therefore, possibly, accidental or experimental find.

Meteoric iron had been known from a very early date, but the terrestrial production of the metal, which involves a much more elaborate technique than does copper, was a slow process. Whereas copper can be smelted in furnaces of a relatively simple type, the smelting of oxide of iron with charcoal demands a higher temperature and the product even then is merely a spongy mass of pasty globules of metal intermingled with a semiliquid slag. The complete separation of iron and slag demands a temperature sufficiently high to melt both and, except in the far east, this was never achieved. By repeatedly reheating the spongy bloom and hammering it, at first on stone anvils, much of the slag can be expressed and a more and more coherent mass of iron gradually produced.

The eye-witness account given by John Percy *(Metallurgy: Iron and Steel,* pp. 257–258, 1864) of the production of iron by primitive tribes in southern India must reproduce almost exactly the practice of early ironworkers some 4,000 years before. *(See* IRONWORK.) This wrought iron is of low carbon content and hence soft — softer, in fact, than is a well-made bronze. It is not surprising, therefore, that the latter alloy retained its value for weapons. The fact that it could be cast, whereas (except in China and possibly India) articles of iron were only made under the hammer, gave bronze a sphere of utility in which the iron could not at first compete. Reference is made in the account given by Polybius of the Celtic invasion of Italy of 223 B.C. to the poor quality of the Celtic iron. Their heavy defeat by the Romans at Addua was largely attributable to the fact that their long iron swords "easily bent and would only give one downward cut — after this the edges got so turned and the blades so bent that unless they had time to straighten them with the foot against the ground, they could not deliver a second blow." Some 2,000 years later David Livingstone recorded that he had seen an iron javelin made from much the same sort of iron light upon the cranium of a hippopotamus and "curl up like the proboscis of a butterfly."

This limited use of iron lasted until it was discovered that, due to the absorption of carbon. long continued heating of iron to a good red heat in a mass of glowing charcoal converted the soft metal into one which was much harder. Such steel has also the further great advantage that, unlike iron, it may be hardened by quenching. If heated to a red heat and quenched in water or other medium, and some very curious ones were used even down to modern times, steel becomes much harder still.

In the history of early iron and steel the Hittites played a leading part. In a well-known letter of King Hattusilis III (1275–50 B.C.) to one of his contemporaries, probably the king of Assyria, after apologizing for not being able to send the iron asked for, says, "To-day now I am dispatching an iron dagger-blade to you." The gift of a single blade from one important monarch to another implies a metal of no ordinary kind, almost certainly a true steel, not impossibly in the hardened condition. It is probable that it was for the same reason that divine or supernatural powers were attributed to especially well-proved "iron" swords.

That the Greeks of the time of the writing of the Odyssey were acquainted with steel and with its heat-treatment is clearly demonstrated by the account of the blinding of Polyphemus by Ulysses:

> As when the smith.....
> .....plunges the hissing blade
> Deep in cold water, (whence the strength of steel)
> So hissed his eye around the olive ood.

Brass. the alloy of copper and zinc, despite mistranslations in the Bible and elsewhere, made its real appearance only in early Roman times. Zinc. as a metal, is a product of a much later age, and Roman brass was made by heating fragments of copper with charcoal and a zinc ore—calamine, zinc carbonate—in a closed crucible to a red heat. The charcoal reduces the ore to metallic zinc, which is a vapour at the temperature of the treatment, and this vapour gradually diffuses into the copper. As a result the melting point is lowered and, if the temperature is nicely judged. the copper-zinc alloy melts and liquid brass collects at the bottom of the crucible. Even after metallic zinc was known, this "calamine brass" was still produced by the same process and esteemed more highly than that made by melting the two metals together. The general establishment of a brass industry was one of the two major metallurgical developments which we owe to Rome.

These then were the metallic materials on which successive peoples had built up their civilizations and of which they made their implements both for war and peace. In addition to these, gold. lead and silver were also produced, and used for artistic or religious purposes. in personal adornment. household utensils or equipment for the chase. Other metals such as arsenic, zinc, antimony and nickel occur only in the alloyed form. and though tin, a metal easily reduced from its ore, may well have been known from an early date, it is too soft by itself to be of real significance. Regarding nickel, a copper coin containing about 20% nickel, of the Bactrian king Agathocles (around 200 B.C.), has been reported, but for such an early date this alloy is unlikely to have been deliberate.

Since gold always occurs in the metallic state, alloyed at times with silver up to almost 40% together with smaller amounts of copper, iron or metals of the platinum group, such as palladium, there is no real extraction metallurgy of this metal. In early times the chief sources would be the dust and nuggets in the sand and gravel of alluvial deposits, the simplest of all contrivances for its recovery being by washing the gravel by hand in pans where, as a result of its much higher density, the gold remains behind, the clay and siliceous materials being washed anay A somewhat more ambitious form of apparatus is provided by carrying the material by a stream of water down an inclined sluice provided with transverse riffle bars behind which the gold collects or, so far as the finer particles are concerned, by covering the base of the sluice with some rough material on which the gold dust is mechanically entangled. It has been suggested that the legend of the Golden Fleece is related to the use of sheep skins, woolly side uppermost, for this purpose, nhile Agricola's book contains a woodcut in which grassy turfs are similarly employed. By Roman times mercury was used to extract the gold, but this amalgamation process falls outside the range which can properly be designated primitive.

As has already been said, native golds often contain quite considerable amounts of silver, as a result of which the colour becomes paler. These silver-gold alloys, knoan as electrum. may be purified in a number of ways, of which the simplest, and therefore presumably the earliest, is by heating in a crucible with common salt. In time the silver is converted into silver chloride. which passes into the molten slag, leaving a refined but usually still impure gold. By repeating the treatment purification can be effected. An alternative process was by heating the alloy with sulfur or some sulfur-bearing compound such as alum or the iron sulfate produced by the weathering of iron pyrites. There is no clear evidence when such refining of gold started, though this was probably around 600 B.C., and like other ancient technical processes it may well have been in use in certain localities long before the knowledge had reached others.

So far as the base metals present in the gold, such as copper and tin, are concerned. their removal can be effected either by mere melting in an oxidizing atmosphere or, and the process is of great antiquity, by cupellation. In essence, the gold to be purified is melted with lead in an air draft in, or on, a porous crucible. The lead is oxidized and the molten lead oxide forms a slag into which the base impurities in the gold pass. This slag is absorbed by the porous cupel, bone-ash may be used, and finally a molten bead of gold, containing only the silver and any platinum metals, remains. The base metals alone are "consumed of the fire." and it may well be that it is to this process that the references to the refining and testing of gold in the Old Testament apply. That the Greeks knew and practised this process is abundantly proved by certain specimens of gold and silver which mere discovered by H. Schliemann on the site of ancient Troy.

In Troy II gold of a purity so high that it is only reasonable to believe that it must have been deliberately refined is not uncommon. By carrying out small-scale tests using the processes employed on a larger scale for the production of the metal, an early form of assaying was developed and was employed in the detection of deliberate debasement.

Although silver does occur in the native state this is not widespread, though the very earliest silver objects may well be of such an origin. It was not until it was recognized that many lead ores also contain appreciable amounts of silver that the latter metal became relatively common. The metallurgies of silver and lead are, therefore, inextricably interconnected. Lead is one of the easiest metals to extract from its ore; the commonest ore, lead sulfide, galena, needs no more than mixing with charcoal or other fuel and then roasting in the open air in a furnace, which need be little more than a hole or trench in the ground. The partial oxidation of the sulfide to lead oxide or sulfate, and the reaction of this with unchanged sulfide, produces metallic lead with

TABLE 11.—Prehistoric and Classical Metallurgy

Period	Smelting and Refining	Alloying and Working
Prior to 4000 B.C.	Native gold and copper and meteoritic iron used occasionally without melting	Hammering to shape and to harden Copper annealed about 4000 B.C.
4000—3000 B.C.	Reduction of oxidized ores of copper and lead Native silver used Copper-arsenic alloys by smelting natural mixed ores, followed by bronzes from intentionally mixed ores of copper and tin (*c.* 3500 B.C.)	Melting and casting nearly pure copper, followed by copper-arsenic and copper-tin alloys (made from ores) Permanent molds of stone and metal Lost-wax process for complicated castings Natural gold-silver alloys Soldering with copper-gold and lead-tin alloys
3000—2000 B.C.	Roasting and smelting of sulfide ores of copper Experimental production of sponge iron Tin smelted (perhaps earlier) and becomes important trade item Cupellation of lead to extract silver, and of gold and silver for purification	Most jewelry techniques known before 2500 B.C.—inlay, stamping, repoussé, raising, soldering, riveting, granulation, surface colouring, etc. Gold leaf Wire made by cutting sheet
2000—1000 B.C.	Gold purified by cementation Bellows used in furnaces by 1800 B.C. Wrought iron becomes important by 1600 B.C. (directly reduced from ore as sponge and forged without melting)	Bronze made from metallic tin and copper (perhaps much earlier). High-tin bronze (Speculum metal) for mirrors. Leaded bronzes for statuary Niello and enameling on gold Silver-copper alloys blanched Brass from copper and zinc oxide ores (not important before 200 B.C.) Steel regularly made by carburization in hearth, perhaps hardened by quenching, 1200 B.C.
1000—0 B.C.	Cast iron (China only) Cast steel ("Wootz": India only) Gold purified by sulfide process Mercury distilled from ores Amalgamation of gold ores	Vast expansion of production of iron, common nonferrous metals, and gold and silver Iron and steel welded into composite tools and weapons Stamping of coins, 700 B.C. Gilding of bronze and silver with gold amalgam Assay by cupellation, cementation, touchstone and (?) by density

Source: Cyril Stanley Smith, The University of Chicago.

the evolution of sulfur dioxide. So simple is the whole process that the early settlers in North America made lead for their bullets by smelting galena in a hollow tree stump, using the wind as a natural blast.

Owing to its softness and to the fact that, unlike most metals, lead is not hardened by hammering, both it and silver are relatively useless materials from a technical point of view. It is thought, however, that processes for the smelting and refining of lead were worked out somewhere in the region of Armenia about the early 3rd millennium B.C. This knowledge spread over the near east and both metals were common about 1500 B.C., though not until Roman times was lead used extensively. Its presence in amounts so substantial as to preclude accident in bronzes of the late 3rd millennium is evidence that by this date it had ceased to be scarce.

The crude lead produced in the manner described may also contain in addition to silver, arsenic, antimony, copper and tin. As a result of this contamination it is hardened and embrittled, and although a superior material for the production of religious or magical castings. is unfitted for hammering into sheet. A refining treatment is therefore required which, since it is little more complicated than the original reduction from the ore, was devised relatively quickly. Most of the impurities present in the crude lead freeze at a higher temperature than does that metal itself. If, therefore, the impure lead is remelted the pure metal does so first and, with its silver still in solution, can be drained away, leaving a pasty dross in which most of the impurities remain. Alternatively this dross, being more easily oxidized by the air, can be skimmed off as a semisolid crust. There is every reason to believe that this process formed part of the technique employed at Laurium, in Greece, where air was blown over the rim of the hearth on which the lead was melted. This refined lead was now ready for desilverization and of the processes available there can be no doubt that cupellation, already described in connection with gold, was the earliest. The inhabitants of Troy II were undoubtedly familiar with the process and could reduce the silver content of their lead down to 0.02%. The lead oxide produced in the process could then be resmelted with charcoal, and a soft. almost pure metal obtained.

These processes by which the early metallurgists produced their metals and alloys required the necessary equipment and tools. It may appear to be paradoxical, but more is known of the detailed construction of the earlier furnaces than of those of a later age. In these early furnaces, little more than holes in the ground lined with clay, a fire of wood was first started, after which layers of wood or charcoal and the ore were added, natural blast being provided by the wind, which was funneled, if possible, onto the furnace by the topography of the ground. At the conclusion of the operation the furnace was opened up for the withdrawal of the metal. In course of time, as the scale of operation increased, a superstructure was added to concentrate the heat and so raise the temperature attained. Due, however, to weathering or to deliberate destruction for the sake of the materials, this superstructure has generally disappeared and the design of the furnace is too often a mere matter of conjecture. A very early iron furnace from Hiittenberg, in Austria, is a mere bowl in the ground, some three feet in diameter and about the same in depth, lined with a thick layer of clay and set in a foundation of broken stone. No means of tapping out any molten slag mas found nor was there anything through which an air blast could be provided. In a later one. from the Engsbachtal. a thick dome with a central vent had been built over the hearth and a taphole for the slag included. In the case of all iron furnaces, since the product was a semisolid mass, some degree of destruction of the structure was inevitable in the withdrawal of the metal.

The working tools of the pre-Iron-Age smith were little more than a stone anvil. a stone, or later a bronze, sledge hammer and withes, or bent pieces of green wood, to hold the crucible during the removal from the furnace and the pouring of the molten metal into the mold in which the casting was made. An excellent illustration of this method of holding the crucible is given in a wall painting from a tomb at Thebes.

With the introduction of iron, however, effective tongs to hold the red-hot mass during forging became essential. The earliest may well have been merely large tweezers, such as those illustrated in an Egyptian tomb of the early 13th century B.C., but these cannot have been very satisfactory. There is some reason to believe that it was not until tongs giving a much firmer grip on the bloom were available that iron became a common metal.

One of the astonishing facts in the history of the metals is the great skill shown by the gold- and silversmiths of the time. Their skills were always in step with those of the men who provided the metals, and soldering. granulation and wirework of quite remarkable perfection were done. In connection with wire it may be noted that the drawing of wire through dies was probably not invented until somewhere around A.D. 1000. Before then the method of production is clearly described in Ex. xxxix, in connection with the manufacture of the gold wire used to decorate Aaron's vestments: "And they did beat the gold into thin plates, and cut it into wires, to work it in the blue, and in the purple, and in the scarlet, and in the fine linen, . . ." If a round wire was required the strips were then hammered on an anvil, and once more or less circular in cross section, the wire was reduced to finer and finer sizes by pure tension.

This brief survey of one side of human progress during a period of some 3,000 years would be incomplete without mention of the impression that, although in the earliest stages chance must often have played a major part, the mind of the observer was sufficiently alert to appreciate what was occurring and to repeat it. Further, as experience was gained, there can be no doubt that real experimentation was carried out. This is well shown in the successive stages in the transition from the copper to the true Bronze Age, and in the gradual development from relatively useless, soft iron to a fully heat-treated steel. The men responsible for such changes were the scientists and research workers of their time.

(F. C. T.)

Over the centuries and especially during the 19th and 20th centuries, metallurgy has developed from an art dependent on trial, experience, and rule-of-thumb, into a combination of art and science involving knowledge of the principles underlying the behavior of metals—principles grounded largely in chemistry and physics. The chronology of this development through the 19th century is traced in Tables III and IV. Modern metallurgical development, so important to civilization, depends increasingly on the science of metallurgy. The art and science have thus combined to give rise to the great metallurgical industry, with its far-reaching effects in the economy and even the political relations of the world.

II. ORES AND ORE TREATMENT

Of the 92 natural chemical elements, about 70 are metals. Metallurgy begins with the treatment of ores to extract metals from them, called production or extractive metallurgy. An ore is defined as a mixture of minerals from which a metal may be extracted with commercial profit; a mineral is a naturally occurring compound of metallic and nonmetallic elements. Thus the treatment of ores involves first, a separation of particles of different minerals with little or no change in their chemical composition, and second, a breaking down of the valuable mineral so as to isolate the desired metallic element. The first step requires crushing and usually fine grinding of the ore, so that the particles of the different minerals present become largely detached from each other, followed by a process called mineral preparation, or ore dressing, which separates most of the particles of the mineral containing the desired metal from the worthless minerals that constitute the gangue, or earth or rock with which the valuable mineral was mixed. The separation is based on some difference in physical properties such as specific gravity, response to a magnetic field, or wettability of the particle surfaces. The result is a concentration of a large quantity of ore into a smaller and richer amount, usually a very necessary step in the economical performance of the second step. As an example, ore dressing may result in an increase of the valuable metal content of the ore from as little as 1% or less to as much as 50% or more, with a corresponding

decrease in the amount of material to be further treated. (See ORE DRESSING.)

1. The Flotation Process. — The process of concentrating ores by flotation was developed in the first quarter of the 20th century. It soon became the leading method of ore dressing. It depends on the fact that certain minerals: notably the sulfides, are not readily wetted by water in which they are immersed, but instead bubbles of air become attached to their surfaces and. when they are finely divided, cause them to float. Other minerals, including oxides and the common constituents of the gangue, are wetted and do not float. Thus the valuable mineral particles of an ore, which must be finely ground, can be separated from the worthless gangue. The action is promoted by addition of several substances to the water, only very small quantities being needed. These include "frothers," of which pine oil is an important example, which make the froth stable and lasting when air is introduced in the flotation cell by agitation or by blowing. It is this froth which carries the desired mineral particles to the surface of the water in the cell. Next are "promoters" or "collectors," such as the organic compound Xanthate, which reduce wettability and assist in the attachment of air bubbles to the surfaces of floatable particles. "Conditioners," such as soda or lime, are often added to produce a slight alkalinity, which aids in frothing, and influence the behaviour of the collectors. Flotation is almost universally used in concentrating sulfide ores of copper, lead and zinc, and about 1924 it mas found possible not only to float these from the gangue but also separate them from other sulfides and from each other, selectively. This is accomplished by adding a "depressant," of which lime and sodium cyanide are examples, which will so affect the surfaces of certain sulfides that they are prevented from floating, while another, not so affected, is floated. Then a "reactivator," such as copper sulfate or sodium sulfide, is added, which counteracts the effect of the depressant and causes the originally depressed mineral to float. In this way many complex ore mixtures, formerly of little value because it was not known how to treat them profitably for extraction of their valuable metal contents, have become among the principal sources of certain metals.

2. Extraction of Metal. — After treatment by ore dressing, the next step necessarily involves a chemical change in the ore (now a concentrate). The chemical change must break down or decompose the valuable mineral into its metallic and nonmetallic components and also complete the separation of the gangue, which could not be fully removed in the first step. Some ores are not subjected to mineral preparation either because they are rich enough without it or because the physical nature of the ore is such as to make separation of the mineral particles ineffective, resulting in large loss of the valuable mineral. An interesting fact is that the processes of mineral preparation have been so improved over the years that huge piles of tailings (the discarded gangue) are being re-treated to recover much of the mineral which formerly was not taken into the concentrate.

The second step in ore treatment is selected on the basis of several considerations, among them the chemical nature of the mineral compound, which may be a sulfide, oxide, carbonate, silicate or other. The most important iron and aluminum ores are oxides; the most important copper, zinc, and lead ores are sulfides. In a few instances, often in the case of gold, and more rarely in the case of copper and silver, the metal is present in metallic form, uncombined with a nonmetal; these are called native ores. Other factors determining the choice of method are the richness of the ore, the specific gravity of the metal, the chemical properties of the metal such as its affinity for oxygen or for sulfur, its solubility in acids or other solvents, its melting and boiling temperatures, and, of course, the relative costs of the different processes. The methods may be divided into three classes: (1) pyrometallurgy, those carried out at high temperatures obtained in fuel-fired furnaces: of which roasting and smelting are examples; (2) hydrometallurgy, those which consist of leaching the ore with a solution such as an acid or a strong alkali, often called a "wet method"; and (3) electrometallurgy, in which electricity is employed, especially to produce heat in an electric furnace or for electrolysis of a solution obtained by leaching or of a molten mixture of salts containing the metal.

A metal may be produced from an oxide by removing the oxygen from the metal with which it was chemically combined. This is a process of chemical reduction. It is perhaps the simplest and the most commonly used method, and is most often accomplished by heating the oxide with carbon. Carbon will thus act as a reducing agent. setting the metal free by taking the oxygen from it. As the metal oxide is reduced to metal, the carbon is oxidized to carbon monoxide or carbon dioxide, both of which are gases which escape from the furnace.

The reaction requires energy, usually applied in the form of heat, to make it proceed; hence it is carried out in a furnace, either fuel-fired or electric. The temperature necessary for the reduction depends on the affinity of the metal for oxygen; all the metals may be arranged in a series in which the position of each shows the reducibility of its oxide and indicates the relative temperature required. The temperature in the furnace is usually, though not necessarily, high enough to cause the metal to become molten as it is produced. At the same time, the gangue present with the metal oxide in the furnace also melts. Since gangue is composed of substances of very high melting points, it is economical to mix the ore with a flux which will combine with the gangue to form a slag. The slag will melt at the temperature reached in the furnace, yet its melting point is usually higher and often much higher than that of the metal.

The process just described is smelting, which is defined as melting accompanied by chemical change. Nearly all iron is produced by reducing smelting of oxide iron ore using carbon in the form of coke both as reducing agent and a fuel. The operation is usually carried out in a blast furnace (*q.v.*).

Many other metals are produced by reduction of oxides, which sometimes are present as such in the ore and sometimes are formed by roasting the ore prior to smelting. Roasting is heating in air without fusion. its chief purpose being to transform sulfide minerals into oxides, the sulfur being removed from combination with the metal by oxidizing it to sulfur dioxide, which escapes as a gas. The metal usually combines with oxygen also. and its oxide is then reduced by smelting or otherwise. Tin is an example of a metal produced similarly to iron by reducing smelting of an oxide ore, while lead, zinc, copper and nickel are examples of metals found as sulfides in ores which are roasted before reduction.

Lead ores are most often smelted in blast furnaces. This type of smelting may also be applied to tin and copper, but the ores of these two metals are usually smelted in furnaces of the reverberatory type, which is heated by oil, gas or powdered coal burned at one end of the furnace. The hot gases pass over the charge, which lies on a broad shallow hearth (see FURNACE, METALLURGICAL). The most abundant ores of copper are sulfide ores. Instead of being smelted directly to metallic copper, these are usually smelted to matte, which is a mixture of sulfides chiefly of copper and iron. The matte is then treated by "converting," a process patterned after the Bessemer steel (see CONVERTER STEEL) process, in which air is blown into the molten matte, oxidizing the sulfur to sulfur dioxide. and changing the iron to oxide which combines with a silica flux to form a slag, leaving the copper as impure metallic copper. Roasting copper ore is a partial roast which has the purpose of adjusting the sulfur content to the amount desired for a suitable matte. With many copper ores roasting is omitted. Nickel ores also are smelted to matte, followed by converting. Distillation is a method of extraction used for metals of low boiling point, notably for zinc, cadmium and mercury. Zinc sulfide is roasted to oxide and may then be heated in a retort with coal as reducing agent. The temperature of reduction is above the boiling point of zinc, which is therefore evolved as vapour. The vapour condenses to liquid zinc in a condenser attached to the retort.

Some metals, instead of being reduced by carbon, are reduced by another metal, one having so high an affinity for oxygen that it will take the oxygen from the oxide of the desired metal when sufficiently heated, or by application of the same principle will take chlorine from the chloride of the metal. Thus titanium is

TABLE 111.— Chronological Table of Development of Metallurgy From A.D. 0—1800

Period	Smelting and Refining	Alloying and Working	Metallurgical Science and Literature*
A.D. 0—1000	Zinc smelted in China and India	Steel made from wrought iron and molten cast iron (China. before A.D. 600). Steel made by repeated welding and forging, carbon controlled by flux, local hardening (Japan, before 8th century A.D.). "Damascus" steel swords (low-temperature-forged Wootz) widespread in Islamic countries. In Europe, steel still made by hearth-carburization; welded compositions common; *e.g.*, pattern-welded sword of Merovingians and Vikings.	*This table omits reference to general developments in physics and chemistry which were of fundamental importance. The growth of crystallography; of chemical atomic, molecular, and ionic theory; of thermodynamics; and of reaction kinetics provided the general background of knowledge without which metallurgical science could not have advanced. Note, however, that practical metallurgists empirically discovered many phenomena centuries before they were theoretically explained.
A.D 1000—1500	Blast furnace for carburizing and melting iron (1380) (outgrowth of bell founders' furnace). Blast furnace for reduction of iron ore to cast iron (*c.* 1440). Refining of cast iron to wrought iron (*c.* 1440) (did not entirely replace direct process until 19th century). Desilverization of copper by liquation with lead and cupellation (*c.* 1470). Bismuth smelted (15th century). Parting of gold and silver with nitric acid (15th century).	Type metals (earliest, c. 1440, were tin-base alloys like pewter; displaced by lead-antimony before 17th century). Etched decoration of armour (mid-14th century). Large reverberatory furnaces for bronze melting (11th century). Iron made fusible (but brittle) with antimony, etc.	Theophilus *Schedula* Diversarum *Artium* (*c.* 1100) with first extant descriptions of metal working processes including casehardening, wire drawing, bell founding, gold- and silversmith work and metal pigment powders Pewter assayed by density (before 1350).
A.D. 1500—1600		Cast-iron cannon (1jog). Rolling mill for narrow strips of coinage alloys. Widespread use of water power for working metals. Tinned iron common.	Printed accounts of quantitative assavina methods, smelting, refining, and working techniques for copper, lead, and precious, metals, (little on iron): *Probierbüchlein* (1524), Biringuccio (1540), Agricola (1556), Ercker (1574).
A.D. 1600—1700	Lead and copper smelted in reverberatory furnaces with coal. Trials with coal in iron blast furnaces. Zinc recovered as condensate in lead-smelting furnaces (prior to 1617).	Blister steel made by cementation (*c.* 1600, possibly earlier). Brass from copper and metallic zinc (before 1627). Chimney to enhance furnace draft (1648). Lead shot by free fall (*c.* 1650). Newton's low-melting-point alloy (1682). Slitting mills for iron; wide sheet rolls for lead; three-high rolls for lead sections. Superiority of bronze and brass bearings for iron shaits recognized.	Mathematical analysis of strength of beams (Galileo, 1638). Glauber's Philosophical Furnaces describes studies of alloys (1648). Law of elasticity (Hooke, 1660). First observations of microstructure (Power, 1664; Hooke, 1665). Expansion of steel on quench-hardening observed (Perranlt, 1680). Books on fine ironwork (Jousse, 1627), mint operations (Boizard, 1696), and gunfounding (St. Remy, 1697) describe metalworking procedures in full detail.
A.D. 1700—1800	Coke for smelting iron (1jog). Zinc smelting in Europe (*c.* 1740). Platinum imported from South America (*c.* 1740). Puddling process for wrought iron (1783).	Malleable cast iron (1722). Crucible steel (1740). Powder-metallurgy platinum (1781). Extrusion of lead pipe (1797). Rolling of iron rods and bars.	Phlogiston theory of metal reduction (Stahl, 1703). Table of chemical affinities of the metals (Geoffroy, 1718). Theory of steel based on composition and structure (Réaumur, 1722). Observation of three different structures in copper-zinc alloys (Geoffroy, 1723). Systematic tensile and hardness tests (Musschenbroek 1729). Systematic study of platinum alloys (Lewis, 1763). Principles of chemical analysis (Bergman and others beginning about 1770). Observation of carbonaceous residue on acid solution of cait iron and steel (Rinman, 1774). Crystallization of alloys related to geometry of parts (Grignon, 1775). Chemical differences between cast iron, wrought iron, and steel studied quantitatively (Bergman, 1781). High-temperature pyrometry (Wedgewood, 1782). Phlogiston theory demolished (Lavoisier, 1783). Carbon theory of steel clearly enunciated (Vandermonde *et al.*, 1786). Comprehensive study of physical properties of all possible alloys (Achard, 1788). Electrochemical reduction of copper and silver (Cruikshank, 1800).

Source: Cyril Stanley Smith, The University of Chicago.

made by reducing titanium tetrachloride with molten magnesium or sodium. Other metals sometimes produced by reduction with another metal are zirconium, manganese, chromium, vanadium, and a number of the rare metals. Some metals have such high melting points that they are reduced without melting, either with carbon or hydrogen as reducing agent. The metal may thus be produced in powder form. Such a method is applied to tungsten, molybdenum, and sometimes cobalt.

Metals whose oxides or other compounds would require excessively high temperatures for reduction by pyrometallurgy are made by electrolysis of a fused salt bath containing a compound of the metal. This is an important method in metallurgy, accounting for all production of aluminum, which by about 1954 had so increased as to equal copper in world tonnage. The process of producing aluminum by electrolysis of a fused bath in which aluminum oxide is dissolved was invented independently by Charles M. Hall in the United States and Paul Héroult in France in 1886. Other metals produced by this method include magnesium, sodium and calcium. The fused salt of the desired metal is mixed with other salts which are not decomposed in the electrolysis but serve to lower the melt-

TABLE IV.—*Metallurgical Chronology in the 19th Century*

Smelting and Refining	Alloying and Working	Metallurgical Science and Literature
Hot-blast stove (Neilson, 1823)	Oxyhydrogen furnace (Hare, 1801)	Alkali metals reduced by electrolysis (Davy, 1808)
Liquation-desilverized lead (Pattinson, 1833)	Research on alloy steel (Stodart and Faraday, 1820)	Meteorite structure revealed by etching (Widmannstätten, 1808)
Pneumatic steel (Kelly, 1851)	Duplication of true Damascus steel (Breant, 1823)	Thermoelectricity discovered (Seebeck, 1821)
Bessemer converter (1855)	"Kickel-silver" alloys (Frick, 1823)	Aluininum reduction (Oersted, 1825)
Manganese deoxidation of steel (Mushet, 1856)	Nickel steels (Fischer, 1825)	Melting points of gold, silver, platinum alloys (Princip, 1828)
Gas-fired regenerative steel furnace (Siemens, 1856)	Galvanized steel sheet (1836)	Cooling curves of alloys (Rudberg, 1829)
Zinc-crust desilverized lead (Parkes, 1856)	Electrotyping (Jacobi, 1838)	Repeated-impact tests (Hodgkinson, 1843)
Regenerative hot-blast stove (Cowper, 1857)	Soft bearing metals (Babbitt, 1839)	Law relating thermal and electrical conductivities (Wiedemann and Franz, 1853)
Electrolytic copper refining (Elkington, 1865)	Parts shaped by powder metallurgy (Osann, 1841)	Electrical resistance of alloys related to constitution (Matthiessen, 1859)
Basic Bessemer process (Thomas, 1875)	Three-high steel mill (Carslund, 1856)	Fatigue tests (Wohler 1860)
Pyritic smelting of copper (Holloway, 1879)	Aluminum bronzes (Debray, 1856)	Allotropy of iron suggested (von Fuchs, 1861)
Bessemerizing of copper matte (1880)	Tungsten steel (Mushet, 1868)	Microstructure of iron and steel (Sorby, 1864)
Electrolytic aluminum (Hall, Héroult, 1886)	Malleable nickel (Fleitman, 1879)	Structural theory of steel hardening (Jullien, 1865)
Cyanide process for gold (MacArthur and Forrest, 1887)	Manganese steel (Hadfield, 1882)	Critical point in steel observed (Tschernoff, 1868)
Carbonyl-nickel process (Mond, 1892)	Seamless tube piercing (Mannesmann, 1885)	Recalescence of steel (Gore, 1869)
Aluminothermic ferroalloys (Vautin, 1898)	Precipitation hardening observed (palladium alloy; Paillard, 1886)	Precise melting point diagram (copper-silver) (Roberts-Austen, 1875)
	High-speed-steel heat-treatment (Taylor and White, 1898)	Fracture and chemical state of carbon in steel related to critical point (Brinell, 1885)
	Silicon iron (Hadfield, 1899)	"Cellular" theory of steel (Osmond, 1885)
		Practical thermoelectric pyrometer (LeChatelier, 1887)
		Thermal analysis of steels (Osmond, 1887)
		Slip bands observed in deformed metal (Charpy, 1896)
		Microradiography (Heycock, 1897)
		Iron-carbon constitution diagram (Roberts-Austen, 1899)
		Phase rule applied to alloys (Roozeboom, 1899)

Source: Cyril Stanley Smith, The University of Chicago.

ing point of the salt bath.

A radically different but very old and important method of extraction is that of hydrometallurgy (*q.v.*), or leaching. This method is applied when a compound of the metal exists in the ore, or can be formed by roasting, which will dissolve in a suitably low-cost solvent. Large tonnages of copper and zinc are produced in this way, as well as most gold and much silver, and other metals. The most common leaching agent is dilute sulfuric acid. which is used for recovery of copper and zinc. Aluminum ore (bauxite) is leached with strong caustic soda, forming a solution of sodium aluminate, from which pure aluminum oxide is precipitated and then electrolyzed in a fused salt bath to produce aluminum. This method, the Bayer process, of making pure aluminum oxide for electrolysis was invented by K. J. Bayer of Germany in 1888. Gold and silver ores are leached with very dilute solutions of sodium cyanide. In the amalgamation (*q.v.*) process liquid mercury is used as a solvent for gold and silver. Tungsten ores, in mhich tungsten exists as insoluble tungstates, are treated to form a soluble sodium or potassium tungstate, which is then leached out with hot water. Ammonia is another leaching agent sometimes employed. Leaching is usually done at atmospheric pressure and without heating the solvent. The leaching of bauxite, however, is done under several atmospheres pressure and temperatures of 140° C. and higher. Pressure leaching is sometimes applied to complex ores, such as those containing copper, nickel and cobalt.

The solution obtained by leaching must be further treated to obtain the metal from it. This is often done by electrolysis; sometimes by cementation, in which the solution is passed over iron, for example, the metal precipitating on the iron, which replaces it in solution. Gold is usually precipitated from cyanide solution by means of zinc dust. Pure hydrated aluminum oxide is precipitated from sodium aluminate solution by "seeding" it with crystals of aluminum hydrate which serve as nuclei to start crystalization of the bulk of the alumina present. Sometimes precipitation is effected by or assisted by heating or by evaporation. In pressure leaching hydrogen is used to precipitate the metals selectively in powder form.

3. Refining. — As first extracted from its ore, a metal is more or less impure. In some cases it may be used industrially in this condition; more often it requires refining; *i.e.*, removal of most of the impurities from it. In many cases the impurities so removed constitute valuable by-products. Thus gold and silver are recovered in refining copper. lead and nickel. Bismuth is recovered in refining lead, cadmium in refining zinc, and the platinum-group metals in refining gold. Methods of refining include oxidation of the impurities with air, often assisted by an oxide flux. The process of making steel from pig iron or steel scrap, as in the Bessemer and open-hearth processes, is to a large extent one of refining by oxidation. Another method is electrolytic refining. Eighty per cent or more of the copper produced is refined by electrolysis. This method is also* applied to purification of silver and nickel, and in some instances to gold, lead, aluminum and other metals. In this method the impure metal to be refined is used as the anode; pure metal is deposited on the cathode. Some of the impurities dissolve in the electrolyte, while others remain insoluble at the anode and fall to the bottom of the tank in a finely divided form. This constitutes the anode slime, which is further treated to recover the valuable metals from it. Thus in copper refining, for example, gold, silver, selenium and tellurium are obtained. Refining may also be accomplished by distillation and by liquation. The latter is a method of melting or slowly cooling, alloning the impurities to separate by virtue of a difference in melting point and either settling or rising because of a difference in specific gravity.

For the processes of extracting and refining various metals, see articles on the individual metals, as ALUMINUM; COPPER; LITHIUM; etc.

III. CAST AND WROUGHT METAL

The preparation of the metal in the pure or approximately pure form, generally in the liquid state, is a distinct stage in most processes. It is only the beginning of the series of operations by which the metal is brought into its finished form. Those operations vary widely according to the form in which the metal is to be finally used. Broadly, however, metallic objects may be divided according to their mode of production into two types: cast and wrought. The cast material is brought into its final shape, so far as metallurgical operations are concerned, by allowing the molten metal to fill and to solidify in a mold of suitable shape. Wrought material, on the other hand, begins its career by solidification in a mold of simple shape, and the resulting solid ingot, slab or other shape is then brought into the desired form by working, which may be done either cold or at an elevated temperature, by operations such as rolling, pressing, forging, stamping, drawing, etc.

Many metals and alloys cannot be wrought because they are, even when hot, too brittle to withstand plastic change of shape. Such materials — of which ordinary cast iron (*q.v.*) is an example — can be used only in the cast state. Finally, the finished or nearly finished material may be subjected to certain forms of heating and cooling known as heat-treatment (*q.v.*), which improve its properties to a marked extent.

The first step in bringing metal into the desired finished state

consists in causing the liquid metal to fill a mold, where it solidifies as a solid casting which has the shape of the interior hollow of the mold. Although superficially simple, this process offers many difficulties. These are greatest where the metal melts at a very high temperature and in those cases where the liquid metal absorbs large volumes of gas which are liberated during solidification. A second required step often is machining after the casting has been removed from the mold.

A. Iron and Steel

A large proportion of the liquid metal produced throughout the world is required for future mechanical working, such as rolling or forging and therefore is cast into molds of very simple shape. The most striking example is the production of steel ingots, which range in size from a small rectangular block weighing a few pounds to huge, tapered, octagonal masses weighing more than 100 tons. Except in the case of crucible-melted steel, the liquid metal is first run from the refining furnace into a large ladle, generally a steel box open at the top and provided with a refractory lining. These ladles are moved about the furnace building by powerful electrically operated overhead cranes. For filling they are brought in front of the furnace, from which the liquid steel is allowed to escape through a taphole at the base. From this hole the liquid steel runs along a gutter or launder lined with refractories and falls into the ladle as a cascade from which great showers of sparks arise. From the ladle the liquid steel is afterward allowed to flow into the cast-iron ingot molds.

The solidification process is comparatively simple in a pure metal free from gas, but as steel is a complex alloy of iron with carbon and other elements, and contains dissolved gas as well as oxides. sulfides and silicates in suspension, the process becomes complex. In spite of an immense amount of laborious investigation the details of the solidification of steel are neither fully understood nor entirely under control. The principal factors which play a part in the process of ingot solidification are briefly as follows:

1. Contraction. — The steel after solidification occupies a smaller volume than in the liquid state. Since the layer of metal next to the wall of the mold solidifies first, and successive layers of solid metal are formed on the solid crust thus initiated, the last liquid portions are left at or near the centre of the ingot. A funnel-shaped contraction cavity or pipe is formed which may extend well down the centre of the ingot. This pipe must, for most purposes, be eliminated, and a large part of the upper portion of the ingot must be cut .off and discarded. This can be partly avoided by using containers, usually of fire clay and known as sinkheads or hot tops, placed on top of the open end of the mold. The molten steel is allowed to fill these as well as the mold proper, and they consequently provide a reservoir of liquid steel from which the shrinkage cavities can be filled. This method confines the pipe more or less to the feedhead of the ingot, and the amount which has to be cropped is much reduced. Further improvement is gained by keeping the metal in the feedhead molten, which may be achieved by a gas torch or an electric arc.

2. Gas Liberation. — Liquid steel, like most liquid metals, is capable of dissolving large quantities of gas, especially hydrogen. Most of this gas is driven out of solution when the liquid metal crystallizes and then partly escapes to the surface. A considerable amount, however, fails to escape unaided and forms cavities or bubbles in the solidified metal. It is contended that in steel which is to be rolled or forged such gas cavities are harmless because their surfaces, when subsequently pressed together at a high temperature during rolling or forging, unite by welding. Such welding, however, is not always complete; a great many of these cavities can never weld because their walls become coated with impurities, such as silicates and sulfides, gathered from the adjacent steel during the pasty stage of solidification. These can be traced as long lines of nonmetallic enclosures in the finished steel. The formation of gas cavities or blowholes in steel can be regulated to a great extent by the manner in which the oxidizing processes in the steel furnace are conducted. If the reactions between oxide of iron and carbon are allowed to complete themselves so that the agitation or boiling of the steel in the furnace ceases, the product is a dead melted steel in which gas cavities will be comparatively few. Such steel, however, shows marked piping as described above. Even if the process is stopped at a point where there is still some oxide of iron present in the bath, the steel can be "killed" by the addition of a relatively small quantity of aluminum. Steel killed in this way pipes like dead melted metal. If, on the contrary, the steel is brought into the ingot mold while still actively generating gas — so-called wild steel — this process continues to some extent during solidification. A good deal of the gas then liberated is trapped in the solidifying steel, which, consequently. contains a large number of blowholes. The formation of these holes counteracts the effects of the normal contraction of the steel, and the steel does not appear to shrink while solidifying; it may, indeed, appear to rise in the mold. Such steel is called rising or rimming steel. It has, from the point of view of mass production. the advantage that as there is no definite pipe almost the nhole of the ingot can be rolled, thus affording a larger yield of finished steel.

3. Segregation. — As steel is a complex substance and the rate of solidification of any but the smallest ingot is necessarily slow. the constituents have time to undergo separation or segregation which results in nonuniformity of chetnical composition in different parts of the ingot. Segregation plays a very important part in affecting the quality of large steel ingots. In general, the impurities concentrate in the centre, although in several alloys the inverse may be true. It is, of course, a natural process which. under conditions of slow. undisturbed cooling in large masses, cannot be prevented except possibly to some extent by a careful choice of the composition of the steel itself. At the same time it has to be regarded as imposing a limitation on the size of the ingot, and consequently of the forgings or plates, which it is desirable to use where high and uniform quality is essential (see Iron and Steel: *Ingots*).

4. Contraction Stresses. — Since the outer portions of an ingot necessarily solidify while the inner portions are still liquid, the latter. on subsequent solidification and contraction, exert a powerful inward pull on the outer portions. hlasses of large size are therefore apt to be under severe internal stress and may sometimes crack spontaneously or when placed in a reheating furnace. The formation of such cracks can be largely avoided by correct design of the ingot molds. Part of the difficulty is also avoided by the practice. adopted also aith a view to economy. of draning the ingots from the molds while the steel is still very hot, so that the interior still may be partially liquid, and placing them in so-called soaking pits, a kind of pit furnace in which the temperature throughout the ingot has the opportunity to become equalized and the steel moreover is kept at a temperature suitable for forging or rough rolling.

B. Nonferrous Ingots and Castings

The production of ingots or slabs of the nonferrous metals and alloys, while subject to the same general laws and phenomena as steel, differs in regard to the conditions which have to be met. Nonferrous ingots are rarely very large. so that many of the problems which arise from large size, very slow cooling and extensive segregation do not enter into the corresponding nonferrous problem. On the other hand the nonferrous ingot has frequently to meet special conditions. The quality of the surface of the cast slab is often important. In steel. so long as there are no cracks or foldings, smoothness of the surface is not essential. Brass, on the contrary, has frequently to be rolled out into a finished product with a smooth surface. so that the nature of the ingot or slab surface is very important In the same way, blowholes lying just under the ingot skin. nhich are often regarded as normal in steel. are not permissible in nonferrous metal which is to be rolled into strip or sheet. since these cavities tend to open out during the annealing process following cold rolling and thus cause defects. Much more attention therefore is paid in nonferrous ingot casting to the details of mold surface, dressing. etc., and also to the method of filling the molds. In steel practice this very frequently is done by allowing the fluid metal to run into the mold from an opening in the bottom of a large ladle. In nonferrous practice, where the

masses to be handled are much smaller, the molten metal often is poured directly from the ladle or even from the furnace into the open top of the mold. Many other processes for filling ingot molds have been developed, some working by gravity with or without the interposition of funnels or separators of various kinds, others by pressure applied to the liquid metal that forces it into the mold. Ingot casting of many nonferrous metals may be done by a continuous casting process. The solid bar is withdrawn from the bottom of a water-cooled mold at the same rate as molten metal is poured into the top. Because of the higher temperatures required this process is more difficult for steels, but its use is developing on a large scale.

In regard to dissolved gases, while nonferrous metals do not undergo a "boiling" action in which gas is generated during refining and melting, as in steel, they still absorb considerable quantities of gas from the atmosphere of the furnace and from other sources. In some cases this leads to difficulty in securing soundness whether in ingots or in shaped castings. Copper is an example of this kind, but the phenomenon is encountered to a marked extent also in aluminum and its alloys and in certain kinds of bronze. Two methods were evolved for freeing nonferrous metals from dissolved gas. The most positive of these is that of presolidification. It consists in allowing the molten metal or alloy to solidify very slowly, preferably in the ladle or else in the furnace where it has been melted. During this slow solidification the crystallizing metal expels the gas, which has time to escape to the surface. As soon as solidification is complete the metal is rapidly remelted and cast.

Another method of gas expulsion consists in bubbling through the molten metal a more or less inert gas which, by local reduction of the partial pressure of the dissolved gas. leads to the removal of the latter. This method is successful when nitrogen is bubbled through molten aluminum alloys. Nitrogen, however, is itself slightly soluble in many metals, so that this process is not universally applicable. In some alloys, on the other hand, one of the constituent metals is volatile, and escaping bubbles of its vapour serve to expel other gases in the same manner as bubbles of an inert gas. This is, perhaps, the reason why brass, with its large content of volatile zinc, readily yields sound castings. Hydrogen is commonly bubbled through magnesium alloy castings.

The production of shaped castings entails processes and problems widely different from those of ingot production, but it is impossible to discuss them even in outline here (see DIE CASTING; FOUNDING). They vary according to the nature of the metal to be cast. Some reference has already been made to cast iron. Steel offers much greater difficulty in regard to casting. The tendency of the metal to liberate gas during solidification is one of these; another is the high temperature of molten steel, which makes severe demands on the materials used as molds; another is the marked shrinkage during solidification. Castings are made in two types of mold, single-purpose molds and permanent molds. The former have to be specially prepared, sometimes by means of machines, from patterns for each casting. The use of metal or permanent molds offers many advantages where the process is applicable, The constantly repeated cost of sand molding is eliminated, but against this must be set the high initial cost of the metal mold or die. The latter usually is justified only where the same casting is required in great numbers. For many metals there is also a distinct advantage in regard to structure and strength which results from the relatively rapid solidification which takes place in a metal or chill mold. For the nonferrous metals chill casting is extensively practised, especially in the case of some aluminum alloys.

C. Die-Casting

For the lower-melting nonferrous metals die-casting has found extensive application because of the accuracy of dimensions which can be attained and especially because of the rapidity with which the castings are made. Die castings can be used for many purposes without subsequent machining and are widely employed in light machinery, domestic and office appliances, automobile door handles and grilles, and a host of other articles.

Die-casting consists essentially in producing castings in metal dies or molds, but as a rule the process is carried out by forcing the molten metal into the mold rapidly under pressure. This is done in machines which also open the die and eject the casting. the operation being rapidly repeated. The widest use of this method is made in castings of low-melting alloys of zinc. tin and aluminum. It has been extended to magnesium alloys and even to certain types of brass and bronze. The difficulties of the process, however, increase rapidly as the melting point of the alloy rises.

D. Precision Casting

Alloys for use when highly stressed while at high temperatures, such as for turbine blades, supercharger buckets and other parts of jet engines, guided missiles, etc., offer special problems in shaping. These alloys are made to maintain their strength and form at high temperatures, and it is not possible to soften them and make them plastic for working by heating as is commonly done with steel and most other metals. Also, most of them cannot be machined. Some can be forged, but with considerable difficulty. Often they must be cast to exact dimensions for final service. For this purpose a method known as precision casting or investment casting is employed, a process adapted from dentistry and jewelry manufacture and now used in making many small objects of intricate form with small dimensional tolerance and good surface finish. Patterns are first made by injecting wax or plastic into a master die. The patterns are placed in a sheet-metal container (flask) and covered with an investment slurry. After the assembly has been dried for about eight hours to harden the investment, the wax or plastic is melted out and the metal poured into the cavity, which forms a hot mold. In one variation the patterns are made of frozen mercury and are stored at low temperature until ready for investment, after which the mercury is allowed to melt and is poured out.

IV. MECHANICAL WORKING

Reverting to the ingots in which a great part of the world's metal production is cast, we have to consider briefly the principal processes by which the finished products are produced. In these the metal is forced to assume new shapes by the application of large mechanical forces, which may be applied to the material while it is either hot or cold.

The purpose of subjecting metal to the mechanical working is not merely that of bringing it into a desired shape. Mechanical work affects the structure and properties of most metals and alloys in a markedly favourable manner. When metal solidifies from fusion, especially if it does so in large masses and therefore slowly, it forms a crystalline structure which is relatively coarse —sometimes very coarse indeed. While it is true that whatever the treatment to which metal may be subjected it remains essentially crystalline, yet the size or scale of that structure is highly important as affecting physical behaviour. Mechanical working always breaks down the original cast structure and replaces it by a much finer and more satisfactory structure. In some metals, of which steel is the most important example, it is possible to produce a refined structure, comparable in scale with that of wrought metal, by heat-treatment alone, but this is practicable only for pieces of moderate size because larger masses cannot be cooled rapidly enough to bring about the desired changes. In addition, mechanical working, particularly in the case of steel, serves to close up and perhaps to bring about welding of cavities existing in the cast material. It also brings about a redistribution of the nonmetallic impurities. These become elongated in the direction in which the metal is caused to flow under mechanical treatment and in some cases confer upon the material something which has the appearance of grain or fibre. There is, however, no true fibre in any metal, although fibrous fractures frequently are obtained and often are regarded rightly as indications of good quality.

1. Forging and Rolling. — The process of forging (*q.v.*) may be carried out under hammers or presses. The former range in size from the hand sledge of the blacksmith to the largest steam hammers delivering blows of many foot-tons. For much of the heaviest

forging great hydraulic presses are used in which the heated metal is pressed or kneaded into the desired shape. Forging, particularly on the large scale. is mainly applied to steel, and in that material very large pieces are sometimes handled. The tubes of heavy naval guns are probably the largest of these, but parts of large ships are also very heavy forgings. These large forgings are always made from the ingot itself, but for much of the smaller uork the steel is first brought into the form of bars by rolling and only then is forged. Work of this kind merges into what is known as drop forging. in which a carefully proportioned piece of steel bar is forged between heavy dies to assume a designed shape. Huge presses are used to shape magnesium alloys in making landing gear for aircraft as well as other structural parts.

Stamping and pressing may also be regarded as allied to forging, but while true forging is applied to highly heated metal, stamping and pressing may be done either hot or cold. Here the metal is used in the form of bar or sheet and is forced into the desired shape, usually without much change of section or real flow of metal, but rather by bending accompanied by a certain amount of drawing. Metal to be used in this way, of course, must possess an ample degree of ductility. The rolling process is used to convert ingots into forms which are small in cross section in comparison with their length. Bars and sheets, rods and wire, rails and girders and all kinds of structural sections are produced in this way. Rolling is carried out in successive stages. In the early stage the purpose is, while gradually bringing the metal toward the desired shape. to improve its quality — especially its ductility — so that it can better stand the more severe subsequent treatment. Yet for this very purpose it is, in many cases, found necessary to make the first deformations of the metal very drastic. It is found in mechanical working that if the change of shape or size forced on the material at any one stage is not sufficient to penetrate and affect the entire thickness there is risk of damage. Accordingly. where an ingot of large size has to be broken down, very large forces and correspondingly heavy deformations are applied. This occurs mainly in the rolling of steel and is carried out in very poaerful machinery. The ingots are so large and heavy that they are handled by automatic appliances which take them from the furnace, feed them backward and forward through the great rolls and finally eject the finished billet from the rolling train.

While steel is broken down hot, some of the softer nonferrous metals and alloys can be treated safely cold. The essential nature of the process does not differ as between hot and cold rolling. The effect of cold rolling, however. is to produce hardening so that, after a time, the metal has to be annealed in order to soften it prior to further cold rolling. Such annealing (*q.v.*) usually consists in placing the metal in a suitable furnace and heating it to a temperature correctly chosen for each metal.

The details of rolling practice vary widely according lo the metal employed and the purpose for which the product is required. Heavy plates and extremely thin sheets naturally demand entirely different treatment. Strip metal is sometimes rolled in so-called continuous mills. In these mills, which are used mainly for steel, the hot metal is fed into the first set of rolls rotating at a moderate speed. The material emerging from the first rolls is fed directly into a second set. which, since the length is increased by the passage through the first rolls, must run at a considerably higher speed, A number of sets of rolls are used in series in this way, the finished product leaving the last rolls at a very high speed. Other types of rolling result in the production of sections; *i.e.*, of material having the form of H- or I-beams, channels, angles, railway rails, etc. These are produced by the action of suitably shaped grooves cut in the rolls, but the differences in the rate of movement at the bottoms of such grooves and near the tops require careful consideration. Successive passes in such rolls must provide for the easy flow of the metal from one shape to the next.

2. Extrusion. — Another method of manipulating metals, more especially nonferrous alloys, for the purpose of bringing them quickly and easily into the form of bars or rods having any desired section or into the form of tubes, is that of extrusion. Here the heated billet of metal, previously produced of the correct size and shape, is placed in a heavy steel cylinder and a steel ram is forced down into the cylinder from one end. At the other end there is an aperture or die through which the metal is forced to escape in the desired form. It is possible to extrude many alloys which are not sufficiently ductile, in the cast state, to stand rolling. In other cases, rolling is still possible if the internal structure of the metal has been modified first, either by previous or by preliminary forging.

V. POWDER METALLURGY

The methods of powder metallurgy (*q.v.*) afford a unique way of producing and shaping alloys. Materials are readily made that could not be made by ordinary methods of alloying; *e.g.*, oxide-metal alloys for applications requiring a combination of ceramic quality and toughness. graphite-metal articles for current-carrying brushes, and metals with controlled porosity for filters or for oil-less bearings. The methods are also competitive under certain conditions with other forming methods. Appropriately mixed powders are pressed to shape, then sintered to achieve bonding by diffusion.

VI. HEAT-TREATMENT

1. Annealing. — while the great majority of metallic products are put into use in the condition — so far as their inner structure and strength are concerned — in which the final stages of production have left them, an increasing number of articles (more particularly those intended for important engineering uses) are subjected to some form of heat-treatment for the purpose of improving their internal structure and mechanical properties. In the case of steel castings, for example, annealing is almost universally applied for the purpose of removing some of the impurities from the intercrystalline boundaries, where they tend to form embrittling cell walls, and bringing them into the shape of small scattered globules which are comparatively harmless. The treatment breaks up the original coarse cast structure; further improvement is effected by normalizing or quenching and tempering the steel.

Simple annealing is also used for softening metal hardened by cold working, as in rolling, stamping, pressing, wire drawing, etc. If carried out at a high temperature or for a long time this may result in the formation of a coarse and brittle structure. Fortunately this occurs only rarely in the nonferrous metals. but in very mild steel it is frequently encountered. In this material, however, it is possible to produce a refining of the structure by normalizing. This consists in raising the steel to a temperature just above the critical range, maintaining it there only long enough to ensure that the whole of the piece has reached the desired temperature. and then removing the steel from the furnace and allowing it to cool rapidly in still air. The result is a marked refining of the crystal structure with a corresponding improvement in the mechanical properties. If. however, the steel is of a very soft variety and is required to possess the greatest ductility without much regard to strength, the final heat-treatment may be simply annealing at a much lower temperature, such as 680° C., which is just below the critical range of the steel. This causes the carbide of the steel to become "balled up" into little spherical masses, making the material very soft and relatively weak (see The *Effect* of *Structure,* below).

2. Hardening and Tempering. — The most important forms of heat applicable to steel, whether a plain carbon steel or an alloy steel containing nickel, chromium, manganese, etc., is a double treatment known as hardening and tempering. In some cases the first stage of this treatment is a true hardening, but in a great many cases it can be called hardening only by analogy. A full discussion of these transformations could be given only after an explanation of the metallography of steel and especially of the equilibrium diagrams of carbon steels and of alloy steels (see IRON AND STEEL: Austenite; ALLOYS; METALLOGRAPHY: Metals and Alloy *Structure*). The general nature of the changes involved in heat-treatment of steel can be explained in an approximate manner if it is realized that the metal iron, which constitutes the great bulk of all steels, even of the more complex alloy steels, can exist in at least two allotropic states, known as the alpha and gamma states, respectively. In pure iron, the gamma state

exists at temperatures between 910° C. and 1,450° C. It is a rather soft, nonmagnetic substance which crystallizes in the face-centred cubic lattice. Below goo° C., pure iron assumes the alpha form, which is also relatively soft and ductile but is—below 768° C.—strongly magnetic; this form of iron has a body-centred cubic lattice. The two kinds of iron differ most widely, ho ever, in their power of absorbing carbon in the condition known as solid solution. Gamma iron has a considerable power of holding carbon in solid solution—up to about 2%—while in alpha iron carbon is soluble only in very minute amounts. "Soluble" as here used simply means that the metal (in this case iron) can take up a certain proportion of the other element into its own crystal structure without the formation of a second constituent or kind of crystal. Thus a carbon steel at a high temperature consists of gamma iron crystals holding carbon in solid solution, while on cooling through the transformation range, if the cooling is slow, the carbon is separated. As the iron itself undergoes transformation into the alpha form, crystals of iron carbide, cementite, Fe_3C, are separated. This is the condition of slowly cooled or annealed steel. By very rapid cooling—chilling or quenching—the transformation can be more or less suppressed or delayed. If certain alloying elements are present, particularly chromium and nickel, the retardation of the transformation is much facilitated, and if enough nickel or manganese is present the transformation may be entirely suppressed. In that case the iron retains the gamma condition and the steel is nonmagnetic and soft. It is in the intermediate condition, where the transformation has been retarded rather than entirely suppressed, that the steel becomes hardened.

The capacity of hardening was at one time believed to be a unique property of steel, but it is now known in the alloys of other metals also. It was long regarded as mysterious and controversy still turns on its theoretical explanation. Here, however, we are mainly concerned with the fact that by suitable quenching, from a temperature above the critical range (*i.e.*, above the temperature at which the gamma-alpha transformation occurs), all but the very softest steels can be more or less strongly hardened. In the high-carbon tool steels hardening is utilized to provide cutting tools, cutlery, etc. Even for these special purposes, however, where the greatest hardness is desirable, it is not possible to use the steel in the fully hardened state produced by direct quenching if that quenching has been drastic, as in water. The steel in that state is too brittle. The steel is therefore slightly reheated and thereby becomes tempered. When quench-hardened steel is gently heated, as the temperature rises the suppressed transformation gradually takes place to a slight but progressive extent. The steel is thereby rendered tougher but at the same time slightly softer. The degree of tempering applied is adjusted to suit the purpose for which the implement is required.

3. Surface Hardening.— It is often desired to make a steel part with a very hard surface, as for wear resistance in an automobile gear or crankshaft, but with a softer, tougher, and less brittle interior. This can be accomplished by casehardening by one of several methods. Steel for casehardening contains about 0.2% to 0.3% carbon, or else an alloy steel may be used. It is first carburized to a small depth below the surface by heating it for some hours while packed in carbonaceous material, such as powdered charcoal plus a carbonate, which causes carbon to be slowly absorbed until the "case" becomes a high-carbon steel while the "core" is still low in carbon. The case is then hardened by quenching. Other methods employ heating in a carburizing gas or immersing in a molten carburizing salt bath. Nitriding is a method of casehardening in which the steel piece is heated several hours in gaseous ammonia. The absorbed nitrogen produces an even harder case than carburizing and requires no heat-treatment. *(See* also SURFACE HARDENING.)

4. **Age-Hardening.**—While the hardening of steel was practised for centuries, heat-treatment of nonferrous metals and alloys was, until a much later time, confined to simple annealing at various temperatures, for the purpose of softening metal that has been hardened by cold working. About 1913, A. Wilm in Germany discovered the well-known structural alloy duralumin, an aluminum alloy containing about 4% copper together with about 0.5% each of manganese and magnesium. This alloy, and many others developed subsequently, notably alloys of aluminum, of copper and of nickel, is hardened and strengthened on a somewhat different principle from hardening of steel. The process is known as precipitation-hardening or age-hardening. It depends in every case upon the fact that the metal to be hardened (solvent metal) can, at a high temperature. hold in solid solution a larger percentage of the alloying element (solute) than it can hold at lower temperatures. The alloy is heated for a short time at a temperature sufficient to form a solid solution. In the case of duralumin at the temperature of about 480° C. the aluminum completely dissolves the copper. If slowly cooled a copper-aluminum component would precipitate in coalesced particles which would produce little hardening. Instead the alloy is quenched in water. The rapid cooling prevents immediate precipitation and leaves the alloy temporarily in an unhardened condition consisting of a supersaturated solid solution. In this condition the alloy may be readily worked, and this is commonly done in practice. On standing four or five days at room temperature, the precipitation occurs in a restrained manner, forming precipitated particles of colloidal dimensions. Formation of these at the low temperature causes stresses in the alloy crystals which result in marked increase of hardness and strength. If duralumin is aged at 100° C. the effect is obtained in less than an hour. Many of the precipitation-hardening alloys will not harden at all at room temperature. but harden readily when moderately heated after quenching. Duralumin, the counterpart of which in the United States was called alloy 2017, was largely superseded for aircraft and numerous other structures by alloy 2024, which contains slightly more of the alloying elements and becomes somewhat stronger, though with some sacrifice of ductility. One of the strongest precipitation-hardening alloys is beryllium copper, composed of copper with addition of about 1.6% beryllium and less than 0.5% cobalt or nickel. The Brinell hardness of this alloy rises from 80 to 400, with an increase in tensile strength from 30,000 to about 200,000 lb. per square inch.

VII. THE EFFECT OF STRUCTURE

A striking example of the effect of structure on the properties of metals is afforded by cast iron (*q.v.*). Ordinary iron castings are made with iron containing about 3% to 3.5% carbon and are cast in sand molds. Part of the carbon is combined with iron in the form of iron carbide, Fe_3C, a hard and brittle component called "cementite." Some of the cementite is in separate crystals and some is intimately associated with crystals of pure iron ("ferrite") forming the constituent "pearlite," which has greater toughness than cementite alone. The remainder of the carbon separates as graphite, which ordinarily occurs as flakes and stringers distributed through the cast iron. The structure of the iron and therefore its properties are profoundly affected by the relative proportions of cementite, pearlite and graphite and by the form in which these are present, even when the total carbon content and the small content of other elements has little or no variation. Often, however, the content of other elements, especially silicon and sulfur, will be varied somewhat in order to bring about a change in the distribution of the carbon between combined carbon and graphite and a change in the shape in which the components exist. The structure of the cast iron is further determined by the rate of cooling when it is cast and by subsequent heat-treatment. Thus cast iron made in sand molds, cooling relatively slowly, will have a high graphite content and this will be in the form of flakes and stringers which tend to make the casting weak and brittle. This form of cast iron has a gray fracture and is called gray iron; for centuries it was the only kind of cast iron made. It cannot be wrought. It is still the most common type of cast iron, because of its low cost and properties satisfactory for most applications. If the iron is cast against a metal "chill," causing rapid cooling, graphite does not separate and white cast iron results. This is very hard, but is also brittle. Parts of the casting which cooled more slowly will be of gray iron, and in chilled cast iron there is a transition from a hard wearing surface to a softer but less brittle interior of gray iron. If cast parts,

not too large in size, are made of white iron throughout and then are subjected to prolonged heating under proper conditions, some of the hard and brittle Fe_3C will break down into ductile ferrite and graphite, but the graphite will be distributed in fine separated particles instead of the usual form; the result is malleable cast iron. In this form the brittleness of cast iron is largely overcome. although the iron cannot be wrought as is steel. Later it was learned how to make cast iron of superior strength by producing a structure in which most of the combined carbon is present as pearlite and the cementite component of the pearlite is spheroidal in shape. Further improvement is obtained by making the grain structure fine and compact. In 1938 a new kind of cast iron called ductile cast iron was introduced. In this type the graphite is entirely spheroidal, avoiding the embrittling effect of flakes and stringers. The graphite spheroids are obtained by addition of a little magnesium, added usually as a nickel-magnesium alloy, but the resulting ductility is not due directly to the magnesium. but rather to the indirect effect of the magnesium on the form of the graphite. The structure of the iron matrix in ductile iron may also be improved by altering the cooling rate and by various heat-treatments. A number of alloy cast irons are also used, in which controlled percentages of alloying elements such as nickel, chromium, copper and molybdenum are used to give directly greater strength, or greater hardness or resistance to corrosion.

VIII. ALLOY STEELS

Special steels have been introduced for machine cutting tools which render much better service than ordinary carbon steels. The action of these high-speed steels, which generally contain a considerable amount (sometimes up to 18%) of tungsten or 9% of molybdenum, along with vanadium and chromium, depends upon the fact that in ordinary carbon steels the hardness is rapidly reduced by rising temperature. When a tool is taking a heavy cut its temperature rises rapidly, and the amount of loading which can be applied to a tool made of carbon steel is limited by the comparatively low temperature which brings about softening. In the high-speed steels the temperature which must be attained to cause softening is very much higher; the steels are for this reason said to possess "red hardness." They owe this valuable property to the peculiar manner in which the transformation temperatures are altered by the presence of the alloying elements.

In structural steel of lower carbon and alloy content, the purpose of heat-treatment is to produce not a material of high hardness but one possessing high tensile strength combined with reasonable ductility and good behaviour in the notched-bar impact test. For this purpose the steel is first hardened by quenching, but this is done more frequently in oil than in water. The subsequent tempering or drawing may be carried out at temperatures which usually lie between 400° and 600° C. Two serious difficulties have arisen in applying this heat-treatment particularly to larger masses of steel. Because of their large heat content and the relative slowness with which heat flows from the interior to the exterior of a mass of steel, it is not possible to secure in the inner portions of a steel forging a rate of cooling sufficiently rapid to bring about hardening. The heat-treatment of large masses—and for this purpose pieces exceeding two inches in thickness must be regarded as large—thus presents grave difficulties in simple carbon and nickel steels. By the addition of suitable amounts of chromium, however, the transformations of the steel are rendered more sluggish so that even the moderately rapid rates of cooling which can be attained in large masses are sufficient to bring about hardening. Such steels, therefore, can be hardened and subsequently tempered in relatively large masses. This property is referred to as "hardenability." The alloying elements vary in the degree to which they increase the hardenability of steel. The greatest actual increase is given by manganese, but the greatest increase per unit quantity of element added is given by boron. Here, however, the second difficulty arises. Steels of this type. especially the nickel-chromium steels, exhibit the phenomenon known as "temper brittleness." which makes itself felt most strongly under the notched-bar impact test. When such steel has been tempered to show the desired degree of high ductility, it gives very low values under the impact test. This type of brittleness can be prevented by accelerating the cooling of the steel immediately after it has been tempered. Rapid cooling, however. is difficult or impossible in large masses.

Fortunately it has been discovered that the presence of a small percentage of molybdenum in the steel prevents the development of temper brittleness even if the material is slowly cooled after tempering.

In regard to iron and steel. reference has been made to the high-speed steels used for cutting tools. To these have been added many types of alloys which can furnish tools of still greater hardness and cutting power than the steels. The Stellite type of alloy contains carbon, chromium, cobalt and tungsten. It can be brought to the desired shape only by casting, as it remains hard and nonductile at all temperatures. The final shaping of the tool is done by grinding. The tools can be used to cut rapidly and up to higher temperatures than the steels, but are apt to break under a blow. Still harder and capable of resisting still higher temperatures are a group of substances whose most important constituent is tungsten carbide. Only thin strips or plates of these substances are used as facings brazed to the front of a steel tool, but with these tools it is possible to cut at fairly high speeds materials, such as toughened manganese steel, which resist all steel cutting tools. The materials themselves are known as sintered carbides. Important advances also were made in regard to steel for magnetic purposes. For permanent magnets tungsten steels were aidely used, but a Japanese discovery showed that cobalt steels were markedly superior. After World War II precipitation-hardened alloys were used *(see* MAGNETISM: *Permanent Magnets)*. In the development of very soft magnetic steels, for transformer cores and for the inductive winding of submarine cables, special alloys also have been developed. Steel containing very little carbon with about 4% of silicon has a lower magnetic hysteresis loss combined nith a higher electrical resistance than ordinary soft steel, and its use has had wide effects in improving the economy of electric current transformers. For the sheathing of submarine cables a magnetic material having the highest possible permeability under very low magnetic fields is required. A remarkable material for this purpose is the U.S. alloy of iron with about 79% of nickel, known as permalloy *(see* MAGNETISM: *Permeable Materials)*.

The immense losses caused by corrosion led to much research on this subject in regard to both ferrous and nonferrous metals. The addition of small amounts of copper to steel has been found to reduce corrosion in many circumstances, but very great resistance to corrosion has been attained by the addition to steel of considerable amounts of chromium. Stainless steel was developed in Sheffield by Harry Brearley; this kind contains 13% of chromium and. with a moderate carbon content. can be satisfactorily hardened and tempered. When properly hardened, tempered and polished. this steel resists corrosion extremely well, although there are certain conditions, such as prolonged exposure to sea water, which cause attack. For purposes where softness and ductility are required, stainless iron was developed with a very low carbon content and containing about 17% of chromium. This, however, is exceeded in properties by the austenitic stainless steels developed in Germany by Eduard Maurer and Benno Strauss. These contain still higher proportions of chromium than ordinary stainless steel, together with a high proportion of nickel. These steels retain the austenitic structure on cooling, whether fast or slow and are thus soft, ductile and nonmagnetic, but they ordinarily cannot be hardened by heat-treatment and are difficult to machine. Compositions are available which can be hardened by the precipitation-hardening process. Molybdenum-chromium-nickel alloys are extremely resistant to corrosion and chemical attack of all kinds and are applied in chemical engineering and elsewhere.

The cost of these rust-resisting steels is, however, too high to allow of their use for general structural purposes. so that methods of preventing or reducing corrosion in ordinary steel are still required Apart from paints and similar coatings, protection of steel by coating with another metal, such as zinc and tin,

is widely used. Galvanized iron (really steel coated with a thin layer of zinc) is used in immense quantities. Perhaps the most striking development in protective coatings is the application of metallic chromium to this purpose. When properly deposited by electrolysis, this metal furnishes a coating of brilliant bluish-white colour which is incorrodible and untarnishable, while it is also so hard that it cannot be readily scratched.

In nonferrous metals the problems of corrosion, although different, are equally important. In regard to the alloys of copper, the production of condenser tubes immune from failure by pitting continued to offer a problem although much important progress was made. In regard to aluminum alloys, the corrosion problem stood for some time in the way of their wider application. Their natural corrosion resistance was enhanced by protective coatings. Aluminum owes its natural resistance to corrosion to a thin. transparent coating of oxide which forms on the metal immediately upon exposure to the air and which to a great extent prevents further attack. As naturally formed, however, this is neither strong enough nor impervious enough to prevent corrosion under more difficult conditions, such as exposure to sea water, etc. It was found, however, that the natural oxide coating could be strengthened and thickened by making the metal the anode in a bath containing chromic acid or sulfuric acid and gradually raising the voltage. Aluminum and many of its alloys when treated in this way became very resistant to corrosion, and this resistance can be increased further by closing the pores of the anodic oxidation film by saturating with fatty matter such as lanolin or by heating. The alloys may be protected by roll-cladding them with pure aluminum. Such material is widely used for aircraft sheathing.

IX. OTHER DEVELOPMENTS

1. Welding. — Among prominent developments in the production and treatment of metals, the great expansion of welding (*q.v.*) operations in the joining of steel may be mentioned. The tno principal processes are oxyacetylene and electric welding. An advanced technique for both methods was developed and welded joints are widely used. While it is admitted that the strength of steel, and especially of heat-treated steel, is locally impaired by the high temperatures applied in welding, yet the great convenience of the process and the saving in weight and labour which it allows as compared with riveting outweigh these disadvantages wherever satisfactory allowance for the impaired properties of the steel in the neighbourhood of the weld can be made. It must be borne in mind further that the correct basis of comparison in estimating the value of a welded joint is not the strength of the solid metal but of any alternative joint such as a riveted seam; in mild steel. however, the strength of the welded joint exceeds that of the metal being joined. The most serious defect of welding is the difficulty of being sure that a given joint is sound. Properly welded joints have proved successful in many severely stressed applications. An outstanding example of the value of welded joints is afforded by the many of large-diameter pipelines carrying natural gas and petroleum in remote and difficult terrains.

2. **Heat-Resistant** Alloys. — Important advances also have been made in regard to materials for use at high temperatures. The demand for these arises from the effort to improve the thermal efficiency of heat engines, stimulated by the struggle between the steam-turbine and the internal-combustion engine. A tremendous stimulation to the development of metals with high strength at elevated temperatures was provided by the development of the gas turbine and the jet engine *(see* also *Precision Casting,* above). The further increase in their phenomenal efficiency was dependent upon developing alloys with increased high-temperature strength. The result was a demand for steels and nonferrous alloys capable of withstanding stress and oxidation at temperatures sometimes as high as goo° C. Ordinary steel becomes too weak to be used at these temperatures, and even materials which show a reasonably high strength under an ordinary tensile test carried out at the high temperatures were found to fail under much lower stresses if exposed to them for a sufficiently long time. This led to the conception of the "creep stress," which is measured by determining the highest stress which the material can bear, at a constantly maintained high temperature for long periods of time, without undergoing changes of length above a desired maximum. The stress required to rupture the material after 1,000 hours at a given temperature is another criterion for evaluating high-temperature alloys. At 980° C. some of the best materials available commercially show a stress-to-rupture value of little more than two tons per square inch. For so high a temperature, however, this constitutes a marked achievement and was attained only by a few special heat-resisting alloys. The alloy steels contain relatively large proportions of nickel, chromium and cobalt, with additions of molybdenum, tungsten, niobium and titanium. The nonferrous alloys suitable for high-temperature use consist mainly of nickel and chromium, nickel and molybdenum, nickel, cobalt and chromium, and cobalt, chromium and molybdenum or tungsten. Pure molybdenum. protected against oxidation, is a very promising material for high-temperature applications, as are titanium carbides bonded with large amounts of nickel. For less extreme conditions, such as those encountered in the construction of high-pressure steam boilers, turbine blading, etc., where 600° C. is not likely to be exceeded, less expensive types of material are available.

3. Furnaces. — As metallurgy progressed, the damaging effects often produced by extremely small amounts of impurities became more and more evident. Often these result from the entrapment or dissolving of gases in the metal while molten. The gas may react to form oxides. nitrides. etc.. which may seriously affect the properties of the metal after solidification. Gases may be avoided by melting the metal in a vacuum, a technique which has been increasingly employed.

Vacuum furnaces are usually electric. The induction furnace is a useful type. Flow of current is produced directly in the charge by induction, the charge being heated by its resistance to the current. By the use of high-frequency current, the flow may be confined to the outer surfaces of a solid piece of metal, since the depth of penetration is inversely proportional to the square root of the frequency. Thus a metal object may be heat-treated for hardening of the surface only. See FURNACE, ELECTRIC.

See BRASS; BRONZE; CORROSION AND OXIDATION OF METALS; ELECTROMETALLURGY; FATIGUE OF METALS; GALVANIZED IRON AND STEEL; OPEN-HEARTH STEEL PROCESS; STAINLESS STEEL; STEELS, ALLOY; TOOL STEEL; and names of individual metals; *see* also Index references under "Metallurgy" in the Index volume.

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(AL. BU.)

X. METALLURGY IN NUCLEAR ENGINEERING

Nuclear metallurgy includes the production, fabrication and application of metals of interest in nuclear engineering and the

study of their properties. The discovery of atomic fission in 1938 resulted in the emergence of several relatively unknown metals into prominence. The way a material interacts with neutrons, *i.e.*, its neutron-capture cross section, determines its suitability for use in an atomic reactor. This criterion divides the nuclear metals into two main categories: those with high and those with low cross sections.

An element with a high cross section may fission as a result of neutron capture or it may be transmuted into another isotope or element.

Uranium and plutonium undergo atomic fission, and thorium can be converted into a fissionable isotope of uranium, U^{233}. These metals are referred to as nuclear fuels. Prior to 1940 uranium and thorium metals were laboratory curiosities only and plutonium was unknown. However, the metallurgy of these metals advanced so rapidly during the next decade that by the time of the 1955 Geneva conference on peaceful uses of atomic energy the information on these metals rivaled that on iron and aluminum. The control of a nuclear reactor depends upon the metals with high-capture cross sections. Because of their affinity for neutrons the metals boron, hafnium, cadmium or gadolinium are used to shut down a reactor or to control its power level of operation.

Metals with low cross sections are equally important since they do not remove valuable neutrons from the atomic reaction. Since uranium metal is highly reactive toward water or air at elevated temperatures, protective cladding of the fuel elements is necessary. Aluminum and zirconium are commonly used for this purpose because of their transparency to neutrons, ease of fabrication and corrosion resistance. Zirconium, particularly, has been used in increasing amounts in industrial and military reactors. Whereas only a few pounds of zirconium had been produced prior to 1945, within a ten-year period its production rate was increased to 1,000.000 lb. annually. Beryllium with its low cross section and low atomic weight is desirable for use as a moderator. Its function is the slowing down of high-energy neutrons produced in the fission process. Another application for low cross section metals is as liquid coolants or circulating fuels. Low-melting sodium and a sodium-potassium alloy are employed as coolants in several reactors. The liquid metal is circulated over the hot fuel elements and then to a steam generator. Another reactor uses a circulating fuel of U^{235} dissolved in molten bismuth.

In addition to the usual problems associated with metals at high temperatures. there are some unique ones in nuclear metallurgy. One such problem is radiation damage, the failure of a material due to the intense radiation in a reactor. Uranium undergoes embrittlement and drastic changes in dimension as a result of irradiation. Another serious problem which eventually results in a shutdown of the reactor is the accumulation of fission products in the nuclear fuel. Direct removal of the fission products and economic reprocessing of the fuel constitute a big challenge to the nuclear metallurgist.

See NUCLEAR ENGINEERING; see also references under "Metallurgy" in the Index volume.

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METALWORK, DECORATIVE. Decorative metalwork from the world's great civilizations—ancient Mesopotamia, Egypt, Crete, Greece. Rome, the orient, Europe during the middle ages, the Renaissance and finally post-Renaissance times—is the subject of this article. It is not concerned with sculpture but rather with the many artistic applications of metals in connection with architecture or with objects for ecclesiastical and domestic use. Before the Christian era, seven metals—gold, copper, silver, lead, tin, iron and mercury—were recognized. Important alloys (bronze, brass, electrum, pewter and steel) were also discovered during antiquity. Certain natural forms of metals were well known in prehistoric times. including copper, gold and silver, small nuggets of which. as well as of meteoric iron, were collected and used as beads or amulets. As they could be shaped by cutting, grinding and hammering, they were often fashioned into ornaments and trinkets. The use of gold and native copper marks the beginning of every ancient metal culture. The metals first found by man in their elemental state were soft because they were pure, hence they were used primarily for ornament.

TECHNIQUES OF METALWORKING

Metallurgy. — The art of copper smelting was developed about 4000 B.C. A thousand years later, copper was produced extensively on the island of Cyprus. The Cypriot copper deposits were so great and so highly prized that control of the island was extremely desirable, and it passed successively to the Egyptians, Assyrians, Phoenicians, Greeks, Persians and Romans.

Bronze (*q.v.*), an alloy of copper and tin, is superior to pure copper for casting both simple and complicated works of art, since its melting point is much lower that that of copper. The subject of bronzes is intertwined with the history of art in all periods. The oldest-known piece of bronze is a rod found in the pyramid of Medum, the date of origin being generally accepted as about 3700 B.C. From Mesopotamia and Egypt the use of bronze spread over the Mediterranean area. The Phoenicians obtained tin from both India and Spain long before they visited the more distant shores of Britain and discovered how rich were the tin mines there. They were the disseminators of much knowledge of metalworking processes.

During the millennium after about 2500 B.C. the art of the founder shows little technical development. The Sumerians made bronze by mixing a copper ore with a tin ore. It was not until about 1500 B.C. that the culminating stage in bronze-making was reached—that is, tin ore was reduced, the metallic tin so-produced being subsequently melted along with metallic copper. In the manufacture of iron and steel there were few outstanding developments from prehistoric days until about A.D. 1860. (See further METALLURGY : History.)

Working Processes. — Many of the technical processes . in use today are essentially the same as those employed in ancient times. The early metalworker was familiar with every process for shaping and ornamenting copper—hammering, embossing, chasing, inlaying, gilding, wire-drawing and the application of niello, enamel and gems.

Hammering and Casting. —All decorative metalwork was originally executed with the hammer. Indeed, hammering naturally preceded casting among early peoples. The several parts were hammered out separately and then put together by means of rivets or pinned on a solid core, soldering not having been invented. Plates of hammered copper could be shaped also into statues, the separate pieces being joined together with copper rivets. The famous life-size Egyptian statue of the Pharaoh Pepi I in the Cairo museum is an outstanding example of such work, dating from *c*. 2300 B.C.

After about 2500 B.C. the two standard methods of fabricating metal, hammering and casting, were developed side by side. The lost-\\-ax (or *cire* perdue) process was being employed in Egypt by about 2500 B.C., the Egyptians probably having learned the technique from Sumerian craftsmen (see SCULPTURE TECHNIQUE: Casting and Finishing). Long after the method of casting statues in molds with cores had superseded the primitive and tedious riveting process, the hammer continued as the main instrument for producing art works in the precious metals. Everything attributable to the Assyrian, the Etruscan and the Greek goldsmith is wrought by the hammer and the punch.

Embossing. — Embossing (or *repoussé*) is the art of raising ornament in relief from the reverse side. The design is first drawn on the surface of the metal and the motifs outlined with a tracer which transfers the essential psrts of the drawing to the back of the plate. The plate is then imbedded face down in an asphalt block and the portions to be raised are hammered down into the yielding asphalt. Next the plate is removed and re-embedded with the face uppermost. The hammering is continued, this time forcing the background of the design into the asphalt. By a series of these processes of hammering and re-embedding, followed finally by chasing, the metal attains its finished appearance. There are three essential types of tools—*i.e.,* for tracing, for bossing and

for chasing—as well as a specialized tool. a snarling iron or spring bar. which is used to reach otherwise inaccessible areas. Ornament in relief is also produced by mechanical means. A thin pliable sheet of metal may be pressed into molds. between dies or over stamps All these methods have been known from remote antiquity.

Chasing.—Chasing is accomplished with hammer and punches on the face of the metal. These punches are so shaped on the face that they are capable of producing any effect, either in intaglio or in relief. that the metalworker may require. The design is traced on the surface and the relief may be obtained by beating down the adjacent areas to form the background. Such chased relief work sometimes simulates embossed work, but in the latter process the design is bossed up from the back. The detailed finish of embossed work is accomplished by chasing; the term is applied also to the touching up and finishing of cast work with hand-held punches.

Engraving.—To engrave is to cut or incise a line. Engraving is always done with a cutting tool, generally by pressure from the hand. It detaches material in cutting. When pressure is applied with a hammer the process is called carving.

Inlaying Processes.—The system of ornamentation known as damascening was oriental in origin and was much practised by the early goldsmiths of Damascus; hence the name. It is the art of incrusting gold wire (sometimes silver or copper) on the surface of iron, steel or bronze. The surface upon which the pattern is to be traced is finely undercut nith a sharp instrument. The gold thread is forced into the minute furrows of the cut surface by hammering and is securely held.

Niello is the process of inlaying engraved ornamental designs with niello, a silver sulfide or mixture of sulfides. The first authors to write on the preparation of niello and its application to silver were Eraclius and Theophilus in or about the 11th century and Benvenuto Cellini during the 16th. According to each of these authors. niello is made by fusing together silver, copper and lead in certain proportions, and then mixing the molten alloy with sulfur. The black product (a mixture of the sulfides of silver, copper and lead) is powdered, and after the engraved metal, usually silver, has been moistened with a flux, some of the powder is spread on it and the metal strongly heated; the niello melts and runs into the engraved channels. The excess niello is removed by scraping until the filled channels are visible, and finally the surface is polished.

Gilding und *Enameling.*—*See* the separate entries GILDING; ENAMEL.

THE ANCIENT WORLD

MESOPOTAMIA

The art of metalworking was developed early in Mesopotamia. The Sumerians were familiar with the art of embossing. in which the metal is treated as a plastic substance to be shaped into the desired forms in a manner analogous to the modeling of wax or clay, as opposed to the carving of wood or stone, in which portions of the surface are removed. Copper, malleable bronze, silver and gold are the metals usually employed.

In the museum at Baghdad. in the British museum and in the University of Pennsylvania at Philadelphia are finely executed objects in gold and beaten copper from the royal graves at Ur in ancient Sumeria. An example of early embossed work is the helmet of Mes-kalam-dug, in the museum at Baghdad, which rivals the gold mask of Tutankhamen, and was made over a thousand years earlier. It was hammered up from a sheet of electrum, its ornamental details being embossed and chased. The workmanship is admirable, reflecting the greatest credit on the goldsmiths of 2600 B.C. Also outstanding is the copper relief that decorated the front of the temple at Al 'Ubaid. This remarkable decoration represents an eagle, having a lion's head, holding two stags by their tails. The stags' antlers—also made of wrought copper—were developed in high relief and were soldered into their sockets with lead. This relief illustrates the high level of art and technical skill attained by the Sumerians in the days of the first dynasty of Ur (*c.* 2550 B.C.). In the Metropolitan Museum of Art, New York city. is a Sumerian bull's head of copper, probably an ornamental feature on the front of a lyre, which is contemporary with the Ur finds.

The malleability of unalloyed copper, which renders it too soft for weapons, is peculiarly valuable in the formation of vessels of every variety of form, and it has been put to this use in almost every age. Copper domestic vessels were regularly made in Sumeria during the 4th millennium B.C., and in Egypt a little later. Bowls and vases were also made of gold, electrum and silver. Small lead tumblerlike vessels have been found in Mesopotamia, but lead was not widely used in the copper period.

The Sumerian metalworkers were followed by the Babylonian, Assyrian. Chaldean and Persian. In the Metropolitan museum is the bronze sword of King Adad-nirari I, a unique example from the palace of one of the early kings of the period (14th–13th century B.C.) during which Assyria first began to play a prominent part in Mesopotamian history. A magnificent example of Assyrian bronze embossed work is to be seen in the gates of Shalmaneser III, erected about 845 B.C. to commemorate that king's campaigns. The gates were made of wood. and the bronze bands. embossed with a wealth of figures in relief, are only about $\frac{1}{16}$ in. thick. The bands were obviously intended for decoration, not to strengthen the gates against attack.

The Persian bronze industry was also influenced by Mesopotamia. Luristan, near the western border of Persia, is the source of many bronzes that have been dated from 1500 to 500 B C. and that include chariot or harness fittings, rein rings. elaborate horse bits and various decorative rings, as well as weapons, personal ornaments and different types of cult objects and a number of household vessels. Many of these objects show a decided originality in the development of the animal style.

EGYPT

Egyptian metalworkers were not less masters of their tools than their fellow artists who wrought in the hardest basalt and the stubbornest varieties of porphyry. From whatever source Egypt may have obtained its metalworking processes, Egyptian work at a remote period possesses an excellence that in some respects has never been surpassed. It is not known how long the use of beaten copper preceded casting. or at what time the ancient Egyptians began to cast statues and other objects in bronze. Many bronzes, however, have. been found from as early as 2500 B.C. Throughout Egyptian history, the same smiths who worked in the precious metals worked also in copper and bronze. The finest Egyptian jewelry depends for its splendour of effect chiefly on its ingenious and richly coloured ornament. achieved by an inlay of brilliantly coloured stones. jaspers, agates, lapis lazuli, or by glass pastes in still brighter colours.

Nearly every fashionable Egyptian. man or woman, possessed a hand mirror of polished copper. bronze or silver; silver was often added to bronze to obtain a highly reflecting surface. Copper pitchers and basins for hand-mashing at meals were placed in the tombs. An unusual example in the Metropolitan Museum of Art is plated with antimony to imitate silver, which was very rare in the Old Kingdom (2780–2242 B.C.). The basins and the bodies of the ewers were hammered from single sheets of copper. The spouts of the ewers were cast in molds and attached to the bodies by means of copper rivets or were simply inserted in place and crimped to the bodies by cold-hammering.

The bronzes that have survived are mainly votive statues placed in the temples from the Saite to the Ptolemaic period (663–630 B.C.), and amuletic bronzes that were buried with the dead. In its simplest form the decoration consisted of lines, representing details of clothing, ornaments and the like, cut in the bronze with engraving tools, sometimes also combined with gilding. A fine example of inlay work of the 22nd dynasty (950–730 B.C.) is a bronze plaque (counterpoise) damascened with gold wire (in the Metropolitan Museum of Art).

The evidence available suggests that in Egypt iron was known as early as copper or bronze. Beads made from meteoric iron, believed to date as early as 4000 B.C., have been found at Gerzeh in Egypt. The oldest Egyptian texts extant, c. 3500 B.C.,

refer to iron, which at this early period was reduced from ores by smelting. Employment of isolated objects made of iron, however, does not constitute a distinct stage of metal culture. The reasons for preferring copper alloys to iron for decorative objects were as strong in ancient times as they are today. Iron was used for humbler objects less likely to be preserved. Early iron objects have long since been oxidized out of existence. Fairly pure wrought iron has no distinct advantage over bronze; it is more malleable but less hard, and the early smiths were unable to cast it. A good bronze when fully work-hardened is considerably superior in hardness to primitive iron. Tools made of hardened iron, however, were in use in both Assyria and Egypt between *800* and 700 B.C. Apart from a dagger with iron blade found in the tomb of the Pharaoh Tutankhamen *(c. 1350* B.C.*)*, the most ancient iron weapon known to have been found in Egypt dates from the time of Ramses III, about *1200* B.C.

Crete

Crete was in communication with Egypt as early as *3400* B.C., and it seems likely that the earliest Cretan copper objects were imported from Egypt. The largest sword of the age comes from the Middle Minoan period *(2200–1580* B.C.). The rapier, which with its hilt is one metre long, was found in the palace of Mallia. By improvement in metalworking, the short dagger was ultimately lengthened into a sword. and the Mallia sword is an example of the extraordinary skill of the Cretan metalworker in casting bronze. The hilt of the sword is of gold-plated ivory and crystal. A dagger blade found in the Lasithi plain, dating about *1800* B.C. (in the Metropolitan Museum of Art), is the earliest-known predecessor of the ornamented dagger blades from Mycenae. It is engraved with two spirited scenes: a fight between two bulls, and a man spearing a boar. Somewhat later (c. *1400* B.C.) are a series of splendid blades from mainland Greece, which must be attributed to Cretan craftsmen, with ornament in relief, or incised, or inlaid with varicoloured metals, gold, silver and niello. The most elaborate inlays, pictures of men hunting lions and of cats hunting birds, are on daggers from the shaft graves of Mycenae, Nilotic scenes shouing Egyptian influence. The bronze was oxidized to a blackish-bronn tint: the gold inlays were hammered in and polished and the details then engraved on them. The gold was in two colours, a deeper red being obtained by an admixture of copper, and there was a sparing use of niello. *See* also Crete: *Archaeology: Metalwork.*

Greece

The Greeks, who learned much about metalwork from the Egyptians, excelled in the arts of hammering, casting, embossing, chasing, engraving, soldering and metal intaglio. Among the ancients, the great emphasis of technology was on aesthetic expression, not on practical utilization. Greek coin dies rank with the finest work of this kind that the world has ever seen. Pottery and bronze hammer- and cast-work were important crafts of ancient Greece. Vases of terra cotta were often designed to resemble those of bronze, and both kinds were widely used in antiquity. Terra cotta is breakable but otherwise practically indestructible. while bronze is subject to corrosion; a Greek bronze vase in good condition is therefore something of a rarity. The body of the vase, which was hammered out of a sheet of malleable bronze. was usually left plain; the handles, feet and overhanging lip, which were cast, were decorated. The applied elements were either riveted or soldered. The Greeks were acquainted with both soft soldering, by means of silver or tin, and hard soldering, by means of a copper alloy.

It was in the time of Lysippus, the distinguished sculptor who flourished about *330* B.C., that the fine Greek beaten work for decoration of armour, vases and objects of domestic use reached its perfection. It was executed by a hammer working from behind, the outlines being afterward emphasized by chisel or punch; or metal plate was beaten into a mold formed by carving the subject in intaglio upon a resisting material. Figures in full relief, such as the exquisite tiny cupids so commonly dependent from earrings, were beaten out in two halves and then soldered together. Melted mastic was then run into the interior to strengthen these fragile creations against pressure.

A silver vase from Chertomlyk, now in the Hermitage at Leningrad, is Greek work of about *400* B.C. and is the finest example of the work of the Ionian Greek silversmiths. A Greek sword sheath of the end of the 5th century B.C. from south Russia, now in the Metropolitan Museum of Art, is of embossed gold; the design, which represents a contest of Greeks and barbarians, was pressed over a die. The embossed shoulder straps of a cuirass, called the bronzes of Siris, dating from the 4th century B.C., in the British museum, represent the combat between the Greeks and Amazons; they are in exceedingly high relief and are beaten into form with wonderful skill with the hammer.

Greek bronze statuettes — originally dedicatory offerings in shrines, ornamental figures on utensils. or decorative works of art — have survived in large numbers. They were usually cast solid, rarely hollow. Sometimes even large statuettes, like the Metropolitan museum Greek horse, were cast solid. The advantage of solid casting is that the mold can be used repeatedly, while in the hollow-casting process the mold is destroyed. Greek bronzes were originally golden and bright, and they were often decorated with silver or niello for colour contrast.

The art of bronze statuary hardly existed before the introduction of hollow casting, about the middle of the 6th century B.C., after which bronze became the most important medium of monumental sculpture; its strength and lightness admitted poses that could not be reproduced in stone.

The Greeks valued iron chiefly as metal for tools and during the early period did not develop its aesthetic possibilities; but in the remains of the Greco-Roman towns of Pompeii and Herculaneum can be seen wrought-iron window grilles and similar small examples of architectural ironwork.

The Etruscans

The Etruscans made extensive use of bronze for cast and beaten work, and, although few large works remain, the museums of Europe display a marvelous variety of admirably formed small bronzes. A masterpiece of bronze Etruscan sculpture is the Chimera from Arezzo, an ex-voto from a sacred building, found in *1553* and partly restored by Cellini (in the Archaeological museum, Florence). Etruscan bronzeworkers produced, often for export, votive statuettes, vessels, furniture, helmets. swords, lamps, candelabra, mirrors and even chariots. An Etruscan chariot of *c. 600* B.C. in the Metropolitan Museum of Art has a body and wheels of wood, sheathing of bronze and tires of iron, the high front embossed with archaic figures of considerable grace. The Etruscans inlaid bronze with silver and gold in a manner that proves their skill in this mode of enrichment to equal that of the Greeks and Romans.

Many delicately engraved bronze objects were made in the Latin town of Praeneste (mod. Palestrina), which possessed a highly developed bronzeworking industry. From Praeneste came a remarkable cylindrical container of the late 4th century B.C., now in the Villa Giulia, Rome; its richly engraved surface provides a good example of the perfection of ancient drawing. *See* also Etruscans: *Art* and *Arts and* Crafts.

Rome

Etruscan cities, like those of Greece, were crowded with bronze statues of the gods and heroes, and Rome derived its best adornment from the pillage first of Etruria and then of Greece. Distinctly Roman work is hard to trace, as the conquered Greeks worked for their masters, and the Romans copied wholesale from the Greeks. Temple statues uere nearly always of bronze, but after about *190* B.C. the metal was chiefly used for architectural decorations and portraiture. The bronze doors of the Pantheon and of the Temple of Romulus in the Forum still occupy their original positions. Two bronze doors in the baptistery of the Lateran are supposed to have been brought from the baths of Caracalla by Pope Hilarius in the 5th century. Also in the Lateran church are four fine gilt-bronze fluted Corinthian columns.

Much Roman small work was exceedingly fine, though it is gen-

erally conceded that Roman productions are less aesthetically attractive than those of the Greeks. Pompeii and Herculaneum mere essentially Greek towns, and the many beautiful bronzes in the Museum of Naples, collected from the ruins of private houses there, are of Greek workmanship. These included statuettes, mirrors and all kinds of bronzework useful and ornamental in a house. Many of these were originally attached to pieces of furniture.

Roman brooches, or fibulae, primarily intended to serve as a means of attachment, gradually passed into the category of ornaments. They were of two main types. one based upon the principle of the safety pin, the other upon that of a pin sliding on an open ring—the so-called penannular type. From the Romans, the round disk form was introduced to the Teutonic world. It reached its highest development in Celtic Scotland and in Ireland.

Distinguished examples of Roman embossed armour, some of them prepared for gladiators, are preserved in the Naples museum, which exhibits the finds from Pompeii and Herculaneum (A.D. 79). A remarkable gladiator's helmet is also exhibited in the John Woodman Higgins armory in Worcester, Mass. Roman embossing may also be seen in the famous visor in the form of a face found at Ribchester in Lancashire and preserved in the British museum. The British museum also has a Roman legionary sword and scabbard (the so-called sword of Tiberius) found at Mainz, Ger.; the upper part of the sheath is covered with a plaque in gilt bronze, representing in embossed work in low relief the emperor seated.

A number of remarkable Roman silver treasures are housed in the British museum, including a splendid group of silver tableware that was unearthed near Mildenhall, Suffolk, Eng.. in 1942 *(see* MILDENHALL).

During the closing years of the republic, brass became an important material for the first time. Its various uses included parade armour, as may be seen in a Roman embossed brass helmet in the Norwich museum, England. Brass was produced by what came later to be known as the calamine (zinc carbonate) method. The modern process of melting a mixture of metallic copper and metallic zinc did not come into general use until the early part of the 19th century A.D.

By Roman times. iron was in common use for both practical and artistic purposes. The Romans did not invent any new technical processes. Rather they introduced into less-developed provinces of the empire the advanced methods they found in regions noted for superior technical skills. See also ROMAN ART: *Minor Arts*.

OUTSIDE THE EMPIRE

Barbarian Europe.— The Celts. like the Romans, were skilful metalworkers and were among the earliest in western Europe to develop the use of enamel decoration on bronze in the champlevé technique. The barbarians who conquered and divided the Roman empire were little versed in the monumental arts and unskilled in figure representation, but in metalworking, in the making of weapons and other utilitarian objects and in the delicate ornament of the goldsmith's art they excelled. The Goths brought elements of Scythian-Sarmatian art into Europe, among them the use of coloured vitreous pastes fused onto metal in designs incised on its surface. The process was transmitted from the Sarmatians through the Goths to other Germanic peoples.

The Germanic invaders brought with them the animal forms that represent the decorative motifs of Scythian-Sarmatian arts. The Greeks and the Egyptians found their ornamental motifs in botanical forms; the art of the Scythians and later of the Sarmatians is a veritable zoology—their belts and buckles often represented animals entwined in mortal combat. Objects of Scythian-Sarmatian origin have been found, dating from the 2nd century B.C., which resemble objects of the epoch of the barbarian invasions. The belt buckle, an indispensable part oi the barbarian warrior's equipment and frequently found in graves, was the object of special care on the part of smiths, who ornamented many buckles with rich and intricate designs in niello and silver.

British Isles.—Late in the 6th century A.D.. the metalworkers of Kent in England worked the most intricate designs and embellished their pieces with garnets and glass, enamel and niello. They also produced many beautiful examples of cloisonnit work. Of slightly later date, in the British museum. is a series of remarkable objects from a cenotaph ship (found at Sutton Hoo in Suffolk) that belonged to a Saxon chieftain of about A.D. 650. Among them are a helmet and shield. both of Swedish origin; a sword belt enriched with jewels; sword belt buckles; and two decorated silver bowls of Byzantine manufacture.

In the 9th and 10th centuries the metalsmiths of Ireland produced brooches and personal ornaments, chalices, covers for books of the Gospels, reliquaries, crosiers and other objects of religious use that were unsurpassed in the rest of Europe. The famous Ardagh chalice in the Dublin museum, assigned to about A.D. 900, is a remarkable example of Irish workmanship, unsurpassed by any Byzantine gold or enamelwork of the same period. This two-handled chalice is made of silver alloyed with one-third part of copper, the surface being of a low white colour and decorated with bands of pierced, plaited and filigree gold as well as with enamels and pastes. The cup has more kinds of ornament, and each kind more varied. than any other known example of the same period. Forty varieties of gold wirework design have been enumerated, some being the Greek fret with Celtic varieties, others spiral trumpet-shaped lines, interlaced bands; knots and arabesques; all are different. The enamel too is of several varieties. *(See* also ROMANESQUE ART.)

Byzantine Empire.— Syria, Egypt and Anatolia were first the teachers and then the rivals of Constantinople. The fusion of antique and eastern elements resulted in the Byzantine style, the great period of which dates from the 9th to the end of the 12th century. The extensive use of embossed work, with filigree. cabochon gems and small plaques of enamel, may be seen in both the east and west during the early middle ages. The most conspicuous examples of large Byzantine metalwork are bronze church doors inlaid with silver. Many objects are still preserved in various European treasuries. which were enriched by the spoils of the sack of Constantinople in A.D. 1201. Venice, in the treasury of St. Mark, has an unrivaled series of Byzantine chalices, bookbindings and other treasures of metalwork, but it is in Kiev, Moscow and Leningrad that broadly representative series of all the categories of Byzantine artistic production may be found.

The art of bronze casting had been preserved in the Byzantine empire. The first bronze doors to be made after the art had died out in Rome were those for Hagia Sophia at Constantinople, which bear the date A.D. 838; the panels, with monograms and other ornament damascened in silver: are framed in borders cast in relief and enriched with bosses and scrolls, the whole in an admirable style. Two sets of doors in St. Mark's. Venice, of Greek workmanship and considerable but uncertain antiquity, are supposed by some to have been removed from St. Mark's at Alexandria. Next in date among surviving doors of Byzantine workmanship is the series ordered by the Pantaleone family (about 1060–80) and destined for cities in southern Italy—Amalfi, Trani, Salerno, Canosa di Puglia and Monte Sant' Angelo.

The Muslims.— The most magnificent example of Muslim enamelwork in existence is a copper plate in the museum at Innsbruck, Aus., decorated in polychrome enamel with figure subjects, birds and animals within medallions separated by palm trees and dancers (first half of the 12th century). The Mesopotamian, or Mosil, style, which flourished from the early part of the 13th century, is characterized by a predominant use of figures of men and animals and by the lavish use of silver inlay. The most famous example of figured Mosil work in Europe is the so-called baptistery of St. Louis, in the Louvre. This splendid bowl, which belongs in style to the Mosil work of the 13th century, measures five ieet in circumference and is covered inside and out with bands of figures richly inlaid with silver, so that little of the copper is visible. It is signed by the artist.

EUROPE FROM THE MIDDLE AGES

ITALY

Damascening.——The splendid damascened metal ork of Mesopotamia, Syria and Egypt had long been familiar to the parts of Europe that were in touch with the east and seems to have been

especially appreciated in Venice; a 14th-century candlestick in the British museum, apparently of Syrian manufacture, bears the arms of the Venetian family of Boldù. The Greco-Italian and Italian metalworkers soon set themselves to imitate the Saracenic style and technique. An admirable plate of copper in the Kunstgewerbemuseum at Vienna, damascened with an oriental interlaced pattern, is signed "Nicolo Rugina Greco da Corfu. fecce 1550" From Venice the practice of damascening passed to all the chief metalworking cities of Italy. A precious 16th-century steel gold-damascened casket in the Trivulzio collection in Milan is a signed work of Paolo Rizzo the most celebrated damascener of Venice. Giorgio Ghisi of Mantua, etcher, damascener and goldsmith. has left his signature on a richly embossed and damascened shield in the British museum And Benvenuto Cellini, in his autobiography, tells of improving upon the Turkish method.

Bronze. — From the decadence of the Roman empire Italy produced practically no decorative bronze until the 12th century. by which time Italian craftsmen had developed a style of their own, as may be seen in the bronze doors of San Zeno. Verona (1171), made of hammered rather than cast bronze Bonnano of Pisa architect and sculptor, was the artist of the doors of the Pisa cathedral and of the famous west doors at Monreale (1186). These, with some other ancient doors — including those made by the bronze founder Barisanus of Trani, who nas responsible for the doors of notable churches at Trani (1175), Ravello (1179) and Monreale (1186) — and the great candlestick in the Milan cathedral (see CANDLESTICK: Middle Ages) are landmarks in the history of bronze sculpture up to the 13th century. In contrast to the Byzantine niello-decorated doors, the Italian doors are- in relief. Their subjects are taken from the Old and New Testaments or, more rarely. from the lives of saints.

Italian bronze work of the Renaissance has never been equaled. Andrea Pisano's south doors of the baptistery at Florence led to the formation of a Florentine school of sculptors in bronze that continued to flourish for three centuries. The baptistery has three pairs of magnificent bronze doors. The oldest (south) are the work (1330–36) of Andrea; the north doors are the first (1403–24) of the two assigned to Lorenzo Ghiberti following the famous competition of 1402 in which Filippo Brunelleschi and Jacopo della Quercia also took part. The east doors (1425–52), the "Gate of Paradise," Ghiberti's masterpiece, are divided into ten framed squares in which episodes of the Old Testament are represented. (*See* also DOOR; GHIBERTI LORENZO.)

The metalsmiths' shop were schools for many of the great artists of the Renaissance — Brunelleschi, Verrocchio, Ghiberti. Pollaiuolo and Luca della Robbia all were trained as metalsmiths before they embarked upon the higher arts. The metalsmith made silver vases for the dinner tables of cardinals; knights sent sword blades to be mounted in rich hilts; ladies came to have their jewels set; princes needed medals to commemorate their victories; popes and bishops wished to place chased reliquaries on the altars of their patron saints; and men of fashion ordered medallions to wear upon their hats.

Great works in bronze were created by the most distinguished Renaissance artists. Donatello's equestrian statue of Gattamelata at Padua (1453) was one of the first great bronzes cast in the Italian Renaissance. The Venetian sculptor and architect Alessandro Leopardi cast in 1488 the bronze equestrian statue of Colleoni, left unfinished at Verrocchio's death and, in the early years of the 16th century, completed the three admirable sockets for flagstaffs that still adorn the piazza of St. Mark's. Many smaller objects of bronze also have survived. Among ecclesiastical items may be mentioned crucifixes. shrines. altar and paschal candlesticks (such as the elaborate examples at the Certosa di Pavia); for domestic use, mortars, inkstands, candlesticks and a large number of splendid door knockers and handles were executed with consummate skill. Works of this kind continued to be made throughout the 17th and 18th centuries.

Iron. — During the 13th and 14th centuries wrought iron came into general use for screens for chapels and tombs, and for window grilles. One of the most interesting examples of early ironwork, at Perugia, is a grille formed of framework enclosing sheet-iron panels pierced with dragons and crowned A's inscribed "Gull. Rufinelli me fecit. 1338." The quatrefoil is found in Italian grilles in great variety all through the 14th and 15th centuries and continued to be used in the 16th century also. The grillwork around the tombs of the Della Scala family at Verona is composed of a network of quatrefoils, each filled up with a small ladder (*scala*). A number of quatrefoil grilles are dated — that in the cathedral of Orvieto is signed "Conte Lelli de Senis me fecit. Ann. 1337"; that in Santa Croce, Florence. is dated 1371.

Notable centres of artistic ironwork were Florence, Siena, Vicenza Venice, Lucca and Rome, where important pieces may be found in the form of gates. balconies. screens, fanlights, well covers and a mass of objects for domestic use such as bowl stands, brackets and candlesticks. One of the principal masters of ironwork was Niccolò Grosso of Florence. under the patronage of Lorenzo de' Medici, nho produced lanterns. cressets, banner holders and horse rings, all of the most artistic designs. Four lanterns executed by Grosso for the Strozzi palace at Florence and set up in 1500 cost 100 florins each for workmanship alone. Giorgio Vasari says that "He was truly unique in his craft, and has never had and never will have an equal." Another artist in iron was Giacomo Cozzarelli, who flourished at the close of the 15th century at Siena and distinguished himself in designing superb lanterns and torch holders.

During the 16th and 17th centuries Venice became especially famous as a centre for ironwork, and railings and gates were sent from Venetian workshops to north Italian palaces. The decadence of 17th- and 18th-century ironwork throughout Italy paralleled that of architecture. The metal was thin and the resulting construction flimsy. Conventional or naturalistic flowers were tacked on apparently as afterthoughts. Ribbonlike bands rather than rods and bars were used, with cast ornaments pinned on. The best examples of this period are confined to Venice and northern Italy. (*See* also IRONWORK.)

Embossing. — The art of embossing was highly developed in the 16th century by the Italians, who even went beyond the ancients and applied it to steel; embossed parade helmets, shields and body armour of almost unbelievable excellence are to be seen in the E iropean national armouries. At that time a close relationship existed between painter, sculptor, goldsmith and armourer. Indeed, many of the most skilful artists distinguished themselves in all these capacities; this is natural, since the skill required to emboss and chase armour in steel is but an extension of the sculptural ability needed to carve a statue. One of the greatest masterpieces of Renaissance metalwork, part of the J. Pierpont Morgan collection in the Metropolitan Museum of Art, is the embossed helmet made in 1543 for Francis I of France and signed by Filippo Negroli of Milan. It is modeled in graceful lines and lavishly embossed with coiling tendrils and foliation, with a central flower from which a cupid half emerges. The crest is fashioned as a supine female figure arising from acanthus leaves, her hands grasping the tresses of a gorgon's head. The boldness of the embossing and the beautiful bronze-black patina give the helmet the appearance of having been cast.

GERMANY

Bronze. — A magnificent series of sculpture in bronze from the early years of the medieval period until its close may be seen in Germany. Under Charlemagne the art of metalworking was given considerable stimulus. The bronze-mounted weapons that came into his hands as spoils of war provided metal enough that he was able to lavish bronze on his new church at Aachen without needing to draw supplies from abroad. The earliest Romanesque bronze doors, to be found at the minster of Xachen, were cast there under Charlemagne, possibly by Byzantine artist-monks. There are one large and three small doors, bearing as their sole decoration beads for framing the fields, and lion heads with door rings.

Three important works of medieval bronze have been preserved from the cathedral of Hildesheim, which was destroyed in World War 1 They are the two wings of the bronze door, the triumphal column and the bronze font. The first two are regarded as the works of St. Bernward, once bishop of Hildesheim, whose name

and the date 1015 appear in a broad band of script on the door. Each wing of the door is cast all in one piece, an achievement requiring exceptional skill. The surfaces are ornamented with sculptural figures depicting Old Testament scenes. On the triumphal column. rising from the bottom, are presented 28 scenes from the life of Christ. The remarkable 13th-century font was made for Hildesheim cathedral at the charge of Wilbernus, one of the canons.

Great doors were also made for Mainz cathedral shortly after the year 1000. and for Augsburg sometime between 1060 and 1065. The doors of Gniezno (Gnesen) and Novgorod cathedrals a ere made about 1150, probably at Magdeburg.

Smaller articles of bronze were manufactured in many places in Germany throughout the middle ages. For example. the lion-headed knockers of the west doors of the cathedral of Trier. which may date from the 11th century, bear the names of John and Nicholas of Bingen; and on the 13th-century font of Würzburg cathedral is the name of Master Eckard of Worms.

The end of the Gothic period in Germany found the great craftsman Peter Vischer of Niirnberg and his sons working on the bronze shrine to contain the reliquary of St. Sebald; this finely conceived monument of architectural form, with rich details of ornament and figures. was completed and set up in 1516. The great monument that closes the series of medieval bronze sculpture in Germany is the incomplete tomb of the emperor Maximilian I in the court church of Innsbruck. Its remarkable feature is a series of 28 colossal bronze figures arranged in two rows on each side of the church. representing ancient heroes supposed to be connected by kinship with the house of Austria; they were cast between 1513 and 1533.

Iron. — Germany is the only country in mhich the ironsmiths' art remained important without a break from medieval times down to the 18th century. By the end of the 13th century Pointed architecture was established, and the new style demanded the use of decorative ironwork. The designs introduced were those associated with the grandest expressions of Gothic ironnork in France. The Germans, however, did not acquire the secret of stamped work—that is, striking the hot iron into prepared dies as wax is pressed into a seal—as practised in England and France. Throughout the Gothic period imitations of natural foliage provided the basis of design.

During the 15th and 16th centuries ironwork was extensively produced at Augsburg, a notable example being the grille in St. Ulrich's church (1470) there. Its tracery. of the flamboyant order, is light and brilliant in the extreme, and the methods of construction, such as welding and collaring, are employed with great skill. Another noteworthy example in the same church is the screen to the Fugger chapel (1588), whose numerous fleurs-de-lis and prickets for candles are distinctive.

During the Renaissance. ironwork in Germany was in use everywhere and for many purposes. Smiths were their own designers, and so far as manipulative excellence went, they were highly skilful. Iron bars. circular in section, were most frequently used, and the commonest features are interlacing bars, terminations of flowers with petals and twisted centres. foliage or human heads. The Germans surpassed all in their fantastically twisted and threaded window grilles, which are marvels of forging. The style may be studied in many German cities — Augsburg, Niirnberg, Frankfurt, Salzburg and Munich — and in Austria at Innsbruck. The railings round the cenotaph of the emperor Maximilian I in the Hofkirche at Innsbruck suggest a fabric of lace; they were designed by the painter Paul Trabel in 1568 and completed in 1573 by Jorg Schmidhammer. Changes in style were very minor until the revolutionary Baroque arrived and was embraced by the Germans with far less restraint than by the French. In German work the leaf designs are highly exaggerated and. rich as are the compositions, they are often crushing in their fantastic elaboration.

The Low Countries

Copper, Brass and Bronze. — In Europe the use of brass for artistic purposes centred largely, in the region of the Meuse valley in scutheast Belgium. together nith northeastern France, parts of Holland and the Rhenish provinces of which Cologne was the centre. As early as the 11th century the inhabitants of the towns of Huy and Dinant are found working in this metal. The word *dinanderie*, derived from the name of the town of Dinant, was used for all copperwork as well as brass or bronze (whether beaten or embossed) that was employed mainly for domestic purposes; it was also applied to work prepared by casting and engraving, and sometimes by enameling, which was more usually devoted to objects for ecclesiastical use. Among the earliest examples of *dinanderie* are the font of St. Bartholomew in Liège and the censer of Lille, both of which are ascribed to Renier de Huy. at the beginning of the 12th century. From that time the art of making objects in copper, brass and bronze reached a high level of popularity and quality.

The *dinanderie* of the Low Countries was freely exported to France. Spain, Germany and England. In London the Dinant merchants, encouraged by Edward III, established in 1329 a hall that existed until the end of the 16th century. In 1466, when Dinant was sacked and destroyed by Charles the Bold, the brass-founders fled to Huy, Namur, Middleburg, Tournai and Bruges, where their work was continued. The containers for water known as aquaemanales were cast from the 12th to the 15th centuries in the form of equestrian figures: lions. dragons, birds, griffins and other animals; remarkable examples may be seen in the principal medieval collections.

Iron. — The Belgian ironsmiths' thorough knowledge of the art is exemplified in the beautifully molded constructive ironwork in the spires of Bruges, Ghent and Antwerp. The most notable examples of 13th-century hinge work in Belgium are to be found in Liège on the treasury door of the Cathedral of St. Paul and on some presses in the Church of St. James. The former appear to be based on the same lines as the great hinges of Notre Dame in Paris. but there is no attempt to emulate their intricacy or richness of detail. The stamped early-15th-century hinges of Hal compare favourably with any other European work of this period. The world-renowned well cover against the cathedral at Antwerp, dated 1470, is considered to be the work of José Massys, architect, clockmaker and chief smith to the municipality of Louvain. The churches of Belgium have been less systematically looted than those of England and France and still contain a great deal of their medieval furniture, which includes most of the finest specimens of ironnork in the country — font cranes of the 15th to the 17th centuries, so conspicuous in many Belgian baptisteries; stands for tapers; hanging lamps, book rests and candelabra.

France

Copper, Brass and Bronze. — In dealing with the history of medieval French metalwork, difficulties are posed by the enormous destruction that took place at difierent periods. The monumental effigies and tombs in bronze that abound in other countries, particularly from the close of the middle ages. have been almost entirely destroyed in France. Although the museums, such as those of the Louvre and the Hôtel Cluny, as well as some of the cathedral treasuries. such as Reims and Sens, preserve a considerable number of the small and more precious pieces of bronze. the larger pieces. such as doors, lecterns, fonts, candlesticks and tombs, which are so numerous in Germany and the Netherlands, have almost entirely disappeared.

By the 13th century the Limoges workshops, with copper available near the city, attained the proportions of an industry, and Limoges metalwork, for both secular and religious use, was to be found all over Europe in the middle ages. In addition to reliquaries, candlesticks, crosiers and book covers, many pieces of metalwork for the furniture of halls and chambers were exported from Limoges. and even monumental effigies such as that of Aymer de Valence in Westminster abbey. The commoner kinds of jewels, such as buckles. brooches or morses, for the belts of knights or the vestments of ecclesiastics too poor to afford to buy silver or gold, nere made in enameled bronze. The guilds of Limoges were probably far more active in this kind of secular manufacture than those of Cologne. whose work seems to have been devoted to shrines, reliquaries, candlesticks, monster-shaped ewers, etc., for religious purposes. Copper and bronze depended much for their

effect upon gilding, which was commonly applied to reliquaries, retables. crosses and crosiers, and to the metal divisions of the enamels. Limoges was the centre of the art of metalworking in France up to the 15th century; this status was revived indirectly in the 16th by the specialty of enameling upon metal that was brought to perfection under Léonard Limosin.

A great outburst of artistic energy is seen from the beginning of the 17th century, when works in ormolu or gilt bronze were produced in huge quantities. The craftsmanship is magnificent and of the highest quality, the designs at first refined and symmetrical but later. under the influence of the rococo style, aiming only at gorgeous magnificence. In their own sumptuous setting these fine candelabra, sconces, vases, clocks and rich mountings of furniture are entirely harmonious. The *ciseleur* and the *fondeur*, such as Pierre Gouthiitre and Jacques Caffiéri, associated themselves with the makers of fine furniture and of delicate Sèvres porcelain, the result being extreme richness and handiome effect.

Iron.—Ironwork attained a high degree of excellence in France by the 12th century. In the medieval period the smith necessarily worked quickly, and his masterpieces reflect the virility of skill applied spontaneously. The extensive use of dies to produce stamped work was first made in France early in the 13th century. French stamped work, which is in some examples richer and fuller than the English examples. is perhaps too extensive to have been produced by any one smith and his assistants. The best examples remaining are at Rouen, Noyon, Sens. Braisne. Vézelay, Mantes-Gassicourt and St. Denis, culminating in the well-known doors of Notre Dame, Paris. They are mostly within the royal domain or in churches designed by architects of the royal domain.

A statute of 1392 made it obligatory for an aspiring metalworker to submit a masterpiece before he could practice in Paris, and even in the 13th century the novice was given a verbal test concerning his craft. The required masterpiece often took a year or more to make. With such training the metalsmith was a master, and creating works of art was part of his everyday life. From the 15th century small ironwork required less and less use of the forge, for the art of the blacksmith gradually merged with the arts of the armourer and locksmith. These were versatile craftsmen who worked the cold metal into shape, sawed it, filed it, chiseled it, carved it even out of the solid.

Iron has been used for a greater diversity of objects than has any other metal, and small iron objects for personal use were esteemed as highly as similar objects made of precious metals. The ironworker produced a bewildering variety of small objects—locks, keys, hinges. knockers, caskets, candlesticks, bag frames, corkscrews, tools, etc.—many of which are excellent examples of sculpture in metal. (For ironwork under the Louis, see IRONWORK: Europe: France.) The French Revolution was the cause of much splendid ironwork being destroyed, when in 1793 certain provinces had to gather together every available piece of iron to transform into weapons. Nevertheless, the Musée de Ferronnerie le Secq des Tournelles in Rouen houses 12,000 items of ironwork dating from Roman times to the mid-19th century.

ENGLAND

Bronze.—Casting in bronze reached high perfection in England during the middle ages. Sanctuary rings or knockers exist at Norwich, Gloucester and elsenhere; the most remarkable is that on the north door of the nave of Durham cathedral, from the first half of the 12th century. The Gloucester candlestick, in the Victoria and Albert museum, displays the power and imagination of the designer as well as an extraordinary manipulative skill on the part of the founder. According to its inscription, this candlestick, which stands about tno feet high and is cast in bell metal and gilded, nas made for Abbot Peter (the cathedral was originally an abbey-church), who ruled early in the 12th century. While the outline is carefully preserved, the ornament consists of a mass of figures of monsters, birds and men. mixed and intertwined to the verge of confusion. As a piece of casting it is a triumph of technique.

There remain in England ten effigies cast in bronze over a period of two centuries (1290–1515), among them some of the finest examples of figurework and metalcasring to be found in Europe. In several instances particulars for the contracts of the tombs survive together with the names of the artists who designed and made them. The earliest examples are the effigies of Queen Eleanor, wife of Edward I (1290), and that of Henry III (1292), both in Westminster abbey. They are the work of William Torel, goldsmith of London, and it is evident that they are the first English attempt to produce large figures in metal. Torel cast his large figures by the same process (lost-wax) that he had employed for small shrines and images.

Monumental Brasses.—Monumental brasses were exceedingly numerous in England, where some 4.000 still exist. From the 13th through the 16th centuries, in France, northern Germany, Belgium and particularly England, it became the vogue to let into the stone slab covering a floor tomb a brass plate engraved with the figure of the deceased. The art began in Flanders and Germany, and many of the English brasses were of foreign origin; in some cases brass sheets were imported and engraved by English artists. The manufacture of unornamented brass plates centred chiefly at Cologne. The oldest English brass in existence in that of Sir John D'Abernon (d. 1277) at Stoke D'Abernon, Surrey. Traces can still be seen in many brasses of the colours that originally enlivened them.

Iron.—English ironworkers also developed a high level of skill by the 11th century. Throughout England, medieval church doors are found with massive iron hinges, the bands worked in rich ornamental designs of scrollwork, varying from the plain hinge band with crescent to the most elaborate filling of the door. The next important application of ironwork came with the erection of the great cathedrals and churches, whose treasures required protection. The grille known as the St. Swithun grille in Winchester cathedral, the earliest example of this class of ironwork. was probably made during the last years of the 11th century. The fully developed stamped iron in England, so familiar from examples at Lichfield, Chester, York, Windsor, Oxford and Westminster. seems to be the work of a single smith, Thomas de Leghtone, and belongs to the end of the 13th century. See further IRONWORK: *Europe: England.*

SPAIN

Medieval Spain, with its large Muslim population, was in close touch with oriental art. A rich effect was produced by the Moorish bronze-covered doors of Toledo (1337), Córdoba (1377) and Seville. Iron was the particular favourite of the Spanish metal craftsman, although there are outstanding works in bronze. Francisco de Villalpando, who won the competition for the *capilla* moyor grille of the Toledo cathedral (1540–48). executed it partly in bronze. He also made the gilt bronze pulpits, the bronze doors with admirable bas-reliefs of the Puerta de los Leones (1545–50), and the font, and the rail to the altar of the Virgin in the coro (1551–64) at Toledo, and the choir screens in the cathedral of his native town, Palencia. Other noteworthy examples of Spanish decorative bronzework are: the pulpits on both sides of the high altar at Santiago, with gilt reliefs by Juan Celma (1563); and the main pillars of the coro and one of three reading desks (called el *Aguila*, from the bronze eagle with outstretched wings), the latter by Vicente Salinas (1646), both in Toledo cathedral

Catalan ironworkers achieved great fame. It was in northern Catalonia that the best type of early forge for smelting iron was evolved. This was the Catalan forge. which yielded an excellent malleable iron and made possible the great quantity of beautiful medieval ironwork. The earliest Spanish grilles are those in the cathedrals of Palencia and Pamplona, from the 13th century. The cathedral of Barcelona. which possessed a guild of ironworkers from the 13th century, has an extensive series of typically Spanish *rejas* (screens) of the 15th century.

The Spanish ironworker, recognizing that the inherent quality of iron, strength, was best expressed on a grand scale. created the monumental screens (*rejas*) that give Spain a unique position in the field of artistic ironwork.' They may be seen in all the large cathedrals of Spain, and one of them, a remarkable wrought-iron *reja* from the central nave of the cathedral of Valladolid, executed in 1668, is installed in the Metropolitan Museum of Art. (See also IRONWORK: *Europe:* Spain.)

Numerous smaller ironwork items are found throughout Spain.

One interesting development was the growth in size and ornamentation of nailheads. which ultimately outgrew their original utilitarian function and became primarily ornamental on doors.

Burgos cathedral contains, besides its many notable *rejas,* another marvel of the ironworker's art. the golden stairway, with a marvelous gilded wrought-iron balustrade. designed by Diego de Siloe in 1519. The gilded iron pulpits in Ávila cathedral, dating about 1520, include panels hammered in relief with figures of apostles and arabesques. Pulpits of wrought iron are by no means uncommon; they are also found at Burgos. Santiago. Seville. Toledo and elsewhere, usually in pairs, one for the reading of the Epistle. the other for the Gospel, in close proximity to the *reja.* The smali grilles for gates and windows have characteristics of the more monumental church works. One of the best-known window *rejas* in all Spain is in the Casa de Pilatos in Seville. It dates from the mid-16th century and is considered to be the work of one of the master *rejeros* employed in the cathedral of the same city. Of small iron objects belonging to the medieval period not many have survived. The richest collection is that of the Episcopal museum of Vich, in northern Catalonia. The Hispanic Society of America as well as the Metropolitan Museum of Art possesses many objects from which the skill of the Spanish smith may be studied.

See CHINESE BRONZE; JEWELRY; ORMOLU; *see* also references under "Metalwork, Decorative" in the Index volume.

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METAMORPHISM, in petrology, is the process of chemical and physical alteration that occurs in rocks under the influence of elevated temperature and mechanical stresses in the earth's crust. Following an introductory discussion of metamorphism and metamorphic alterations, this article presents a survey of methods of investigation and study of metamorphic rocks and discusses grades of metamorphism and the theories on nhich they are based, temperature and pressure involved in metamorphism, the texture and structure of metamorphic rocks and metamorphic differentiation. In addition to references to related and supplementary material given in the several sections of this article, *see* also the general article GEOLOGY and articles on various rocks and rock-forming minerals, as MICA SCHIST; GNEISS; MARBLE; FELDSPAR; WOLLASTONITE, etc.

INTRODUCTION.

Petrologists divide rocks into three broad classifications: igneous rocks *(see* PETROLOGY), which have been solidified from molten substances (magmas); sedimentary rocks (*q.v.*), formed by the slow process of consolidation of sedimentary deposits; and metamorphic rocks. Metamorphic rocks, which constitute a major part of the earth's crust, are rocks that originally belonged to the other groups but that were altered in various ways. The alteration consists in part of chemical reactions among the minerals in the rocks or between incoming fluids and the original minerals. These changes in physical and chemical properties of rocks, under the new environmental pressures. transform them into new species. For example, clay sediments change to shale and slate at temperatures around 100° C.–200° C. At higher temperatures in the earth's crust, clay may change to mica schists or various types of gneisses. Limestone, originally formed as a sedimentary rock from the calcareous shells of primitive animals, changes to marble by the chemical reactions and recrystallization occurring during metamorphism.

Mechanical deformation of rocks is another common occurrence in metamorphism. This deformation is in part of a plastic nature —the rock yields more or less like metal under crustal stresses. However, crustal stresses are sometimes strong enough to crush rocks to fragments varying from pieces a foot long to fine powder.

Alterations of a physical and chemical nature are caused also by weathering of rocks in contact with the atmosphere and surface water, and by diagenesis (*q.v.*) of sediments. but such changes are generally not included in the term metamorphism. Weathering and diagenesis occur at temperatures below those at which true metamorphism takes place. On the other hand too high temperatures—above 600° C.–goo° C., depending on rock type—causes silicate rocks to melt and brings us thus into the realm of magmatism and magmatic rocks. *(See* also GEOCHEMISTRY: *Geochemistry of the Lithosphere.)* Rocks exposed to these extreme physical conditions are called ultrametamorphic.

Metamorphic Alterations.— All kinds of rocks may be exposed to metamorphic alterations. Alterations without change of bulk chemical composition of rocks are called isochemical metamorphism. If change of bulk chemical composition is involved the term allochemical metamorphism applies *(see* also METASOMATISM).

Some chemical constituents are very mobile in rocks undergoing metamorphism. The content of such mobile constituents. as for example water and carbon dioxide, is rarely constant in a rock during metamorphic alterations. Thus, for example, a gabbro which consists of two anhydrous minerals, plagioclase feldspar and pyroxene, picks up several per cent of water if metamorphosed at low temperatures (say 300° C.) because hydrous minerals such as chlorite and hornblende are formed. On the other hand, a sedimentary rock containing hydrous clay minerals loses large amounts of water when metamorphosed at high temperatures (500° C. to 600° C.) at nhich essentially anhydrous minerals become stabilized. Similarly, rocks may gain or lose carbon dioxide rather readily because at high-temperature metamorphism calcite and other carbonate minerals react with quartz or silicates to form calc-silicates and carbon dioxide gas which escapes from the altered rocks. Rocks containing calc-silicates such as wollastonite, diopside and anorthite often develop carbonates at lorn-temperature metamorphism. This means considerable introduction and gain of carbon dioxide. As an example of reactions involving carbon dioxide consider the following:

low temperature			high temperature		
$CaCO_3$	+ SiO_2	$\rightleftharpoons$	$CaSiO_3$	+ CO_2	
calcite	quartz		wollastonite	carbon dioxide	

The right-hand side of this metamorphic mineral reaction corresponds to high temperature and loss of CO_2, the left-hand side to low temperature and gain of CO_2.

Many rock-making chemical constituents other than water and carbon dioxide are mobilized during metamorphism thus making change of hulk chemical composition a common phenomenon.

Types of **Metamorphism.**—Metamorphism is conveniently classified as contact metamorphism, which occurs in rather narrow zones around hot magma masses, and regional- or dynamothermal metamorphism, which encompasses vast complexes of rocks involved in the evolution of fold mountains. The latter type of metamorphism is not caused by heat from molten magmas, but rather by tectonic, or structural, stresses in the earth's crust and regional rise in crustal temperature. The reason for such regional rise in crustal temperature is not known for certain but it is probable that it is caused by dissipation of the potential energies which create fold mountains *(see* also FOLD).

Contact *Metamorphism.*—Rocks altered by contact metamorphism show little or no sign of strain such as plastic flowage or mylonitization, or crushing of minerals. In contact metamorphic rocks. recrystallization (for example: formation of coarse-grained

marble from limestone, of quartzite from sandstone) and neomineralization are the most prominent features. Neomineralization means formation of new mineral assemblages more stable than the old ones. Such rocks are generally called hornfels (*q.v.*).

Regional Metamorphism.—Regional metamorphic rocks bear signs of mechanical strain in addition to recrystallization and neomineralization. The strain is seen as schistosity or foliation and other kind of anisotropic structures in the rock bodies, much like the structures found in rolled metal plates and drawn wires. Crystalline schists such as mica schists and green schists, many marbles, most gneisses, certain soapstones, amphibolites and granulites are regional metamorphic rocks.

Progressive and Regressive *Metamorphism.*—Rock alteration taking place at increasing temperature (and pressure) is called progressive metamorphism (for example: clay sediment altered to mica schist). Alteration at decreasing temperature is called regressive metamorphism or diaphoresis (for example: green schist formed from basic lava).

Polymetamorphism.—A polymetamorphic rock has been exposed to two or more periods of metamorphism. Such rocks may carry proof of their complex history in the form of structural or mineralogical relics from earlier stages in their evolution. The term palimpsest (from the Greek for scratched or scraped. that is, marked. again) structure mas coined by J. J. Sederholm for features of this kind.

METHODS OF INVESTIGATION

The basis for all geological investigations are the observations which the geologist does out in the field. Investigations of metamorphic rocks and phenomena are no exception in that respect. By making geological maps. constructing profiles of rock complexes and observing detailed structural relations of rocks in the field the geologist gets valuable information as to origin and evolution of metamorphic rocks.

The collected sample's are studied by various physical and chemical methods in laboratories. Microscopic studies of thin sections or powdered rocks give information about type of minerals present, their relative amount and the microscopic texture and structure of the rocks. Chemical analyses of rocks and minerals are performed by conventional chemical methods as well as by various spectrographic techniques. Mass spectroscopy gives data on isotopic distribution in rocks and minerals. Such data are useful for age determination of rocks. There are, of course. other properties of metamorphic rocks which are studied in the laboratories. Stress and strain tests of rock samples tell about the mechanical properties such as elasticity, strength and viscosity. These data are important for the understanding of the behaviour of rocks when exposed to stresses in the earth's crust.

Fundamental thermodynamic parameters of minerals—such as their heat of formation, heat capacity, entropy, etc.—are determined in laboratories. Such data are necessary to understand the behaviour of mineral assemblages in rocks when effected by the changing pressures and temperatures in the earth. Thermodynamic data are of course necessary for calculation of the whole energy balance during metamorphism.

The above outline is a brief description of methods used to gather important data on metamorphic rocks. Such data are meaningful only if they contribute to more or less comprehensive theories of origin and evolution of metamorphic rocks. To achieve this goal the data are treated by various mathematical tools and interpreted by the aid of theoretical physics. Theoretical methods of this kind must be considered a very significant part of the investigation of metamorphism.

Syntheses of metamorphic minerals under equilibrium conditions at varying pressure and temperature conditions are important in the sense that they may give better knowledge of the pressure and temperature conditions at which rocks have formed or recrystallized. (See also GEOCHEMISTRY; GEOLOGY; PETROLOGY.)

GRADES OF METAMORPHISM

Rfetamorphic rocks provide an illustration of the fact, established by atomic science, that the concept of "dead matter" is an illusory one. Exposed to changing geological conditions in the lithosphere, they respond by alterations—mineralogical, structural and chemical. Thus rocks tend to develop mineral assemblages, or recurring combinations, and structures best suited—*i.e.*, most stable—under the conditions of temperature, pressure and anisotropic stress which affect rocks during their evolution.

The principal processes taking place in rock bodies during metamorphism are recrystallization and neomineralization, referred to above. The change of mineral assemblages in response to varying temperature and pressure conditions makes it possible for geologists to distinguish among various grades or degrees of metamorphism. The different grades are determined by the occurrence of characteristic minerals or mineral assemblages which represent—and presumably are stable at—unlike pressure and temperature (P,T) conditions.

Grades and Depths.—The Swiss petrologist Ulrich Grubenmann (1850–1924) in his classification of crystalline schists distinguished among three grades of metamorphism, the epi (upper), meso (middle) and kata (downward) zones. Grubenmann believed that depth of burial in the earth's crust was the chief reason for unlike grades of metamorphism because pressure obviously increases with depth and. generally, so does temperature as shown by the geothermal gradient, or increase in temperature of the earth from the surface toward the interior, averaging about 3° C. per 100 m.

Epizonal rocks were regarded as product of shallow depths because of their content of minerals characteristic of low temperature such as chlorite, talc, serpentine and other hydrous minerals.

Mesozonal rocks carry minerals generally formed at moderate temperature (some 300° C. to 400° C.). Such rocks were consequently believed to have developed at intermediate depth in the crust.

Katazonal rocks consisting mostly of anhydrous minerals such as garnet, kyanite, hypersthene. cordierite, feldspar, etc., were considered ambassadors from the deepest portions of the earth's crust now exposed by erosion.

Unlike Grades and Constant Composition.—G. Barrow, working in Scotland, demonstrated that the grade of regional metamorphism changed in horizontal direction across the Caledonian fold-mountain chain which extends in a northeast-southwest direction through the Highlands. Zones of rocks exposed to the same grade of metamorphism are approximately parallel to the axes of the mountain chain. low-grade rocks generally occupying marginal zones and high-grade rocks central zones, with rocks of intermediate grade between. Similar conditions are encountered in other areas of more or less eroded fold-mountain chains such as the Caledonian chain in Scandinavia and many Pre-Cambrian deeply eroded mountain chains in Fennoscandia (the Baltic shield), Canada, west Greenland and other areas. Barrow studied chiefly alterations of argillaceous. that is, clayey, sediments which are very responsive to changing P,T conditions. Certain index minerals were used to identify certain grades of .metamorphism, one index mineral would change over to another along a more or less curved boundary line in the field. Such a line is termed isograde and represents the intersection between the earth's surface and a boundary surface separating two neighbouring zones of metamorphism. Such boundary surfaces between adjacent but unlike zones of regional metamorphism are curved surfaces which often, but not always. show fold axes more or less parallel to the axis of the mountain chain. Chlorite, biotite. garnet. kyanite, staurolite, sillimanite were minerals used by Barrow to indicate increasing grades of regional metamorphism.

Constant Grade and Unlike **Compositions.**—V. M. Goldschmidt was the first to apply extensively physicochemical principles in a study of metamorphic rocks. His treatise of the Oslo (Kristiania) area in Norway has become classic. In this area numerous magmatic bodies of Permian age have intruded a sedimentary complex of sandstone, limestone and argillaceous schists. These sediments have been exposed to high temperature in a contact zone of varying thickness around the intrusive magmatic rocks. At a constant distance out from the rim of a given

magma body the temperature in the surrounding sediments has been constant. Therefore Goldschmidt was able to study in great detail how rocks of unlike bulk chemical composition (sandstone, limestone, claystone, etc.) responded to a given temperature, viz., the crystallization temperature of the magma. In other words Goldschrnidt studied the effect of a given grade of metamorphism (the grade of contact metamorphism, or the pyroxene hornfels facies of P. Eskola. discussed below) on a number of rocks of unlike chemical composition. Barrow had studied the effect of unlike metamorphic grade on rocks of nearly constant composition. viz., argillaceous sediments. We shall see below that Eskola combined both types of study: he studied the effect of various grades of metamorphism on rocks of various bulk composition.

Chemical Equilibrium and the Phase Rule.— The important Oslo area t\ork led to the interesting conclusion that chemical equilibrium had been approached rather closely in sediments baked in the heat from intrusive magmas. Subsequent studies have shown that chemical equilibrium among niinerals in rocks generally is attained also during regional metamorphism, probably more commonly here than under contact metamorphism. The laws of chemical equilibrium in heterogeneous systems as developed by Josiah Willard Gibbs and others are consequently applicable to metamorphic rocks, a fact largely responsible for the recent progress in metamorphic petrology. Metamorphic rocks frequently obey the chemical phase rule: $P + f = C + 2$ where P stands for phases, which in petrology correspond to minerals. f means degrees of freedom, and C components. In silicate rocks simple oxides are conveniently counted as components; if sulfides are present sulfur is an additional component.

Under iaochemical metamorphism, rocks are closed systems not permitting communication of chemical constituents with the environment. Two degrees of freedom have then generally prevailed inasmuch as pressure and temperature are independent variables, and the so-called mineralogical phase rule is valid: $P = C$. That is, a metamorphic rock formed under equilibrium conditions should have the same number of different minerals as it has components. It is interesting to note that metamorphic rocks very rarely have more minerals than components counted in terms of simple oxides, such as those of potassium, calcium, magnesium, silicon. etc. Indeed, in most metamorphic rocks the number of minerals is considerably less than the number of components. For example, many amphibolites. which are common metamorphic rocks in terrains of gneisses and crystalline schists, have only the two minerals plagioclase and hornblende, yet cheniical analyses may show ten or more simple oxides. The reason for this apparent discrepancy is in part that many minerals are mixed crystals in which several atoms or ions can substitute for one another in identical structural positions. Sodium and calcium are interchangeable in plagioclase. so are silicon and aluminum to some extent. In hornblende a great number of cations substitute for one another. Magnesium, iron. titanium. aluminum. manganese, nickel and cobalt are all encountered in identical structural sites. This means that several unlike chemical elements must be counted as one component because they are identical from a mineral-chemical point of view.

Mineral Assemblages.— The general approach to chemical equilibrium among minerals in metamorphic rocks results in an order and regularity which invite natural classifications of such rocks. Contact metamorphic rocks can be grouped in [illegible] shown in fig. 1. This particular three-component diagram with Al_2SiO_5, $CaSiO_3$ and $(Mg,Fe)SiO_3$ at the corners is only applicable to rocks with excess silica metamorphosed in the contact zones around magmas. Any one of the possible mineral assemblages shown in fig. 1 may develop. There are. however, restrictions as to the number as well as types of associated minerals at equilibrium. If chemical analysis of a hornfels places it on a joint line between two minerals in fig. 1, then only these two minerals are permitted at stable equilibrium. (Minerals containing elements not shown in the diagram may certainly occur in addition to those indicated by the phase diagram.) A hornfels falling within one of the three angles in the figure must contain the three minerals at the corners. Only one mineral can be present stably in a hornfels with bulk chemical composition coinciding with that of the mineral itself. Incidentally. such monomineralic rocks are not as rare as one may assume in view of the small chance that hulk composition of sediments should coincide with that of a pure mineral. Pure diopside hornfels and wollastonite hornfels are described from various places.

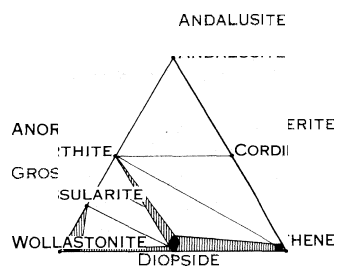

FIG. 1.—MINERAL ASSEMBLAGES OF CONTACT METAMORPHIC ROCKS

The Oslo hornfelses adjacent to the magmatic intrusives follow very strictly the rules of permitted mineral assemblages. Ten classes of hornfels were recognized by Goldschmidt in the field:

Class 1 rocks with andaluiite and cordierite (albite)
Class 2 rocks with andalusite. cortlicrite and anorthite
Class 3 rocks n-ith anorthite and cordieritc
Class 4 rocks with anorthite, cordieritc and enstatite
Class 5 rocks with anorthite and cnstatite
Class 6 rocks with anorthite, cnstatite and diopside
Class 7 rocks n-ith anorthite and diopside
Class 8 rocks with anorthite, diopside and grossularite
Class 9 rocks with grossularite and diopside
Class 10 rocks with grossularite (vcsuvianitc), diopside and wollastonite

This sequence of classes of hornfels corresponds to increasing amounts of calcite (calcium) in an argillaceous sediment. Andalusite is the metamorphic product of the typical clay mineral kaolinite, and wollastonite forms at high temperature by interaction between calcite and silica (fig. 4).

Metamorphic Facie%— :it grades of metamorphism different from contact metamorphism other minerals and mineral associations occur. These assemblages can be shown in diagrams similar to fig. 1. viz.. with calcium. aluminum and magnesium + iron silicates at the corners. .Eight grades. each with its characteristic phase diagram (called ACF diagram), have been recognized and described by Eskola in his studies of areas in Finland and Torn-ay. The characteristic mineral association of each grade is called mineral facies or metamorphic facies, with the narne of each facies chosen from the kind of rock most dominant within that grade. Basic rocks rich in calcium and magnesium are most sensitive to changes of metamorphic grades. The various facies are named after such rocks rather than acidic and alkali-rich ones. This does not mean. however, that acidic and alkaline rocks are not found in the unlike facies or grades; it only emphasizes that it is difficult to distinguish among unlike metamorphic grades in rocks such as granitic gneisses. quartzites. nepheline syenites and the like. Quartz, potash feldspar and acidic plagioclase, the chief minerals in such rocks, are stable over the whole P.T field in which most metamorphism takes place. Thus a granitic gneiss consisting of quartz, potash feldspar and albite

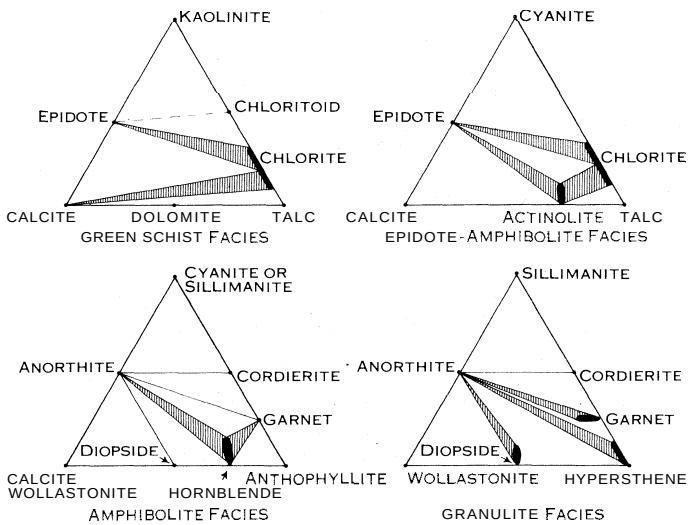

FIG. 2.— VARIOUS GRADES OR FACIES OF REGIONAL METAMORPHISM

remains a granitic gneiss with the same minerals at all grades of common metamorphism. On the other hand minerals occurring in basic rocks, being of magmatic or sedimentary origin, such as

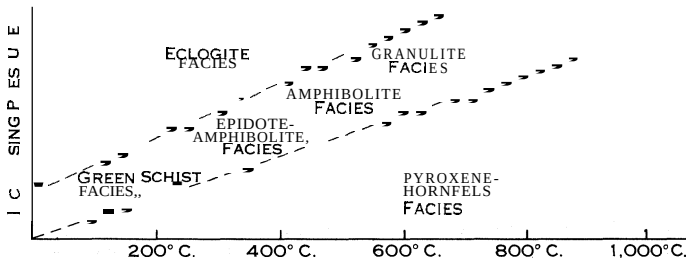

FIG. 3.—VARIOUS FACIES OF CONTACT METAMORPHISM

pyroxenes, hornblendes, chlorites, talc, serpentine, olivine, anorthite and epidote have narrow fields of stability. A basic rock of given bulk composition may, for example, yield a gabbro (pyroxene and plagioclase) at high metamorphic grade, an amphibolite (hornblende and plagioclase) at intermediate grade and a green schist (chlorite epidote and albite) at low grade.

The sequence of metamorphic grades from low to high grade of regional metamorphism is green schist facies, epidote amphibolite facies, amphibolite facies and granulite facies. Corresponding ACF diagrams are shown in fig. 2. Contact metamorphism belongs to the pyroxene hornfels facies.

Other facies less commonly encountered are eclogite facies, glaucophane schist facies and sanidinite facies. Fig. 3 shows the approximate positions of the various facies in a P,T diagram.

TEMPERATURE AND PRESSURE OF METAMORPHISM

Our knowledge of temperature and pressure represented by the various metamorphic facies is unfortunately limited. It seems rather certain, however, that granulite facies, being the highest of regional metamorphic grades, corresponds to about 600° C.–700° C. Green schists must have developed at much lower temperatures, perhaps 200° C.

Temperature.— Assuming that chemical equilibrium mas attained in metamorphic rocks at the time of recrystallization, their mineral assemblages should reveal the correct P,T conditions of metamorphism. Laboratory studies have given some information on stability relations of mineral assemblages. Such studies indicate that a temperature of 600° C.–700° C. can be assigned to the granulite facies. The two alkali feldspars, microcline and albite, constitute a complete mixed-crystal series above 600° C. At lower temperatures a gradual unmixing takes place, the two coexisting feldspar phases becoming more and more pure. At room temperature only negligible amounts of soda in microcline or potash in albite can exist stably.

In granulites albite and microcline are often found as one single phase of solid solution whereas in lower-grade rocks albite with varying amounts of dissolved potash and microcline with varying amounts of dissolved soda are found as two independent minerals. (See also FELDSPAR: *Unmixing* at **Low** Temperature.)

A similar situation exists in the calcite-magnesite (calcium carbonate and magnesium carbonate) system. Calcite takes varying amounts of magnesium carbonate in solid solution, depending upon prevailing temperature during recrystallization. It has been determined that magnesian marbles metamorphosed in granulite facies often carry calcite with concentrations of magnesium corresponding to temperatures around 600° C.

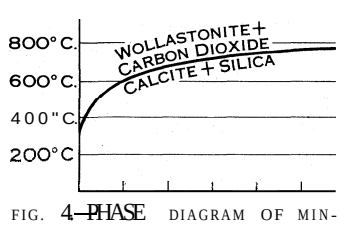

FIG. 4.—PHASE DIAGRAM OF MINERAL SYSTEM APPLIED AS A GEOLOGIC THERMOMETER

Muscovite is a hydrous silicate occurring in many metamorphic rocks. At somewhat elevated temperature the mineral reacts with quartz and loses water whereby sillimanite and potash feldspar are produced:

$$\underset{\text{muscovite}}{KAl_3Si_3O_{10}(OH)_2} + \underset{\text{silica}}{SiO_2} \rightleftharpoons \underset{\text{feldspar}}{KAlSi_3O_8} + \underset{\text{sillimanite}}{Al_2SiO_5} + H_2O$$

Muscovite is never found in true granulites but sillimanite and potash feldspar occur frequently together. In lower-grade rocks muscovite and quartz are commonly found together. Thus the P.T conditions at which the above reaction takes place should give the lowest boundary of granulite facies, *i.e.*, the boundary line between granulite facies and amphibolite facies. At low pressures this reaction is very sensitive to pressure variations because water vapour is involved. At higher pressures, however, laboratory investigations have shown that the reaction temperature at equilibrium is close to 600° C. over a wide pressure range. This is then the third mineral system which indicates that the highest temperature in regional metamorphism is not much higher than 600° C. to 700° C. At higher temperatures silicate rocks begin to melt and magmas are born, a process called anatexis or palingenesis.

A mineral system often applied as a geologic thermometer in metamorphism is calcite + quartz and wollastonite + carbon dioxide. The phase diagram is shown in fig. 4.

Pressure.— Pressure also varies from one facies to another. In a general way it is known for example that pyroxene hornfels facies represent much lower pressures that granulite facies, the latter not only corresponding to the highest temperature in regional metamorphism, but also the highest pressure. Reactions among minerals with unlike molal (gram-molecular) volumes are useful geologic barometers. As an example, consider the rather rare mineral jadeite, $NaAlSi_2O_6$, which mostly is found in rocks altered or formed at high pressures (see JADE). Jadeite has much higher density than albite although the composition of the two minerals is nearly the same, albite having the formula $NaAlSi_3O_8$. Jadeite can form from albite according to the following reaction:

$$\underset{\text{albite}}{NaAlSi_3O_8} \rightleftharpoons \underset{\text{jadeite}}{NaAlSi_2O_6} + \underset{\text{quartz}}{SiO_2}$$

The jadeite-quartz combination has considerably less volume than albite so that high pressure favours the jadeite-quartz assemblage. Within the temperature range in which this reaction occurs stably, albite is stable at low pressures and jadeite plus quartz at high pressures. Thus eclogites, which are considered high-pressure rocks by most petrologists, have a high percentage of jadeite molecules in their pyroxene (*q.v.*). (See also ECLOGITE.)

TEXTURE AND STRUCTURE OF METAMORPHIC ROCKS

The mineral assemblages of metamorphic rocks have developed by recrystallization and chemical reactions in the solid state, often under conditions of tectonic stress. Such rocks have therefore texture and structure different from those of magmatic and sedimentary rocks, the former crystallizing from melts (see PETROLOGY), the latter precipitating in lakes, rivers and oceans (see SEDIMENTARY ROCKS).

Mineral grains in metamorphic rocks are mostly without crystal faces and border against their neighbours along irregularly curved surfaces not related to their internal crystalline structure. Such texture is called crystalloblastic. An idioblast is a mineral grain with well-developed crystal faces. During metamorphism certain minerals show greater tendency to form idioblasts than others. Garnet, for example, often forms perfect idioblasts in mica schists whereas quartz never does and feldspar only rarely.

Minerals may be placed in the so-called idioblastic series according to their tendency to develop crystal faces during metamorphism. The major members of this series are as follows: sphene, rutile, garnet, kyanite, epidote, pyroxene, hornblende, albite, chlorite, quartz, microcline. Sphene almost invariably forms idioblasts, quartz and microcline very seldom.

Riecke's Principle and Force **of** Crystallization.— A min-

eral growing in a metamorphic rock has to produce space for itself in a solid environment. Surrounding minerals must then either be pushed aside bodily or disintegrate chemically (for example dissolve in a pore moisture). The so-called force of crystallization or pressure of growth is of importance in this connection. Any crystal is able to grow against excess pressure if the system is supersaturated with reference to that crystal, the more supersaturated the system. the higher the pressure of growth. On the other hand, if a crystal is exposed to excess pressure in a saturated system it becomes unstable and tends to disintegrate chemically. (Excess pressure here means higher pressure on the crystal than in the rest of the system.) In solid rocks such disintegration does not necessarily mean dissolution in a fluid because liquid solutions are not always present. It generally means disintegration into individual ions, atoms or molecules which are carried away by diffusion along mineral interfaces or even through their crystalline body. This phenomenon of chemical disintegration under excess pressure is referred to as Riecke's principle. It not only explains plastic flow of solid rocks under stress, but is also important in explaining recrystallization and neomineralization. A newly stabilized mineral grows in a metamorphic rock because the rock has become somewhat supersaturated with reference to the nen mineral owing, for example, to changing P,T conditions. The growing mineral surrounds itself by a field of pressure in excess of that prevailing elsewhere in the rock. Minerals present in this field of excess pressure disintegrate according to Riecke's principle and thus provide space for the newly stabilized growing mineral. Thermodynamic analysis shows that under otherwise like conditions (same P,T values, same degree of supersaturation) dense minerals develop higher pressure of growth than less dense minerals. In this connection it is interesting to note that the above-mentioned idioblastic series of minerals as determined empirically from field studies also is a density sequence, sphene and garnet being dense structures, quartz and feldspar loose, open structures.

Analysis of Structure. — The structure of rocks is called isotropic or massive if it is identical in all directions in space. Some contact metamorphic rocks may show such structure, but practically all regional metamorphic rocks have anisotropic structure, *i.e.*, structures xith planar and linear features. Planar structure shows up well in most mica schists where the majority of mica flakes may be parallel to a given plane — the plane of foliation, or schistosity. In ideal planar structure all directions in the schistosity plane are identical. Needle-shaped minerals such as sillimanite and hornblende show statistic parallelism to the schistosity plane, but they are oriented at random within that plane. In linear structure needle-shaped minerals show preferred parallelism to a line. This line is called lineation. In most natural rocks linear and planar structures are mixed.

Origin. — The origin of anisotropic structure is twofold:

(1) The structure may be relic after premetamorphic anisotropic structure of various kinds. Sediments with deposition structure and lavas with flow structure may preserve their anisotropic structure as relic during metamorphic recrystallization even if not exposed to anisotropic stress. Structures formed in this manner are termed mimeoblastic. In polymetamorphic rocks anisotropic structures formed in earlier periods of metamorphism may remain as relic mimeoblastic structure through later recrystallization. In contact metamorphic rocks mimeoblastic structure is common because anisotropic stress is not likely to occur in contact zones around magmas.

(2) Anisotropic structure develops in rocks recrystallized under anisotropic stress. The stress causes strain of the rock bodies (cataclastic, with fractures. and plastic, without fractures) and consequent rearrangement of mineral grains into various types of anisotropic structures. The structure of most regional metamorphic rocks is of this kind.

The mechanism causing such structures to form is little known and probably very complex. It is assumed that the following processes occur in a rock under stress: (1) rotation and relative movement of mineral grains by slip along interfaces; (2) slip along certain crystallographic planes and lines inside mineral grains (so-called glide planes and lines); (3) dissolution (or other kind of chemical disintegration) at points of high compressive stress and redeposition at points of low stress in accordance with Riecke's principle; and (4) fracturing and crushing of mineral grains — so-called cataclasis.

Crushing. — Evidence of any one of these processes may be found in metamorphic rocks. If fracturing is dominating the phenomenon is called mylonitization and the produced rock a mylonite (*q.v.*). Such mylonites occur usually only in narrow zones in metamorphic terrains, demonstrating intensive shear movements along these zones with corresponding crustal stresses exceeding the crushing strength of minerals. However, many metamorphic rocks show no sign of mineral crushing.

Rotation. — Evidence of rotation of mineral grains during metamorphism is not uncommon, the most cited example being the so-called snowball garnet with inclusions arranged in a spiral as a result of rotation during growth.

Slip — Calcite and other carbonates yield readily by slip along certain lattice planes often resulting in polysynthetic twinning and bending of grains. This is observed in many natural marbles in thin sections under the microscope. Laboratory experiments with marble blocks under stress at elevated temperature also show that gliding along crystallographic glide planes is important in rock deformation. It seems, however, that most silicate minerals deform via chemical processes more or less in harmony with Riecke's principle during regional metamorphism. Tectonic stress is generally too weak to produce crushing and lattice slip. Slow creep due to recrystallization seems more important in rock deformation.

Orientation. — The statistic parallelism of mineral grains in rocks with anisotropic structure may be dimensional orientation or lattice orientation. Dimensional orientation refers to the external shape of mineral grains, whereas lattice orientation refers to the internal structure of minerals. Quartz grains in schists and gneisses may, for example, have lenticular shapes unrelated to the internal crystal structure. Such quartz lenses are often dimensionally oriented parallel to the schistosity plane. This kind of anisotropic structure is most likely a result of dissolution at points of high compressive stress (*i.e.*, at mineral interfaces which are perpendicular to the highest compressive stress) and redeposition at points of low compressive stress (*i.e.*, at interfaces or surfaces more or less perpendicular to direction of least compressive stress or maximum tensile stress).

Minerals with equidimensional outline such as those belonging to the regular crystallographic system may shou preferred lattice orientation which can be detected only by accurate microscopic studies.

METAMORPHIC DIFFERENTIATION

During metamorphism, originally homogeneous rock bodies may become heterogeneous in the sense that schlieren (alternating bands of contrasted composition) and veinlets develop. Such phenomena are called metamorphic differentiation. For reasons not clearly understood minerals disintegrate chemically at certain sites in rocks and redevelop at other sites, the transfer probably being in the form of diffusion. Quartz veinlets and clusters commonly form in crystalline schists, "knots" of epidote in green stone, and segregations of diopside or other calc-silicates in crystalline limestone. Such metamorphic differentiation is most prominent in strongly deformed rocks. It is therefore concluded that stress and strain are instrumental in metamorphic differentiation. Minerals which dissolve more readily than others in zones of intensive stress and shearing are leached out from such localities and may be deposited anew where stress is low, thus causing metamorphic differentiation. Interfacial tension. energy of nucleation, and force of crystallization are properties which seem significant in metamorphic differentiation.

Many features in metamorphic terrains caused by metamorphic differentiation are difficult to distinguish from features resulting from magmatic activity. Pegmatite dikes and mineral veins in crystalline schists are commonly products of metamorphic differentiation although similar rocks may also form from magmas.

Some workable ore bodies in regional metamorphic terrains are probably also products of some sort of metamorphic differentiation.

See also references under "Metamorphism" in the Index volume.

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METAMORPHOSIS, a Greek word meaning change of shape, is applied in zoology. (See INVERTEBRATE EMBRYOLOGY.) All animals begin their existence as undifferentiated cells and attain their characteristic features by growth which entails changes of shape. If we were to magnify the model of a baby to the size of a man we should discover how striking are the changes in the proportions of the human figure as manhood is attained and yet these changes are not regarded as metamorphosis. The best definition of metamorphosis is "a conspicuous change in shape and mode of life in an animal occurring in a comparatively short time without any increase in size or even with a decrease in size." In the common English frog, the tadpole stage lasts from two to four months, during which the animal increases very much in size but retains the same general appearance and proportions. The rudiments of the hind limbs gradually increase in length while the forelimbs break through the skin of the breast region. The creature then ceases to feed and begins to crawl out of the water, though it remains within reach and takes to it if alarmed. In about four days the tail is reduced to a vestige and finally disappears and the young frog takes up land life. The froglet is smaller than the completely grown tadpole and requires four years to attain sexual ripeness and full size.

In an insect such as a butterfly there is a striking and abrupt change in form when the caterpillar sheds its skin and becomes a chrysalis or pupa, and when the perfect insect emerges from the pupal shell. The stages vary greatly in duration, but the outward change from larva to pupa and from pupa to adult requires only a few minutes.

The term metamorphosis is not applied to embryos, only to larvae. Since the change in shape is accomplished without increase in size, it always involves the casting off or absorption of certain larval tissues. In the case of the tadpole's tail, wandering cells (phagocytes) carried by the blood stream attack and devour the contained muscles, nerve cord and notochord, the skin is thrown into internal folds and these folds in turn are attacked by phagocytes and so the whole skin area shrinks in size, till the tail is reduced to a stump.

Metamorphosis is found only in those life-histories where the larva and the adult have very different habits. Among vertebrates it only occurs in Cyclostomes, in certain groups of fish, and in Amphibia (frogs, toads and newts). Below the level of vertebrates, however, it is found in every great division of the animal kingdom. The newt is especially interesting. This creature differs from a frog in having the forelimbs and hind limbs of approximately equal size and in retaining the tail throughout life. The larva differs from the tadpole in retaining during the whole of its aquatic existence the external featherlike gills which the tadpole at first possesses but later casts off when they have been covered by the growth of the gill cover. This cover in the tadpole hides the forelimbs which are only revealed a short time before the little frog leaves the water, but in the newt larva this cover is rudimentary and the forelimbs appear in development first, to be followed later by the hind limbs so that in the older larvae all four limbs are obvious and fully formed. Now in certain species of newt such as the Mexican axolotl the habit has been acquired of spending the whole life in water. In normal circumstances the larvae of these newts never metamorphose but develop their genital organs and eventually lay eggs. For reasons discussed below it is possible to induce metamorphosis in these newts by feeding them with thyroid gland. No more startling phenomenon can be witnessed than this. In a week or two in the writer's laboratory a large fat axolotl lost its gills, closed up its gill slits, lost the bladelike fin on its tail, darkened in colour, shrunk considerably in size and emerged from the water as a rather small black newt.

Among fishes metamorphosis is comparatively rare, because both young and adult swim in the water and get their food in much the same way. The best examples are the flatfishes (Heterosomata), in which the adult swims lying on one side. The eye belonging to this side is twisted on to the upper side, and the mouth is distorted toward the lower side, for the fish feeds on the animals (worms and molluscs) which burrow in the sand and mud beneath it. The young fry swim upright in the water and the eyes are on opposite sides of the head. When they have reached a certain size they fall to the bottom and rest on one side. Darwin, quoting Malm, says that they make violent effort to twist the lower eye on to the upper side and that as the skull is soft these efforts meet with considerable success. In a comparatively short time both eyes are on the upper side and the metamorphosis has been accomplished.

The lamprey (*q.v.*) *(Petromyzon)* is separated by such a deep gap from all fish that it is placed in a different class, Cyclostomata *(see* CYCLOSTOME). No true jaws exist; the mouth is surrounded by a circular cartilage and the animal lives by attaching itself by suctional action to a larger animal and then rasping a hole in its victim's flesh by means of horny teeth which are developed on a pistonlike tongue. The larval form, known as ammocoetes, lives in a totally different manner. The mouth is overhung by a hoodlike upper lip separated by a lateral cleft from a small straight underlip. The gill sacs open directly into the oesophagus instead of into a special tube as in the adult. But the greatest peculiarity of the ammocoetes is that the organ from which the lamprey's thyroid gland is later developed is a saclike structure with an opening into the throat, through which the mucous secretion escapes in the form of a cord. This entangles any minute organisms in the water which the animal swallows. The mucus with its contained food is passed back into the oesophagus while the surplus water escapes through the gill openings.

After living like this for two or three years the ammocoetes undergoes a rapid transformation into the adult form. In 1912 the writer received a consignment of "young lampreys" from the Severn. They were about six inches long and half of them were full grown ammocoetes larvae and half young fully metamorphosed lampreys. They were equal in size.

The animals known as Tunicata (*q.v.*) are also primitive members of the phylum Vertebrata. The egg develops into a tadpolelike larva with a hollow spinal cord expanding into a brain vesicle in front. There is a notochord in the tail and the alimentary canal consists of a pharynx, opening above by a mouth in front of the brain, and at the side by a pair of gill pouches. The pharynx is succeeded by a loop of intestine leading to an anus high up on the left side. This larva after swimming for some hours attaches itself to the substratum by three adhesive papillae on the chin beneath the mouth. Metamorphosis occurs within a few minutes. The tail and notochord are cast off. The spinal cord shrivels and the brain vesicle is replaced by a little solid ganglion, while the mouth by the elongation of the chin is elevated above the substratum.

Among the Invertebrata, metamorphosis occurs in the life histories of echinoderms, molluscs, Crustacea, and insects (*q.v.*). The kind of changes that take place may be illustrated by reference to the Echinodermata.

In this phylum the larva and the adult are so unlike each other that the change from one stage to the other was formerly supposed to be an alternation of generations. We may consider the case of the common British sea urchin, *Echinus miliaris.* The larva is a beautiful transparent free-swimming form with outwardly perfect bilateral symmetry. It has a scooplike mouth leading into a narrow gullet. This is followed by a globular stomach from which a short straight intestine leads back toward the mouth

to end in the anus, The skin is drawn out into four symmetrical pairs of long arms supported by transparent calcareous rods. These arms are covered by cilia—are in fact prolongations of a lobed, ciliated band which crosses in front of the mouth, passes down the sides and then crosses on the undersurface in front of the anus. Behind the ciliated band the larva has a circle of four crescents carrying powerful cilia.

This general form characterizes larval life for six weeks, gradually increasing in elaboration as the larva grows older. The arms are at first four, then six and finally eight, and the ciliated crescents are cut off from the ciliated band. Then the larva sinks to the bottom and extends from its left side the first adult tentacles or "tube-feet" which have been formed under a screen of skin. As soon as the larva has thus come to anchor a marvellous and rapid change supervenes, which, in the case of another species, the writer has seen completed in about half an hour. The long ciliated arms literally melt away, the protoplasm of the skin covering them seems to gather up into drops and flow backward off the spines into the body. A large part of the fluid in the primary body-cavity is expelled into the stomach, and the globular body of the larva becomes compressed into a flat disc nhich then crawls away as the young sea urchin. The mouth becomes cut off from the gullet, shallows out and disappears and a new mouth is formed on the left side in the middle of the circle of tentacles.

The common starfish *Asterias* undergoes a similar metamorphosis, but when its free-swimming life is over it attaches itself to the substratum not by the adult tentacles but by a temporary sucker or stalk developed in front of the mouth.

This attached stage lasts a week or ten days, during which the adult organs are developing at the hinder end of the larva, and the stalk is reduced to a mere knob. The starfish then wrenches itself loose and walks away.

The larva of *Asterias* must find firm rock or at any rate seaweed to which to attach itself, but there is another British starfish, *Astropecten,* which habitually lives on sandy ground. When the larva of this starfish reaches the age at which it should attach itself, this is impossible; so it continues to swim until the locomotor organs of the future starfish are so far developed that they are capable of functioning. Then the great ciliated preoral lobe is suddenly amputated; the hinder part of the body falls to the bottom and crawls away as the young starfish.

The comparison of the development of *Asterias* and *Astropecten* gives the clue to the meaning of metamorphosis; it is always a period of rapid change of structure during which the animal does not feed. which bridges over the transition from one set of habits to another. Always this involves the casting off of organs required by the earlier set of habits—and this casting off is the principal element in the change of structure. For in most cases the structures required for the second set of habits have already begun to form while the first set of habits persists, but these new structures are, as it were, sketched out in embryonic tissue and packed away under a fold. Metamorphosis is therefore a secondary falsification of the ancestral record embedded in a life history. *See* ISVERTEBRATE EMBRYOLOGY. (E. W. MacB.; V. B. LV.)

EXPERIMENTAL WORK

The crisis of metamorphosis, by which an organism wholly changes its structure and mode of life, is not only of great interest as a phenomenon of general biology, but offers the most interesting opportunities of research in the field of developmental physiology. Gudernatsch in 1912 demonstrated that tadpoles could be caused to metamorphose precociously by feeding them with thyroid gland. He thus showed that amphibian metamorphosis was due to a hormone (q v) circulating in the blood, which would explain the synchronization of all the numerous changes which occur together at metamorphosis. Since then a number of important facts have been elicited. All Amphibia which normally rnetamorphose can be made to do so precociously by the thyroid of any vertebrate, whether fresh or dried, given as food or injected. The effect is a quantitative one up to a point. The greater the dose, the more rapid and abrupt the metamorphosis; after a certain threshold value has been reached, however, increase of dose has no further effect. The rapidity of thyroid-induced as of normal metamorphosis is also affected by external, factors. A protein-rich diet accelerates it, one rich in fat slows it down. Heat hastens, while cold may actually inhibit it.

Further experiment showed that larvae whose thyroids were removed never metamorphosed, but continued to gro as tadpoles. It is now certain that the secretion of the animal's own thyroid is the main agency in producing normal metamorphosis.

As the thyroid secretion is exceptionally rich in iodine, the natural supply of this element must constitute a limiting factor, and in waters exceptionally poor in iodine, we should expect a retardation or suppression of metamorphosis.

It has been shown experimentally that amphibian larvae do not metamorphose if reared in water practically devoid of iodine, and cases of this sort are known to occur in nature.

If iodine in various combinations is administered to tadpoles, precocious metamorphosis can be induced but its potency depends upon the chemical combination in which it occurs. When tadpoles are reared in solutions of different iodine-containing substances so measured as to give an equal concentration of iodine, it is found that thyroglobulin, the natural thyroid hormone, is most effective and thyroxin, its essential component, is slightly less so, while vastly greater amounts of iodine must be used when it is present in other combinations or in elemental form. We may thus conclude that the thyroid gland takes the very minute quantities of iodine normally present in food and water and makes it vastly more potent by manufacturing it into the thyroid hormone.

We must briefly mention some points concerning the time relations of metamorphosis. The common European frog, *Rana temporaria,* normally takes about four months to metamorphose; some toads only four to six weeks; the American leopard frog over a year; and several bullfrogs over two years. The thyroid of leopard frog or bullfrog tadpoles contains the metamorphosis hormone, since if engrafted into tadpoles of other species it induces rapid metamorphosis. Apparently the prolongation of larval life in these animals is due to an alteration in the relative rates of thyroid growth and body growth. A definite concentration of thyroid hormone in the blood must be reached before metamorphosis can occur. If the thyroid grows relatively more slowly. metamorphosis will be postponed. The same postponement could equally well be effected by diminished sensitivity of the tissues to thyroid. Thus the relative rate of thyroid growth and the absolute degree of tissue sensitivity between them decide the date of metamorphosis.

The compensatory reactions of the thyroid are interesting. At high temperatures. a tadpole's thyroid diminishes in size and activity, at low temperatures it increases. Similarly, after a small dose of thyroid. the animal's own gland is not called upon. and shrinks. Interesting results have been obtained by utilizing these facts. If tadpoles are kept at high temperatures till half-grown, and then placed at low temperature, they fail to metamorphose. This is because their thyroids, first much reduced by heat, are unable to respond to the extreme demands made on them by cold, and can only react by forming a goitre which vainly tries to compensate by quantity of tissue for lack of quality of secretion.

Again, if half-gronn normal tadpoles are put at very low and very high temperatures after receiving a small dose of thyroid, those at high temperature will metamorphose in under 48 hours, but those at low will proceed half-nay with metamorphosis. and remain thus even if put at medium temperature. The dose of thyroid was sufficient to cause their onn thyroid to shut down its activity, but not sufficient to counteract the cold.

The thyroid gland is governed by the anterior lobe of the pituitary gland through a special thyrotropic hormone. In the absence of the pituitary the thyroid gland simply does not function. Both these glands can be removed at their inception from very young tadpoles. If either is removed or if both are extirpated the eifect in preventing metamorphosis is precisely the same, but they can be made to metamorphose if very large quantities of iodine are administered. This would seem to indicate that other tissues have some slight capacity for using it in the absence of these glands.

In any given species of amphibian, development will proceed to a certain point under the guiding influence of the genes and the other factors that shape the developmental process, but a stage is finally reached at which further development is impossible without the thyroid hormone or adequate quantities of other iodine-containing substances. In short, it is one of the guiding factors of development. This point is reached in *Rana pipiens* and *R. aurora* nhen the hind limb buds have attained a length of two or three millimetres, and do not show the slightest differentiation into parts. On the other hand, in toad tadpoles—*Bufo*—the hind limbs grow to a much greater length and show full differentiation into parts with knee, toes, etc. It is thus clear that each type has its own pattern of development in which the thyroid gland plays its special role.

The thyroid hormone does not affect development during the earlier stages as shown by immersion of eggs in solutions of the hormone. These go through segmentation, gastrulation. neurulation, etc.. in normal manner and speed, responding to thyroid stimulus only at the approach of the critical stage at which the thyroid influence normally plays its part.

In principle the thyroid gland stimulates tadpoles to follow the normal pattern of development, but when used with half-grown stages disproportion results from insufficient body substance. In the normal tadpole, metamorphosis involves the growth of the legs, the shortening of the intestine and the absorption of the tail. Adequate thyroid stimulus simply hastens all of these processes in their proper order but there is evidence to show that certain structures require larger amounts of hormone than do others to induce their development.

The maturity of tissues plays an important role, as shown in certain experiments upon the regenerated tail. In anuran tadpoles, it shrivels toward the end of metamorphosis and becomes completely resorbed. If one cuts off a large part of the tail shortly before this process commences, the missing part regenerates; and if the end portion is again cut off, it will again regenerate. When the tadpoles so treated are exposed to thyroid hormone, the original basal part is the first to shrivel, then the older regenerated part, and last of all the most recently regenerated portion, thus showing that tissue age or maturity is an important factor in susceptibility to the thyroid influence.

While the general tissues of the body (soma) are subject to the influence of the thyroid gland, this is not primarily true of the germ cells and germ glands, which continue their development in tadpoles from which the thyroid gland has been removed and equally fail to respond to thyroid stimulus. For fullest development they are indirectly dependent upon body size for adequate nourishment; but the testes of male thyroidectomized tadpoles have continued to develop and have actually produced ripe sperm, which normally does not occur before metamorphosis in the species studied. Correspondingly. ovaries have continued to grow and the eggs have reached a size far beyond that attained at metamorphosis. These facts are paralleled by the reproduction of the axolotl. in spite of the fact that it remains in its larval condition throughout life in its normal habitat.

The anterior lobe of the pituitary gland is the timekeeper of metamorphosis because it is essential for stimulating the activity of the thyroid gland. Pituitary glands taken from tadpoles of different stages of development have been transplanted into tadpoles of a stage well before the beginning of metamorphosis. Several pituitary glands transplanted from young donors of this same age wholly failed to induce metamorphosis, while single glands from metamorphosing donors, or from frogs after metamorphosis, so stimulated the thyroid gland that rapid metamorphosis resulted.

The thyrotropic hormone of the anterior lobe of the pituitary gland has a twofold function in that it both stimulates the thyroid gland to manufacture its hormone. which is stored in the follicles, and, equally important, it causes the gland to discharge this stored hormone When the thyrotropic stimulus is at a low level. quantities of thyroid hormone are thus stored to be liberated nhen the thyroid is whipped into greater activity by this same thyrotropic hormone.

The possibility of removing these endocrine glands at their inception in tadpoles, coupled with their spectacular effects upon metamorphosis. has given such experimental studies great importance in the solution of the difficult problems of interpreting their functions.

The metamorphosis of insects is likewise regulated by means of hormones. In certain insects secreting cells within the brain liberate a "moulting hormone" which leads to the casting off of the old skin (ecdysis). If the larval form is retained after this process it is termed simple moulting; if the insect is transformed into a pupa. or into an adult sufficiently different from the larva. it is termed metamorphosis. Throughout its larval life the insect has latent within it the power of developing into the pupal and adult forms. These powers are realized only in the presence of the proper hormones. In some insects at least (Lepidoptera, Hemiptera) there is present in the blood during larval life a hormone which ensures the persistence of larval characters. When the moulting hormone acts in the presence of this larval hormone simple moulting occurs. At metamorphosis the moulting hormone alone is secreted into the blood and then the adult or pupal form emerges. The larval hormone is secreted by a small gland (the corpus allatum) somewhat resembling the pituitary gland of vertebrates. If this gland is removed from the young larva it turns, immediately it moults, into a diminutive adult in the Hemiptera, or into a diminutive pupa in the Lepidoptera. Conversely, if the gland from young larvae is transplanted into old larvae these will retain their larval form when they moult and turn into giant larvae instead of into adults. In other invertebrates, such as the sea urchin, little is yet known about the regulation of metamorphosis.

See also references under "Metamorphosis" in the Index volume.

(J. S. H.; B. M. A.; V. B. W.)

METAPHOR, a figure of speech, which consists in the transference to one object of an attribute or name that strictly and literally is not applicable to it, but only figuratively and by analogy. It is thus in essence an emphatic comparison, which if expressed formally is a simile; thus it is a metaphor when Rochester writes "Dead. we become the lumber of the world" and a simile when Dryden writes, "Errors, like straws, upon the surface flow." *See* FIGURES OF SPEECH: *Metaphor, Simile and Kindred Figures.*

(G. W. A.)

METAPHYSICS. The term "metaphysics" derives from the title posthumously given to a treatise that Aristotle wrote after he had written the *Physics.* According to one view. this title originally meant simply "written subsequently to the *Physics"* But the word. "metaphysics" then came to be used as a label for the sorts of topics dealt with in Aristotle's *Metaphysics,* or rather, as these topics are very heterogeneous, for the topics in it which have seemed most important At some times it has been Aristotle's "theology" that has seemed most important; at other times his discussions of such notions as those of substance. essence, accident. form. matter, actuality and potentiality. Aristotle himself called his subject "first philosophy" and said that its central topic was "being *qua* being."

Whatever may be the historical origin of the term, "metaphysics" has always connoted some antithesis between physical and nonphysical inquiries. John Stuart Mill sometimes called empirical psychology "metaphysics," to contrast the science of the mental with the sciences of the physical. But the main tradition has been to use "metaphysics" as a title for philosophical as distinct from scientific or experimental inquiries. Sometimes "metaphysics" has been used just to mean what is meant in modern times by "philosophy." But more often it is used to denote one branch of philosophy, as distinct from moral philosophy, political philosophy. aesthetics and logic and, less regularly, from epistemology Even so the contrast with physical inquiries has been a shifting one. We think of physics as a natural science, the theoretical structure of which is intrinsically connected with the results of experiments and observations. But in his *Physics* Aristotle combines a little discussion of factual. for instance mechanical. matters with a great deal of philosophical discussion of such concepts as those of motion, space and time. So whereas we

should regard Kepler's study of the motions of the planets as belonging to physics and exclude from physics Zeno's purely logical arguments against the possibility of motion, Aristotle included in his *Physics* a protracted discussion of Zeno's paradoxes, with the result that we are inclined to say that Aristotle's ***Physics*** contains very little physics but a great deal of philosophy of physics and even some metaphysics.

The contrast between philosophy and science, or between philosophers and scientists, is itself of late origin. The word "scientist" was first coined in 1840. Before then and for some time afterward. "philosopher" was the title both for a Plato and for an Archimedes, both for a Newton or a Harvey and for a Locke or a Butler. To distinguish them it was necessary to call Sir Isaac Newton, say: a "natural philosopher." Butler a "moral philosopher" and Plato a "metaphysical philosopher." As late as 158; scientific implements like test tubes, retorts and Bunsen burners could still be described in popular literature as "philosophical instruments."

Before this distinction between philosophers and scientists was clearly drawn, first of all by Kant, there was no easy way of distinguishing even philosophy of physics from physical science, much less of distinguishing metaphysical philosophy from natural science. There has been, however, the general though not universal practice of reserving the title "metaphysics" for inquiries or speculations mhich, unlike those sponsored by the Royal society, claim to rest not on premisses established by observation and experiment but on a *priori* grounds or grounds of pure reason.

Thus arguments for the existence of a first cause or of a Creator and Controller of the Universe and arguments for the existence in man of an immortal soul were typical examples of nonempirical, metaphysical arguments. Indeed theological philosophy in general, or natural theology, has always constituted a large part of what has been derided and championed as "metaphysics." Kant rightly identified the permanent problems of metaphysics mith those of God, freedom and immortality. Other theories or speculations, however, would also be classed as metaphysical, though they have been connected less closely with the bases of theology than with the bases of the natural sciences, namely cosmological theories like Democritus' theory of atoms, Descartes' theory of extension and vortexes and Leibniz' theory of monads. The quasi-biological theory of a life force and the abandoned theory of ether (in physics) would be further candidates for the title "metaphysical" For all these theories, with many others of the same general type, essentially contain assertions of the existence of natural or supernatural agencies inaccessible to direct observation and even to indirect experimental tests. Their existence was supposed to be established by pure reason.

In line with this tradition we might distinguish metaphysical from other philosophical arguments, like those of ethics and logic, by saying that the former do. where the latter do not, claim to establish by pure reason truths of existence. This is what characterizes philosophers' attempts to demonstrate the being and the nature of a first cause; of a reality behind all appearances; of a necessary being other than contingent beings; of an infinite beyond everything finite; of something immutable beneath all that changes; of something unconditioned, other than, or else within. the things and happenings the being of which is dependent on, or conditioned by. other things and happenings. Plato's "forms," Spinoza's God, Leibniz' monads, Kant's things-in-themselves and F. H. Bradley's Absolute are famous instances of entities supposedly disclosed by nonempirical or philosophical reasoning.

Metaphysical arguments, as so defined, have been accused, since Hume and Kant, of being fallacious. Pure reason (*ie.*, reasoning from nonempirical premisses) cannot prove the existence of anything. Matters of fact, including supernatural matters of fact, cannot be deduced from nonfactual or purely conceptual premisses Existence is not a property or attribute and cannot therefore be a defining property or attribute of anything. From no description can it follow that there exists something satisfying that description. The negation of an assertion of existence cannot be self-contradictory, so a *priori* reasoning cannot prove, though it can sometimes disprove. statements to the effect that there exists something of a certain description. Consequently metaphysics, if it claims to be or to contain a body of truths of existence, established a *priori*, is impossible. So far as this destructive argument goes, it might still be a part of the proper business of philosophers to explore, for example, the cardinal concepts of theology, and such a conceptual investigation might be called "metaphysical" in a less rigorous use of this term. But it would remain the case that such an investigation would be unable to prove, for instance, the existence of God or the immortality of the soul, just as neither Zenonian nor anti-Zenonian arguments, conceptually clarifying though they may be, can possibly prove that anything is actually in motion, or is actually stationary.

In the 1930s an even more radical polemic against metaphysics was waged by the members of the famous Vienna circle. This was a group of thinkers, mostly scientists and mathematicians, who met regularly. under the leadership of Moritz Schlick, to discuss the foundations of mathematics and natural science. As a group they combined the general outlook of Ernst Mach with the logic of Bertrand Russell and **A.** N. Whitehead. They were also powerfully influenced by Ludwig Wittgenstein, who was not, however, himself a member of the circle. These logical positivists, as they are often called, followed Mach in wanting to banish metaphysical theories and speculations from the sciences, but they took from Russell and especially from Wittgenstein a weapon more potent than any wielded by Mach. They took over from Russell the notion of the nonsensical and from Wittgenstein the notion of a general criterion between sense and nonsense. Their criterion was the principle of verifiability. A proposition, other than an analytic proposition, is significant if it can in principle be empirically verified or falsified. Otherwise it is nonsense. "The meaning of a proposition is the method of its verification."

Metaphysical questions are therefore not merely unanswerable, as earlier challengers had maintained: they are unaskable. The nonempirical terms mhich they contain express no genuine concepts.

The original unmitigated principle of verifiability was soon seen to exclude too much. It had been intended to exclude primarily a certain class of pseudo-scientific speculations proffered by philosophers as solutions of very general theoretical problems in the physical, biological, social and psychological sciences. It was expected also to exclude certain sorts of near-theological speculations, together with certain sorts of very sweeping philosophical views, such as those of Hegel, Husserl and Bergson. But as originally formulated it threatened to ostracize as well ordinary moral political and aesthetic discourse, together, less certainly, with most philosophical discourse, even of quite unmetaphysical kinds. Worst of all it seemed to reduce to nonsense the scientists' own statements of natural laws and their formulations of the theoretical principles of their sciences. For these too are not conclusively verifiable or falsifiable by any finite set of experiments.

The criterion of empirical verifiability or falsifiability had therefore to be made more tolerant. with the result that the epithet "metaphysical," defined as meaning "not amenable to scientific checks," became correspondingly vaguer and less abusive. But the wheel has not turned full circle Certain sorts of pseudo-scientific speculations are now relatively easily exposed as fraudulent; and philosophers are less inclined to try to solve by philosophical reasonings cardinal problems in scientific theory. Nor, on their other flank, are they so ready to try to construct a *priori* proofs of the existence of God and the immortality of the soul. *A priori* cosmology and *a priori* theology are both suspect, and the term "metaphysics" is nidely, though not universally, treated either as a redundant synonym of "philosophy" or else as a valedictory label for those suspect philosophical enterprises. Doubtless some of the intellectual motives which generated those a *przori* cosmologies and theologies will. in due course, generate other patterns of synoptic world-views. The word "metaphysics" may then, if the hankering for labels survives, come back into ordinary or pedagogic use with yet another signification.

See also references under "Metaphysics" in the Index volume.

(G. R.)

METAPONTUM, ancient city, Magna Graecia (mod. Meta-

ponto). on the Gulf of Tarentum, near the mouth of the Bradanus river. about 24 mi from Tarentum and 13 mi. from Heraclea. It was founded by an Achaean colony from Sybaris and Croton about 700 B.C. At Metapontum Pythagorus died in 497 B.C.

Its support of the Athenian expedition to Sicily (415 B.C.) was trifling. In 332 B C. it allied itself with Alexander of Epirus. After the battle of Cannae (216 B.C.) it declared in favour of Hannibal and became his headquarters. After the defeat of Hasdrubal at the Metaurus (207 B.C.), the inhabitants of Metapontum followed him in his retreat. From this time the city sank.

METASOMATISM, in petrology, refers to processes capable of changing the bulk chemical composition of solid rocks. In metasomatism substances are introduced into the rock from outside sources, and other substances are removed. The mechanism of this transfer of chemical substances through the solid rocks is complex and as yet only incompletely understood, leaving room for several schools of thought among petrologists. In some instances the mineral-building substances have been carried in fluid solutions soaking through rocks, in other cases vapours have operated, or matter has migrated through rocks as individual ions, atoms or molecules, partly through the mineral structures (volume diffusion), partly along surfaces and interfaces.

When the source of introduced material in metasomatism is a magma the process is known as contact metasomatism. Volatile substances which become enriched in residual magmas during fractional crystallization are forced into adjacent rocks to cause metasomatic alteration.

However. more commonly metasomatic alteration of rocks has taken place without detectable magmatic source of the introduced material. This is particularly true in regional metamorphic terrains; here metasomatic change of chemical composition of rocks is frequently associated with metamorphic recrystallization and neomineralization. Although some petrologists prefer hypotheses that make a magma responsible for all metasomatic alterations. there is strong evidence that this is not so. Not only are magmatic bodies absent in many intensively altered rock complexes, but the introduced material is often of a nature inconsistent with magmatic residual solutions, or the temperature during the alteration has been too low to permit magmatic melts to operate.

Sources of Introduced Material. — Two kinds of sources have been suggested for introduced material in nonmagmatic metasomntism. One of these is a deep-seated source of unknown nature, which becomes activated during various kinds of tectonic, or structural, deformations, releases mineral-making substances which migrate upward and alter the superincumbent rocks. The alteration is selective, occurring only at certain combinations of rock types and structural situations. The second kind of source is disseminated throughout in the surrounding solid rocks or localized in a limited region in these. Minerals rendered unstable during changing pressure-temperature conditions could represent such sources. When newly stabilized minerals form at the cost of unstable ones, all the original constituents cannot always be accommodated in the new mineral assemblage. Such superfluous constituents tend to migrate from the altered rocks — which are chemically open systems — and may function as sources for metasomatic alteration elsewhere.

Minerals are less stable (*i.e.,* have higher chemical potential) under high compressive stress than under tension or low compressive stress *(see* METAMORPHISM: *Riecke's Principle* and *Force of Crystallization).* Consequently, regions where high compressive stress has accumulated in a rock complex generally act as sources, and regions of tensile or low compressive stress act as sinks or receptacles for migrating rock-making matter in metasomatism. Many mineral veins such as quartz veins, pegmatite veins, some ore veins. calcite veins, etc., in regional metamorphic terrain have formed in this manner *(see* also ORE DEPOSITS). The vein-forming minerals have grown by metasomatic activity at sites where compression has been exceptionally low or tension high. Sites of this kind are often called pressure shadows.

Methods of Fixation. — The mechanism by which introduced material becomes fixed in altered rocks is at times a simple chemical interaction between old minerals and introduced matter. Examples: (1) muscovitization of sillimanite and quartz:

$$\underset{\text{sillimanite}}{3Al_2SiO_5} + \underset{\text{quartz}}{3SiO_2} + \underset{\text{introduced}}{K_2O} + H_2O \rightarrow \underset{\text{muscovite}}{2KAl_3Si_3O_{10}(OH)_2}$$

(2) biotitization of hornblende:

$$\underset{\text{hornblende}}{Ca_2Fe_4Al_2Si_7O_{22}(OH)_2} + \underset{\text{introduced}}{Al_2O_3} + K_2O + H_2O \rightarrow$$

$$\underset{\text{biotite}}{2KFe_2Al_2Si_3O_{10}(OH)_2} + \underset{\text{enter or escape}}{SiO_2 + 2CaO}$$

(3) dolomitization of calcite:

$$\underset{\text{calcite}}{2CaCO_3} + \underset{\text{introduced}}{MgO} \rightarrow \underset{\text{dolomite}}{CaMgC_2O_6} + \underset{\text{released and removed}}{CaO}$$

In other instances fixation of introduced material is not related to chemical reactions because the old minerals and newly formed ones have no chemical constituents in common, as for example when galena, PbS, replaces limestone, $CaCO_3$. The reason for such fixation of introduced mineral-making matter may be that nucleation is affected by the type of pre-existing minerals. Minerals do not precipitate out of a fluid solution unless the solution is somewhat supersaturated, the magnitude of needed supersaturation depending on the type of pre-existing minerals which function as nucleation sites.

Minerals introduced in a rock may grow in open space such as cracks and fissures, they may cause an expansion of the rock body, or they may replace the old minerals in a volume for volume fashion. In constant-volume replacement, old structures such as banding, etc.. may persist as relics in the altered rock. It is clear that this must mean much removal of material from the rock. Material removed from an altered rock may become fixed in other rocks and cause metasomatic alteration there, as when for example basification is associated with granitization. Granitization is a term applied to the sum of complex processes by which various Rinds of rocks become more or less granitic in composition without going through a liquid state. Potash, soda and silica are most frequently introduced in granitization, with microcline, sodic plagioclase and micas being the common newly formed minerals. If the original rock was basic, *i.e.,* rich in such constituents as CaO, MgO and FeO, these elements must move out of the theatre of granitization. In some cases, but by no means always, the released basic constituents have become fixed in adjacent rocks which thereby are rendered even more basic than originally. This phenomenon is called basification. Granitization, with or without associated basification, has affected vast rock-complexes in fold-mountain zones. Thus large parts of the Pre-Cambrian shield areas (the Fennoscandian, or Baltic, shield, the Canadian-Greenland shield, etc.) consist of rocks granitized through several periods of Pre-Cambrian mountain folding.

Examples of Rocks. — Recognized examples of metasomatically formed rocks are dolomitized limestone, silicified limestone and dolomite, several kinds of ore bodies in limestone, certain granitized schists such as some augen gneisses, tourmalinized schists (boron metasomatism) and scapolitized rocks. There are, however, numerous rocks and mineral occurrences which some petrologists would classify as metasomatic, others as magmatic or mere metamorphic uithout change of chemical composition.

For further discussion of the mineralogical and petrological processes referred to above *see* also GEOCHEMISTRY; MINERALOGY; PETROLOGY; VOLCANISM. *See* also METAMORPHISM. (H. RG.)

METASTASIO, PIETRO (originally PIETRO ANTONIO DOMEXICO BONAVENTURA TRAPASSI) (1698–1782), Italian poet and the most celebrated librettist in Europe writing during the 18th century for the *opera seria,* nas born in Rome on Jan. 3. 1698. His father, Felice Trapassi, a native of Assisi, kept a grocer's shop, and as a boy Pietro was apprenticed to a goldsmith. In 1708, however, his astonishing skill in verse improvization attracted the attention of the learned Gian Vincenzo Gravina, a man of letters, who made him his heir adoptive and hellenized his name from the prosaic Trapassi into "Metastasio." In 1712, after receiving a

good education from Gravina, Metastasio was taken to Scalèa in Calabria where he studied for some months with Gregorio Caloprese, the Cartesian philosopher. At the age of 14 he wrote *Giustino,* a tragedy in the Senecan style; and in 1717 he published a book of verses. In Jan. 1718 Gravina died; three months later Metastasio entered the Accademia degli Arcadi *(see* ITALIAN LITERATURE) ; and in 1719 he left Rome for Naples where he took employment in a lawyer's office and entered aristocratic circles as the mellifluous author of voluptuous epithalamia.

In honour of the birthday of the empress of Austria Metastasio composed *Gli Orti Esperidi* (1721), a serenata in which the principal role was taken by Marianna Benti-Bulgarelli (1684–1734). This prima donna. La Romanina as she was called, became enamoured of the poet. In her *salon* Metastasio formed his lifelong friendship with the *castrato* Farinelli; and through La Romanina he also became acquainted with composers, such as Niccolò Porpora (from whom he took music lessons), Domenico Sarro, J. A. Hasse and Leonardo da Vinci, who were later to set his works to music. In this environment Metastasio's success was assured; and at the request of La Romanina he gave up the law and composed his first *melodramma,* a lyric tragedy in three acts on the conflict of love and duty. called *Didone abbandonata* (1723, first performance 1724). *Didone* was followed, between 1726 and 1730, by *Siroe, Catone in Utica, Ezio, Semiramide riconosciuta, Alessandro nell'Indie* and *Artaserse.* In the meantime, on the recommendation of his friend and patroness Marianna Pignatelli. countess of Althann. Metastasio received an invitation (1729) from the emperor of Austria. And in March 1730 he set out for Vienna where he lived until the end of his life. as poet laureate to the imperial court in succession to Apostolo Zeno.

During the reign of Charles VI Metastasio wrote cantatas, oratorios and 11 *melodrammi,* some of the best of which—*Demetrio, L'Olimpiade, Demofoonte, La clemenza di Tito* and *Attilio Regolo* —were performed as plays in their own right as well as set to music by practically every composer from Pergolesi to Mozart. After 1740, however, with the accession of Maria Theresa. Metastasio was not quite so well placed. Until 1771 he was extremely productive and his work was always honoured. But the empress did not permit the same lavish expenditure on operatic spectacles as her predecessor and in any case Metastasio's talents gradually went into decline. With the rise of the *opera buffa,* moreover, and the growth of the German manner. a new type of libretto came into use; and with the spread of romanticism at the end of the century Metastasio's works even fell into disrepute.

Metastasio's *melodrammi* (1723–71), 26 in number, show the influence of the classical theatre on operatic dramaturgy. A staunch supporter of orthodoxy in all its forms, he chose for preference themes typical of the French theatre in the 17th century. And in each of his works he aspired to create a delicate fusion of gallantry, morality and passion. The plots, though regular in structure, are often absurd. But the verse is based on speech rhythms and characterized by an inimitable musicality. A conflict between "reason" and "passion" is always present; and in general it may be said that Metastasio's *melodrammi* owe their phenomenal success to the pathos with which they are suffused and to an exquisite propriety of utterance that was completely in tune with the tone of life fashionable in 18th-century society.

Metastasio's other writings include a rich *Epistolario* and five *canzonette,* two of which—La *liberth* (1733) and *La partenza* (1746)—are outstanding examples of Italian verse in the Arcadian tradition. In his later years he wrote works of criticism, the most interesting being the *Estratto della Poetica d'Aristotele* (1782) which contains an exposition of his dramatic theories.

Metastasio's works ran into innumerable editions. During the 18th century his verses were translated into many European languages; and on his death at Vienna on April 12, 1782, a medal was struck in his honour with the inscription: *Sophocli Italico.*

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METATHEORY. For certain logical problems a theory is constructed whose subject matter is another theory. The former is then known as the metatheory of the latter. A result proved in the former which deals with the latter is known as a *metatheorem.*

The most notable example of a metatheory was David Hilbert's metamathematics. Hilbert set out to construct an elementary proof of the consistency of mathematics. For this purpose he needed a theory that studies mathematics and has mathematical proofs as its objects to be investigated. While the theorems of Kurt Gödel *(see* MATHEMATICS, FOUNDATIONS *OF)* made it unlikely that Hilbert's program could succeed, his metamathematics became the forerunner of much fruitful research. Rudolf Carnap extended this inquiry, under the headings metalogic and logical syntax, to the study of formalized languages in general.

In discussing a formalized language it is usually necessary to employ a second, more powerful language. The former is then known as the object language, while the second is its metalanguage. *See* SEMANTICS IN LOGIC. (J. G. KY.)

METAURUS (mod. METAURO), a river of Italy which flows into the Adriatic a little southeast of Fanum Fortunae (mod. Fano).

In 207 B.C., during the Second Punic War. Hasdrubal had marched from Placentia (Piacenza) to the aid of his brother Hannibal. and, on reaching the Cesano, the next stream south of the Metaurus. halted and encamped. The forces of the consul Livius Salinator and the praetor Porcius Licinus, the latter of whom had previously been watching his movements, were encamped near Sena Gallica (mod. Senigallia) only about half a mile away from him (no doubt on the opposite bank of the Cesano). He was about to attack them, when he discovered that the other consul. Claudius Nero, who had been watching Hannibal's movements at Canusium (Canosa di Pugliaj had brought his army to swell the Roman forces, having, as a fact, intercepted Hasdrubal's message to Hannibal that he would meet him "in Cmbria," *i.e.,* at this very place—for the name Umbria extended to the coast before the time of Augustus. Hasdrubal then attempted to retreat to the Metaurus and cross it. but his guides deserted him, and he was unable to hit on the ford without them; he then marched up the tortuous stream to find another, but had only reached the hills of Sant' Angelo, some two or three miles from the coast, where he tried to pitch his camp. when he found the Romans. who had started their pursuit at dawn, too close on his heels, and was obliged to halt and give battle. His left wing was protected by the terrain, but there was room for fighting on the right, where he drew up his Spanish troops in deep formation, with his ten elephants in front of them, taking position himself in the centre. He then attacked the advancing Romans and the clash was a violent one; but the fighting was indecisive, until Nero, who at first remained inactive on the right x-ing. with a deep streambed in front of him, decided to pass behind Livius' position and advance on his left, thus taking the enemy on their right flank; the distance he had to traverse was less than a mile, and the move was a decisive one. Hasdrubal, who had seen that he must win or perish, sought and found the death of a hero. Livy's statement that 56,000 of his army fell and only 5.400 prisoners were taken, is probably an exaggeration; and if we reckon his whole force very roughly at 30,000, we may accept Polybius' figure of 10.000 killed, and assume 10,000 prisoners; while the other third of the army, the Gauls and Ligurians, who had either taken no part in the battle or escaped. was allowed to make off undisturbed. The defeat ended Hannibal's hopes of success in Italy.

See also HAKNIBAL; HASDRUBAL; PUNIC WARS.

METAXAS, IOANNLS (1871–1941), Greek army officer and statesman, was born on April 12, 1871, on the island of Ithaca. He became a professional soldier, graduating from the Officers' school in 1890, and first saw active service in the Greco-Turkish

war of 1897. Thereafter he was sent for higher military training in Germany. from which he returned with a brilliant reputation in 1903. He joined the general staff in 1912 and served with distinction in the Balkan Wars. being promoted colonel and appointed chief of the general staff in 1913. After the outbreak of World War I, Metaxas quarreled with the Greek prime minister, Eleutherios Venizelos. Metaxas' professional advice was directly opposed to Venizelos' policy, but King Constantine refused his resignation in 1915.

Metaxas nas promoted general in 1916 and remained chief of staff until the Allies deposed Constantine in 1917, when he left the country. He was tried for treason in *absentia* in 1920 but was pardoned in 1921, when he returned to Greece after the restoration of Constantine. After an abortive attempt at a revolution. he left Greece again in 1923, when the monarchy was again deposed; but he returned under the republic, and held ministerial office briefly for the first time in 1928. For the next seven years he was in opposition, and would not join another government until after the abortive Venizelist revolution of March 1935 had brought to a head the trend in favour of restoring the monarchy. In April 1936, under the restored King George II, he succeeded to the premiership. On Aug. 4 he suspended parliamentary government in order to defeat the threat of anarchy. From then until his death Metaxas ruled as dictator with the support of the king. In World War II when the fascist government of Italy attacked Greece on Oct. 28, 1940. he brought a united country into the western alliance. He died on Jan. 29, 1941. (C. M. WE)

MÉTAYAGE SYSTEM, a type of land tenure under which the cultivator uses land without owning it and pays rent in kind to the owner. Pure *me'tayage* is a form of share tenancy involving payment of half the annual output, not a fixed amount; the métayer's family permanently occupies the land it works. The term is French and describes what was probably the dominant type of land tenure in 18th-century France, certainly in southern France.

The economic and social conditions from which *mktayage* emerged in late medieval France, including great population pressure on a limited land supply, have at various times also existed elsewhere—in Italy, India, Japan, eastern Europe and southern United States—and have produced similar sharecropping systems. There is no English equivalent.

The typical métayer's holding in France was small, whether it consisted of a single compact unit or scattered plots. The landowner usually furnished the chief capital items possibly including livestock. Custom rather than written contracts prevailed. With the increasing use of money contracts that accompanied the growth of a market economy after 1800, *mktayage* yielded largely to fee simple peasant tenure.

Italy.— The Italian counterpart of *mktayage* is known as *mezzadria* (literally "half day"), and in a variety of impure forms is the tenure arrangement obtaining in about two-thirds of the cultivated area of central Italy. *Mezzadria* is also widespread in Lombardy where the usual association of the system with extreme poverty is not the case. *Mezzadria* tenure was imposed upon the cultivating class in central Italy by large landowners beginning about the 16th century. The pure *mezzadria appoderata* holding is small. compact and fixed in area. The tenant has permanent occupancy, receives half the produce and uses the owner's implements. The pure form is rare but Italians refer to all impure variants as *mezzadria.*

India.— In most of India various forms of *mktayage* prevailed at least as early as the 16th century. The standard practice until well into the 19th century was for tenant cultivators to pay half the gross produce in kind. subject to adjustment for changing conditions. Cultivators at the bottom of an ill-defined pyramid of tenure rights strove to produce subsistence shares for themselves on holdings that were continually being subdivided. The English rental settlement for Madras legalized a *quasi-métayage* system by assessing the productivity of lands under the ryotwari system of property relations (small, owned holdings grouped in villages under a head man) and fixing the land revenue or tax at one-half the net produce. English policy, together with the great importation of silver, hastened the substitution of money for grain or other produce rents in most provinces. Payment in money represented a basic deviation from pure *mktayage*. The Congress party and the Indian development plans attempted with modest success the liquidation of the system of pyramided landlordism under which sharecropping prevailed for centuries.

Japan.— In Japan, unlike France. share tenancy of the *métayage* type increased in importance as modern capitalistic institutions spread subsequent to the Meiji restoration in 1868. Here as elsewhere *métayage* represented a transition form of small holding which grew out of the elimination of bondage to the soil. The upsurge of Japanese share tenancy accompanied the industrial capitalist epoch, whereas in other countries it generally accompanied preindustrial capitalism. Land hunger and extreme rural population pressure have been so persistent during the advanced capitalist era that the essentially manorial tenant status of cultivators in the Tokugawa era (1603–1868) was carried over, save for bondage to the soil. The labour service of serfdom was commuted to a produce rent as serfs were converted into tenants. This process is the archetype of the historical origin of *mktayage* in most cultures nhere it has appeared. In Japan, small owners were also reduced to *mktayage* status under pressure of market economy, high taxes and high man-land ratios in most regions (Hokkaido being a notable exception). Substantial increases in agricultural productivity were largely siphoned off for industrial accumulation. From the Meiji restoration to the great land reform following World War II, pure *métayage* was less common than various modifications, such as tenancy at will and the exaction of a fixed amount of rice. However, even where a fixed payment was nominally set, the one-half rule was widely applied except for years of poor crops. *See* also FARM TENANCY.

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METAZOA, a zoological term for all animals other than Protozoa (*q.v.*). Metazoa are multicellular animals with at least two cell layers; they are usually divided into the Parazoa. containing only the sponges, and the Eumetazoa, including all other multicellular animals.

See ZOOLOGY: *The Phyla of the Animal Kingdom; see* also references under "Metazoa" in the Index volume.

METCALFE, CHARLES THEOPHILUS METCALFE, BARON (1785–1846), Indian and colonial administrator. was born at Calcutta on Jan. 30, 1785. Having been educated at Eton, he sailed in 1800 for India as a writer in the service of the East India company. Four years later he was appointed political assistant to General Lake, who was conducting the final campaign of the Maratha nar against Holkar. In 1808 he became envoy to the court of Ranjit Singh at Lahore, where in April 1809 he concluded the treaty securing the independence of the Sikh states between the Sutlej and the Jumna. He was made resident at Delhi tno years later and appointed secretary in the secret and political department in 1819 In 1822 he succeeded his brother in the baronetcy; in 1827 he obtained a seat in the supreme council. In March 1835, after he had acted as the first governor of the proposed new presidency of Agra. he provisionally succeeded Lord William Bentinck in the governor generalship. His liberation of the press so complicated his relations with the directors that he resigned the service of the company in 1838. In the following year he became governor of Jamaica, where the difficulties created by the recent passing of the Negro Emancipation act called for tact. Ill health compelled him to return to England in 1842, but six months afterward he was appointed governor general of Canada. Metcalfe died on Sept. 5, 1846.

METCHNIKOFF, ELIE (ILYA ILICH MECHNIKOV) (1845–1916), Russian biologist and 1908 Nobel laureate in medicine, was born at Ivanovka in Kharkov on May 15. 1845. At the age of 17 he entered the Kharkov university and two years later went to Germany. Returning to Russia in 1867, he became a *dozent* in zoology both at St. Petersburg and at Odessa, where in 1870 he

was made professor of zoology and comparative anatomy. In 1882 he went to Messina and there began his studies on the nature and habits of microbes. Thereafter he devoted himself to pathological study and in 1888 went to work in Paris with Louis Pasteur, who gave him a laboratory in the École Normale. By 1892 Metchnikoff's views on the essential importance of phagocytosis (*q.v.*) were firmly established. In that year he published *The Comparative Pathology of Inflammation*, followed in 1901 by his chief work, *Immunity in Infectious Diseases* (Eng. trans., 1905), and a more popular treatise, *The Nature of Man* (1903; Eng. trans., 1904). In later years he made a special study of the bacteria infesting the gastrointestinal tract of man. He died in Paris on July 16, 1916.

See ***Life*** by his wife, Olga Mechnikov (1920; Eng. trans., 1921).

METELLUS, the name of a distinguished family of the Caecilian (plebeian) gens at Rome.

LUCIUS CAECILIUS METELLUS, general during the first Punic War. Consul in 251 B.C., he gained a decisive victory at Panormus in Sicily over Hasdrubal, who had the larger force, a victory chiefly attributable to a panic caused among the Carthaginian elephants by his clever manoeuvring. A number of these elephants figured in his triumph, and later the elephant frequently occurs on coins issued by the Metelli. The story that in 241 he rescued the Palladium from a fire in the temple of Vesta at the cost of his eyesight is not to be found in the extract from his funeral oration in Pliny (*Nat. Hist.*, vii. 43 [45]). Consul again in 247, he died in 221.

QUINTUS CAECILIUS METELLUS, son of Lucius Caecilius Metellus, became consul in 206 B.C. as a reward for his services at the Metaurus and was dictator for holding the elections in 205. He was attacked by Gnaeus Naevius (*q.v.*) until the poet was imprisoned. While Scipio was absent in Africa, Metellus supported his interests against political attacks (204–202). In 201 he served on a commission to provide land for veterans: in 186 he conducted an embassy to Macedonia, afterward proceeding to Peloponnesus to investigate the quarrel between Sparta and the Achaeans.

QUINTUS CAECILIUS METELLUS MACEDONICUS (d. 115 B.C.), praetor in 148 B.C., defeated the usurper Andriscus in Macedonia and forced him to surrender. Under his superintendence the country was made a Roman province. In 146 he attacked the Achaeans to avenge an insult offered to a Roman embassy at Corinth. He was superseded during a successiul campaign by L. Mummius. On his return to Italy he received a triumph and the title of Macedonicus. Consul in 143, he subdued the Celtiberians in northern Spain. In 131, when censor with Q. Pompeius (they were the first two plebeian censors). he proposed that all citizens be compelled to marry. He was an opponent of the Gracchi, although not averse from moderate reform. He built a colonnade in the Campus Martius and two temples dedicated to Jupiter Stator and Juno.

QUINTUS CAECILIUS METELLUS NUMIDICUS, consul in 109 B.C. and commander in the Jugurthine War, won an indecisive victory over Jugurtha (*q.v.*) by the river Muthul. Thereafter he concentrated rather on wearing Jugurtha's resources down; *e.g.*, by capturing his desert stronghold. Thala (108). In 107 he was replaced in his command by his own legate, Gaius Marius (*q.v.*), but he received a triumph and the title of Numidicus. Saturninus, whom as a censor (102) he tried to remove from the senate. passed in 100 B.C. an agrarian law, inserting a provision that all senators should swear to it within five days. All complied but Metellus, who retired to Asia. After Saturninus was killed he returned (99). He died probably in 91. He mas one of the chief leaders of the aristocratic party. Cicero speaks highly of him as an orator.

(X.)

QUINTUS CAECILIUS METELLUS PIUS was surnamed Pius for his attempts to recall his father. Numidicus. from exile. He was praetor in 89 B.C. and, probably as proconsul, defeated the Marsian leader Q. f'ompaedius Silo in the Social War (88). After Sulla's departure and Marius' return to Italy, Metellus refused the request of h i soldiers that he should replace the consul Gnaeus Octavius (87); he retired to Africa and afterward to Liguria. resuming his proconsular command on Sulla's return (83). In the war against the Marians he gained a decisive victory at Faventia over Gaius Norbanus (82). Consul in 80 with Sulla, he went to Spain to fight Q. Sertorius, From his headquarters at Metellinum (Medellin) he tried to reduce Lusitania (79–78). After Pompey's arrival Metellus routed Sertorius' lieutenant L. Hirtuleius at Italica in 76 and again at Segovia in 75, which proved the decisive battle of the war; then joining Pompey he saved him from defeat near Saguntum. In 71 he returned to Rome and triumphed. He had been *pontifex maximus* from *c.* 81; he died c. 64 B.C. (H. H. SD.)

QUINTUS CAECILIUS METELLUS CRETICGS, Roman general. Consul in 69 B.C., he was appointed to the command of the war against Crete: the headquarters of the pirates of the Mediterranean. In 67 Pompey demanded the control of the campaign under the Gabinian law. The Cretans offered to surrender to Pompey, who instructed Metellus to cease operations. Metellus refused. and himself annexed the island. His triumph was delayed by Pompey's partisans. and he joined the opposition in the senate and helped to defeat the ratification of Pompey's Asiatic settlement. He was one of a commission of three sent (60) to investigate the state of affairs in Gaul where disturbances were apprehended. He appears to have been alive in 54.

QUINTUS CAECILIUS METELLUS CELER, legate of Pompey in Asia in 65 B.C.. and praetor in 63. was dispatched to cut off the retreat of Catiline to the north by blocking the passes. In 62 he went to Cisalpine Gaul with the title of proconsul. although he did not become consul till 60. A supporter of the optimates and an eneniy of Pompey. he successfully opposed the agrarian law that was to provide for Ponipey's veterans. He also tried, though fruitlessly. to obstruct Caesar's agrarian law in 59. He died suddenly in the same year—it was usually supposed from poison administered by his wife Clodia.

QUINTUS CAECILIUS METELLUS PIUS SCIPIO, son of P. Scipio Nasica, was adopted by Metellus Pius. He was accused of bribery in 60 B.C., and defended by Cicero. In Aug. 52 he became consul through the influence of Pompey, who had married his daughter Cornelia. In 49 he proposed that Caesar disband his army within a definite time! under pain of being declared an enemy of the state. His first command during the civil war was the province of Syria. He commanded the centre at Pharsalus and afterward went to Africa, where by Cato's influence he received the command. In 46 he was defeated at Thapsus; while endeavouring to escape to Spain he fell into the hands of P. Sittius and put himself to death.

METEMPSYCHOSIS. The theory of the transmigration of souls is usually associated with the ancient Egyptians, who are said to have practised embalming to prevent or delay reincarnation; with the teaching of Pythagoras and the Buddha and with a sect of early Christian heretics spoken of by Jeremy Collier as "Metempsychi." The idea, however, is much older than any of these creeds and exists throughout the world.

Metempsychosis in Primitive Cultures. — Where the passage of the soul, or the vital essence, into some particular form is associated with ideas of retribution for the sins or accidents of this life, the influence of the Buddhist or Hindu religions has probably been at work, *see* BUDDHISM; HINDUISM. The primitive idea, independent of moral teaching, is bound up with the conception of an objective soul and often with ideas as to a plurality of souls in a single individual, one of which is separable and able to go in and out through the mouth or nostrils. Thus the Poso-Alfures of Celebes believe in three souls, the *inosa* or vital principle, the *angga*, or intellectual, and the *tanoana* or divine element which leaves during sleep and which is of the same nature in many plants and animals. This separable soul is clearly a conception based on the phenomena of dreams taken to be actual experiences undergone during sleep and postulating some sort of embodiment able to roam while the body sleeps.. This soul must be small enough to leave by the mouth, and it appears as a manikin in India and in Celebes, as a snake, a weasel or a mouse in Germany. or as an insect in farther India. Thus the soul is commonly spoken of as "flying" in Greek and represented as a butterfly, as, indeed, all over Europe, from Ireland to Lithuania, in China, Assam, Burma, Japan and the Pacific. So, too, the soul appears as a bird—in Europe the dove is the commonest, and poles bearing pigeons were erected over Lombard graves; but the soul also appears in the

form of ducks, ravens, owls or hawks, and as a hawk again it appears in Egypt and in Assam.

This belief in a separable soul with an insect or other form must obviously influence beliefs in the eschatology of the soul. We find accordingly that the soul is believed to pass into an insect on the decease of the body. Thus the Angami Naga credits the soul with a number of subsequent existences in insect form, while the Chang holds that the souls of those who can sing become cicadas, but the souls of others dung beetles. Thus the Bakongs of Borneo believe that their dead are reincarnated in the bearcats which frequent their raised coffins; wood-boring wasps and hornets take up their abode in the wooden soul figures put up by some tribes of Assam, and Nagas and Lusheis regard wasps and hornets (atnong other insects) as souls.

If the soul can leave an individual during sleep and re-enter him, it should be able to enter and be reborn in another individual. In Germany, a dying man's heart passes into his brother, whose courage is doubled; in the Garo hills the soul, after a sojourn in the abode of the dead, returns for another incarnation. The range of this conception of reincarnation is indicated by the frequency of tabu on giving children names already borne by living members of the family. The notion is that identity of name implies identity of personality and that one of the two bearers would die. Hence the Lhotas, for instance, never give the child the name of a living relative. A belief in reincarnation within the family would naturally be strengthened by the recurrence of marked family resemblances. In any case a belief in the reincarnation of human souls is indicated by such rites as those of the Akikuyu women of east Africa, who, in order to have children, worship at a ficus tree inhabited by the souls of the dead, or of the Konyak Nagas of Assam, who perform ceremonies over phallic cists containing skulls of deceased persons, in order to secure a birth of corresponding sex to that of the skull.

Reincarnation is not confined to animal forms. The stories of trees that grow up from the graves of lovers, such as Tristram and Iseult, and twine themselves together are familiar in Europe; and the human soul also reappears in a flower growing on the grave. In the case of flowers springing from drops of blood, as from that of Ajax, the soul is possibly regarded as located actually in the blood itself. In farther Asia and elsewhere the soul goes into the crops, and by preserving the corpse, which is smoke-dried, funeral ceremonies are accommodated to the agricultural year, so as to afford the crop the full benefit of the soul matter from those who have died recently; and in the case of the Karens of Burma a specific theory is evolved of a cycle of life on these lines (see HEAD-HUNTING).

The Lushei theory that the soul takes the form of dew and is reincarnated in the body on which it descends may be a version of the Karen theory.

The idea of transmigration has been influenced and inevitably confused by ideas as to the external soul, generally associated with magicians, where the vital principle depends on a soul kept in an animal in the forest, or in an egg below the sea, etc., which has to be secured before the magician can be killed, and by ideas as to totemism and lycanthropy (*qq.v.*). Beliefs in the reincarnation of the soul in predatory forms such as tigers (India and Sumatra), sharks (Melanesia) or alligators (Africa) have perhaps arisen in connection with those ideas.

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Metempsychosis in Western Thought.—Although the word "metempsychosis" and its better synonym "metensomatosis" first occur only in late Greek and Latin writers, the idea is not later than the late Archaic period (*i.e.*, the 6th century B.C.), for it occurs in the writings known as Orphic and it is alleged that Pherecydes of Samos (fl. *c.* 550 B.C.) was the first to speak of it. In Orphism it is combined with an elaborate theory of the origin of mankind and with a doctrine of something like original sin. Man sprang from the soot from the burning bodies of the Titans slain by Zeus with his thunderbolts after they had murdered and eaten his son Zagreus. Hence man has in him a small divine element (Zagreus) and a large and wicked Titanic one, which it is his first duty to eliminate in order to rise to divine status. His soul survives bodily death and, at least in some versions of the doctrine, is rewarded or punished in another world and later reincarnated in a human or animal body, so continuing in what some documents call the "wheel" or "circle" (*cyclos*); but it has hopes of ultimate release. Two different accounts of this happy outcome are found in the earliest surviving source, Pindar. On the one hand (Olympians, ii), Pindar represents this world and the next as each reciprocally the place of temporary reward or punishment for conduct in the other; those who can live righteously three times on either side of the grave pass to a state of final bliss. On the other hand, in a fragment (no. 127 in C. M. Bowra's edition [Oxford, 1947]; no. 133 in O. Schroder's [Leipzig, 1900]), he makes Persephone accept "satisfaction for her ancient grief" (the murder of Zagreus, whose mother she was) from some of the dead, who are reincarnated after eight years, live distinguished lives on earth and then attain the rank of heroes.

The source of all these doctrines is quite uncertain. Their influence, however, was considerable. Something of them seems to have been imported into the Eleusinian mysteries, or rather into the beliefs ahich the initiates deduced from the ritual thereof. Pythagoras is said, though on rather doubtful evidence, to have taught reincarnation, and certainly Empedocles did so.

More important for the history of thought is Plato, who was decidedly influenced by Orphic or Orphico-Pythagorean views and reinterpreted them after his own fashion, notably in the great myths of the *Republic,* of the Phaedo and of the Phaedrus but also elsewhere, as in the *Meno,* in the *Timaeus* and in the Laws. The soul, according to him, is immortal, the number of souls fixed, and reincarnation regularly occurs.

The aim of the philosopher is to purify and free the divine element in the soul and thus to return to his proper home in the company of the gods (so the *Phaedrus*). Although nothing of the kind was accepted by Aristotle, and it is inconsistent with both Epicurean and orthodox Stoic views of the soul, the Platonic doctrine with various modifications and elaborations mas taken up by later schools of thought, above all by Neoplatonism, as is clear from the works both of the great Plotinus and of the lesser thinkers of that group.

In nonphilosophical literature occasional references to reincarnation are found. It is mentioned by Menander (*Theophorumene*) and satirized by Lucian (*Gallus*). In Roman literature it is found as early as Ennius. who in his Calabrian home may have been familiar with the Greek teachings which had descended to his time from the cities of Magna Graecia.

In a lost passage of his Annals, Ennius told how he had seen Homer in a dream, who assured him that the same soul which had animated both poets had once belonged to a peacock. Persius (Sat., vi, 9–11) laughs at Ennius for this; it is referred to also by Lucretius (i, 121–126; see note in Cyril Bailey's edition [Oxford, 1947]) and by Horace (Epist. *II,* i, 50–52). Virgil works the idea of metempsychosis into his account of the Underworld (Aeneid, vi, 724 et seq.).

Attempts to find metempsychosis in early Jewish literature have met with little success, but there are traces of it in Philo and it is definitely adopted in the Kabbala. Within the Christian church it was held by isolated Gnostic sects during the first centuries and by the Manichaeans in the 4th and 5th centuries, but was invariably repudiated by orthodox theologians. In the middle ages these traditions were continued by the numerous sects known collectively as Cathari. The doctrine is found in Giordano Bruno at the Renaissance and in the theosophist J. B. van Helmont in the 17th century. During the classical period of German literature metempsychosis attracted much attention; Goethe played with the idea, and it was taken up more seriously by Lessing, who borrowed it from Charles Bonnet, and by Herder. Modern theosophy, drawing its inspiration from India, has taken metempsychosis as a cardinal tenet. See IMMORTALITY; see also Index references under "Metempsychosis" in the Index volume

See M. P. Nilsson, *Geschichte* der *griechischen Religion,* vol. i, 2nd ed, p. 678 ff. (1955), vol. ii, p. 376 ff. (1940). (H. J. R.)

METEOR, from the Greek mefeora, meaning "things up in the air In astronomy it is the luminous "shooting-star" effect seen in the night sky when a small particle, known as a meteoroid, enters the earth's upper atmosphere at high speed and dissipates its kinetic energy in the form of heat, light and ionization. The word meteor is commonly used as a synonym for meteoroid. and as an adjective in referring to related aspects, such as meteor radiant or meteor velocity. It is in this broad sense that the word is used in this article. Cntil the 19th century the meaning of meteor was even more broad. It included not only the aurora as well. but also a wide variety of phenomena in the lower atmosphere, such as clouds, rainbows. lightning. hail. etc., which are now embraced by meteorology. the science of weather. However. the meteorologist currently incorporates the word in his language chiefly as a prefix or suffix; *e.g.,* a raindrop may be called a hydrometeor.

The vast majority of meteors burn themselves out in the upper atmosphere, but the occasional large mass that survives its fiery plunge and falls to the earth as a solid body is known as a meteorite (*q.v.*). Meteorites interest the physical chemist and the mineralogist, while the astronomer, the upper-air physicist and the radio communications engineer are concerned with meteors and their effects.

The falling of stones from the sky has been noted in literature at least as far back as 600 B.C., and there are early Chinese and European records of both single spectacular meteors and showers of shooting stars. However, not until about the beginning of the 19th century was the extraterrestrial origin of meteors and meteorites generally accepted. Serious study of the subject was really initiated by the great meteor shower of Nov. 12, 1833. which was seen all over eastern North America. Hundreds of thousands of shooting stars were observed in one night, some leaving persistent trains, but none reaching the earth. It was noted that all the meteors seemed to radiate from a point in the constellation Leo. This point'. known as the radiant. was in the same position in the sky for all observers, hence it was deduced, first: that the meteors must come from far outside the atmosphere and. second. that their apparent divergence from the radiant was simply a well-known effect of perspective, and that the meteors were really moving in parallel paths.

It was later established that the Leonid shower recurred at 33-year intervals, and occasional records of its appearances were traced back as far as 902 A.D. It appeared on schedule as a magnificent display in 1866. Since that time a few Leonids have been seen in November each year. but the numbers seen in the predicted peak years of 1899 and 1932 fell far below those of 1833 and 1866.

Shower Meteors and Cometary Associations.--Using the radiant point. together with the 33-year period of the Leonids. it was possible to compute the elements of the elliptical orbit which these particles pursue around the sun. A remarkable coincidence was noted between this orbit and that of Comet 1866 I (Tempel's comet). Similarly. Comet 1862 III was found to follow the path of the well-known Perseid meteors which were once known as the "Tears of St. Laurence." and which appear with great reliability each year in August. Halley's comet. which comes close to the earth both while approaching and while receding from the sun, has been tentatively connected with two annual showers. the Eta Aquarids in May and the Orionids in October. Other cometary associations are the Lyrids with Comet 1861 I, the Bielids with Comet 1852 III (Biela's comet), the Taurids with Enke's comet and the Giacobinids (or Draconids) with Comet Giacobini-Zinner. On the other hand. several prominent meteor showers. such as the Geminids, the Quadrantids and the Delta Aquarids, can be associated with no known comets. Furthermore, comets have been known to cross the earth's orbit without leaving any appreciable meteoric traces. However, despite the obvious lack of complete correlation which prevents a general conclusion being drawn. it does seem clear that at least some of the meteor showers are definitely connected with parent comets.

An elementary view of the structure of a comet (*q.v.*) is that its nucleus is made up of a large number of small solid particles of various kinds of minerals stuck together loosely by frozen gases. such as ammonia and methane, nhile the comet is far from the sun. As the comet approaches the sun the gases evaporate and the particles are released to form a "flying gravel bank." as it were, albeit a rather loosely knit one, as even in the densest shower the particles are many miles apart. Planetary perturbations, particularly due to Jupiter, and other selective forces associated with the sun's radiation act to disperse the particles 'into slightly different orbits.

The smallest particles are most widely dissipated and eventually spiral into the sun. After the comet has made several passages around the sun. the particles will be spread out along the original orbit and also over a considerable volume in space. Thus, as in the case of the Leonids, a strong meteor shower may be observed in the year that the comet is nearest the earth. The shower may last for a few hours, or even for several days if the dispersion is wide enough. while a few shower meteors may be seen in the same month in off years. In the case of the Perseid shower, which is roughly estimated to have an age of at least 40,000 years, the dispersion around the orbit is so complete that no evidence of a long-term periodicity can be found. Such well-established shon-ers appear to have relatively few very small meteors. compared to the normal nonshower distribution that is always present. Planetary perturbations can swing the meteoric orbits so that they miss the earth entirely. This is probably what has happened to the major part of the Leonid stream, which may never again provide a brilliant display.

The Giacobinid shower is a vivid example of a newly created meteor stream. The associated comet. discovered in 1900, has an orbit that intersects the earth's path about Oct. 10, with a period of nearly 6.j years. Hence, every 13 years there is a chance that a strong meteor shon-er will appear if the comet should happen to be within a reasonable distance of the earth. In 1933 and in 1946 the circumstances were favourable and rates of several hundred per minute were observed. In each case. these high rates were sustained for about half an hour only. indicating that the meteoric fragments were fairly closely bunched near the cometary orbit. Observations in the 1950s, including those made by radio methods during daylight passages, have shown that some of the meteors are appearing well ahead of or behind the comet, but the lateral spread of the orbits is still small; *i.e.,* the earth passes through the stream in an hour or two. The Quadrantids are an example of an annual shower that lasts not more than a couple of hours at maximum activity.

Annual Meteor Showers

Name of shower	Radiant position		Mean date	Shower duration in days	Hourly visual rate	Meteor velocity (miles per second)
	Right ascension	Declination				
Quadrantid	232°	+50°	Jan. 3	0.5	40	25
Lyrid	274°	+34°	April 21	2.5	10	30
Eta Aquarid	336°	00°	May 4	18	20	40
Delta Aquarid	339°	−17°	July 29	20	20	25
Perseid	046°	+58°	Aug. 11	5	50	37
Orionid	095°	+15°	Oct. 20	8	25	41
Leonid	152°	+22°	Nov. 16	4	15	45
Geminid	113°	+32°	Dec. 13	6	50	22

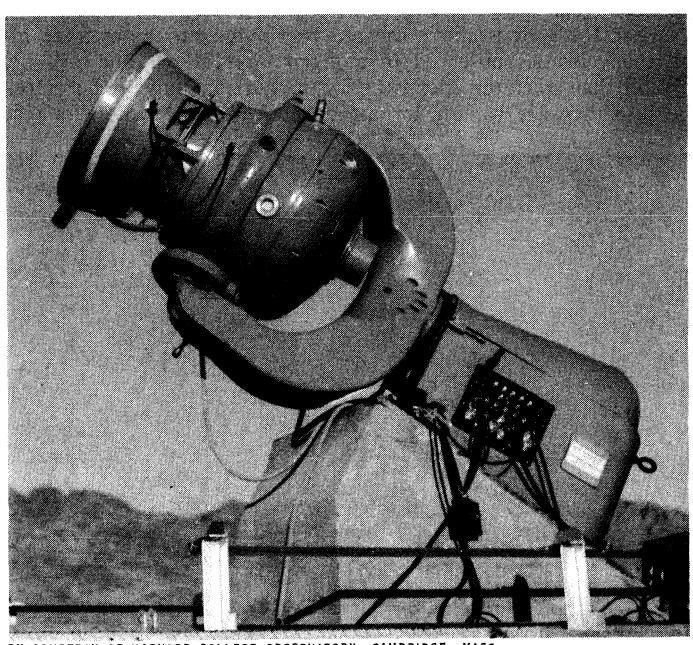
The table lists some of the stronger annual meteor showers that can be seen by the naked-eye observer. The right ascension and declination co-ordinates given will enable the amateur astronomer to locate the radiants fairly precisely. but it may be noted that for casual observations it is only necessary to ensure that the constellation for which the shower is named is visible, because, if the radiant point is above the horizon, meteors from that radiant may be seen in any part of the sky. (The Quadrantids were named after an obsolete constellation. Quadrans Muralis, which was located just east of the handle of the Big Dipper.) The shower duration is the approximate interval. bracketing the mean date, during which the shower rate exceeds one-quarter of the maximum. The hourly visual rate is the average rate at the maximum point of the shower. as seen by a single observer. It may vary widely from year to year. These rates are superimposed on

the normal background rate of nonshower meteors visible on any clear, moonless night, which may be from j to 10 per hr. The meteor velocities given in round numbers in the last column of the table are velocities relative to the earth that have been obtained by photographic or radio methods.

Radio observations have revealed the presence of at least four very strong daylight showers. These are the Omicron Cetids (Rlay 19), the Arietids (June 6). the Zeta Perseids (June 6) and the Beta Taurids (June 28). Each of these annual showers extends over several days, and the equivalent visual rates may run as high as 70 per hr.

Asteroidal Associations. — Laboratory examinations of meteorites suggest that they may be fragments of one or more large bodies, of the order of size of our earth. It is tempting to speculate that at some time in the distant past there nas a planet, betneen Mars and Jupiter, say. which disintegrated into fragments, either due to an internal explosion or to a collision nith a somewhat smaller body than itself. Qualitatively, this hypothesis could account for the creation of the asteroids. nhich may range in size from a few hundred miles in diameter down to the sizes of the meteorites or the brighter meteors known as fireballs. There are some serious difficulties in this theory. particularly with the cosmic time scale of the events, but until further information becomes available there does not appear to be an attractive alternative.

The Origin of Meteors. — The identification of meteorites as asteroidal fragments seems reasonable, and the association of some meteor streams with comets has been demonstrated, therefore, one can only conclude that the origin of meteors as a class is intimately bound to the histories of both these possible parents. Whether or not the asteroidal type may extend in size down to particles of dust and thus form an appreciable part of the sporadic or background meteor activity is not yet known. It is unlikely, however, that this type can be responsible for any meteor streams in the normal sense. On the other hand, there are a fen very brilliant fireballs among the cometary types, and no meteorites have been known to fall from the recognized shoners At the other end of the scale, the meteor sizes decrease through the so-called micrometeorites. which are particles small enough to be sloned up in the atmosphere without vaporizing, to the motes that make up the zodiacal dust cloud. There is no evidence that any significant fraction of the meteor population is made up of visitors from interstellar space. so the question of the origin of meteors is a part of the larger problem of the origin and evolution of the solar system.



BY COURTESY OF HARVARD COLLEGE OBSERVATORY, CAMBRIDGE, MASS.

FIG. 1. — BAKER-SUPER-SCHMIDT METEOR CAMERA IN OPERATION AT A METEOR OBSERVING STATION. THE CAMERA HAS AN APERTURE OF 12 IN. AND AN OPTICAL FOCAL RATIO OF *f*/0.65. ITS EQUATORIAL MOUNTING ENABLES THE CAMERA TO FOLLOW THE STARS. THE OVER-ALL HEIGHT OF THE INSTRUMENT IS ABOUT 8 FT.

BY COURTESY OF HARVARO COLLEGE OBSERVATCRY CAMBRIDGE MASS

FIG 2 — THREE PERSEID METEORS PHOTOGRAPHED WITH THE BAKER-SUPER-SCHMIDT CAMERA A ROTATING SHUTTER. MOUNTED ON A SHAFT EXTENDING THROUGH THE CENTRE OF THE PHOTOGRAPHIC PLATE BREAKS THE METEOR TRAILS 60 TIMES A SECOND THE GREAT NEBULA IN ANDROMEDA IS VISIBLE AT THE LEFT OF THE PICTURE

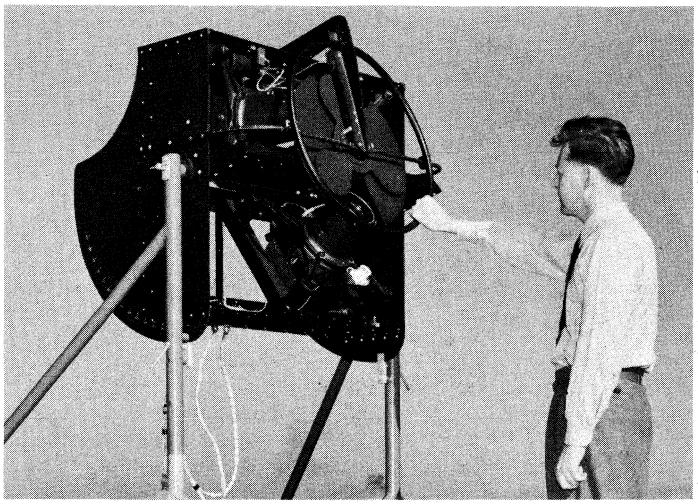
Meteor-Observing **Techniques.**—*Visual.*—For many years, the only method of obtaining information about meteors was by naked-eye observing. The basic equipment needed is a star chart and a good clock. The watcher plots the path of the meteor among the stars on his chart, and notes the time, apparent magnitude of the meteor, colour, train duration if any. etc. A similar plot of the same meteor made at another station about 40 mi. away will enable rough measurements of height and of radiant position to be made. Such measurements cannot compare in accuracy with those made by photographic or radio methods, and visual estimates of meteor velocities are notoriously weak. Nevertheless, the visual observer continues to be essential to the art. particularly in the matter of determining meteor rates as a function of magnitude, and also in supplying some important correlations for the instrumental methods.

Several aids to the visual observer have been developed but not used extensively, such as wire graticules to improve his plotting accuracy. In another arrangement, the meteor path is viewed not directly, but in a rocking mirror which appears to put a number of kinks in the meteor path, from which the meteor velocity may be deduced.

Binoculars and telescopes have been employed to extend the range of visual observations from the limit of the naked eye. which is about the 5th or 6th magnitude, to the 12th or 13th magnitude. See STAR: Brightnesses *of* the Stars, for definition of magnitude.

Photographic and *Spectroscopic.*—Direct photographs of the meteor trail, taken at two points on the earth's surface several miles apart. yield by far the most accurate data for computing the orbit of an individual meteor. The camera lens is left open as long as the background light will permit, since the advent of a meteor cannot be anticipated.

A rapidly rotating shutter in front of the open lens serves to chop the photographed path into short segments from which the velocity and deceleration of the meteor can be computed. The camera mounting may be fixed or it may be guided to follow the stars. Using high-speed emulsions, cameras with *f*/4 lenses will record meteors down to about zero magnitude, and those with



BY COURTESY OF NATIONAL RESEARCH COUNCIL, OTTAWA, CAN.

FIG. 3 — A BATTERY OF THREE WILLIAMSON F-24 AERIAL CAMERAS. WITH SLIGHTLY OVERLAPPING FIELDS OF VIEW. IS DIRECTED AT A SELECTED SKY AREA AND IS THEN LEFT FIXED DURING THE TIME EXPOSURE THE TWO-SECTOR ROTATING SHUTTER (NEXT TO LENSES) ,CHOPS THE IMAGES OF THE METEOR TRAILS 12 TIMES PER SECOND FOR VELOCITY MEASUREMENTS TRANSMISSION GRATINGS MAY BE PLACED IN FRONT OF THE LENSES TO CONVERT THE CAMERAS TO SPECTROGRAPHS

f/1 j lenses will capture some and magnitude meteors. A type of Super-Schmidt camera nas developed especially for meteor photography, and. with a lens system equivalent to *f*/0.65, it can photograph 3rd to 4th magnitude meteors in a field of view 55° in diameter (See figs. 1 and 2.)

A conventional camera can be converted to a meteor spectrograph by mounting a prism or a grating in front of the lens and alloning the meteor trail to act as a slit light source The sensitivity of the spectrograph is two or three magnitudes less than that of the same camera without the grating. The rotating shutter is usually included in the system. (See figs. 3 and 4.) Photoelectric recording of meteors has been tried with some success, but has not been developed or used extensively.

Radio. — There was evidence in the 1930s that radio waves could be reflected from meteor trails, and, after World War II, intensive development of new techniques in this field took place. In the radar method short bursts of radio-frequency energy are emitted from a transmitting station on the ground The meteor trail scatters a small fraction of this energy back to a receiver located at the same station, and by electronic methods the elapsed time of flight of the pulses. equivalent to the distance to the trail, can be measured. (See fig. j.)

Alternatively. the energy may be emitted continuously in order to emphasize the amplitude variations in the received echo instead of the distance information. The radio frequencies that have been used range from 2 or 3 mc./sec. (megacycles per second, or millions of cycles per second, which is just above the broadcast band) to 500 mc./sec., though most of the work has been done in the band a5–100 mc./sec. Relatively simple antennas are usually employed, though sometimes additional complexity is introduced for height-finding or for determining the wind drifts of the enduring trails. With radar transmitters of moderate power the limiting sensitivity of a typical system may be as small as the 10th magnitude. High power and larger antennas have been used to detect 14th magnitude meteors.

It should be noted that even a large meteoric particle is far too small to be directly detected by the most powerful radars. The radio waves are scattered back, not by the particle itself, but by the long trail of ionized atoms created in its wake by collisions nith air molecules. This ionized trail may extend from a few miles to a hundred miles long, and may endure as an effective scatterer for a fraction of a second up to many minutes. The trail acts as a linear reflector. in a sense, and the strongest echo will usually be obtained when the line of sight from the station to the trail is perpendicular to the trail. This characteristic is utilized in the radio methods of measuring radiants, and has made possible the delineation of several important daylight meteor showers which cannot be observed by the older techniques, and which were unsuspected until the advent of radio. The fluctuations in echo amplitude that are observed as the meteor crosses the line of sight are used to measure the velocity of the meteor. (See fig. 6.) This effect is closely analogous to the optical theory of the diffraction of light from a slit source.

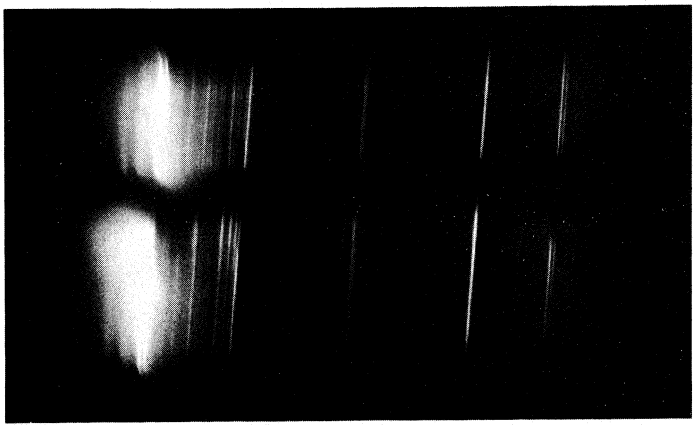
Observational Data. — Heights. — The height in the atmosphere at which a meteor appears depends on the size of the particle and on its velocity. In broad terms, a meteor moving with a velocity of 45 mi. per second (m.p.s.) will be at its brightest at a height of 6j mi.. and one with a velocity of 15 m.p.s. will show a maximum light intensity at a height of about 55 mi. The fainter meteors in a given velocity class burn up at greater heights, while the brighter ones may survive to heights as low as 20 mi.

Velocities. — Nearly all meteoric velocities measured by photographic and radio techniques lie in the range 7 to 45 m.p.s. This includes both shower meteors and nonshower meteors! from the brightest fireballs down to about 8th magnitude. The observed velocity of a meteor is slightly less than the true velocity in the absence of the earth's atmosphere because of the deceleration of the meteor. Various corrections may be applied to allow for deceleration. the attraction of the earth on the particle and the earth's rotation, in order to determine the true velocity.

Radiants.—The photographic method is capable of locating the radiant point in the sky with a precision of better than 0.1° of arc, which is at least 10 times more accurate than the radio methods. However, the photographic data are limited to meteors brighter than the 3rd or 4th magnitude, while the radio observations extend down to 8th magnitude meteors or fainter.

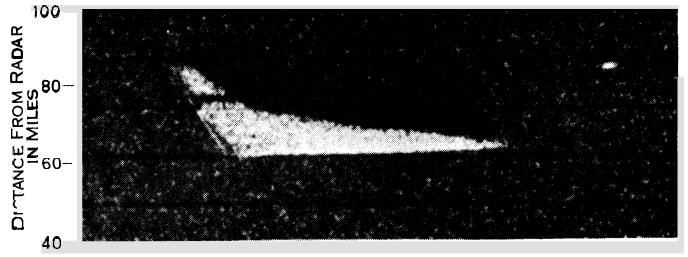
Daily and *Annual* Rates. — Three to five times as many meteors per hour are seen in the second half of a typical night compared to the first half. provided, of course, that no strong shower is present. Similarly, during an average night in the autumn almost twice as many meteors may be seen as during a spring night. Both variations are a general consequence of the earth's revolution about the sun with an orbital velocity of 18.5 m.p.s. The point in space toward which the earth is moving at any given moment. is known as the "apex of the earth's way." The meteor velocity in its own orbit relative to the sun (heliocentric velocity) is added vectorially to the earth's velocity to yield the observed geocentric meteor velocity.

When the apex is above the observer's horizon the average of all the velocities observed in a given interval of time will be greater than when the apex is below the horizon, and furthermore, because they are coming in faster, there are more meteors per



BY COURTESY OF DOMINION OBSERVATORY, OTTAWA, CAN.

FIG. 4.— SPECTRUM OF A BRIGHT METEOR PHOTOGRAPHED WITH ONE OF THE CAMERAS OF FIG. 3. THE METEOR MOVED FROM TOP TO BOTTOM OF THE PICTURE. AND THE TRAIL HAS BEEN BROKEN BY THE ROTATING SHUTTER. THE VIOLET PART OF THE SPECTRUM IS AT THE LEFT AND THE RED PART AT THE RIGHT. NEAR THE LEFT. THE VERY STRONG PAIR OF LINES IS DUE TO IONIZED CALCIUM. NEXT ARE MANY FAINT IRON LINES. IN THE CENTRE IS A CLOSE PAIR OF MAGNESIUM LINES, THEN A STRONG SINGLE LINE OF SODIUM, WHILE THE BRIGHT PAIR AT THE RIGHT IS IONIZED SILICON



BY COURTESY OF NATIONAL RESEARCH COUNCIL, OTTAWA, CAN

FIG. 5.— ACCURATE MEASUREMENT OF DISTANCE TO THE METEOR TRAIL IS STRESSED BY THE PULSE RADAR TECHNIQUE. THE THIN. SLANTING LINE AT THE LEFT IS A TRANSIENT ECHO THAT HAS OUTLINED THE ACTUAL PATH OF THE MOVING METEOR RELATIVE TO THE STATION. THE ENDURING ECHOES FROM VARIOUS PARTS OF THE LONG IONIZED TRAIL HAVE MERGED INTO A BROAD BAND ECHO LASTING FOR FIVE SECONDS. A SHORT-DURATION ECHO FROM A MUCH FAINTER METEOR IS VISIBLE AT THE UPPER RIGHT

hour. The apex is above the horizon more frequently both after midnight and during the last six months of the year. hence the observed rate variations follow. Other factors are involved as well, but the earth's motion is the major one.

Magnitude and Mass Distributions.— The total number of meteors seen per hour down to a given magnitude limit is between two and four times the total number seen down to one magnitude brighter than the selected limit. In the visual range the increase in numbers per magnitude is about 3.j while for the fainter telescopic and radio meteors the ratio is probably about 2.j. Little was known in the late 1950s about the range of the still smaller particles extending down to the zodiacal dust level. Quantitatively. it is estimated that over the entire surface of the earth one fireball of the brilliance of the full moon may be seen every few days. A meteor of this brilliance would almost certainly fall to earth as a meteorite; rough guesses of the total number of meteorite falls run from 5 to 30 daily. In a 24-hour period about 1,000,000 meteors of zero magnitude (comparable to the well-known star Vega) or brighter may strike the earth's atmosphere, and in the same interval the total number of naked-eye meteors will be about 200 000,000.

The mass of a zero-magnitude meteor is probably about $\frac{1}{30}$ of an ounce, and its size, if a solid stone particle, would be comparable to a small grape. The total weight of meteoric material falling on the earth every 24 hours, from the brightest fireballs to meteors just visible to the naked eye, is of the order of 10 tons. The dust particles, which do not become incandescent, appear to be much more numerous in proportion to their sizes, and the daily accretion of dust may be in excess of 1,000 tons.

Spectra.--On entering the atmosphere, the surface of the meteoroid melts and vaporizes as a result of the heat evolved by collisions with air molecules. and the constituent atoms become excited and also ionized, giving rise to light emission. The major portion of the visible light consists of bright line spectra of common elements; *e.g.*, iron. calcium, magnesium, silicon, etc. Some continuous emission is also present, and oxygen and nitrogen lines are sometimes recorded, indicating that the air molecules are also excited. Meteoric spectra are similar to spectra obtained in the laboratory from meteorites but there are some significant differences.

Ionization.——The radio techniques are very sensitive as detectors of the ionization produced in the meteor trail. It is estimated that a 5th magnitude meteor. near the limit of naked-eye visibility, creates 5,000,000,-000,000 ɔ and free :ı ɔr y i] it , and a ɜrɔ g ıde meteor produc 100 times as much.

Physical Theory f Meteors.—It is assumed first that the t at which atoms are evaporated from the meteor is t ɔ the energy available fı r collisions with tl air particles, , second, that tl rate t which the neteoroid itself is slowed down is proportional t the momentum transferred to the air. From these two basic hypotheses, together with reasonable assumptions l t the density of the air at meteoric t (comparable t good laboratory vacuums), it is possible to predict tl light intensity and ionization production in terms of various parameters associated with the meteor and the atmosphere. The basic theory assumes the particle to be made of solid iron or stone. and modifications are needed to account for some observational evidence that many meteors may be porous bodies, or "dust balls," with a density less than that of water.

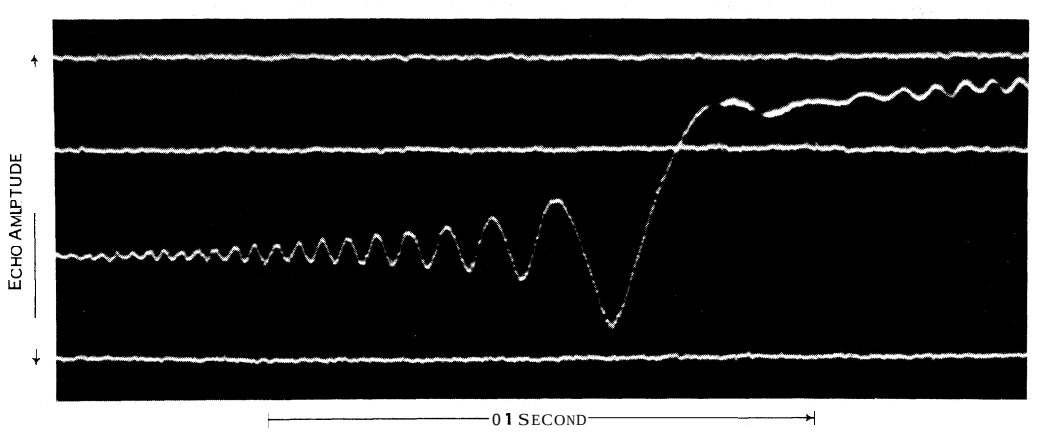
By working backward, it is possible to deduce the temperature and pressure of the air in the meteoric region. Prior to the advent of rockets and satellites. this aspect of meteor research yielded very useful data about the upper atmosphere.

In radio work the meteors are divided into two classes according to the amount of ionization they create. The fainter meteors produce "underdense" trails; that is, the radio wave penetrates the long column of ionization and is scattered back by the free electrons, each acting independently. The received echo fades out as the trail expands laterally.

The brighter meteors produce "overdense" trails. so defined because the wave does not penetrate the column but is reflected from the surface of the column in a manner similar to the reflection of broadcast waves from the ionosphere. The duration of the echo in either case varies as the square of the radio wave length, and, of course, is dependent both on the amount of ionization produced initially and on the rate at which the ionized atoms diffuse and recombine.

Winds in the upper atmosphere cause the ionized trail to drift and also to twist and distort. Radio observations yield much useful information about the magnitude and direction of these winds. Visual observations of the glowing trains left by the brighter meteors also show the effects of winds.

The Problem of Hyperbolic Velocities.— The smallest observed velocity that a meteor can possess is about 7 m.p.s., corresponding exactly to the "escape velocity" of a rocket that just manages to break free from the earth's gravity. Particles moving in elliptical orbits about the sun will have heliocentric velocities (at the earth's distance from the sun) not greater than 26 j m.p.s. If a particle is moving faster than this it is said to have a hyperbolic velocity; that is, it must have entered the solar system from interstellar space, and, if not stopped or perturbed, it will leave the system again, never to return. An observed velocity well in excess of 45 m.p.s., the sum of the earth's orbital velocity



BY COURTESY OF NATIONAL RESEARCH COUNCIL OTTAWA CAN

FIG. 6.— RADIO RECORD OF A METEOR ECHO. THIS RADIO TECHNIQUE (UNMODULATED TRANSMITTER) DOES NOT MEASURE DISTANCE BUT BRINGS OUT IN DETAIL THE RAPID AMPLITUDE FLUCTUATIONS OF THE ECHO AS THE METEOR CROSSES THE LINE OF SIGHT. IF A LOUD-SPEAKER IS USED, THE FLUCTUATIONS MAY BE HEARD AS "DOPPLER WHISTLES." FIRST DESCENDING IN PITCH. THEN RISING THE METEOR VELOCITY CAN BE DETERMINED ACCURATELY BY MEASURING THE TIME INTERVALS BETWEEN SUCCESSIVE OSCILLATIONS

and the limiting elliptical velocity of a particle, would clearly denote the arrival of a visitor from outer space. For many years the possibility that a significant fraction, or even a preponderance, of the influx of meteors came from outside our system was argued intensely and at length. It is now generally agreed that the earlier data, based on visual estimates of velocities, and on rates and radiant distributions, were not sufficiently reliable or unambiguous. Modern photographic and radio techniques have been brought to bear on the problem. Several intensive surveys. some that concentrated on precise velocity measurements alone, and others that determined both velocities and radiants in order to compute the actual orbits, have shown conclusively that very few meteors, if indeed any at all, from the brightest donn to the 8th magnitude, can have come from outside the solar system.

Meteors and the Weather.— There may be a possibility that meteors affect the world's rainfall. The formation of raindrops in the lower atmosphere is, in part at least, a process of condensation on small nuclei such as minute dust particles. Fine meteoric material, whether as debris from the visual range of meteor sizes. or as micrometeorite dust, will drift slowly down from meteoric heights to the weather region in about a month. Some statistical evidence has been presented to show a connection between rainfall and meteor showers occurring a month earlier. Although the research is intriguing, the data are extremely difficult to analyze. and the correlations deduced by the late 1950s were by no means convincing.

Meteors and Radio Communications.— Normally no communication can be established between a low-powered radio transmitter, using a frequency in the range 30–100 mc./sec., and a receiver several hundred miles distant, because the earth's curvature cuts off the direct wave, and the sky wave penetrates the ionosphere and is lost. However, whenever a suitably orientated meteor trail appears in the upper atmosphere, roughly halfway between the stations, the radio wave may be reflected to the receiver as long as the trail endures, which may be for a fraction of a second or for several seconds.

In a practical communication system there is a transmitter and a receiver at each end of the link, with one or both transmitters emitting unmodulated carrier naves. The message to be transmitted is stored on high-speed tape which can be started and stopped quickly. When a meteor reflection occurs, and the carrier wave is received at either end, the tape is started and the intelligence is transmitted just as long as the trail lasts. Despite the intermittent nature of the operation, this meteor system has several unique features which have led to its adoption as a useful member of the family of point-to-point communication systems. High-power ionospheric scatter systems also depend on meteor trails to a great extent. In this case, it is the myriad of small meteors that assist in maintaining a weak but continuous signal between the stations.

Meteors and Space Travel.— Collisions with meteoric particles will be among the many hazards to face the space traveler. The kinetic energy released by a small high-speed meteoroid of iron or stone, if it were to strike a large body like a space ship, could be as much as a thousand times greater than the explosive energy of an equal weight of TNT. A pinhead particle might blast a hole in the shell of the vehicle that would allow the air within to escape in a few seconds. A meteoric pellet the size of a grape would almost certainly destroy the ship. Fortunately for the astronaut the probability of serious damage is very small. He should be able to travel for days before having to patch minor leaks in the ship's shell, while many years might elapse before a catastrophic collision took place. His chances for survival will be enhanced by steering clear of cometary orbits and the asteroidal belt between Mars and Jupiter.

See A. C. B. Lovell, *Meteor Astronomy* (comprehensive) (1954); Fletcher G. Watson, *Between the Planets* (popular) (1956).

(*D.* W. R. McK.)

METEORA, a group of monasteries in Thessaly, north of the Peneius valley, near the village of Kalabaka (the ancient Aeginium, medieval Stagus or Stagoi), not quite 20 mi. N.E. of Trikkala. From the Cambunian hills two masses of rock project southward into the plain, eroded into isolated columns 85 to 300 ft. high, "some like gigantic tusks, some like sugar loaves, and some like vast stalagmites," all of iron-gray or reddish-brown conglomerate of gneiss, mica slate: syenite and greenstone. The monasteries stand on the summit of these pinnacles; accessible only by rope and net worked by a windlass from the top, or by a series of almost perpendicular ladders.

The peak on which St. Stephen's is built does not rise higher than the ground behind, and the deep, narrow chasm is spanned by a drawbridge. Because of the confined area, the buildings are closely packed, but each monastery contains, besides the monks' cells and water cisterns, at least one church and a refectory, and some also a library. At one time they were 14 in number, but now not more than 4 (the Great Monastery, Holy Trinity, St. Barlaam's and St. Stephen's) are inhabited by more than two or three. monks. The present church of the Great Monastery was erected, according to W. Leake's reading of the local inscription, in 1388 (Björnståhl, the Swedish traveler, had given 1371), and it is one of the largest and handsomest in Greece. A number of the manuscripts from these monasteries are now in the National library at Athens. Aeginium is described by Livy, and Stagus by Byzantine writers.

See L. Heuzey and H. Daumet, *Mission archéologique de Mace'doine* (1876), where there is a map of the monasteries.

METEOR CRATER (also known as Crater Mound and Coon Butte), a bowl-shaped, rimmed pit 4,000 ft. in diameter in the rolling plain 19 mi. W. of Winslow, Ariz.. produced by a large meteorite. It is about 600 ft. deep inside its uplifted rim which rises nearly 200 ft. above the plain. Drillings reveal undisturbed rock under 500 to 800 ft. of fill: about 100 ft. of which are lake sediments. These sediments are under 30 ft. of blow sand, and the water level is approximately 200 ft. below this floor. Large numbers of nickel-iron fragments from gravel size to 1.400 lb. have been found in a 100-sq.mi. area; the distribution and composition of several thousand tons of sand-grain size nickel-iron droplets indicate that they are condensation droplets from a cloud of metallic vapours. Surveys show only fragments within the pit but the 1960 discovery there of coesite (*q.v.*), a high-pressure modification of silica, tended to confirm its meteoric origin. The estimated age is 50,000 years.

See also METEORITES: *Meteorite Craters.* (H. H. NR.)

METEORITES are lumps of solid matter which occasionally can be seen to fall from the sky. The historical records of every civilized country in the world, from the earliest days onward, contain references to such events; as in most cases they were accompanied by luminous phenomena, it was customary to distinguish them as "fiery meteors" from the much more common "aqueous meteors" such as rain, snow, hail, etc. The origin of the two groups is entirely different and the name meteor is no longer used for the aqueous kind, although the science dealing with them is called meteorology. Accordingly, the name "fiery meteors" also became obsolete; meteors have come to mean, without any attribute, fast-moving luminous objects in the sky, also described as shooting stars, or—if very conspicuous—as fireballs, and are called meteorites when they fall to the ground.

The science devoted to the study of meteorites is called meteoritology, or meteoritics.

As all meteorites show peculiarities not observed in any terrestrial mineral: it is possible to recognize them as such, even if their fall has not been witnessed. Recognition is particularly easy in the case of the so-called iron meteorites, which consist mainly of an alloy of iron and nickel; also the other big class of meteorites, the stone meteorites: are so different in several respects to rocks formed on earth that their identification is usually no problem for the expert.

They are, however, more likely to be overlooked by laymen and are moreover more quickly destroyed by atmospheric exposure; this explains why in museums the proportion of "finds" to "falls" (*i.e.*, meteorites of which the fall has been observed) is much greater in the case of irons than in that of stones. *See* the round figures in Table I, which are based on the inventories of meteorite collections.

TABLE *I.—Number of Meteorites in Collections*

	Irons	Stony-irons	Stones
Finds . . .	410	40	200
Falls . . .	40	10	550
Total	450	50	750

From this table we can learn the further fact that considerably more stones than irons have been seen to fall. Since there is no reason why it should be easier to observe one than the other, we must assume that stone meteorites do predominate in nature, and that the comparatively large number of irons in our collections is only a result of the ease with which they can be recognized. The table lists also a third and much smaller class, the stony-iron meteorites, which forms a link between the first two. A fourth class, the glass meteorites, is in several respects so different from the others that it will be treated separately (see section 9). In 1947 the total number of different meteorite specimens known was thought to be still below 1,400.

1. Phenomena of the Fall.— The fall of a meteorite of any considerable size is accompanied by such startling light and sound phenomena that, all over the world, from prehistoric times, such events have been remembered and recorded. These descriptions, and the more or less successful attempts at pictorial representations agree with one another to a remarkable extent. The general story is that a fiery mass suddenly appears in the sky, describing a shorter or longer orbit and leaving a luminous trail behind it. At the end of its path, it disintegrates with a loud explosion and the dark fragments drop to the ground with a rumbling or hissing noise. The speed of the falling mass is no greater than that of a stone of equal size coming down from the same height. Even in soft soil therefore the meteorites rarely bury themselves to a depth of more than a yard, and any damage done is only slight. Observation and timing of meteorites in flight show, however, that the speed at which they enter the earth's atmosphere is of a very different order; the observational data have never been sufficient for a very accurate determination, but it is certain that the initial velocity of meteorites amounts to many miles per second. This is slowed down by the increasing resistance the meteorite encounters when it enters the denser regions of the atmosphere, and kinetic energy is transformed into heat. The compressed air in front of the meteorite becomes luminous; what we notice as a fireball is mainly this mass of luminous gas of a diameter much greater than that of the solid body. The surface of the meteorite melts with the heat and gives off glowing particles which produce the luminous tail, and, later, the trail of smoke which can often be observed in the sky for some time after the disappearance of the other phenomena. As the flight of a meteorite inside the earth's atmosphere lasts only a few seconds, the heat produced on its surface has no time to penetrate deeply into the interior, which remains at the temperature of the outer void. If picked up immediately after its fall, a meteorite is usually too hot to handle, but after an hour or so this superficial heat is conducted away and the meteorite, if lying in moist ground, may well be covered with ice—an obvious proof of its low internal temperature. Because of their better conductivity, iron meteorites are warmed up to a somewhat greater depth than stone meteorites. The sound produced by the meteorite's flight—which is frequently described as terrifying, like the thundering of guns—is mainly due to the eddies of air behind the moving body, but sometimes also to the explosive rupture of the meteorite. It has occasionally been observed that the stones found in different places fitted together, thus showing that they were but fragments of the bigger mass which had entered the atmosphere.

It is customary to name a meteorite after the place nearest to which it came down on earth.

2. Meteorite Showers.— It has been mentioned before that meteorites often break into fragments shortly before reaching the ground; but sometimes that explosion occurs at a great height and the pieces produced further disintegrate during their flight through lower regions. In such cases a swarm of separate meteoritic bodies may arrive together, a phenomenon called a meteorite shower. The number of bodies in a shower can be very great; it was estimated that about 100,000 fell in 1868 at Pultusk (Poland), perhaps 14,000 in 1912 at Holbrook (Arizona), 2,000 to 3,000 in 1803 at L'Aigle (France), and 200 to 300 in 1808 at Stannern (Moravia). All these observed showers consisted of stones, but from the large concentrations of iron meteorites of one and the same type which have been found in certain areas we must conclude that showers of iron meteorites have also occurred; the numerous fine octahedrites (see section 6) near Bethany in Africa, the dozen or so hexahedrites in northern Chile (Coahuila) and the Hanbury craters in Australia (see section 8) are examples.

The area in which the stones fall is generally a rough ellipsis along the direction of flight. The larger the stone, the less will its velocity have been affected by air resistance and the farther, therefore, it travels. Accordingly, within this region, the stones are found to increase in average size in the direction of the flight. The stones of any one shower vary greatly in size and in shape.

3. General Appearance of Meteorites.— Although the shape of most meteorites is rather irregular, indicating that they all are fragments of some bigger mass, many of them show at least a rough approximation to a conical form. The explanation is that they frequently maintain their orientation to the direction of flight, and that the forward corners are morn away by the air blast until a rough cone is produced. From both front and rear of the meteorite, molten material is constantly blown away during the period of rapid flight; but when the velocity has been sufficiently reduced, the air acts as a cooling agent and helps to solidify the rest of the liquid material, which then forms the so-called crust. "Flow lines" in the crust and characteristic "pitting" often clearly indicate the direction of the air current. All this is true of irons as well as of stones.

On stone meteorites the molten crust is deep black and rarely more than $\frac{1}{25}$ in. thick; the contrast in colour between it and the whitish-gray interior with its shining specks of metallic iron is one of the most characteristic features of many stone meteorites and generally makes it easy to distinguish them from terrestrial rocks. From the more or less perfect development of the crust it is often possible to draw conclusions as to the length of time during which the surface had been exposed to the impact of hot air; the gradual breaking up of the stones in a shower can sometimes clearly be read from their crust. The crust of iron meteorites consists of an iron oxide and is dark brown. It is best seen in fresh falls; old finds have usually lost it.

4. Chemical Composition.— Meteorites consist of the same chemical elements as terrestrial matter; no element unknown on earth has ever been found in meteorites, and nearly all of the known ones can be detected, if sufficiently sensitive analytical methods are employed. The quantitative distribution of the elements, however. shows marked differences from terrestrial rocks not only in the iron meteorites, but also in the stone meteorites, as can be seen from the following table.

TABLE II.—*Composition of Meteorites and of the Earth's Crust*

Meteorites				Earth's Crust	
Irons		Stones			
Iron	90.8%	Oxygen	36.3%	Oxygen	49.4%
Nickel	8.;	Iron	2j.6	Iron	4.7
Cobalt	0.59	Silicon	18.0	Silicon	25.8
Phosphorus	0.17	Magnesium	14.2	Magnesium	1.9
Sulphur	0.04	Aluminum	1.5	Aluminum	7.j
Carbon	0.03	Nickel	1.4	Nickel	0.02
Copper	0.02	Calcium	1.3	Calcium	3.4
Chromium	0.01	Sodium	0.6	Sodium	2.6
		Chromium	0.27	Chromium	0.03
		Phosphorus	0.19	Phosphorus	0.12
		Manganese	0.18	Manganese	0.08
		Cobalt	0.14	Cobalt	<0.001
		Potassium	0.13	Potassium	2.4
		Titanium	0.10	Titanium	0.58

The figures given represent the average composition of iron and stone meteorites. Individual meteorites show considerable variations; *e.g.*, the nickel content of iron meteorites may be as low as 5%, or as high as 20%.

The identity of the chemical elements found in meteorites and

on earth is most convincingly proved by their isotopic composition. Since most elements contain various kinds of atoms, it would be conceivable that the relative proportion of the atoms in meteoritic elements might not be the same as in terrestrial ones. Very careful investigations have, however, established that the relative abundance of the isotopes of carbon, oxygen, silicon, chlorine, iron, cobalt and nickel is constant, from whatever source these elements are derived.

5. Mineralogical composition. — The chemical elements present in meteorites are mostly combined in well-defined compounds. Many of these minerals are also found in terrestrial rocks, but others are completely absent. Table III gives a selection of the most important meteoritic minerals.

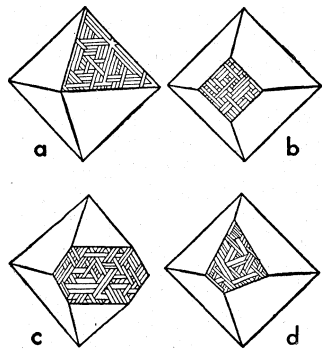
TABLE 111.—Important Meteoritic Minerals

Elements	Name of Mineral	Chemical Composition	Formula
	Diamond; graphite	Carbon	C
Alloys	Kamacite	iron with 5% to 7% nickel	Fe; Ni
	*Taenite	iron with 13% to 48% nickel	Fe; Ni
Sulphides, Phosphides and Carbides	*Oldhamite	calcium sulphide	CaS
	Troilite, Pyrrhotite	iron sulphide	FeS
	*Daubréelite	iron-chromium sulphide	$FeCr_2S_4$
	*Schreibersite; *Rhabdite	iron-nickel phosphide	$(Fe,Ni)_3P$
	Cohenite	iron carbide	Fe_3C
Chlorides	*Lawrencite	ferrous chloride	$FeCl_2$
Oxides	Quartz; Tridymite	silicium oxide	SiO_2
	Magnetite	iron oxide	Fe_3O_4
Silicates	Plagioclase	sodium-aluminum, and calcium-aluminum, silicate	$NaAlSi_3O_8$ and $CaAl_2Si_2O_8$
	Enstatite	magnesium silicate	$MgSiO_3$
	Diopside	magnesium-calcium silicate	$MgCa(SiO_3)_2$
	Olivine	magnesium-iron silicate	$(MgFe)_2SiO_4$

Asterisks in the above table indicate that the minerals are known in nature only from meteorites; they can, however, easily be prepared in the laboratory, and that they are not found on the earth is obviously because under terrestrial conditions they would quickly be decomposed by oxygen or water. It is equally significant that some of the most abundant terrestrial minerals are missing in meteorites, especially those which have been formed by crystallization from aqueous solutions, such as, for instance, calcium carbonate ($CaCO_3$).

6. Structure. — The minerals mentioned in Table III coalesce in very characteristic ways to form the fabric of stone and iron meteorites. This structure of the meteorites can best be seen in a cross-section; for the recognition of details a microscope is often essential. About 90% of the stone meteorites contain very peculiarly rounded spherules, called chondrules, sometimes easily recognizable without magnification, sometimes only of microscopic dimensions. They consist of olivine, enstatite or another of the meteoritic minerals, and are embedded in a ground-mass of similar material. The structure of chondrites — as the stone meteorites containing chondrules are called — vaguely resembles that of some terrestrial rocks, the volcanic tuffs, but has several distinguishing features; *e.g.*, the eccentricity of the point from which the fibres in the chondrules diverge and the not uncommon enclosure of one chondrule inside another. The comparatively few chondrule-free stone meteorites are called achondrites.

The structure of the iron meteorites is best revealed by etching a ground cross-section with dilute acid. Most iron meteorites reveal then a very unusual design, called affer its discoverer the "Widmanstatten pattern." It consists of bands of kamacite with narrower borders of taenite (*see* Table 111), the meshes being filled with a mixture of these two alloys. The pattern shown on the planes is to be interpreted as the section through a three-dimensional structure, a system of lamellae parallel with the faces of an octahedron. The angles at which the kamacite bands meet depend on the direction in which the section is cut (*see* fig. 1) and are, therefore, not characteristic; but the width of the bands is, and varies so considerably that the classification of the iron meteorites with octahedral structure, the octahedrites, is conveniently based on it. We distinguish octahedrites as of coarsest structure, having kamacite bands of a thickness of 2.5 mm. ($=\frac{3}{20}$ in.) and over, coarse structure (bands 1.5 to 2.0 mm.), medium (0.5 to 1 mm.), fine (0.2 to 0.4 mm.), and finest structure (0.2 mm. and under). The respective symbols for these classes of octahedrites are Ogg (*g* standing for the German *grob*, meaning coarse), Og, Om, Of, and Off.



FROM A PAPER BY G. TSCHERMAK, VIENNA

FIG. 1.—STRUCTURE OF AN OCTAHEDRITE

On etching, another group of iron meteorites do not reveal the figures significant for octahedral structure. Here the surface of an etched plane remains quite uniform but for the occasional appearance of very narrow straight lines in different directions called Neumann lines after their first observer. The angles of the Neumann lines, and the cleavage of the meteorites which possess them, are indicative of a cubic structure; these meteorites are, therefore, called hexahedrites (classification symbol: H). Hexahedrites consist of the same iron-nickel alloy (about 6% nickel) as the kamacite bands of the octahedrites which, as a whole, have a nickel content up to 15%, owing to the presence of the nickel-rich taenite; the kamacite bands are usually the finer, the higher the nickel content of the octahedrites. Some iron meteorites contain less than 6%, or more than 15%, nickel; they show neither Widmanstätten structure nor Neumann lines and hexahedral cleavage, and are called nickel-poor and nickel-rich ataxites, respectively.

The stony-irons form the transition group between iron and stone meteorites. Some, the lithosiderites, contain so much iron that in sections this element appears as a coherent mass which includes separated stony parts, and shows in the larger areas well-developed Widmanstatten structure; others, the siderolites, are very similar to stone meteorites, but contain an unusually large quantity of interspersed metallic iron.

The appearance of the Widmanstatten pattern on an etched iron-nickel alloy is definite proof of its meteoritic origin; an artificially produced alloy of the same composition does not show it. The explanation is that the alloy solidifies first as a whole and that the separation into the two constituents of the Widmanstätten structure, the nickel-poor kamacite and the nickel-rich taenite, takes place only afterward; such an internal rearrangement of a solid phase is an extremely slow process, and it may have taken thousands of years for the beautiful Widmanstätten pattern in meteorites to develop. If we carefully cool an iron-nickel alloy very slowly, we may obtain a somewhat similar structure, but only on a microscopic scale. If, on the other hand, we heat a meteorite, without melting it, up to a temperature of not less than 850° C. (=1,562° F.), the Widmanstatten pattern is completely destroyed and cannot be restored; it may be difficult to distinguish such a meteorite from ataxites and from artificial irons.

7. Size. — Meteorites can be of any size. In a large meteorite shower, many of the stones are often no bigger than a pea; they may, nevertheless, be covered all over by the typical black crust and to all intents and purposes be complete meteorites. It is frequently reported that still smaller bodies and "dust," come down; under favourable circumstances, *e.g.*, when the ground is covered by snow, these black dust particles can be collected and identified as miniature meteorites. On the other hand, some meteorites are very large. The biggest known stone meteorite is that of Long Island, when found it had been broken on impact into four large and more than 3,000 small fragments of a total weight of more than 1,230 lb. Several somewhat smaller stones were actually

seen to fall; that of Paragould (Arkansas) weighs about 880 lb., of Bjurbole (Finland) 730 lb., and of Knyahinya (Czechoslovakia) 640 lb. Still more impressive in bulk are some iron meteorites, though the heaviest ones observed in flight are smaller than these stone falls; there was one at Treysa in Germany of 139 lb., one at Cabin Creek in Arkansas of 106 lb. and one at Hraschina in Croatia of 88 lb. On the west coast of Greenland, near Cape York, four big iron meteorites have been collected; the largest, weighing 79,200 lb. is now in New York. A still more massive one, Hoba, estimated at 132,000 lb. was lying in 1947 where it fell in South-West Africa.

There is a brief report on a gigantic stony-iron meteorite discovered in 1921 in the Adrar desert in French West Africa, but the meteoritic nature of the whole mass has not been established beyond a doubt. We possess, however, indirect evidence that much bigger iron meteorites than Hoba have occasionally struck our earth, producing by their impact the so-called meteorite craters (see section 8).

8. Meteorite Craters. — In Arizona, southwest of Winslow, a large level plane of limestone and sandstone is interrupted by a roughly circular crater of 1,200 *m.* in diameter. All attempts to explain its origin by familiar geological forces, such as volcanic action or gas explosions, proved impossible, and the view is now generally held that the crater was produced by the impact of an enormous iron meteorite. This assumption can explain all the very peculiar geological features: the craterlike depression; the presence of pulverized and partly molten sandstone mixed with particles of nickel-iron inside the crater; the huge upward tilted rocks on the crater rim, and the many rock fragments lying outside. More convincing still, a great number of iron meteorites, ranging in size from little pieces to blocks weighing hundreds of pounds, have been found lying in the neighbourhood of the crater up to a distance of many miles. Admittedly, the main mass of the supposed giant meteorite — which would have to be of the order of millions of tons — has not yet (1947) been located, but the asymmetry of the crater walls seemed to indicate that it came down not vertically, but from the north, and buried itself under the southern rim; special borings carried out there actually revealed the presence of considerable quantities of nickel-iron, at a depth of 400 yd., which may be the top of the meteorite.

Once the geologists' attention had been drawn to this new principle for the explanation of crater formation, in several other regions of the earth round depressions were discovered which appeared to demand the same interpretation. The case for a meteoritic origin of such a crater can be considered as proved if, in the crater or in its immediate vicinity, fragments of an iron meteorite are found; in their absence final judgment frequently has to be withheld.

To the west of Hanbury, in central Australia, 13 craters are situated within an area of half-mile square; they are all much less conspicuous than the Arizona crater, as the largest diameter is only c. 200 yd. and the smallest 9 yd., and most of the crater walls have been removed by erosion. It is mainly their capacity to hold rain water and the resulting growth of trees in an otherwise arid land which reveal their presence. A great quantity of nickel-iron fragments are scattered over the whole region; they are of all shapes and vary in weight from a fraction of an ounce up to 290 lb. Their jagged form and the distortion of their Widmanstatten pattern show more clearly than in the case of the Arizona irons that they are fragments, dispersed in a plastic state at the moment of the explosive formation of the craters; another indication of the heat then produced is the presence of black glassy material, obviously formed by the fusing of the country-rock as a result of the impact of the meteorite. In view of all this evidence, the inevitable conclusion is that the Hanbury craters were made by a shower of at least 13 separate iron meteorites (see section 2).

Other craters whose meteoritic origin seems beyond doubt are situated near Wabar in the Arabian desert, on the island of Ösel in Estonia and in five or six other places. No convincing evidence had been forthcoming so far (1947) that a few craters near the Tunguska river in Siberia owe their origin to the enormous meteorite which on June 30, 1908, was widely seen, and whose fall, devastating large areas of woodland in that region, was recorded by many distant barographs and seisniographs. It may be that it consisted of stone and that, therefore, the search for meteoritic material undertaken 15 years later, was unsuccessful.

9. Glass Meteorites. — In addition to the stone and iron meteorites and the intermediate class of stony-irons, there is another group of bodies to be found on earth which must be considered as of meteoritic origin, although their fall has never been observed. In several widely separated regions, in Czechoslovakia (near the river Moldava), Australia, Billiton in the Netherlands Indies, Indo-China and four or five other districts, large numbers of little pieces of glass are strewn over the surface of the earth. They are called "tektites" (molten bodies) and are named after the place where they were found as moldavites, australites, billitonites, indochinites, etc. Those in Bohemia and Moravia are green and transparent; the others are mostly opaque, and dark brown to black in colour. In shape they differ; the most varied forms are exhibited by those from Australia. Their high silica content and, therefore, elevated melting point exclude the possibility of their being products of a prehistoric glass manufacture; their geographical distribution shows no connection whatsoever with a supposed volcanic origin, and, moreover, they cover such extensive parts of the earth's surface — many millions of australites are strewn over an area of more than 2,000,000 sq.mi. — that only the hypothesis that they fell from the sky seems to fit all the facts. As there is not a single well-authenticated record of the fall of such a glass meteorite, let alone of a whole shower, we must supplement our hypothesis by the further assumption that this event was confined to a comparatively short period in the past history of the earth; the strata on which they were found belong to the late Tertiary and early Quaternary.

10. Frequency, Geographical and Geological Distribution. — A statistical survey of all meteorites whose hour of fall is known shows clearly that more of them hit the earth in the afternoon than in the morning. The figures are about 240:155. From this we must conclude that at least the majority of the meteorites move in "direct" orbits, *i.e.*, in the same direction around the sun as does the earth; perhaps there are no "retrograde" meteorite orbits at all, for those falling in the morning hours may have been overtaken by the faster revolving earth. The number of meteorite falls observed during the various months of the year is greatest in June, and fairly high in the adjoining months. This may not, however, be because of any astronomical reason, but simply because in the summer months a greater number of potential observers are likely to be out-of-doors than in winter.

The same caution has to be applied if we discuss regularities of the geographical distribution of meteorite falls. It is only natural that many more have been recorded from densely populated and, at the same time, highly civilized countries than from other parts of the world. Some rather curious facts, as for instance the relative frequency of very heavy stone meteorite showers during a period of only 60 years in eastern Europe (Stannern and Knyahinya in Czechoslovakia, Mocs in Hungary, Pultusk in Poland) can be understood as due to the frequency fluctuations which any statistics based on a very small number of observations is likely to show. The geographical distribution of meteorite finds made in recent times is, in some ways, the reverse of that of falls. Here the largest contributions have come from lonely places such as the coast of Greenland, the deserts of Chile and Mexico, etc. It is understandable that no appreciable chance of discovering a big iron meteorite exists in countries of an old civilization, where such a valuable object would have been utilized long ago. Although the plowing of fields and, in recent years, scientific searching with magnetic devices have helped to trace a large number of iron meteorites, none have been unearthed by mining operations in greater depths of the earth. This fact is rather astonishing if we consider that alone the quantity of coal mined during the last century is to be reckoned in many billions of tons; if the same average number of meteorites had fallen during the period when the coal deposits were formed as in recent years, about a thousand meteorites should have been dug

out with the coal; it is impossible to assume that every miner would have overlooked such an unusual find. Equally complete is the absence of meteorites in any other geologically old material that has been dug up in the course of technical operations. It may further be significant that the collections of strange objects brought together by stone-age men contain glass meteorites (moldavites), but no iron meteorites.

The conclusion seems unavoidable that — quite different from the case of glass meteorites (see section 9) — the iron and stone meteorites did not begin to fall before the middle of the Quaternary. There are indications that their frequency was then, for a time, higher than it is now; for it was general knowledge in the centuries before Christ among Mediterranean people that iron was a celestial metal (see section 13), and the very small number of iron meteorites which can now be observed to fall could hardly have created such a widespread belief. Between 1800 and 1900 scientists made careful records of all meteorite falls; during that century the methods of communicating news steadily improved and the general level of education and the interest in natural phenomena rose, but the annual number of reports on meteorite falls, averaged over ten years, remained fairly constant at between four and five. This seems to point to an actual diminution in the number of falls even after 1800; the data, however, are too scarce to allow any definite conclusion as to whether we are approaching a time when once again no meteorites will be falling on earth.

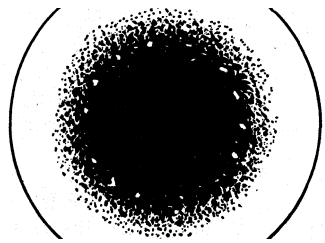
11. Age of Meteorites. — If we speak of the age of a meteorite, we do not mean the time since its arrival on earth, but since its solidification — wherever this may have taken place. It is the same sense in which geologists speak of the age of a rock or mineral. Knowledge of the geological age of meteorites is of interest in connection with the question of their origin.

Like all other rocks, meteorites contain minute traces of uranium and thorium and it should, therefore, be possible to apply to them the radioactive methods of age determination; their principle is to measure the quantities of lead or helium which have accumulated since solidification as a result of the radioactive decay of uranium and thorium. The lead method, however, is not applicable to any meteorite, because they are contaminated by too much original lead; and the helium method is not reliable for stones because they are not gas-tight. Iron meteorites, however, occlude the helium produced therein so safely that even heating to 1,000° C. cannot drive it out. Unfortunately, iron meteorites contain less uranium and thorium than the poorest rocks or even stone meteorites (see Table IV). This makes the measurements difficult, and so far only those comprised in Table V have been completed. From the last column of Table V, it appears that there are iron meteorites which are at least twice as old as the most ancient rocks found in the earth's crust, but that others have solidified at much later periods.

TABLE IV.—*Average Uranium and Thorium Content of Rocks and Meteorites (in 10^{-6} gm. per gm.)*

	Uranium	Thorium
Acidic igneous rocks	4.1	13.0
Basic igneous rocks	1.1	3.9
Stone meteorites	0.35	1.0
Iron meteorites	0.007	0.04

12. Origin of Meteorites. — Many hypotheses have been conceived to explain how meteorites come into existence. Early 19th century scientists believed them to be ejected from the craters of the moon; others thought that big terrestrial volcanoes might have done that in past geological epochs. Later a connection with comets was assumed, or even an independent growth from gaseous interstellar matter. The theory which seems best to account for all the facts known to us today, however, is the origin of meteorites as the result of the breaking-up of a planet, similar in size and composition to the earth. The irregular form (see section 3) and varying size (see section 7) of meteorites is certainly in accordance with their interpretation as fragments of a larger body. The iron and stone meteorites, with the stony-iron between, form a continuous series for which a common origin must be assumed; a similar separation into three components — iron, a mixture of iron with stone, and stone — from an originally homogeneous mixture, probably took place when the earth solidified from a uniform liquid mixture. Fig. 2 represents a cross-section through the earth, showing the iron core in the centre, the silicate shell outside, and, between the two, a zone of mixed iron and silicates as assumed by some geologists. On complete disruption such an earth would yield some kind of stone, stony-iron and iron meteorites; the geological age of some of the iron fragments from the interior might well prove to be greater than that of any rocks from the crust (see section 11). It is, however, by no means certain that there would be a close resemblance between these terrestrial fragments and meteorites. Some of the meteorites we know have a very complicated structure, revealing a long and wild geological history, not a smooth separation into phases; many chondrites, and several of the lithosiderites include angular stony pieces, indicating that the last synthesis must have been preceded by the breaking into fragments of another solid body; these fragments were at some later stage cemented together by the stony ground mass of the chondrites and the iron of the lithosiderites respectively. No process known to geologists accounts for that, nor have real chondrules ever been found in terrestrial material (see section 6). A further difference is evident from the presence in meteorites of minerals missing on earth (see section 5). The body from which meteorites sprang must have been a member of the solar system; we cannot otherwise account for the predominance of direct orbits among meteorites (see section 10), or for the identity in the isotopic composition of meteoritic and terrestrial elements (see section 4). It cannot have been much smaller than the earth, because otherwise its gravitational field would not have been strong enough to separate the iron core from the stone layer. It might have been the hypothetical planet between Mars and Jupiter, whose disruption is supposed to have created the asteroids; there is, perhaps, no essential difference between the smallest asteroids which we can discern in the sky and the huge iron and stone masses which we hold responsible for the meteorite craters on earth (see section 8; incidentally, it may be remarked that the craters on the moon may have the same origin). On the other hand, the much more common meteors, or shooting stars, may be nothing but meteorites too small to survive the consumption of matter during the flight through the atmosphere. Some meteors (*e.g.*, the Leonids) are travelling in swarms which, through the centuries, have met the earth from time to time, but no longer do so, their orbits having been changed by the influence of the big planets. A similar explanation may be given for the fact that the fall of meteorites did not take place before the middle of the Quaternary, and that their frequency seems to



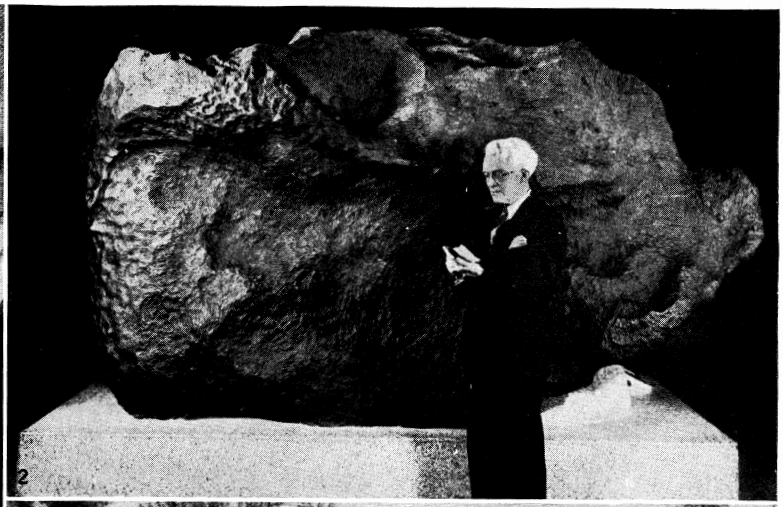
FROM A PAPER BY L. A. ADAMS AND H. S. WASHINGTON, WASHINGTON, D. C.

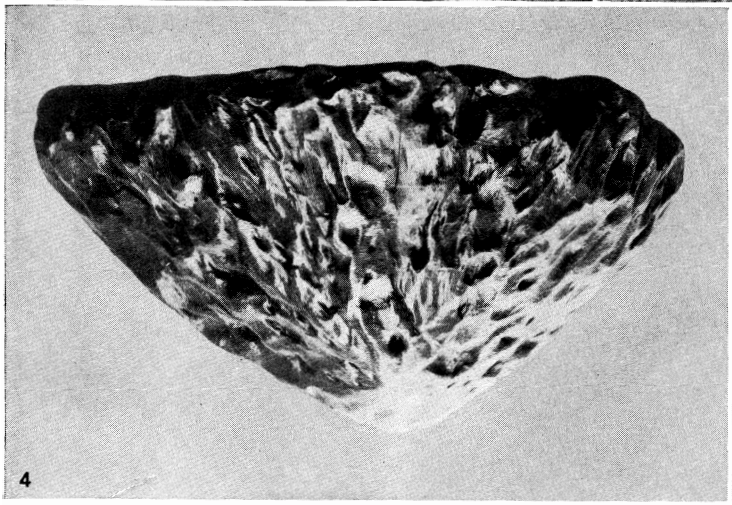
FIG. 2.—CROSS SECTION OF THE EARTH

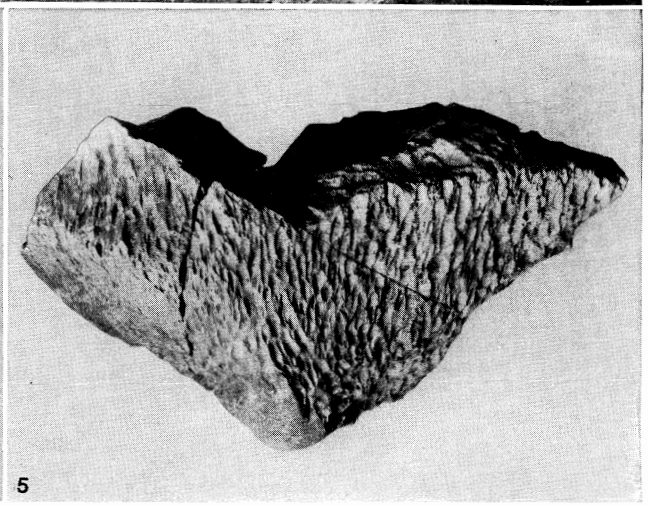
TABLE V.

Name of Meteorite	Class	Nickel (%)	Uranium (10^{-8}gm./gm.)	Thorium (10^{-8}gm./gm.)	Helium (10^{-6}c.c./gm.)	Age in Millions of Years
Bethany, Goamus	Of	8	1	4	0.15	60
San Martin	H	5.3	0.6	8	1.6	500
Bethany, Amalia	Of	8	1	4	3.0	1,100
Carthage	Om	7.7	0.5	4	25	6,500
Thunda	Om	8.5	0.8	4	28	6,100
Mount Ayliff	Og	6.6	0.4	2	40	7,600

METEORITES



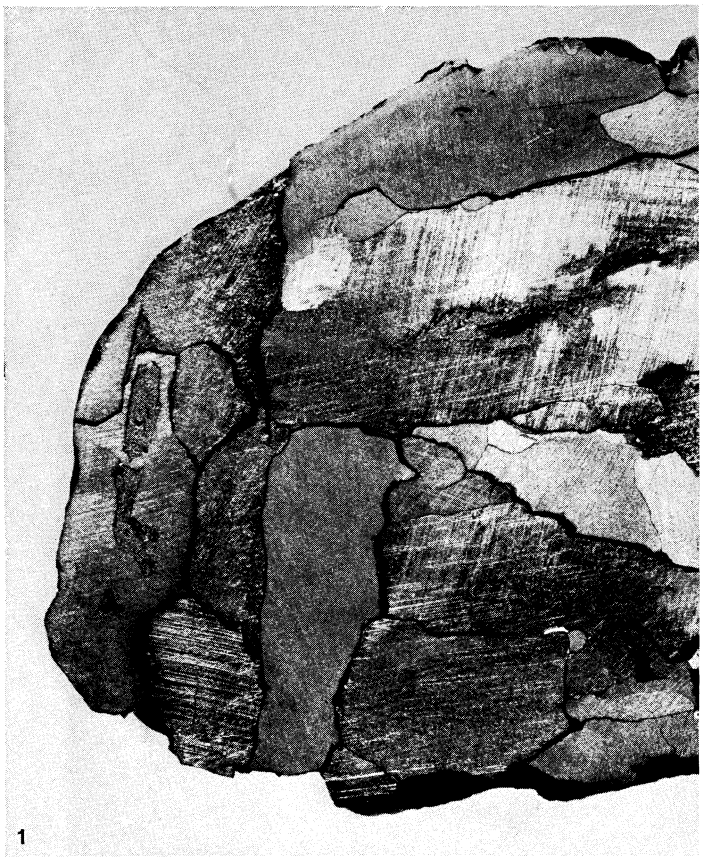




BY COURTESY OF (2) DR. CLYDE FISHER, AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK; (3) DR. W. T. GORDON, KING'S COLLEGE, LONDON; (4) BRITISH MUSEUM, NATURAL HISTORY DEPARTMENT, LONDON; (5) CHICAGO NATURAL HISTORY MUSEUM

1. Fall of a stone meteorite near Maurkirchen on Nov. 20, 1768 (reproduction of an anonymous German print of 1769)
2. Iron meteorite; Ahnighito (about 79,000 lb.)
3. Iron meteorite; Hoba (about 132,000 lb.)
4. Iron meteorite; Morito (about 24,000 lb.)
5. Stone meteorite; Long Island, after the four largest pieces have been fitted together (about 1,100 lb.)

METEORITES



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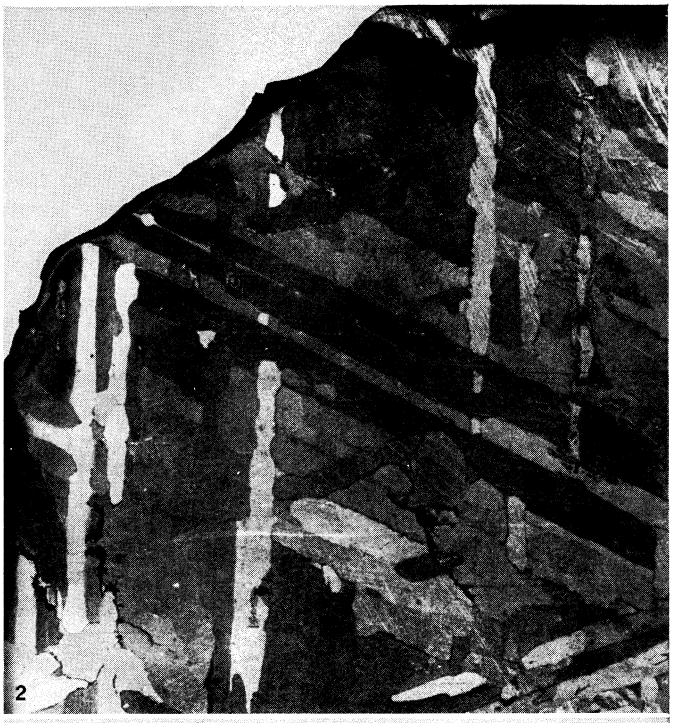

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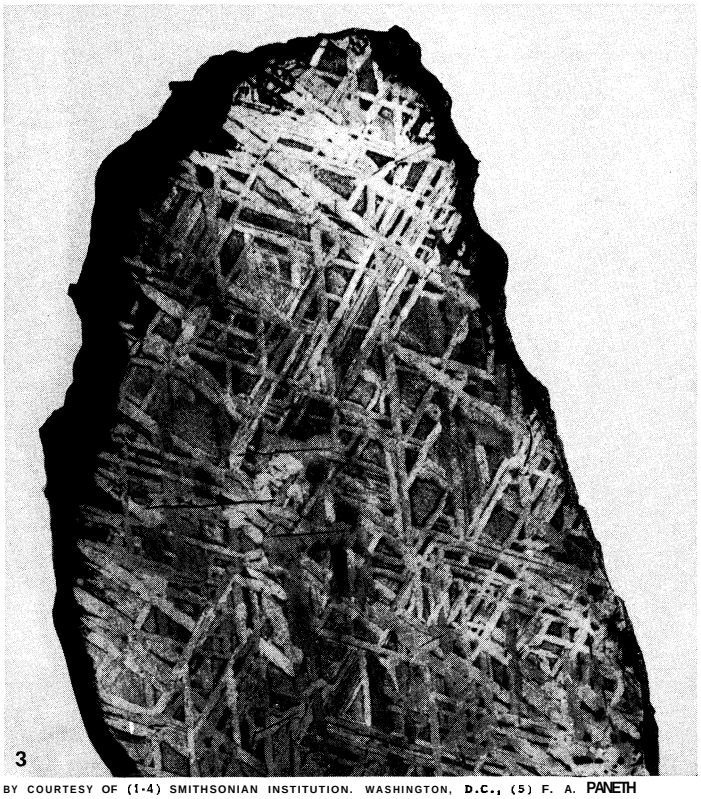
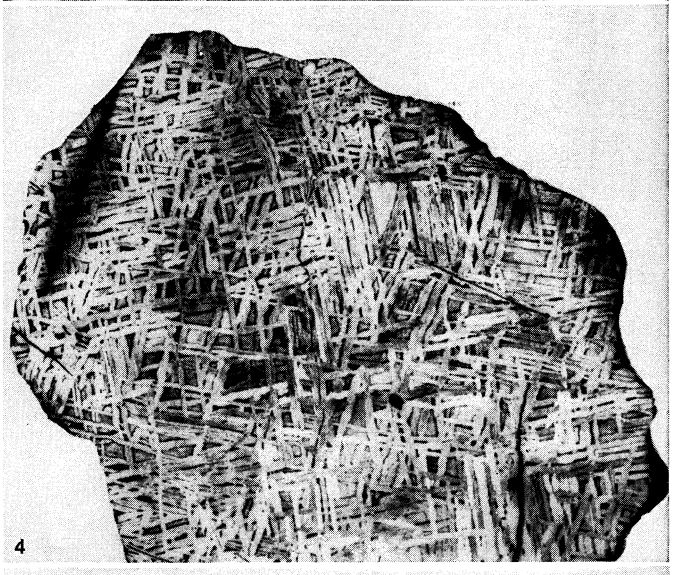


3



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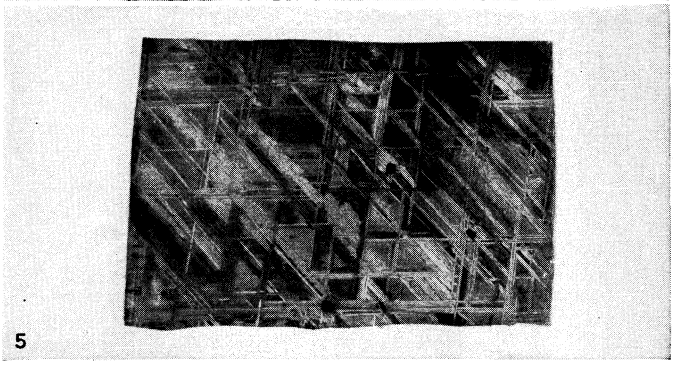
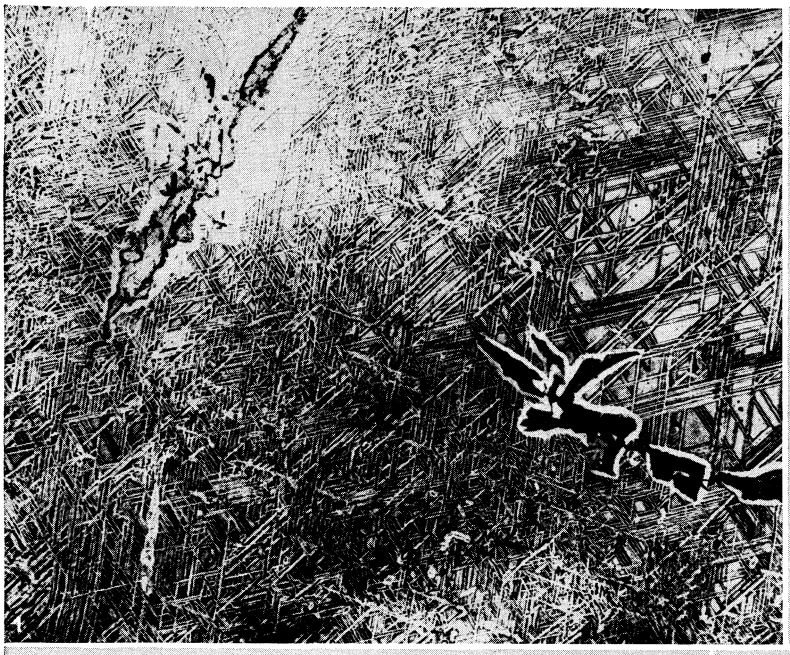


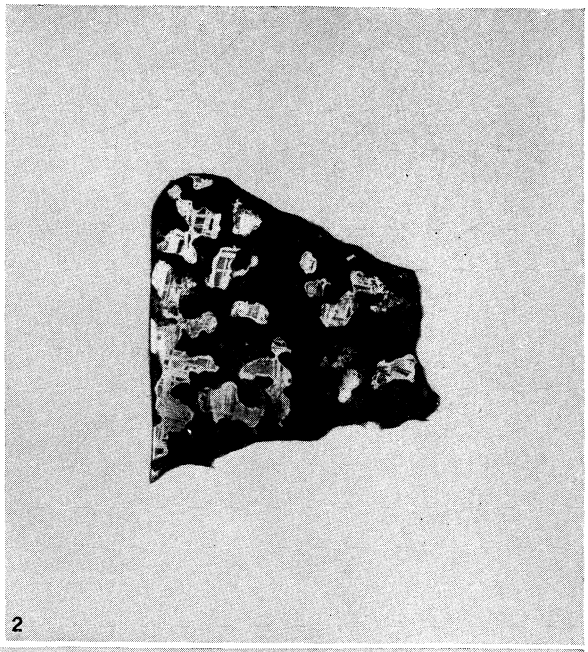
5

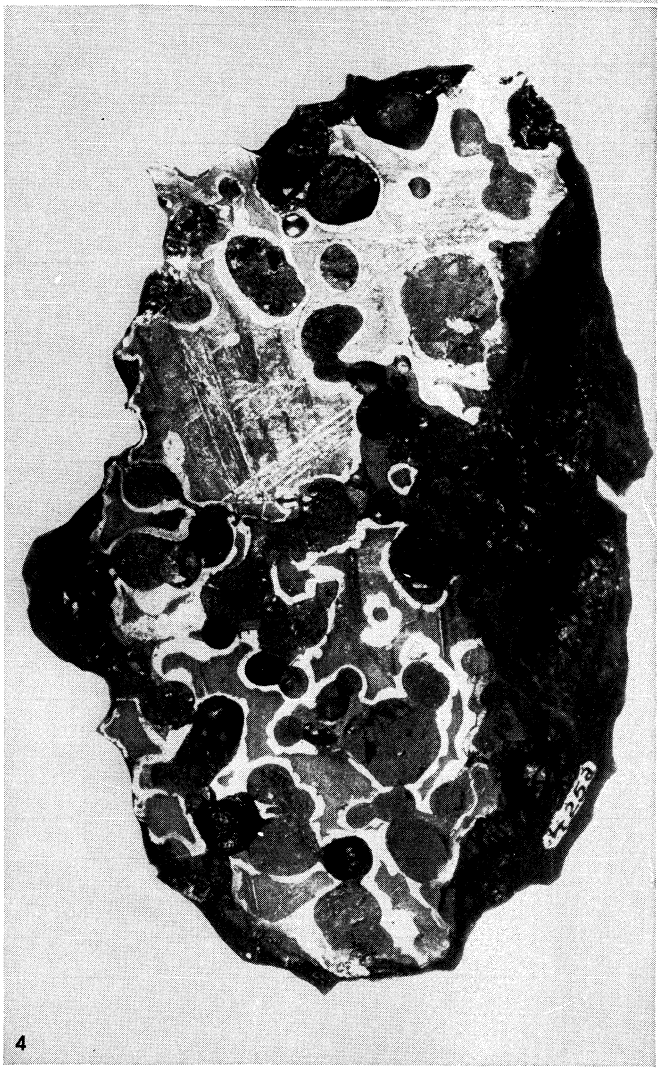
BY COURTESY OF (1-4) SMITHSONIAN INSTITUTION. WASHINGTON, D.C., (5) F. A. PANETH

1. Very coarse octahedrite; Sandia mountains
2. Coarse octahedrite; Arispe
3. Medium octahedrite; Staunton
4. Medium fine octahedrite: Drum mountain
5. Fine octahedrite; Muonionalusta

ALL FIGURES IN NATURAL SIZE





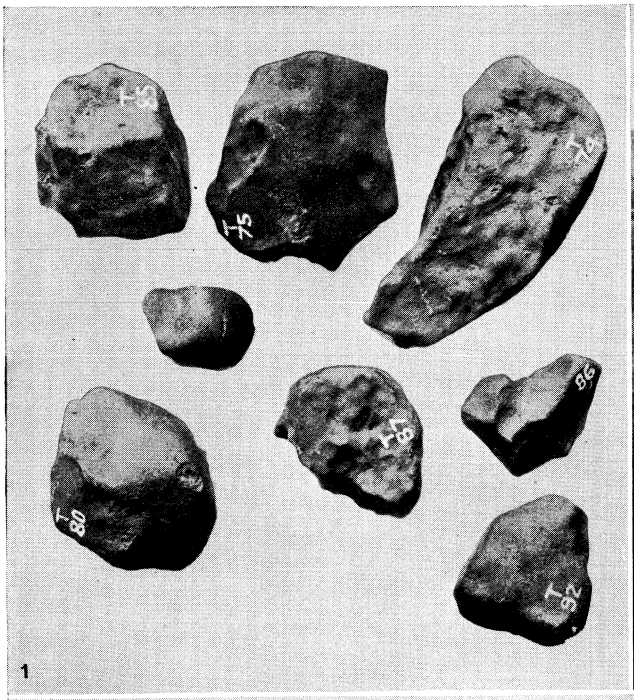


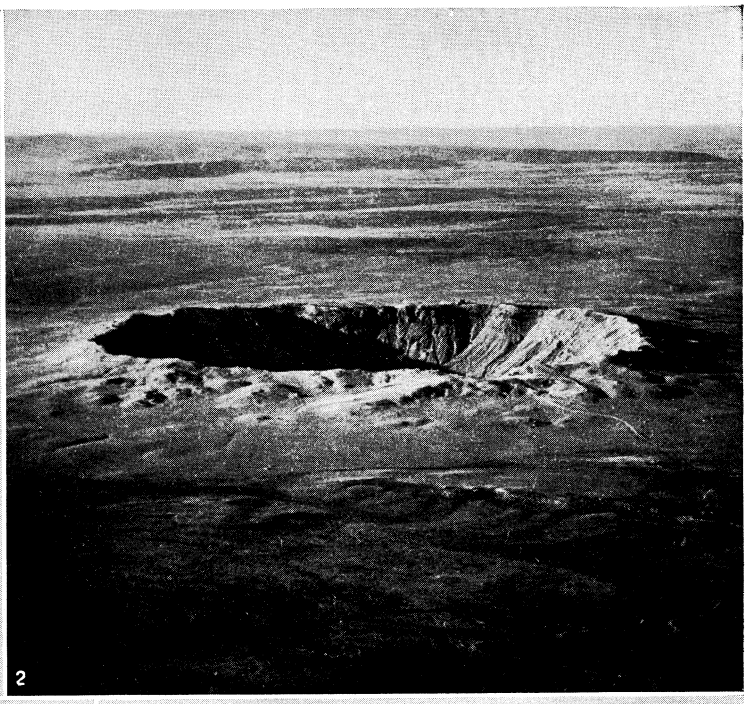
BY COURTESY OF (1, 3) SMITHSONIAN INSTITUTION, WASHINGTON, D.C., (2, 4) F. A. PANETH

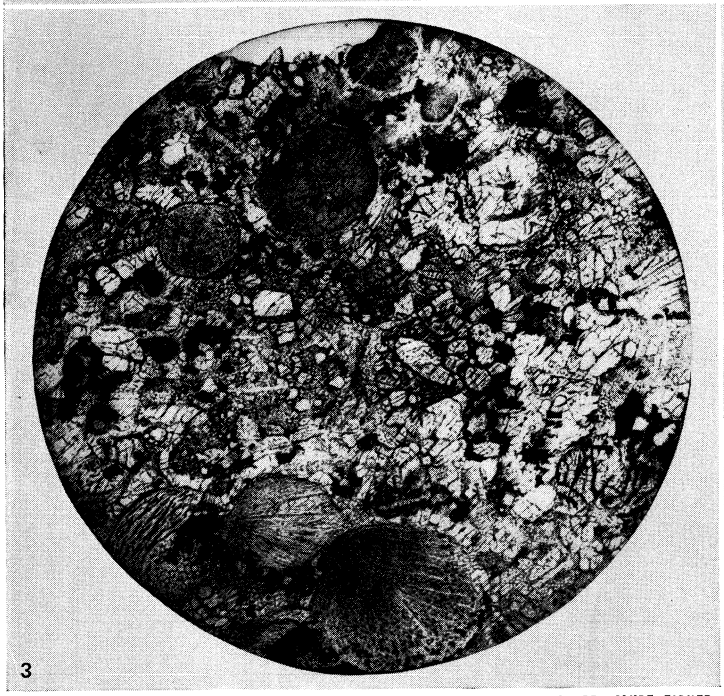
1. Very fine octahedrite: Carlton
2. Siderolite; Steinbach
3. Hexahedrite; Coahuila
4. Lithosiderite: Brenharn township

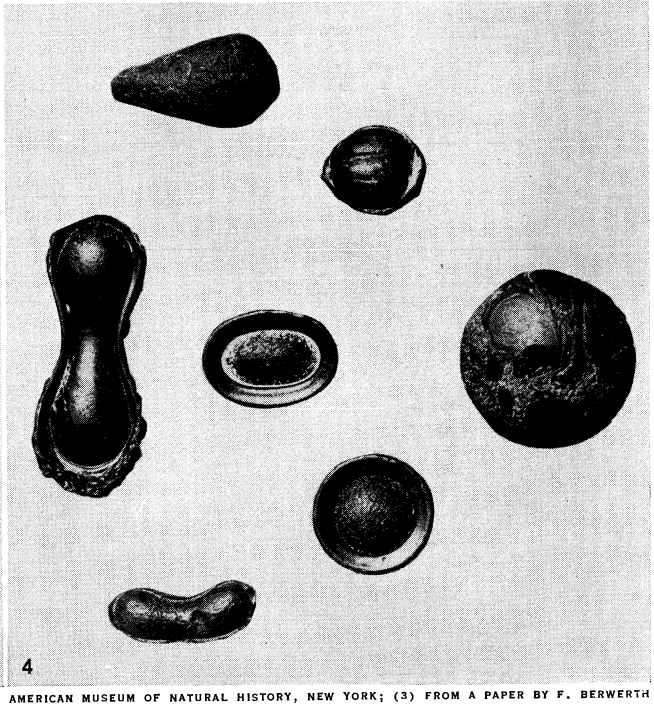
ALL FIGURES IN NATURAL SIZE. THE DARK PORTIONS IN FIGS. 2 AND 4 ARE STONE. THE LIGHTER ONES. SHOWING WIDMANSTATTEN STRUCTURE IN SOME PLACES. ARE IRON

METEORITES









BY COURTESY OF (1, 4) BRITISH MUSEUM (NATURAL HISTORY), LONDON; (2) DR. CLYDE FISHER, AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK; (3) FROM A PAPER BY F. BERWERTH (VIENNA, 1901)

1. Stones from the Tenham shower (reduced to about ¼)
2. Meteor crater in Arizona from a plane at 2,000 ft.
3. Microstructure (magnification x 20) of chondrite; Zavid
4. Australites (natural size)

have been greater before Christ than now (see section 10).

While the disruption of a small member of the solar system seems to be the best explanation which today can be given for the origin of meteorites, we can not hope to develop a scientifically sound, detailed picture of the processes involved so long as some fundamental questions of astrophysics, *e.g.*, that concerning the origin of the planets themselves, are not answered. We may, however, be confident that all essential progress in our understanding of the formation of meteorites will help in the solution of the many puzzling problems connected with the solar system, its origin and final fate.

13. History of Meteoritics.—The knowledge of the fall of meteorites is of extreme antiquity, but the scientific study of meteorites is hardly older than 150 years.

Long before man learned to smelt iron, he used meteorites for the manufacture of iron tools, and we have proof that he knew of the precious metal's celestial origin; for in many languages the name for it contains a reference to the sky, and in some records its origin is contrasted with that of terrestrial metals like gold, silver and copper. The awe-inspiring phenomena accompanying the fall of meteorites convinced primitive people all over the world that they came from the gods; accordingly we find them as objects of awe in many cults, and frequently venerated in temples. One of the best known instances is probably that of the Ephesians; they were worshippers not of the goddess Diana and of the "image which fell down from Jupiter." as the very unfortunate translation of Acts xix, 35, runs in the authorized English version, but of Diana and of the "thing that fell from the sky," obviously a meteorite. Similarly, in Delphi besides Apollo a holy stone was the, object of adoration. The "iron shield" which fell in Rome under the reign of Numa Pompilius was put in the perpetual custody of a college of 12 priests. The "Black Stone" of the Kaba, the holiest of holies of the Mohammedans, is no doubt a stone meteorite with its strange black crust. In the ruins of an ancient Mexican temple an iron meteorite was unearthed, carefully wrapped in mummy cloths. A stone which fell in 1492 near Ensisheim in Alsace was interpreted by King Maximilian I of Germany as an exhortation to a crusade against the Turks, and hung by his order in the village church, where it can still be seen. In India, a stone that fell not long beiore 1885 was worshipped, decked with flowers and daily anointed. Many more examples could be cited.

It was just this miraculous character of meteorite ialls and the favour they found with the churches which, during the period of enlightenment, made scientists suspicious of their reality. In the 18th century members of the French academy, then the highest authority in all scientific matters, were convinced that such an irregular phenomenon as the iall of a stone from heaven was impossible, and preierred to doubt all the reports of witnesses and to change their statements to conform with acknowledged scientific theories. Following their lead, keepers in many museums of Europe discarded genuine meteorites as shameful relics of a superstitious past. It is an interesting iact that the preservation of the precious iron meteorite of Hraschina, which fell in 1751, is due to the protection given to it by the bishop of Zagreb's consistory; they collected the sworn statements of eyewitnesses and sent the document, together with the iron, to the Austrian emperor. Both came into the possession oi the Vienna museum. The influence of this clerical report on the Hraschina fall went even further; it became one oi the strongest weapons in the hand of the German physicist E. F. F. Chladni when he began his fight against the scientific authorities mho ridiculed belief in meteorites. His paper of 1794, in which he defended the trustworthiness of this and oi a few similar accounts and explained meteorites as being pieces of cosmical matter which enter our atmosphere, marks the beginning oi the science of meteoritics. Most of his colleagues remained skeptical; but a shower of stones which fell from the sky in 1803 at L'Aigle, not far from Paris, finally convinced the Paris academy and the rest of the scientific world of the reality of the iall of meteorites. From then on astronomers, physicists, chemists and mineralogists of many countries have contributed to our knowledge. A meteoritical society in the United States publishes regular reports on new discoveries and studies in the periodical *Popular Astronomy*. Collections oi meteorites are to be found in most natural history museums; the richest and most instructive ones are those in Vienna, Berlin, Paris, London, New York, Chicago and Washington, D.C.

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METEOROLOGICAL SOCIETIES. The first meteorological society was the Societas Meteorologica Palatina in Mannheim. Ger. (1780–1792), which published the *Ephemerides* (1783–1795). Next to be organized was the Meteorological Society of London (1823–1843). Contemporary societies are listed below.

The Royal Meteorological society, London, was iounded in 1850 and known as the British Meteorological society until 1871; it publishes the *Quarterly Journal* (1873 *et seq.*) and *Weather* (1946 *et seq.*). The Scottish Meteorological society (founded 1855) was incorporated with the Royal Meteorological society in 1921. Societe Meteorologique de France, Paris (1852), publishes *La Météorologie* (1926 *et seq.*) and *Journal Scientifique de la Météorologie* (1949 *et seq.*). The American Meteorological Society of Boston (1919) publishes the *Bulletin* (1920 *et seq.*), *Journal of Meteorology* (1944 *et seq.*), *Meteorological Monographs* (1947 *et seq.*), *Weatherwise* (1948 *et seq.*) and *Meteorological Abstracts and Bibliography* (1950 *et seq.*). The Meteorological Society of Japan. Tokyo (1882), publishes the *Journal* (1903 *et seq.*). Meteorological Society of China, Nanking (1924), published the *Meteorological Magazine* (1932 *et seq.*). Deutsche Meteorologische Gesellschait (1883) publishes *Meteorologische Rundschau* (1947 *et seq.*). Österreichische Gesellschait für Meteorologie, Vienna (1865), publishes *Wetter und Leben* (1948 *et seq.*). Magyar Meteorológiai Tarsasag. Budapest (1932), publishes *Időjárás* (1897 *et seq.*). Polskie Towarzystwo Meteorologiczne i Hydrologiczne, Warsaw (1947), publishes *Przeglad Geofizyczny*, formerly *Przegląd Meteorologiczny i Hydrologiczny* (1948 *et seq.*). Société Belge d'Astronomie, de Météorologie et de Physique du Globe, Brussels (1895), publishes *Ciel et Terre* (1880 *et seq.*). Others are: Vereiniging voor Sterrenkunde, Meteorologie, etc., Antwerp (1944); Societa Italiana di Geofisica e Meteorolopia, Genoa (1953), successor to the Società Meteorologica Italiana (1859–1944), which publishes *Geofisica e Meteorologia* (1953); Sociedad Meteorologica, Montevideo, Uruguay (1950); Indian Meteorological Society (1957); and International Society of Bioclimatology and Biometeorology (1957), which publishes the *International Journal of Bioclimatology and Biometeorology*.

Some of the above societies, such as the British, U.S. or German, have highly active local or overseas branches.

In many countries geophysical, geographical or medical societies embrace the fields of meteorology and climatology, as the American Geophysical Union, U.S. (publishes *Transactions* [1920 *et seq.*]); Vsesoiuznoe Geograficheskoe Obshchestvo, U.S.S.R. (*Izvestiia* [1940 *et seq.*]); Geofysiska Foreningen, Sweden (*Tellus* 11949 *et seq.*]); Geoiysiikan Seura, Finland (*Geophysica* [1935 *et seq.*]), and others.

There are two international organizations having somewhat different purposes. The World Meteorological organization (1950), formerly the International Meteorological organization (1878–1950), is an association of meteorological services of the world under the United Nations. Its functions are largely administrative but it publishes various manuals and the quarterly *Bulletin* (1952 *et seq.*) irom its headquarters in Geneva, Switz. The International Association of Meteorology is one of several associations forming the International Union of Geodesy and Geophysics (an organization created at. Brussels, Belg., in 1919). It publishes proceedings of its general assemblies and triennial reports. (K. C. S.)

METEOROLOGY, the science of the atmosphere (Gr. μετέωρα and λόνος, the science of things in the air). Meteorology comprises in its entirety much more than the science of the weather which the term frequently is used to connote. It includes the study of the highest atmosphere, notably the ionosphere and the ozonosphere, which are not known to contribute directly to the weather processes of the lower atmosphere, or troposphere. (*See* ATMOSPHERE; IONOSPHERE.)

The following discussion is restricted primarily to the weather phenomena which are produced in the troposphere. Also omitted for the most part are several branches of atmospheric physics which constitute a part of meteorology, but which deal with phenomena that are incidental results rather than essential parts of the weather processes. These branches include (1) atmospheric acoustics, which deals with the effect of the weather on the transmission and reflection of sound; (2) atmospheric electricity, of which some of the manifestations include space charge, potential gradient and electric currents in the atmosphere, notably lightning (*see* ELECTRICITY, ATMOSPHERIC; also LIGHTNING); (3) atmospheric optics, which treats a variety of phenomena produced

by refraction, diffraction, reflection and scattering of light in the atmosphere. These phenomena include mirages, looming, etc., by atmospheric refraction; rainbows and halos by the refraction of light by water droplets and ice crystals respectively; coronal diffraction patterns formed by small dust or water particles in the air; sky colours. etc. (See HALO; MIRAGE; RAINBOW.)

The subject matter of meteorology, as applied to the weather phenomena of the lower atmosphere, is most conveniently treated under four headings, as follows:

(1) Instrumental meteorology, which deals with the instruments and techniques of observation by which information of the meteorological condition of the atmosphere is obtained.

(2) Physical and dynamic meteorology, which deals with the qualitative and quantitative explanation of the weather processes as observed.

(3) Synoptic meteorology, which is concerned with the study of synoptic meteorological observations by means of a great variety of synoptic weather charts (weather maps) for the primary purpose of forecasting the weather.

(4) climatology, which statistically treats the meteorological observations from all parts of the world in order to determine the mean or normal conditions in terms of which climate is expressed and defined.

The present article is concerned primarily with the physical and dynamic meteorology of the lower atmosphere, and very briefly with synoptic meteorology (see *Weather Forecasting*, below). References are included to separate entries which treat in more detail selected subjects in these fields. Instrumental meteorology is scarcely touched upon. For information in this field reference should be made to any standard textbook on the subject, or to an observer's handbook. (*See* Bibliography of Instrumental Meteorology at end of article. *See* also ANEMOMETRY; BAROMETER; THERMOMETRY; etc.) Climatology likewise is scarcely referred to as such, although the meteorological factors which control climate are discussed (see CLIMATE AND CLIMATOLOGY).

The Meteorological Elements. — The elements in terms of which the meteorological condition of the atmosphere is usually expressed by a weather observation taken at the ground are the following:

Temperature. — The air temperature is measured by an accurate dry bulb thermometer which is well shielded from direct or indirect solar radiation. The wet bulb temperature, obtained from a thermometer the bulb of which is covered by a single layer of wet cloth and exposed to sufficient ventilation to ensure the maximum possible amount of cooling by evaporation, is recorded for the determination of humidity.

Atmospheric Pressure.—This element, which is usually read from a mercurial barometer, expresses the weight of the overlying atmosphere per unit area of exposed surface. It is usually expressed either by the height of a column of mercury of equal weight (in inches or millimetres), or by a unit of pressure, the millibar, which represents a force of 10^3 dynes/cm.^{2}. Standard atmospheric pressure of 760 mm., or 76 cm. of mercury, is approximately 29.92 in. or 1,013 mb.

Wind.—The direction and speed are observed, usually as averaged over an interval of one minute. The direction is always recorded as that from which the wind blows, and may be reported either to 16 or to 32 points of the compass, or to the nearest 10° of the 360° angle which starts north at 0° and increases clockwise. The speed, as indicated by the anemometer, may be expressed in miles per hour, kilometres per hour or metres per second.

Humidity. — This element expresses the water vapour content of the atmosphere, exclusive of condensed water. Its determination is usually based on the difference between the observed dry and wet bulb temperatures, with the help of tables. Humidity may be expressed in a number of forms, namely: (1) the vapour pressure e, which is that part of the total atmospheric pressure p that is exerted by the water-vapour gas; (2) the relative humidity $\frac{e}{e_s}$, which is the percentage ratio of the existing vapour pressure to the maximum possible (saturation) vapour pressure as determined by the existing temperature. It is to be noted that the saturation vapour pressure is a function of temperature alone, increasing exponentially with the temperature (fig. 1); (3) the mixing ratio, $w = 0.622 \frac{e}{p-e}$, which is the ratio by weight of water vapour to dry air in the atmosphere (0.622 is the ratio of the molecular weight of water vapour to that of dry air); (4) the dew point, which is the temperature to which the air must be cooled, under the existing vapour pressure, in order to reach saturation.

Condensation Forms. — These include all of the products of atmospheric condensation, liquid or solid. Condensation on cold objects on the ground is observed as dew or hoar frost (*see* DEW; FROST). Condensation in the atmosphere that produces particles so small that they have no perceptible fall velocity is observed as cloud, or fog at the ground. Fog and cloud usually consist of water droplets rather than ice crystals even at temperatures far below freezing, although the supercooled water particles do freeze when they are sufficiently cooled. Cloudiness is usually observed and recorded in terms of the estimated fraction (in tenths) of the sky which is covered by each cloud type (*see* CLOUD; FOG). Condensation particles which are large enough to fall perceptibly to the ground constitute precipitation. Forms of precipitation include (1) rain, which is referred to as drizzle when the droplets are numerous and small; (2) snow, formed by direct sublimation in the atmosphere (*see* SNOW); (3) sleet, consisting of rain that is frozen to solid ice pellets while falling through cold air near the ground (*see* SLEET); (4) hail, consisting of rain that is carried aloft into the cold upper atmosphere by strong vertical currents and there frozen (*see* HAIL); and (5) glaze, or ice storm, which is formed by the freezing of rain on cold surfaces which it strikes.

Sunshine is expressed as the number of hours in the day, or the percentage of the day, during which sunshine is indicated by the sunshine recording apparatus.

Visibility is defined as the horizontal distance at which prominent objects are visible.

Ceiling refers to the vertical visibility, which is determined by the height of the cloud base. When the clouds are broken, the ceiling is defined as being that height at which the sky is more than five-tenths overcast, including all clouds at or below that level.

A complete weather observation at any level in the upper atmosphere includes a measurement of the temperature, the pressure and the relative humidity as obtained by some form of the meteorograph, a recording instrument which is carried aloft by kite, aeroplane or balloon, and a measurement of the wind direction and speed by means of the pilot balloon or by radar.

HISTORY

The weather has been a primary concern of mankind since before the dawn of civilization. This fact is reflected in fragments of the earliest writings and in the numerous ancient deities that were associated with various weather phenomena. The earliest known systematic treatises on meteorology are the famous *Meteorologica* of Aristotle (384–322 B.C.) and the writings of his pupil, Theophrastus, on winds and on weather signs. During the next 2,000 years the science of meteorology did not progress substantially beyond the point to which it was carried by Aristotle, in spite of a number of philosophical treatises on the subject. The development of the exact science, like that of the other physical sciences, was forced to await the invention of the instruments by which the primary physical elements are measured.

The Beginning of Meteorology as a Physical Science.— The 17th and 18th centuries in physical science constitute essentially a period of instrumentation and establishment of the elementary physical laws of gases, liquids and solids. Especially significant for the development of meteorology were the inventions of the thermometer by Galileo Galilei in 1607 and of the barometer by Evangelista Torricelli in 1643, followed by the discovery of Boyle's law in 1659. An explanation of the trade winds, includ-

ing for the first time the effect of the earth's rotation on atmospheric winds, was given by George Hadley in 1735. When the true nature of atmospheric air was determined by Antoine Lavoisier in 1783, and John Dalton in 1800 had explained the variations of water vapour in the atmosphere and the relation between the expansion of air and atmospheric condensation, the physical basis of modern meteorology was established.

The First Weather Charts and Weather Forecasting.— The development of the science during the 19th century occurred primarily in the field of synoptic meteorology. The principal advance in this field consisted in the organization of networks of weather observing stations, in the preparation of daily synoptic charts (weather maps), and in the initiation of modern weather forecasting. The first international compilation of weather observations was made by Chevalier de Lamarck (with Pierre Laplace, Lavoisier and others) from 1800 to 1815. The use of synoptic weather observations by such men as H. W. Brandes (1820), William C. Redfield (1837), James P. Espy (1841) and many others established the meteorological nature of storms and empirical rules for their development, movement and the accompanying sequence of weather changes. Following the lead of these men, between 1850 and 1875, many nations throughout the world established meteorological services based on synoptic observations from networks of weather stations. International conferences first at Brussels in 1853, and more extensively at Vienna in 1873, established international co-ordination of these national weather forecast services by arranging for standard observational techniques and for the international exchange of weather observations by telegraph and wireless. The development of weather forecasting progressed rapidly during the same period.

Modern Meteorology as Based on the Study of the Upper Air.—The principal advance in the science of meteorology in the 50 years before 1946 resulted primarily from the rapidly increasing number of upper air (aerological) observations from the lower 20 km. of the atmosphere that were made regularly available to the meteorologist. This information contributed greatly to a better understanding of many unsolved problems in theoretical and applied meteorology.

Isolated observations of temperature in the free atmosphere were made by kites as early as 1749 by Dr. Alexander Wilson at Glasgow, and in manned balloons as early as 1784 by J. Jeffries and Jean Pierre Blanchard. Systematic observation of temperature, pressure and humidity at higher levels in the atmosphere by means of recording meteorographs carried aloft by small free sounding balloons was initiated by Gustave Hermite and Georges Besançon in France in 1892. This type of observation, supplemented by the use of kite and captive balloons, was undertaken in a number of countries during the following ten years. During the same period regular measurements of winds in the free atmosphere were established in a number of countries by means of kites and of pilot balloons.

World War I emphasized the need of more and quicker observations of meteorological conditions in the free atmosphere. For this purpose the use of the aeroplane to carry meteorographs aloft was initiated in both the German and the British armies during 1917–18. Another important meteorological advance which was induced by World War I was the formulation of the polar front theory and the wave concept of cyclogenesis (development of storms) by the Norwegian meteorologists, V. Bjerknes, H. Solberg and J. Bjerknes (1918–21).

The daily use of current aerological data, and the development of suitable upper-level charts to utilize these data in current weather forecasting practice, were strongly stimulated by the development of the radio meteorograph by such men as P. Moltchanoff (Russia, 1928), R. Bureau (France, 1929), and P. Duckert (Germany, 1930). Since 1936–37 the radio meteorograph used with free sounding balloons which frequently reach a height of 20 km. or more, largely superseded other methods of making atmospheric soundings *(see* UPPER AIR SOUNDINGS).

World War II created an unprecedented demand for more and better weather information, particularly for high-level flight operations and for relatively long-range military planning. Almost unlimited manpower and resources were made available to meet these demands. The development of the radar technique to measure winds at high altitudes supplemented the world-wide use of the radio meteorograph. The net result of this war stimulation of meteorological activity appeared in a great increase of the synoptic weather information, especially upper-air data, available from many parts of the world, and in a multiplication of new synoptic charts and forecasting techniques applicable to a variety of types of weather forecasts extending from a few hours to a month or more in range. But there did not appear corresponding advances in basic meteorological theory or in forecasting skill. The advance of the science of meteorology during the years immediately following World War II must lie in the more effective utilization of the mass of synoptic weather data made available as a result of war activity, for the development of basic meteorological theory and of forecasting techniques which are more scientific and less statistical and empirical than those used prior to 1946. *(See* WEATHER FORECASTING.)

THE COMPOSITION AND VERTICAL DISTRIBUTION OF ATMOSPHERE

The physical phenomena of the lower atmosphere which constitute the weather are a result entirely of the heating and the cooling of the atmosphere. This heating and cooling of the atmosphere produce the evaporation and condensation of atmospheric moisture as well as the differences of temperature which are the cause of all atmospheric circulations (wind systems). In order to understand this meteorological activity, it is necessary first to consider briefly, in turn, some of the physical properties and physical laws which obtain in the lower atmosphere, notably the following: (1) the composition and vertical distribution of atmosphere; (2) adiabatic changes and the vertical stability of the atmosphere; (3) the heat balance of the atmosphere in relation to the observed temperature distribution; (4) the atmospheric condensation processes and their manifestations; (5) wind, and its vertical distribution in the atmosphere.

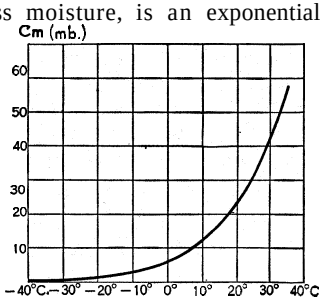
The Composition of Dry Air.—Dry air in the lower atmosphere is a constant mixture of gases of which the principal constituents occur approximately by volume as nitrogen 78%, oxygen 21%, argon 0.93% and carbon dioxide 0.03%, with measurable traces of a number of other gases, notably hydrogen and ozone (for exact proportions of all constituents, *see* ATMOSPHERE). The continuous mixing of the lower atmosphere by winds and vertical convection keeps the dry air mixture so constant that up to a height of at least 20 km. the mixture is observed to have a constant molecular weight of 28.96. This corresponds to a density of $1.276(10)^{-3}$ g./c.c. at a pressure of 1,000 mb. and at a temperature of 0° C.

In the higher atmosphere (the stratosphere) vertical stability prevents any extensive vertical mixing of the air layers (see *Adiabatic Changes and the Vertical Stability* of *the Atmosphere,* below). Consequently the interpenetration of the gases of the atmosphere by the slow process of molecular diffusion may lead to some redistribution such that increasing proportions of the lighter gases might be expected at greater heights, above 20 km. There is little direct evidence, however, to substantiate the predominance of the lightest gases even at great heights, nor would such a distribution have any obvious significance for the weather of the lower atmosphere. It is possible that even in the upper stratosphere there is enough turbulent mixing by wind to prevent the slow redistribution of the gases by molecular diffusion.

Ozone (O_3) is an unstable gas which is both formed and dissociated by solar radiation in the upper atmosphere. Apparently it does not occur in significant proportions at any point in the atmosphere. but it is believed by reason of its selective absorption of radiation of a number of wave lengths, notably of the ultra-violet of the solar radiation, to play an important role in maintaining the temperature of the upper atmosphere above 30 km. The temperatures prevailing in this upper atmosphere have been variously estimated by different indirect methods at from −60° C. to more than 1,000° C. There has been no clearly demonstrated effect, however, of the ozone concentration in the

upper stratosphere on the weather processes of the troposphere.

Water Vapour in the Atmosphere. — Water vapour is the only constituent of the atmosphere which undergoes change of phase under normal atmospheric conditions. Consequently the percentage by volume of water vapour alone of the atmospheric gases shows significant fluctuations, such that any expression of the state of the atmosphere requires specifically a measure of humidity. Experiment has established empirically that the saturation vapour pressure e, which cannot be exceeded without leading to condensation of the excess moisture, is an exponential function of the temperature alone (fig. 1).



FROM "DESCRIPTIVE METEOROLOGY" BY HURD C. WILLETT (ACADEMIC PRESS)

FIG. 1. — VARIATION WITH TEMPERATURE OF SATURATION VAPOUR PRESSURE OVER WATER

For the range of temperature that occurs in the lower atmosphere, e_m varies from a small fraction of a millibar to more than 50 mb., but it is only in the lowest 2 or 3 km. of the more humid tropics and subtropics that water vapour is likely to constitute as much as 3% of the atmosphere by volume. Since the molecular weight of water vapour is 0.622 that of dry air, the presence of water vapour reduces the density of air by $\rho=\rho_d(1-0.378\,\frac{e}{p})$, where p and ρ_d are the densities of moist and dry air, respectively, and $\frac{e}{p}$ the ratio of vapour pressure to total atmospheric pressure. Thus it is only in the lower levels of the atmosphere in lower latitudes that air density may be reduced by as much as 1% by water vapour; at high latitudes and high levels the effect is usually only a small fraction of that amount. The real significance of water vapour for the weather processes of the lower atmosphere lies not in its effecton air density, but rather in three other facts, namely: (1) that condensation phenomena constitute an essential part of the weather; (2) that the release of latent heat of condensation is an important source of energy in the maintenance of weather processes; and (3) that water vapour is the most important constituent of the atmosphere in the absorption and emission of the radiational energy which maintains the heat balance of the atmosphere. Above an elevation of from 10 to 1j km. the moisture content of the atmosphere becomes so small that it is of negligible significance in any respect.

The Variation of Atmospheric Pressure with Height. Hydrostatic Equilibrium. — The effect of the compression or expansion of gases is such that any explanation of the physical weather processes of the atmosphere must consider the variation of atmospheric pressure with height. Since atmospheric pressure is produced by the weight of the overlying atmosphere, the difference of pressure between any two pressure levels should equal the weight of the column of air of unit cross section which is included between those levels. If the pressure difference is not exactly balanced by the weight of the intervening air layer, then the layer suffers an acceleration upward or downward, according as it is too light or too heavy to balance the vertical pressure gradient. The condition that the pressure difference-weight balance must be satisfied, or that there is no vertical acceleration operating other than that due to gravity, is referred to as the condition of hydrostatic equilibrium. This condition defines the rate of change of pressure with height at any level. The small pressure difference dp between two pressure levels separated by the small vertical distance dz equals the weight of the thin slice of the air column of unit cross-section which is intercepted between the two pressure levels. Since the volume of the slice is dz, then if its density is p and the local acceleration of gravity is g, $dp=-\rho g dz$ or $\frac{dp}{dz}=-pg$, the pressure decreasing upward in the direction of increasing elevation. This expression is known as the hydrostatic equation, for it defines the condition of hydrostatic equilibrium in any fluid. Actually vertical accelerations in the atmosphere are so localized and so small compared with the gravity acceleration g, that extremely small error is involved in assuming the condition of hydrostatic equilibrium to hold universally throughout the atmosphere.

The Pressure-Height Formula. **Hypsometry.**—Since the acceleration of gravity is slightly variable with latitude and elevation, while the air density p varies widely with the pressure, temperature and moisture content of the air, the vertical pressure gradient in the atmosphere is highly variable. The computation of the finite difference of elevation h between a lower pressure-level p_o and an upper pressure-level p in the atmosphere requires some approximate integration of the hydrostatic equation. Such an integration is given by the pressure-height formula (hypsometric equation) in the form

$$h(\text{metres})=18{,}400(\log_{10}\frac{p_o}{p})\frac{G}{g_m}\left(\frac{1+\frac{t_m}{273}}{1-0.378w_m}\right)$$

where the subscript m refers to the mean value between p, and p, G is the normal gravity (sea level at 45° latitude), t the temperature in degrees C., and w the vapour-pressure ration $\frac{e}{p}$. The accuracy of this formula depends on the exactness with which t_m and w, are known for the air layer to which it is applied. Throughout most of the lower 20 km. of the atmosphere (except in the-most humid tropical portions) the moisture and gravity factors in the hypsometric formula differ by less than 1% from unity, but the temperature factor may depart by more than 30%. Hence for approximate reckoning the hypsometric formula is used in the form

$$h(\text{metres})=18{,}400(\log_{10}\frac{p_o}{p})(1+\frac{t_m}{273}).$$

There are three important practical applications of the hypsometric formula, in one form or another, each of which require. that the vertical temperature distribution t, be known or assumed. These applications require the solution for either h, p, or p when the other two variables are known.

Measurement of Elevation, *Altimetry.*—The standard method of determining elevation is by means of the hypsometric formula. to compute h from measurements of pressure, of temperature and if accuracy is desired, also of humidity. When the meteorograph is carried aloft by aeroplane or balloon, the record of the height of the sounding is computed at all points from the meteorograph recording of pressure, temperature and humidity.

The standard altimeter is based on the above simplified form of the hypsometric formula. The instrument records the pressure p by means of an aneroid (vacuum chamber) barometer, it is set for the desired reference pressure level p_o (usually sea-level pressure) and is calibrated to read the elevation h above p_0 on the assumption of the vertical temperature distribution of the standard atmosphere, which, for the troposphere, is defined by $t=15°\text{ C.}-0.0065h$. This assumes a normal sea-level temperature of 15° C. decreasing with elevation through the troposphere at the rate of 6.5° C. per km. Maximum departures of atmospheric temperatures from those of the standard atmosphere require corrections of the indicated elevation, reducing by as much as 20% the standard altimeter reading under conditions of extreme cold, and adding as much as 10% under conditions of extreme heat.

Reduction of Station Pressure to Sea Level. — The drawing of isobars on a weather map requires that the observed station pressures must be reduced to sea level or some other standard level. The elevation h of the station is known, the pressure p is observed, and the standard-level pressure p_o is obtained from tables which are based on the hypsometric formula. The temperature t at the station is always known, but there is frequently considerable doubt about the correct assumption to be made about t_o at the standard level, or the value of t_m to be used in the reduction. Consequently the sea-level pressures reported from high-level stations frequently fail to fit the sea-level isobar pattern as drawn on the weather map. The errors are most noticeable under conditions of extremes of temperature at the high-level station, the reported sea-level pressures tending to be too high with excep-

tionally cold temperatures, and too low with exceptionally warm readings.

The Computation of Atmospheric Pressure at Great Heights.—It is important for many purposes to know what density of atmosphere, or how much pressure, is to be expected at very high elevations. The complete hypsometric formula can be used to compute the pressure p at any arbitrary height h above a selected reference pressure level p_o. When this formula is applied to great heights in the atmosphere, above 20 km.. there are certain considerations to be kept in mind. The moisture factor can be omitted, for the moisture content of the upper atmosphere is probably negligible. The correction of the gravity coefficient becomes increasingly important. The temperature t may be assumed to remain near −60° C. between 20 and 30 km., but at great heights the temperature, as pointed out above, may increase considerably. Finally the constant 18,400 in the formula is inversely proportional to the molecular weight of dry air. If the composition of dry air changes significantly at great heights in favour of the lighter gases, this constant must be correspondingly increased.

The atmospheric pressure at 20 km. normally ranges between 4% and 5% of that of sea level. Above 20 km. the hypsometric formula shows that the pressure is given approximately by a factor $\frac{1}{5}$ for each 10 km. increase in elevation, so that it becomes vanishingly small by the 100 km. level, if it is assumed that the composition of dry air and the temperature of −60° C. continue upward with little change. However, the factor $\frac{1}{5}$ may be considerably increased at great heights by the prevalence of a high temperature or a large decrease in the molecular weight of dry air. Consequently the density and pressure as well as the composition of the atmosphere at great heights is highly speculative, but in any case the atmosphere must merge gradually into the emptiness of outer space within a few hundred kilometres of the earth's surface.

ADIABATIC CHANGES AND THE VERTICAL STABILITY OF THE ATMOSPHERE

Changes of Air Temperature.—The prevailing temperature of the atmosphere may be changed by one or more of three significantly different processes.

(1) A mass of air of one temperature may replace an air mass of a different temperature, by simple advection. Such advective temperature changes are normally effected by atmospheric circulations (see *Atmospheric Circulations*). No change of temperature of individual air particles is involved in a purely advective temperature change.

(2) The temperature of a mass of air, as of any gas or mixture of gases, may be changed by compression or expansion. The temperature increase which is caused by compression, or the cooling by expansion, is the equivalent of the mechanical work which is done upon the air in compressing it, or by the air in expansion against the restraining force. If there is no transfer of heat as such between the air and its environment, then the change of temperature produced by a given compression or expansion (change of pressure) is perfectly definite in amount. Such changes of pressure and temperature are referred to as adiabatic (or isentropic). Adiabatic changes in the atmosphere occur on a large scale wherever vertical air currents subject large masses of air to rapidly changing pressure. This is by far the quickest means of effecting large changes of temperature of individual air particles in the atmosphere.

(3) Heat, as such, may be added to, or removed from, a mass of air by non-adiabatic processes such as radiation, conduction and the condensation or evaporation of water vapour. Non-adiabatic processes maintain the horizontal temperature gradients in the atmosphere which are the primary cause of all atmospheric circulations (see *The Heat Balance of the Atmosphere*). Since the change of temperature of individual air particles by non-adiabatic processes is normally very slow compared with the adiabatic changes, it is primarily the adiabatic cooling of moist air below its saturation temperature which produces the more active condensation phenomena in the atmosphere, including nearly all precipitation. Consequently it is important to investigate the amount of adiabatic cooling and the conditions under which the necessary vertical motion is possible in the free atmosphere.

Adiabatic Changes in Dry Air.—The mixture of gases which constitutes dry air behaves very nearly as an ideal gas in the range of temperature and pressure which is found in the free atmosphere. Consequently, in the free atmosphere all changes of pressure, density or specific volume, and temperature of dry air must satisfy the equation of state. $pv=RT$ or $p=\rho RT$, where T is the absolute temperature and R the gas constant for a gas of molecular weight 28.96. The first law of thermodynamics states that for adiabatic changes the gain or the loss of heat represented by the change of temperature of each unit mass of air must exactly equal the work of compression done upon, or the work of expansion performed by, the unit mass of air, *i.e.*, $C_v dT+pdv=0$, where C_v is the specific heat at constant volume. The adiabatic relationship between temperature and pressure in dry air is obtained by eliminating the specific volume v between these two equations, remembering that the specific heat at constant pressure $C_p=C_v+R$, and integrating between initial conditions T_o and p_o, and final conditions T and p. The relationship thus obtained, known as Poisson's equation, is expressed by

$$\frac{T}{T_o}=(\frac{p}{p_o})\frac{R}{C_p}=(\frac{p}{p_o})^{0.288}$$

This result shows that the change of temperature which is produced adiabatically depends on the percentual, rather than on the absolute, change of pressure. Thus an expansion which starts from any normal atmospheric pressure effects a large degree of cooling if the air is expanded to a small fraction of the initial pressure. By combining the hydrostatic equation, $dp=-\rho g dz$, with Poisson's equation and the equation of state, it is readily found that the rate of change of temperature with height of a particle of dry air which is rising or sinking adiabatically through the atmosphere is given by $\frac{dT}{dz}=-\frac{g}{Cp}\frac{T}{T'}$ where T and T' refer to the absolute temperature of the air particle and of the surrounding atmosphere respectively. Since the ratio rarely departs as much as 5% from unity during vertical convection in the free atmosphere, this result shows that the dry adiabatic rate of cooling of ascending air, or heating of descending air, is very nearly linear, as given by $\frac{dT}{dz}=-\frac{g}{cp}=\frac{-1°\text{C.}}{10{,}293\text{cm.}}=-1°$ C. per hundred metres, approximately. This figure is very convenient for rough computation. It indicates the extensive cooling which air undergoes in rising only a few kilometres through the atmosphere.

In order to distinguish between adiabatic and non-adiabatic processes in the atmosphere, it is highly convenient to express the temperature in some form that remains constant for adiabatic changes. This is accomplished by using the observed temperature reduced adiabatically to some standard reference pressure. The standard pressure of 1,000 mb. (millibar) is used for this purpose in meteorology. The temperature which is obtained by adiabatic reduction to this Pressure is called the potential temperature. It may be computed directly from the observed temperature and pressure by Poisson's equation, potential temperature

$$\Theta=T_o=T(\frac{p_o}{p})^{0.288}=T(\frac{1{,}000}{p})^{0.288}$$

Adiabatic Changes in Moist Air.—The presence of water vapour in the atmosphere in amounts less than saturation affects the behaviour of the dry air mixture of gases by a slight modification of the constants R, C_p and C_v, all of which vary approximately inyersely as the molecular weight of the air. Consequently the presence of water vapour in the free atmosphere increases these constants at most by slightly more than 1%, therefore the exponent $\frac{R}{C_p}$ in Poisson's equation remains practically unchanged, while the dry adiabatic rate of change of temperature of rising or sinking air, $-\frac{g}{C_p}$ is decreased at most by slightly more than 1%.

When adiabatic cooling or heating of air leads to the condensation or evaporation of water, the adiabatic process is at once affected by the release or the removal of the latent heat of water vapout. This realization of latent heat changes significantly the dry adiabatic rate of change of temperature. Adiabatic changes which take place under a condition of saturation are referred to as saturated adiabatic changes. If the water which is condensed during a saturated adiabatic expansion remains suspended in the expanding air, then a corresponding compression evaporates the water, removes the same latent heat which was released by condensation, so that the air particle returns to its initial temperature and relative humidity at the initial pressure, *i.e.*, the process is reversible. But if the water which is condensed during a saturated adiabatic cooling process falls out in the form of precipitation, then a subsequent compression heats the air dry adiabatically, for there remains no liquid water, the evaporation of which can keep the process saturated and can remove the latent heat realized during the initial cooling. Consequently in this process the air is returned to its initial pressure drier than it started by the amount of the liquid water which was precipitated out, and warmer by the amount of the latent heat released by the condensation of that water. Such an irreversible process which consists of saturated adiabatic cooling and dry adiabatic heating is referred to as pseudo-adiabatic. Obviously the potential temperature is increased in a pseudo-adiabatic process.

Since the capacity of air for water vapour in the saturated condition (the saturated mixing ratio) is accurately known in the range of temperature and pressure which occurs in the atmosphere, the amount of condensation produced, and therefore latent heat released, per degree cooling of saturated air is readily computed for all atmospheric conditions. Thus the saturated adiabatic rate of heating or cooling is accurately determinable. Since the saturated vapour pressure, and therefore also the saturated mixing ratio, approaches zero asymptotically at very low temperatures, but increases rapidly at high temperatures (fig. 1), the difference between the dry and the saturated adiabatic rate of change of temperature becomes vanishingly small at low temperatures, but percentually large at high temperatures. It follows that the saturated adiabatic rate of change of temperature with elevation in the free atmosphere is not linear like the dry adiabatic rate, but much less than the dry adiabatic rate at high temperatures, approaching it as a limit at low temperatures. At a pressure of 1,000 mb. the saturation adiabatic rate of change of temperature at 30°C. is approximately one-third, at 0°C. approximately two-thirds and at −30°C. nearly 95% of the dry adiabatic rate. This fact is important for the vertical stability of the atmosphere.

Lapse Rates.—The term lapse rate refers to the vertical distribution of temperature in the atmosphere, or specifically to the rate at which temperature lapses, or decreases, in passing upward from one layer of air to the next. The term is to be carefully distinguished from the adiabatic rate of cooling, which refers to the change of temperature of a particle of air that is rising through the atmosphere. The lapse rate is referred to as steep when the condition is one of rapid decrease of temperature with height, and small when the decrease takes place slowly. An increase of temperature with height is not infrequently observed for short distances in the lower atmosphere. Such a negative lapse rate is referred to as an inversion of temperature, or simply an inversion.

Two particular lapse rates which are of special thermodynamic significance are defined in terms of the dry and of the saturated adiabatic rates of cooling of rising air. The dry adiabatic lapse rate is defined as a vertical distribution of temperature such that any unsaturated particle of the atmosphere which suffers an adiabatic vertical displacement finds itself at every level at the same temperature as the surrounding atmosphere. This is a linear lapse rate of approximately 1°C. per 100 m. Since potential temperature is constant for adiabatic changes, a dry adiabatic lapse rate corresponds to vertical isothermalcy of the potential temperature distribution in the atmosphere. The saturated adiabatic lapse rate, also called moist adiabatic, is defined as a vertical distribution of temperature such that any particle of the atmosphere which suffers an adiabatic vertical displacement under saturated conditions finds itself at every level at the same temperature as the surrounding atmosphere. The saturation adiabatic lapse rate is not linear, but approaches the dry adiabatic as a limit at low temperatures. The corresponding lapse rate of potential temperature, which is always 1°C. per 100 m. less than the lapse rate of actual temperature, is negative (increase of the potential temperature with height).

Vertical Stability.—When a limited mass of air is displaced vertically through the surrounding atmosphere, it changes its temperature either dry or saturated adiabatically, irrespective of the prevailing lapse rate in the atmosphere. Since the prevailing lapse rate of the atmosphere is subject to a wide range of variation such that it is rarely either exactly dry or exactly saturated adiabatic, the vertically moving air usually reaches other levels either warmer or colder than its surroundings. Since the pressure must be that of the surrounding atmosphere, the moving air experiences a buoyancy force, acting upward or downward, according as the air is warmer or colder than its surroundings. The atmosphere is said to be in a condition of vertical instability when an air particle which is displaced upward becomes warmer, and when displaced downward, colder, level for level, than its surroundings. Under this condition the moving particle experiences a buoyancy force which accelerates its vertical motion away from its initial level, and which tends to induce an extensive overturning of the atmosphere with a redistribution of temperature such as to reduce the instability (decrease the lapse rate). The atmosphere is said to be in a condition of vertical stability when an air particle which is displaced upward becomes colder. and when displaced downward, warmer, level for level, than its surroundings. Under this condition the moving particle experiences a buoyancy force which tries to effect its return to the initial level, *i.e.*, the atmosphere resists any disturbance of the existing stratification. In terms of the two critical lapse rates, the dry and the saturation adiabatic, it is possible to define the following significant equilibrium states of the atmosphere.

Stable Equilibrium.—This equilibrium exists where the prevailing lapse rate is less than the saturation adiabatic rate. In this condition the atmosphere resists all penetrative vertical movements, whether of saturated or unsaturated air particles, although there is nothing to prevent the entire atmosphere in stratified form from sinking or being lifted. The stable condition, which includes all inversions of temperature, is present probably more than half of the time in the lower atmosphere. It occurs at the lowest levels principally when the ground surface is colder than the air above, a condition which is usually observed at middle and high latitudes over continents in winter and over oceans in summer, and in general where the atmosphere is in motion from warmer to colder regions. Where the stable condition prevails in the atmosphere the wind tends to be steady, rather than gusty, and flying conditions smooth, rather than bumpy, because vertical turbulence is damped out. If condensation forms are present, cloudiness is of the low stratiform or fog variety, produced by surface cooling. while any precipitation formed in a stable atmosphere must be of the fine drizzle type which is produced by the slow non-adiabatic cooling processes in contrast to the rapid adiabatic cooling uhich produces all heavy precipitation.

Conditionally Unstable (also Conditionally Stable) *Equilibrium.*—This equilibrium exists where the prevailing lapse rate is steeper than the saturation adiabatic, but less steep than the dry adiabatic rate. In this condition the atmosphere is stable for unsaturated air and unstable for saturated air. conditional instability occurs much of the time in the lowest atmosphere when the ground surface is warmer than the air above it. It occurs most widely in the lower latitudes. In middle latitudes it is found most frequently over the continents in summer and over the oceans in winter, and generally where the air movement is from colder to warmer regions.

As the prevailing lapse rate approaches the dry adiabatic, winds tend to become gusty and turbulent, and flying conditions rough, especially over mountainous terrain, because of the decreased resistance of the atmosphere to the vertical motion of turbulent elements. Condensation forms, if present, are of the convective

type, cumulus and eumulo-nimbus clouds, showers and thundershowers. Most general storms are characterized by conditional instability of the atmosphere, and most moderate or heavy precipitation is formed in a conditionally unstable atmosphere. Evidently forced ascent of the air, at least to the condensation level, is necessary on a large scale before precipitation can be formed in an atmosphere which is initially unsaturated in conditionally unstable equilibrium. Such forced ascent of large-scale moisture-bearing air currents is effected either by topography (orographic lifting), by conflict with a denser cold current (frontal lifting) or by horizontal convergence within the air flow pattern.

Neutral Equilibrium.—This equilibrium exists where the prevailing lapse rate is equal to the dry adiabatic rate. This is a condition of instability for saturated air, the equilibrium being neutral only for unsaturated air. The potential temperature is constant, *i.e.*, the atmosphere is isentropic, wherever neutral equilibrium exists.

Strictly speaking, neutral equilibrium rarely occurs in the atmosphere. It is significant only as the boundary condition between conditionally unstable and unstable equilibrium. But neutral equilibrium is approximated relatively frequently in the lowest atmosphere, because continued stirring of unsaturated air, by either surface heating or frictional turbulence at the ground, tends to produce homogeneity of the potential temperature, or a dry adiabatic lapse rate.

Unstable *Equilibrium.*—This equilibrium exists where the prevailing lapse rate exceeds the dry adiabatic rate, *i.e.*, is superadiabatic, but is less than 3.4°C. per 100 m. In this condition the potential temperature of the atmosphere decreases with height, so that the condition is unstable for the vertical displacement of either saturated or unsaturated air.

Even an unstable atmosphere is in vertical equilibrium, because, in spite of the temperature lapse rate, the decrease of pressure with height maintains a decrease of air density. Any vertical motion once initiated is accelerated by the instability, but there is no automatic initiation of such vertical motion. However, if the lapse rate becomes sufficiently steep, a point must be reached beyond which the density of the atmosphere increases with height. Beyond this point no true vertical equilibrium is possible in the atmosphere.

It is readily found from the equation of state and the hydrostatic equation that the vertical temperature gradient for which air density remains constant with elevation, or $\frac{dp}{dz}=0$, is given by $\frac{dT}{dz}=-\frac{g}{R}=\frac{-3.4°\text{C.}}{100\text{m.}}$, approximately. Consequently an upper limit to the condition of unstable equilibrium is placed by a lapse rate of 3.4°C. per 100 m.

Unstable equilibrium is observed much less frequently in the atmosphere than are the states of stable and of conditionally unstable equilibrium. It is restricted principally to arid or semiarid continental areas in middle and lower latitudes during periods of maximum solar heating of the ground. Usually the superadiabatic lapse rate is restricted to the lowest kilometre of the atmosphere, but during periods of extreme insolational heating of desert regions, it may extend to 3 km. or more above the ground. Under these conditions quite violent dry convection (dry thermals) and rough flying conditions prevail. Desert sand whirls (sand devils) including the violent Haboob of the Sahara desert occur under these conditions. In less arid regions, unstable equilibrium doubtless plays some role in the initiation of summer afternoon local convective showers and thunderstorms, but the superadiabatic lapse rate rarely extends to any portion of the atmosphere where saturated conditions prevail, and almost never is found associated with the development of major storms and widespread precipitation.

Auto-convective Instability.—This is a state of non-equilibrium which exists where the lapse rate exceeds 3.4°C. per 100 m. This condition is extremely rare in the atmosphere. It is probably restricted to the first few metres above a strongly heated dry surface, such as desert rock or sand. Dry thermals, dust whirls and sand whirls, which extend much higher in the atmosphere, frequently originate in such a superheated layer of air at the ground, a layer which is also the cause of most desert mirage effects by the changed index of refraction of the heated air.

Change of Lapse Rate Effected by Vertical Displacements.—If entire layers of the atmosphere undergo subsidence by reason of outflow of air near the ground and inflow aloft, or are subjected to lifting by the reverse process, the temperature lapse rate may be importantly modified in the sinking or rising air strata. Since these processes nat infrequently occur on a rather large scale in the atmosphere, it is important to note the effect on the lapse rate. Such sinking or lifting of the stratified atmosphere takes place slowly compared with penetrative convection, but it can be assumed to occur approximately adiabatically, hence the potential temperature in each air stratum remains unchanged. It is evident that horizontal inflow near the ground (convergence) with outflow aloft and vertical lifting of the lower stratified atmosphere must lead to a vertical stretching of any air column within the ascending atmosphere, *i.e.*, to an increase of the vertical distance between successive isothermal surfaces of potential temperature. When the potential temperature increases with height, the normal case of a stable lapse rate, this process decreases the rate at which the potential temperature increases, the temperature lapse rate is increased. If the initial lapse rate is superadiabatic, then the rate of decrease of potential temperature with height is lessened, and the temperature lapse rate is decreased. When horizontal outflow at the ground (divergence) and inflow aloft occur with sinking of the lower atmosphere, the sinking atmosphere is vertically compressed, isothermal surfaces of potential temperature are brought closer together, so that the normally stable lapse rate is made more stable, or even a temperature inversion formed. Divergence and subsidence of the lower atmosphe're in highs, convergence and lifting in lows, contribute importantly to the temperature lapse rates and characteristic weather phenomena of these atmospheric pressure centres (see Atmospheric Circulations, below).

Graphical Representation — Graphical representation of the adiabatic and of the saturated adiabatic processes in the atmosphere is very convenient for the quantitative reckoning of all such changes, and for the accurate determination of the vertical stability of the atmosphere. A number of thermodynamic diagrams have been developed for this purpose, each one of which has its advantages for particular uses. Among the more commonly used of these charts in 1946 were the tephigram, the emagram, the equivalent potential temperature diagram (Rossby diagram) and the standard adiabatic and pseudo-adiabatic diagrams.

THE HEAT BALANCE OF THE ATMOSPHERE
THE RADIATIONAL HEAT BUDGET

The Insolational Heating of the Earth's Surface and of the Atmosphere.—The source of the heat that maintains the warmth of the earth's surface and of the atmosphere consists almost entirely of the solar radiation which constitutes the visible sunlight. An infinitesimal amount of radiational energy is received from the other celestial bodies. From a knowledge of the prevailing temperature gradients in the earth's crust and of the thermal conductivity of this crust substance, it is readily computed that a negligible amount of heat flows from the hot interior of the earth to its surface.

Largely through the work started in 1905 by the Astrophysical observatory of the Smithsonian institution in Washington, D.C., long series of solar energy measurements have been carried out at a number of widely scattered mountaintop observatories. Except for possible significant fluctuations of the approximately 2% of the solar energy which lies in the short-wave ultra-violet part of the solar spectrum that is completely absorbed in the upper atmosphere and is therefore not directly measurable, the amount of solar energy which is incident on the earth (insolation) is regularly measured with an accuracy closer than 1%. At mean solar distance of the earth from the sun the amount of this total insolational energy is approximately 1.94 gram calories per minute per square centimetre of surface normal to the sun's rays before

depletion by the atmosphere. This quantity is referred to as the solar constant. It represents an incidence of solar energy on the earth, when the sun is directly overhead, at a rate in excess of 4,500,000 h.p. per sq.mi.

The solar constant as measured is observed to undergo irregular minor fluctuations of less than 1% which probably represent errors of observation, and a longer period fluctuation, probably real, that indicates a variation of approximately 1% in the course of the 11-year sunspot cycle. An additional 1% or 2% long-period variation might be contributed by the ultra-violet radiation without detection. All of these fluctuations, however, are so small that for the discussion of the heat balance of the atmosphere it can be assumed that the earth intercepts solar energy in the amount of 1.94 gram calories per square centimetre per minute over the area of one great circle, or averaged over the entire earth, in the amount of 0.485 gram calories per minute per square centimetre of earth surface. In the following discussion, 1% of this figure, or 0.00485 gram calories per minute per square centimetre, is referred to as one unit of heating or cooling.

Only that part of the insolational energy intercepted by the earth which is absorbed by the ground or atmosphere constitutes effective heating energy. It is estimated that 43% of the incident solar energy is returned to space as reflected or scattered sunlight. This figure of 43% is referred to as the albedo, or reflective capacity of the earth. The remaining 57%, the effective insolation, supplies an average of 57 heating units to the ground and the atmosphere. Of these 57 heating units only a small part, at most 14 units, are absorbed selectively by the atmosphere, principally by the water vapour in the lower atmosphere and to a lesser extent by the ozone in the upper stratosphere.

The remaining 43 heating units of the short-wave solar radiation are absorbed by the earth's surface. This absorption of insolational energy is effected most efficiently by continental areas (dry soil or rock surface) which become strongly heated during periods of intense insolation. Water surfaces, which are more reflective of solar radiation than land, show much less effect of insolational heating, partly because of the high specific heat of water and the transport of heat downward from the surface by wave turbulence. A snow surface is very little heated by the sun because it is so highly refiective of short-wave radiation (white to sunlight).

Much more insolational energy is received per unit area on the average in the course of a year in tropical than in polar latitudes. Best estimates, which make allowance for variations in the conditions of the atmosphere and of the reflective characteristics of the ground surface, indicate that the annual average effective insolational heating of the earth-atmosphere system decreases from a maximum value of about 70 units at the equator to a minimum value of about 30 units at the poles.

The Radiational Cooling of the Earth's Surface and of the Atmosphere.—The heat energy which is supplied to the earth's surface and atmosphere by absorption of the effective insolation, undergoes a variety of transformations while effecting such diverse phenomena as plant growth, atmospheric winds and wind-driven ocean currents, the evaporation of water vapour, the melting of ice and snow, etc. But in the long run no appreciable part of this thermal energy is permanently stored in chemical or in any other form, nor does the earth's surface or atmosphere manifest any persistent trend toward higher or lower temperature. Consequently the earth and atmosphere combined must lose, on the average, by radiation to space 57 cooling units to balance the insolational heating. This outgoing terrestrial radiation, whether it comes from the ground or from the atmosphere, is radiated primarily in the temperature range from 200°–300°A., in contrast to the indicated 6,000°A. temperature of the effective radiating surface of the sun. Consequently the terrestrial radiation is entirely of the long-wave infra-red variety in contrast to the short-wave visible sunlight.

Since most of the material of the earth's surface, including even water and snow, radiates very nearly as a black body (with 100% efficiency) in the range of temperature which is observed to exist, the amount of the terrestrial radiation is readily computed for the observed mean annual average temperature of the earth's surface, approximately 288°A. The terrestrial radiation upward from the ground is thus found to amount to 115 units of cooling. The water vapour of the atmosphere is much more absorptive of this long-wave terrestrial radiation than it is of the incoming short-wave solar radiation. Water vapour is quite opaque to all but a narrow band of the terrestrial radiation, so that with clear skies an average of only 22 of the 115 cooling units is transmitted through the atmosphere and lost to space. A layer of clouds intercepts the terrestrial radiation completely. Consequently on the average approximately 11 of the 115 cooling units are actually lost to space. The remaining 104 units are absorbed by the water vapour of the lower atmosphere, which is correspondingly heated. The greater part of this intercepted energy is radiated by the atmosphere downward to the earth's surface, where it is completely absorbed to maintain the high temperature and a radiational output of the ground surface greater than the entire incident solar energy. This effect of the atmosphere, by which only a small portion (14%) of the insolational energy is intercepted while 90% of the outgoing terrestrial radiation is absorbed, represents effectively a trapping of radiational energy. It maintains an average temperature of the earth's surface and lower atmosphere more than 30° C. warmer than would exist without this differential absorption of long- and short-wave radiation.

The loss of heat by radiation from the atmosphere to space takes place largely from the uppermost moist air layers, near the −50°C. isotherm in the upper troposphere, above which there exists insufficient water vapour to absorb any large part of the outgoing terrestrial radiation. It is from this upper portion of the troposphere, with a slight contribution from the ozone layers of the upper stratosphere, that there occurs most of the 46 units of radiational cooling which, together with the 11 units radiated directly to space from the ground surface, constitute the necessary total 57 units of radiational energy that must be lost to space by the earth-atmosphere system.

Since a −50°C. temperature zone is found in the upper troposphere at all latitudes, accompanied by a similar vertical distribution of moisture, decreasing upward, the radiational loss of heat to space from the upper troposphere is approximately the same everywhere. The direct radiation of heat from the ground to space doubtless exceeds the average value of 11 units in the tropics, and decreases toward the poles. Best estimates of the latitudinal distribution of the annual mean effective loss of radiational energy from the earth-atmosphere system to space indicate a cooling of approximately 60 units in tropical and subtropical latitudes, decreasing only to 50 units at the poles.

From the above approximations as to the radiational heating and cooling of the earth-atmosphere system, the following conclusions concerning the radiational heat budget of this system are drawn:

(1) The system as a whole is in approximate radiational equilibrium with respect to outer space, returning the same amount of radiational energy as is received.

(2) The latitudinal distribution of radiational heating and cooling is such that the system receives more heat than it loses in tropical and subtropical latitudes (approximately 70 against 60 units at the equator), and loses more heat than it receives at middle and higher latitudes (approximately 50 against 30 units at the poles).

(3) The vertical distribution of radiational heating and cooling is such that net heating occurs principally at the ground and from the ground to the lowest layers of the atmosphere with the highest water-vapour content, while net cooling occurs primarily in the zone of the upper troposphere where the water-vapour content becomes very small with increasing height.

(4) Radiational equilibrium, in the sense that each air particle radiates the same amount of energy that it absorbs, is generally nonexistent in the troposphere.

(5) Since there exist no appreciable trends of temperature in the troposphere from year to year toward higher temperature in regions of excess radiational heating, or toward lower tempera-

ture in regions of excess radiational cooling, it follows that there are one or more non-radiational processes operating on the atmosphere to transport heat from equatorial to polar latitudes, and from the lower to the upper troposphere, in order to maintain the existing over-all heat balance of the atmosphere.

The **Non-radiational** Transfer of Heat in the Atmosphere.—Most of the transfer of heat by non-radiational processes in the earth-atmosphere system, by means of which the heat balance of the atmosphere is maintained, is effected by the atmosphere. It is true that the poleward transfer of heat by ocean currents contributes appreciably to the latitudinal transfer, but only to a minor degree compared with the transfer by the atmosphere. This transfer of heat by the atmosphere, like that of any other element which is associated in definite amount with mass of air, *i.e.*, momentum and water vapour, is effected by any one of three diffusion processes which are essentially alike in nature but which differ greatly in magnitude, namely:

Molecular Conduction.—In this process heat is transferred from warmer to colder air by molecular diffusion, or the interpenetration of individual molecules. The transfer consists of the exchange of molecules of higher kinetic energy of motion (heat) for molecules of less kinetic energy. This flow of heat through unit area of any plane in the atmosphere is proportional to the temperature gradient across the surface, to the rate of exchange of air molecules through the surface, and to the average mean free path normal to the surface which each molecule moves in crossing. Since at normal pressures in the lower atmosphere the mean free path of individual molecular movements is extremely short, the flow of heat by molecular conduction is a very slow process. Only in the immediate vicinity of a relatively cold ground surface, under conditions of complete calm of the air, does the effect of molecular conduction affect the air temperature appreciably, and then only to a distance of a very few feet from the surface after many hours of conduction. Consequently molecular conduction is quite insignificant as a means of heat transport in the atmosphere. Exactly the same reasoning and conclusion applies to the molecular diffusion of water vapour (transport of latent heat) and to the molecular diffusion of momentum (molecular friction) between air layers in relative motion.

Turbulent Conduction.—In this process heat is transferred from warmer to colder air by turbulent diffusion, or the interpenetration of individual turbulent elements. The process is exactly analogous to that of molecular diffusion, except that the elements of exchange vary from a few centimetres to a few kilometres in diameter, and the mean free path of the exchange of individual turbulent elements is of the same order of magnitude. The individual turbulent elements, which may be produced either mechanically by frictional stirring or thermal convectively by vertical instability over a warm ground surface, are assumed to mingle their properties with their environment after the displacement occurs. Since these turbulent elements are subjected to adiabatic compressions and expansions, it is potential temperature, and not actual temperature, which is transmitted by this process, *i.e.*, the heat transfer is in the direction of, and is proportional to, the potential temperature gradient. The horizontal transfer of heat is not appreciably affected by this fact, but the vertical flow of heat by turbulent or thermal convective diffusion is upward only in case of a superadiabatic lapse rate, unless the turbulent exchange takes place under saturated conditions. In that case the release of latent heat by the condensation of water vapour in the ascending elements effects an upward transport of heat when the lapse rate exceeds the saturation adiabatic.

Under normal conditions of atmospheric turbulence, the coefficient of turbulent, or eddy, diffusion ranges from 10^3 to 10^5 times that of molecular diffusion. Turbulent conduction of this order of magnitude is not normally significant for the horizontal (latitudinal) transfer of heat in the atmosphere, as the latitudinal temperature gradient is relatively small. But vertical temperature gradients are relatively very large. Consequently this convective turbulent conduction is the principal means of transporting from the lower to the upper troposphere the heat which is required to maintain the vertical heat balance of the lower atmosphere. The upward transport of latent heat, which is realized by the condensation of water vapour, plays a major part in the process. Turbulent (eddy) diffusion is the principal means of distributing water vapour vertically through the atmosphere. Likewise the eddy diffusion of momentum, *i.e.*, turbulent in contrast to molecular viscosity, is the frictional force that determines the vertical wind shear in the atmosphere (see Wind, below).

Advective Conduction.—In this process heat is transferred horizontally from warmer to colder regions by air-mass diffusion, *i.e.*, by the exchange of large-scale air masses in the general circulation of the atmosphere (see Atmospheric Circulations, below). This process is analogous to that of turbulent diffusion, except that the elements of exchange vary from a few hundred to a few thousand kilometres in diameter, and the mean free path of the exchange of individual air-mass elements is of the same order of magnitude. These air masses are the large-scale warm and cold air currents of tropical and polar origin which are so frequently observed in interaction on the weather map. It is assumed that the air masses, after suffering large latitudinal displacements, eventually mingle with the surrounding atmosphere, thereby communicating their properties to the environment.

The advective exchange of air which is effected by these largest circulation elements is many times greater than that which is effected by ordinary eddy diffusion. Consequently it is this advective conduction that effects significant latitudinal heat transfer in the normal temperature field of the earth's atmosphere. It is this latitudinal advective transport of heat from equatorial to polar latitudes which maintains the over-all heat balance of the atmosphere against the radiational accumulation of heat in the tropics and depletion in the polar regions. As in the case also of the vertical transport of heat by thermal convective turbulence, the latitudinal transport of latent heat in the form of water vapour is a significant part of the advective heat transport. In contrast to the dry polar air masses which move equatonvard, the poleward-moving tropical air masses carry an excess of moisture which is condensed as the air mass cools at higher latitudes, especially where it is forced to ascend over colder air masses.

From the nature of the over-all heat balance of the atmosphere, it is evident that the vertical unbalance of the radiational heating and cooling must increase temperature lapse rates until thermal convection becomes strong enough to transport just enough heat upward to offset the lack of vertical radiational equilibrium. Similarly the latitudinal unbalance must increase the poleward temperature gradient until the general circulation (tropical-polar air mass exchange) becomes just strong enough to compensate for the lack of latitudinal radiational equilibrium.

The Observed Distribution of Temperature in the Atmosphere.—The distribution of temperature that is observed to exist in the atmosphere should correspond in its principal features to the distribution of radiational heating and cooling as outlined above, and to the occurrence of the convection and advection which are necessary to the over-all heat balance of the atmosphere.

The Latitudinal Variation of the Annual Mean Temperature.—Annual mean temperatures at sea level range from a maximum average value which is slightly in excess of 80°F. in equatorial regions to minimum average values at the poles, which are not accurately known, but which certainly are well below 0°F. at the north pole and even considerably colder at the south pole. This temperature distribution corresponds to the heat balance of the atmosphere and, for reasons that appear later (see Wind, below), must cause a circulation of the atmosphere that transports heat from equatorial to polar latitudes.

Above sea level the mean temperature decreases significantly with height in the lower atmosphere. This zone of significant positive lapse rate in the lower atmosphere has a definite upper limit, which ranges in approximate average height from 16 km. in the tropics to 8 km. near the poles. The point of termination of the significant positive lapse rate is called the tropopause. It marks the boundary between the stratosphere, in which the vertical temperature distribution tends to approximate isothermalcy, and the troposphere, in which the primary active weather

processes occur. The poleward slope of the tropopause is steepest in middle latitudes where the poleward temperature gradient is strongest.

In middle and lower latitudes, where the heating of the ground and lower atmosphere is strongest, the prevailing lapse rate of temperature in the tropopause tends to approximate the saturated adiabatic. This fact indicates that the lapse rate is largely conpolled by the vertical convective transport of heat and water vapour, as required by the vertical heat balance of the atmosphere. For this reason the troposphere, in contrast to the stratosphere, is usually referred to as being in convective equilibrium. This condition requires the lapse rate to be steeper the colder the air. In middle and lower latitudes the prevailing lapse rate does vary from nearly dry adiabatic in the coldest upper troposphere to approximately half of the dry adiabatic in the lower tropical troposphere. At higher latitudes the prevailing lapse rate is substantially less than the saturation adiabatic, a fact which indicates that vertical convection does not significantly affect the vertical distribution of temperature in the less-heated portion of the atmosphere.

The annual mean temperature at the top of the troposphere varies roughly from −85°C. near the equator to −50°C. in the polar regions. The maximum of the depth of the troposphere in the tropics, as well as the minimum of the temperature at the top, can be explained most conveniently as a result of the excessive heating of the earth's surface and Iower atmosphere in that zone. This heating forces the maximum vertical convection in the tropics, which in turn extends convective equilibrium to the highest level in the atmosphere, and maintains thermodynamically the lowest temperature at the top of the convective layer. Above the cold tropopause in the tropics, the temperature in the stratosphere increases rapidly to nearly the same value which is found at higher latitudes, a fact which justifies the conclusion that the coldness of the upper troposphere in the tropical zone is maintained dynamically or thermodynamically, rather than by radiational equilibrium.

In the lower stratosphere, at least to a height of 25 km., beyond which very few sounding observations extend, the annual mean temperature is near −60°C., ranging from −50° in the polar latitudes to approximately −65° in tropical latitudes above the cold tropopause. It is usually assumed that the stratospheric temperatures are approximately those of radiation equilibrium, in contrast to the convective equilibrium of the troposphere. Apart from the slight absorption by very small amounts of ozone in the upper stratosphere, the thin atmosphere of the stratosphere transmits with very little absorption both the short-wave solar and the long-wave terrestrial radiation. A stratospheric temperature of −60°C. is entirely reasonable for radiation equilibrium with respect to the outgoing terrestrial radiation. But the fact that the stratospheric temperatures average higher in the polar regions, where both terrestrial and solar radiation are less, proves that the temperature distribution of the stratosphere is not a simple matter of uniform radiation equilibrium. There has been offered no satisfactory explanation of the observed distribution of temperature in the stratosphere. The relative warmth of the polar stratosphere may be due in part either to the observed maximum of ozone in that part of the stratosphere, or to a high-level circulation of the atmosphere such that the polar stratosphere undergoes slow sinking and adiabatic heating.

The Seasonal Variation of Latitudinal Distribution of Temperature.— The equatorial belt of maximum temperature at the ground (the thermal equator) shifts from an average position approximately 15° south of the equator during February to a similar northerly latitude during August. The annual variation of mean temperature (the difference between the mean temperature of the warmest and of the coldest month) is at most only a few degrees in the equatorial zone, but this difference increases poleward with the increased seasonal variation of the insolational heating. On the northern hemisphere this annual variation of mean temperature averages approximately 50°F. in the higher latitudes. The average poleward temperature gradient becomes twice as great in winter as it is in summer. In middle and higher latitudes on the southern hemisphere the annual variation of mean temperature is uniformly less than 20°F. Consequently the poleward temperature gradient changes much less than it does on the northern hemisphere.

On the northern hemisphere the annual variation of mean temperature tends to decrease with height in the troposphere, to a value of approximately 3°C. at the tropopause, *i.e.*, lapse rates average slightly steeper and the vertical convection stronger, during the summer season. The tropopause becomes variably higher in summer, by as much as 3 km. in some continental areas in middle and higher latitudes where the annual variation of the mean sea-level temperature exceeds 40°F. In the stratosphere the annual variation of the mean temperature amounts to only 2° or 3° C. in tropical latitudes, but the variation increases to some 10°C. in the polar regions, where upper stratospheric temperature readings as low as −80°C. have been observed in winter, in contrast to readings occasionally in excess of −40°C. in summer.

The Thermal Influence of Continents and Oceans.—Land surfaces (except when glaciated) become heat sources of the atmosphere under strong insolation, and cold sources in the absence of insolational heating. Glaciated (snow) surfaces are always cold sources. Ocean surfaces, because of their extreme thermal sluggishness, tend to be cold sources, at least relatively, under conditions of predominant insolational heating, and warm sources in the absence of insolational heating. High moisture content of the atmosphere, and especially the presence of cloudiness, fog or other condensation forms, reduces both insolational heating and radiational cooling of the ground surface and atmosphere, combining with the thermally conservative influence of an ocean surface to maintain the uniformity of temperature which characterizes a maritime climate. Dryness of the air and clear skies (absence of all condensation forms) favour both insolational heating and radiational cooling of the ground surface and atmosphere, combining with the strongly contrasting thermal influence of a continental surface to effect the extreme variation of temperature which characterizes a continental climate (see CLIMATE AND CLIMATOLOGY).

These facts, which are explained in the preceding discussion of the radiational heating and cooling of the atmosphere, account for a number of features of the sea-level temperature distribution. Most of the southern hemisphere is an area of continuous ocean surface, the only extensive land areas lying in tropical latitudes, except for the glaciated antarctic continent, which is centred at the south pole. Consequently, except for a few minor irregularities in the subtropical continental areas, notably the presence of limited centres of a summer maximum of mean temperatures which exceed 90°F. in Australia and South Africa, the poleward temperature gradient in the southern hemisphere is extremely uniform both summer and winter, the mean isotherms paralleling the latitude circles very closely. Furthermore the reason for the small annual variation of temperature and poleward temperature gradient is obvious from the expanse of ocean in the higher latitudes broken only by the glaciated antarctic continent at the pole.

In the northern hemisphere the bulk of the North American continent in the west, and the great Eurasian and North African land-mass in the east, extend northward well beyond the Arctic circle, most of which passes over land rather than water. This distribution of land and water largely destroys the uniformity of the poleward temperature gradient. In winter the mean sea-level isotherms dip far southward over the continents and northward over the oceans, the mean temperature between 60° and 70°N. varying by more than 80°F. on the same latitude circle. The coldest known sea-level temperatures, as low as −60°F., for the January mean, are observed in the interior of northeastern Siberia. In summer the sea-level temperature distribution is reversed, the isotherms dipping northward over the continents and southward over the oceans. The highest known temperatures in the atmosphere are observed in the arid regions of southwestern Asia and North Africa. A vast area of the Sahara desert, between 20° and 30°N., has a July mean temperature in excess of 100°F. The annual variation of the mean temperature is uniformly less than

20°F. over the open ocean, but over the interior of the continents it ranges from 40°F. at lower latitudes to 100°F. in northwestern North America and as much as 120°F. in northeastern Siberia. It is this great annual range of temperature over the northern continental areas on the northern hemisphere that is responsible for the doubling of the poleward temperature gradient from summer to winter, in contrast to the absence of marked seasonal variation on the southern hemisphere.

The contrasting continental and maritime thermal influences, which so dominate the sea-level distribution of temperature on the northern hemisphere, largely disappear at an elevation of 3 or 4 km. above sea level in the free atmosphere. However a small part (less than 20%) of the sea-level continental-maritime contrast of temperature remains in evidence throughout the troposphere. The tropopause is somewhat lifted over the strongly heated areas and lowered, at least relatively, over the areas of strong cooling of the atmosphere.

The Diurnal Variation **of** Temperature. — The regular diurnal sequence of insolational heating by day and radiational cooling by night effects a normal diurnal variation of temperature, in which the minimum is reached Shortly before sunrise and the maximum toward midafternoon. This diurnal variation of air temperature near the ground, which constitutes the principal heat and cold source of the overlying atmosphere, is extremely variable. It ranges from nothing in the polar regions during the winter night to a maximum of 50°F. or even more in arid continental regions (deserts) in middle and lower latitudes where the winds are prevailingly light. The maritime climate is characterized by a small diurnal temperature range which is at most only a few degrees over the open oceans and practically nothing in regions of prevailingly overcast stormy weather. The continental climate in lower and middle latitudes, and at higher latitudes in summer, is characterized by a normal diurnal variation of temperature of some 20°F., less during windy and overcast weather, and greater during periods of clear skies and light winds. The extreme diurnal variation is observed in the regions of driest air, clearest skies, and lightest winds, from topographical depressions into which the radiationally cooled air drains at night, and which are strongly heated by the sun during the day.

The diurnal variation of temperature decreases rapidly in the free atmosphere above the ground. In most regions at elevations more than 5,000 ft. above ground, and in desert regions at more than 10.000 ft., the diurnal range of temperature is not observed to exceed 2" or at most 3°C. Consequently a large diurnal temperature range implies correspondingly large variation of the lapse rate in the lower 2 or 3 km. of the atmosphere. At great heights above the ground there is some doubt as to the observed temperature range, because of uncertainty as to the accuracy of the meteorograph recordings of air temperatures under conditions of strong insolation.

Irregular Advective (Air Mass) Temperature Changes. —The interplay of air currents of polar and tropical origin (air masses) superposes large irregular day-to-day variations of temperature on the normal seasonal and diurnal variations. These advective temperature changes usually amount to only a few degrees in the uniform tropics, and are moderate in amount, seldom exceeding 20°F. over the open ocean. But in continental areas in middle latitudes in winter, where the coldest polar continental and warmest maritime tropical air masses frequently come in contact, the 24-hr. advective changes of temperature occasionally exceed 50° and may reach even 80°F. The advective changes of temperature aloft in the troposphere are observed to be only moderately less than those at the ground (over the oceans in winter they are larger), while even in the lower stratosphere in middle latitudes in winter they appear to reach values of 10° to 15°C.

EVAPORATION AND CONDENSATION IN THE ATMOSPHERE

The occurrence of evaporation or of condensation in the atmosphere is caused by the changing capacity of air for water vapour, *i.e.*, by the heating or cooling of moist air. The normal ater-vapour content of the atmosphere is less than that of saturation. especially so near the ground where the effective heating of the atmosphere is greatest. Saturated conditions occur in a rather small part of the total volume of the troposphere, most frequently at upper levels where the cooling of air by adiabatic ascent is most pronounced. Thus evaporation into the lowest atmosphere takes place steadily, most of the time without visible manifestation, from the ground, from growing vegetation, from water, ice or snow surfaces and occasionally from condensation forms in the air. The great part of the condensation occurs rapidly in large amounts in restricted zones in the middle troposphere, giving rise to important weather phenomena by which the moisture is returned to the ground as precipitation. This water-vapour cycle transfers a significant amount of heat from the earth's surface and from the tropics, where an excess of evaporation occurs, to the middle troposphere and to the higher latitudes, where an excess of condensation occurs, thus contributing to the maintenance of the heat balance of the atmosphere (see *The Heat Balance of the Atmosphere,* above).

Evaporation. — The great part of the moisture that maintains the water-vapour cycle in the atmosphere is supplied by evaporation at the earth's surface. The rate at which this evaporation occurs at any point is proportional to the difference between the saturation vapour pressure at the temperature of the evaporating surface and the vapour pressure prevailing in the air into which the evaporation takes place. As the moisture evaporates it is diffused through the atmosphere, vertically by thermal or frictional turbulence, horizontally by wind advection. If the wind is light and the atmosphere is stable, a nocturnal condition to be expected over land with clear skies and settled weather conditions, the diffusion of water vapour into the atmosphere is reduced almost to that of molecular diffusion. Consequently a shallow layer of air next to the ground is rapidly moistened, the 24-hr. maximum of vapour pressure is reached, and the rate of evaporation becomes very slow. A small amount of radiational cooling of the ground is sufficient to reverse the process and start condensation in the form of dew. As soon as the sun rises sufficiently for the ground and the overlying atmosphere to be appreciably heated, thermal convection sets in, the wind velocity increases (see *Wind,* below), and the high moisture content of the lowest air layer is diffused rapidly upward, causing a decrease of the vapour pressure, a sharp fall in the relative humidity, and an abrupt increase in the rate of evaporation at the ground. The thermal convection, the mind velocity, and the rate of evaporation all reach their maximum value at the time of the diurnal temperature maximum toward midafternoon, when the vapour pressure, the dew point and the relative humidity reach minimum values. This diurnal regime is highly typical of a continental climate during periods of good settled weather. In general, any influence that raises the temperature of the evaporating surface, or that increases the horizontal wind, the wind turbulence or thermal convection, is highly favourable to an increased rate of evaporation. Reduction of the prevailing vapour pressure by the wind advection of drier air (change of air mass) is likewise f'avourable. Any influence that lowers the temperature of the evaporating surface, or that decreases the horizontal wind, wind turbulence or thermal convection, as well as any increase of the prevailing vapour pressure by the advection of moist air, act to retard the rate of evaporation from the ground.

Visible Manifestations of Evaporation in the Atmosphere. — The weather phenomena which are directly attributable to evaporation in the atmosphere are relatively insignificant. One phenomenon which is so attributed is that of visible steaming. Rapid evaporation from a relatively warm water surface produces almost immediate supersaturation of very cold air or relatively cool moist air. The result is to produce immediate condensation on the spot in the form of visible steaming, which in very stable air may form a dense overhanging fog. More frequently the fog is dissipated by convective mixing with drier air aloft, in which case convective cloud-forms may develop at higher levels due to the adiabatic cooling of the heated moist air as it rises. The wind movement of extremely cold polar air over open water forms dense clouds of rising steam that are sometimes even more ob-

structive to vision than a dense fog of the usual variety. This phenomenon is referred to as arctic sea smoke. Essentially this steaming is a phenomenon of condensation, but it is caused by evaporation at the spot.

True evaporation phenomena are to be seen in the dissipation by evaporation of fog or cloud forms. Such dissipation of a fog layer occurs when the temperature of the foggy air is raised above the dew point, either by a warm ground surface or by direct insolational heating after sunrise. Similar dissipation of a cloud layer at higher levels may be effected either by direct insolational heating or by any descending (down slope) movement with the attendant adiabatic heating of the saturated air stratum. The dissipation of the heavier condensation forms is usually effected more by advection than by evaporation, *i.e.*, by the displacement of a moist by a dry air mass. The condensation forms are transported away with the retiring moist air mass.

Physical Aspects sf Atmospheric Condensation. — Condensation on Cold *Surfaces*.—Condensation occurs on any exposed surface the temperature of which lies below the dew point temperature of the surrounding air, just as evaporation occurs from anv moist surface whose temaerature is above that of the surrounding air, quite irrespective of the temperature and relative humidity in the air. Examples of such condensation are to be seen during muggy warm weather, in the "sweating" of a pitcher of ice water, or of pavements or stones that are imbedded in cool ground and protected from insolational heating, even though the relative humidity in the air is far short of 100%. Similarly dew condenses during clear calm nights on ground objects which, by effective radiation of their heat to space, cool to temperatures below the dew point of the surrounding air. A grass lawn may become 6°–8°F. colder than the air only a few feet above it. Hoar frost (frost crystals) form on surfaces which cool below freezing, even though the free air temperature may be several degrees above freezing (see FROST).

Hoar frost, of this crystalline sublimation variety which is light in amount, is to be distinguished from the amorphous rime frost which is much heavier in amount. Rime frost is formed on the windward edges of exposed objects by the deposit of small windborne supercooled water-droplets (fog and cloud particles) at temperatures below freezing. Rime frost is a whitish, opaque, amorphous and relatively dense deposit which approaches clear ice glaze in character at temperatures close to freezing, with increasing size of the water droplets. Rime frost feathers, several feet in length, may build into the wind in'less than 24 hr. on a mountaintop exposed to a high wind and dense fog at subfreezing temperature. Obviously this formation represents the deposit of water that is already condensed, rather than direct condensation on the spot as in the case of dew or hoar frost. The icing of aircraft in flight consists of identical rime formations. The lighter rime type of icing occurs on the leading edges of aircraft in flight through fog or cloud in the lower temperature range, below −10°C. In the range from −10°C. to 0°C. the amount of liquid water present in a cloud, and the size of the individual droplets, is usually larger. Consequently icing deposits on aircraft tend more toward the heavy dangerous variety of dense clear ice-glaze in the higher temperature range.

Condensation *Within* the Atmosphere. — When condensation occurs within the atmosphere in the form of tiny water-droplets, the question arises as to how the process starts. Experiment shows that in air from which all impurities have been removed, condensation in the form of water-droplets does not occur even at ten times the saturation vapour pressure. In other words, some type of particle which is not a constituent of pure air, a particle which is referred to as a nucleus of condensation, is necessary to initiate the condensation of water vapour. It is the disruptive effect of surface tension on very small water-droplets which necessitates the action of some kind of nucleus to permit such a droplet to form. Experimental evidence indicates that the common nuclei of condensation in the air are tiny particles of hygroscopic substances (material characterized by a chemical affinity for water), such as sea salt (from wind-blown sea spray) and in regions of industrial pollution of the atmosphere, the oxides of sulphur, phosphorous and other substances which are formed by the oxidation of coal and other combustibles.

The sea-salt type of nucleus or other similar particles are widely distributed throughout the lower troposphere, in numbers which range from 10^2 to 10^4 per cu.cm. of air. These nuclei act generally in the lower atmosphere to produce ordinary visible fog or cloud wherever the relative humidity approximates 100%. The nuclei of industrial pollution, on the other hand, are more strongly hygroscopic. In the restricted portions of the lowest atmosphere where they are produced, they occur in very large numbers, up to 10^7 per cu.cm. They react frequently in great numbers at less than 100% relative humidity, in extreme cases at as low as 80%, to produce the persistent dense type of fog, of numerous very small particles, like the famous London fogs or the smog (smoke and fog combined) of the large U.S. industrial cities.

Normally fogs and clouds of the lower troposphere consist of between 10^2 and 10^4 tiny water-droplets per cubic centimetre. It is evident that even with the smaller number, the complete condensation of all the water vapour present in a volume of air, divided equally between so many particles, is insufficient to produce droplets with an appreciable fall velocity. There is some doubt as to how raindrops, or other precipitation particles, are formed in clouds. Observations indicate that numerous small droplets, of the size that constitute the usual fine drizzle rain, may be found in any dense layer of cloud which exceeds 2,000 or 3,000 ft. in thickness and which experiences cooling. There apparently is required no very active turbulence, no strong vertical motion, nor any vertical extent of the cloud-mass up to the level of freezing temperature in the atmosphere. The numerous small droplets are formed presumably by the coalescence of many minute cloud particles in the dense cloud, aided by small-scale turbulence. Although rain of the drizzle variety frequently is very dense, in the sense that the numerous small droplets cause poor visibility, it is never very intense, in the sense that the rate of accumulation of precipitation is always relatively slow. In localities where this type of rainfall occurs continuously, for example where a prevailing wind forces a steady current of warm and moist, but stable, air upslope against a moderate mountain range, drizzle rain may accumulate heavy precipitation over a long period of time.

Intense rainfall of the large-droplet shower type that accumulates heavily in a short time, falls from clouds within which strong vertical motion occurs, and which, at least in middle latitudes, extend vertically to heights in the atmosphere well above the freezing level. This is seen most clearly in the thunderstorm cumulo-nimbus cloud. All moderate or heavy rain that falls in the form of large droplets apparently is formed under these conditions. The generally accepted theory (proposed by T. Bergeron) ascribes the formation of such large raindrops to the introduction of ice crystals into the upper portions of the clouds where supercooled water droplets prevail. The ice crystals may fall from a higher cloud level, or be supplied by the congealing of a few supercooled droplets. Because at subfreezing temperatures the saturation vapour pressure is significantly less over ice than over water, sublimation immediately occurs on the few ice particles at the expense of the numerous water droplets. In this manner a relatively small number of large particles are rapidly formed, particles which grow by accretion and melt as they fall through the cloud beneath, giving rise to the usual moderate or heavy rainfall consisting of a relatively few large drops. If most of the cloud mass is in the subfreezing temperature range, the falling particles are not melted, but fall as snowflakes. In most heavy snowfall the snow crystals are partly melted and iced by the deposit and freezing on the crystals of large numbers of supercooled water droplets, *i.e.*, cloud particles. In the tropics there is some uncertainty as to the occurrence of subfreezing temperatures in upper portions of all heavy rain clouds, and consequently as to the universal validity of the ice crystal theory of raindrop formation.

Meteorological Aspects of Atmospheric Condensation. — It can be assumed that there are always condensation nuclei present in the lower troposphere such that condensation occurs as the

air becomes saturated, or even sooner in localities of strong industrial pollution of the air, and that precipitation is formed in clouds where rapid condensation occurs, fine drizzle or powdery snow in stratified clouds of limited vertical extent, and the large-droplet type of moderate or heavy precipitation in deep clouds (5,000 ft. or more thick) within which strong vertical motion extends to above the freezing level in the atmosphere. Hence the occurrence of the condensation forms depends primarily on the meteorological conditions which produce saturation of the atmosphere.

Causes of Saturation of the Atmosphere.—Saturation, and subsequent condensation, can be effected either by adding water vapour to air until the vapour pressure equals or exceeds that of saturation at the existing temperature, or by cooling air until the saturation vapour pressure at the existing temperature becomes equal to or less than the prevailing vapour pressure. The first process occurs locally where cool air is in contact with a relatively warm moist surface. It produces visible steaming, in extreme cases steam fogs or arctic sea smoke, as explained above. All important condensation in the atmosphere is caused by the second process, the cooling of moist air below its dew point. The cooling processes which usually operate in the atmosphere to produce condensation are as follows:

(1) Cooling of the lowest atmosphere by a cool underlying surface. In the absence of wind, this effect forms a layer of coldest air at the ground, and pools of cold air in valleys and other topographical depressions, to produce shallow ground fog or valley fogs. In the presence of wind turbulence, the level of maximum cooling is lifted by turbulent mixing to the top of the surface frictional layer of the atmosphere to form a low cloud layer above the ground (see *Wind,* below). The stronger the wind turbulence the higher is the condensation level raised. This cooling process produces fog or a low overcast, but at most only a light drizzle in the way of precipitation.

(2) Direct radiational cooling of moist air. This process effects the greatest cooling of a layer of moist air which underlies dry air. Depending on the vertical moisture distribution, it effects maximum cooling either of the air stratum at the ground or of a higher moist layer, such as that at the top of the turbulence layer or at the base of a higher temperature inversion. Consequently it may contribute either to ground fog, or to a low or intermediate overcast. This cooling action is slower than that of a cold ground surface, consequently this process likewise rarely produces precipitation, at most a very light drizzle.

(3) Mixing of warm saturated air with cold air. The shape of the saturation vapour-pressure curve (fig. 1) shows that if masses of saturated air at markedly different temperatures are mixed, the resulting mixture must be somewhat supersaturated, *i.e.,* some excess moisture condenses. The amount of this excess moisture is small and it exists only if the air masses, especially the warm one, are almost saturated at the start. This is the least significant of the condensation processes. Its action is probably restricted to the formation of fog or cloud (no precipitation) in the border zone of mixing (frontal zone) between two saturated air masses which differ strongly in temperature.

(4) Cooling by adiabatic expansion. Rapid cooling by adiabatic expansion occurs when air rises freely or is forced to ascend in the atmosphere. Such ascent of large masses of air is effected either by free convection, or by the upward deflection of wind currents by topography, by conflict with other currents (frontal lifting) or by other crowding of the stream lines within the current (horizontal convergence). Adiabatic expansion effects the quickest and greatest cooling of air and condensation of water vapour, to produce all of the most active condensation forms, including all precipitation of moderate or heavy intensity.

Condensation Forms in the Atmosphere.—The condensation forms which are produced in the atmosphere, especially the cloud forms, are so varied and complex that no complete classification or listing, much less identification, of the forms can be made here. (See The *International* Cloud Atlas, or U.S. Weather Bureau Circular S, Codes for Cloud Forms and States of *fhe Sky.)* The following table contains a brief outline of the primary basic cloud forms and the typical associated forms of precipitation:

Primary Basic Cloud Forms

Type	Height of Cloud Base (ft.)	Cloud Form	Precipitation (if present)
Stratiform			
very low	on the ground	fog	fine, misting drizzle
low	<3,000	low stratus (st)	drizzle, fine snow
	3,000–8,000	stratus (st)	moderate to heavy rain
		nimbo-stratus (nb st)	snow, sleet or glaze
intermediate	8,000–18,000	alto-stratus (a st)	light to moderate rain or snow
high	>18,000	cirro-stratus (ci st)	
Limited Convective			
very low	<3,000	low strato-cumulus (st cu)	light showers of drizzle or fine snow
low	3,000–8,000	strato-cumulus (st cu)	shos ers of drizzle or fine snow
intermediate	8,000–18,000	alto-cumulus (a cu)	trails of light falling precipitation aloft
high	>18,000	cirro-cumulus (ci cu)	
Free Convective			
very low	on the ground	visible steaming, arctic sea smoke	
low	3,000–10,000	cumulus (cu)	
low-towering	3,000–10,000	cumulo-nimbus (cu nb)	heavy showers of rain, snow or hail; thunderstorms
high	>20,000	cirrus (tufted and filamented forms) (ci)	trails of fine falling ice particles at high levels

The identification of the cloud forms is based always upon their appearance from the ground. When a low overcast is observed, the cloud form is reported as observed, although there may be higher cloud layers of an entirely different form which yield precipitation of a type which does not belong to the observed cloud form. This is particularly true of the nimbo-stratus form. The moderate to heavy precipitation of the large-droplet variety, which frequently accompanies this form, falls from a convectively active cloud layer aloft which is completely obscured by the lowest formation.

The height of the cloud base, which in regions of uneven terrain is to be taken as height above the lowest ground level in the region, can be listed only approximately for the different cloud forms. The height range listed is the range within which that cloud form is usually observed, but it may occur outside of that range. Frequently the height of the observed cloud form is not even approximately known. Especially with respect to the cirrus clouds, which are normally the highest form in each basic group. the height range is uncertain, for the cirrus are composed by definition of ice crystals, whereas the other forms are water-droplet clouds, which may exist in the supercooled state to temperatures as low as −30°C. In cold weather ice-crystal clouds may exist at quite low heights, even as a surface fog in extreme cases, a fact which extends the possible range of the cirrus cloud forms from the ground to the top of the trdposphere.

The precipitation forms which are associated with the different cloud forms may or may not be observed in any particular case. Only with the clouds that are designated as nimbus forms must falling precipitation be present.

Of the three basic cloud forms. the stratiform are the unbroken layer or sheet clouds, which uniformly cover all or a considerable portion of the sky. They are characterized by a stable lapse rate and absence of vertical motion at least in the base of the cloud sheet where the uniform continuity of the cloud mass is observed from below. The upper portion of the cloud mass is in many cases convectively turbulent and very uneven in vertical

extent. The stratiform condensation forms are produced by processes which cool the lower air layers relative to the upper, thus producing a saturated stratum with a stable lapse rate, or by the advective lifting of a warm air mass over a colder (frontal lifting) which produces a stable lapse rate at the base of the cloud layer.

Surface fogs are of three principal varieties. The radiational, the typical inland nocturnal ground fog or valley fog, is formed on clear calm nights by the radiational cooling of the ground and the lowest atmosphere, as already explained. It is lifted and dissipated either by wind turbulence or by the insolational heating of the rising sun. The advective type is formed when warm moist air blows lightly over a cold surface. It is most frequent over cold coastal waters or cold lakes in the late spring and early summer. It accounts for the high spring and summer fog frequencies over the Newfoundland Grand Banks, along the coast of California, generally in arctic regions and in all other areas of exceptionally cold water temperatures. With moderate winds, turbulence tends to lift this fog to a low stratus cloud. The prefrontal type is an extensive inland variety which forms principally in winter where rain falling from warm air aloft saturates a layer of cold air at the ground (warm front precipitation). Any cooling of the surface air by adiabatic expansion, due to falling pressure or upslope mind, or by melting snow on the ground, contributes to the fog formation. As in the case of the advective fog, a moderate mind tends to lift the fog to a low stratus cloud.

Low stratus clouds are formed by the lifting of a surface fog off the ground by moderate heating or by wind turbulence. Stronger heating or turbulence break up the stratus into a strato-cumulus, and may dissipate it. Low stratus is also formed by the direct radiational cooling of a layer of moist air beneath a low dry temperature inversion.

The higher stratus, nimbo-stratus, alto-stratus and cirro-stratus cloud forms are typical of frontal lifting, especially at a warm front, of an overrunning current of warm moist air. It is the typical cloud sequence with increasing distance ahead of a warm front (see *Secondary Circulations* of *the Dynamic Type*, below). The occurrence of heavy precipitation with the nimbo-stratus clouds is caused by strong vertical convection within the overrunning moist air. Cirro-stratus and alto-stratus cloud sheets are sometimes formed also by the horizontal spreading. in an upper stable layer of the atmosphere, of moist air which is carried up to the level of stability by widespread thermal convection.

The limited convective cloud-forms are produced primarily by the breakdown of a stratiform cloud layer. **A** steepening of the lapse rate within the cloud layer, such that convective cells can extend from the base to the top of the layer, breaks up the stratiform cloud sheet into an irregular cellular pattern. The unstable cloud layer must be topped by a uniform stable layer, preferably by a temperature inversion, to prevent the individual convective cells from developing into the free convective forms. Any drifting stratiform cloud layer tends to disintegrate slowly into the cellular limited convective pattern, due to the radiational heating of the cloud base by the absorption of outgoing terrestrial radiation, and the radiational loss of heat to space from the top of the layer. Low stratus clouds are lifted and broken into strato-cumulus by heating from the ground or by increased wind turbulence. Strato-cumulus is the typical cloud formation to occur at the top of the surface frictional layer of the atmosphere.

The free convective condensation forms are those produced by relatively unrestricted vertical convection in the atmosphere, hence the formation requires deep layers of the atmosphere in which the prevailing lapse rate exceeds the saturation adiabatic. The cumulus and cumulo-nimbus clouds usually originate in convection from quite low levels. Especially during periods of strong insolational heating of the ground, and in the absence of other clouds, the base of the clouds is usually near or slightly above the condensation level of the surface air, the height varying greatly with the humidity. These forms tend to predominate over land during the warm season and during the day; over water during the cold season. Much of the time when conditions are favourable to strong insolational heating of the ground, lapse rates are stable at the higher elevations, so that the cumulus clouds stop short of the development to cumulo-nimbus. Consequently they are known as fair weather clouds. But when the prevailing lapse rate is steep to high levels, the cumulus clouds rapidly tower up to great heights. When they extend well beyond the freezing level, the typical ice-crystal cirrus top formation of the cumulo-nimbus appears as a heavy afternoon shower or a thunderstorm develops.

Convective cirrus clouds that are dissociated from thunderstorms or lower level convection frequently form in the steep lapse rate zone of the upper troposphere. They do not appear to have much weather significance, nor is much known about the changes with which their appearance and disappearance are associated.

WIND

The Pressure Gradient Force.—There are only two forces which initiate movement in the resting atmosphere. One of these is the force of gravity which acts to accelerate each particle of air vertically downward. Atmospheric pressure exists because this force of gravity compresses the atmosphere by its own weight. Since the internal pressure of a gas acts equally in all directions, there is no net pressure force which acts to accelerate any particle of the atmosphere where the pressure is the same at all points, but wherever a pressure gradient exists each particle of air is subjected to a net differential of pressure which exerts a net force in the direction of decreasing pressure.

The hydrostatic equation, $-\frac{1}{\rho}\frac{dp}{dz}=g$, expresses the state of exact balance in the atmosphere between these two forces, the force of gravity acting vertically downward, and the pressure gradient force acting upward. Where this condition is not satisfied, vertical acceleration of the atmosphere is observed in the establishment of thermal convective or other vertical displacements of air.

If the isobaric surfaces (surfaces of equal pressure) are not horizontal in the atmosphere, then there exists a horizontal component of the pressure gradient, $\frac{dp}{dn}$, that is not balanced by the force of gravity, which by definition has no horizontal component. Consequently the existence of a horizontal pressure gradient leads inevitably to the acceleration of horizontal air movement, *i.e.*, to the development of wind in the atmosphere. It is in this manner that all of the atmospheric circulations, or wind systems, are generated. The slope of the isobaric surfaces in the atmosphere is always small, so that horizontal pressure gradients are only a small fraction of the vertical gradients, but the condition of hydrostatic equilibrium is so nearly satisfied that in general the horizontal winds are many times stronger than the vertical winds. Only rarely and very locally in the case of intense thermal convection or of strong vertical deflection of surface winds by topographic barriers do vertical winds occur which are comparable in strength to the prevailing horizontal winds.

By reasoning exactly analogous to that which was used in the derivation of the hydrostatic equation, it is readily shown that the acceleration which is caused by a horizontal pressure gradient $\frac{dh}{dn}$ is given by $a=-\frac{1}{\rho}\frac{dp}{dn}=F$, where ρ is the density of the air and F the pressure gradient force which acts on each unit mass of the air. This is the force which initiates and maintains all horizontal wind in the atmosphere.

The Principle of Thermal Circulation.— Horizontal pressure gradients and the accompanying winds of the atmosphere are caused primarily by the presence of horizontal temperature gradients. To illustrate how this thermal influence works in principle, assume that to begin with along a certain section of the atmosphere there exists horizontally neither pressure gradient nor temperature gradient, so that both isobaric and isothermal

surfaces are horizontal, and the atmosphere is at rest. If now heating takes place at one end of the section (south) and cooling at the other end (north), the isothermal surfaces, sloping from south to north, cut the isobaric surfaces so that the temperature between any two isobaric surfaces decreases from south to north. The vertical distance between any two isobaric surfaces is contracted in the north, where the density of the air is increased, and expanded in the south, where the density of the air is decreased. Consequently the isobaric surfaces acquire a northward slope which increases with elevation above the ground. This northward pressure gradient aloft sets the air in motion from the warm to the cold region, consequently at the ground a pressure gradient is established, and the surface air set in motion, from the cold to the warm region. At some intermediate level there is no horizontal pressure gradient or wind. The atmosphere rises in the warm region, to maintain the northward outflow aloft, and sinks in the cold region, to maintain the southward outflow at the ground. These vertical movements do not require a superadiabatic lapse rate, for they occur as a rising or sinking of the entire stratified atmosphere rather than as penetrative convection.

The steeper the existing horizontal temperature gradient becomes, the greater is the relative slope of the isobaric surfaces and the stronger is the acceleration of the indicated circulation. The primary drive of all atmospheric wind systems is found in such thermally direct circulations, although there do exist thermally indirect or forced circulations which are driven in turn by the thermally direct circulations. The largest scale thermally direct circulation is that of the general circulation of the atmosphere which operates between the equatorial heat source and the polar cold source. A small-scale example of such a circulation is that of the land and sea breeze, which operates between adjacent heat and cold sources at a coast line (see Tertiary *Circulations,* below). Circulations that exist in the earth's atmosphere are considerably modified from the simple form outlined above, by effects of the earth's rotation and by friction. It is useful to consider first the frictionless wind balance of the rotating earth, and then the modifications that are effected by friction.

The Frictionless Wind **Balance.**—*The* Horizontal *Deflecting Force* (*Coriolis Force*).—The horizontal pressure gradient force initiates and maintains all horizontal air movement, but immediately the air is set in motion the Coriolis force comes into play. Any particle that moves freely over the earth's surface apparently suffers a deflection to the right on the northern hemisphere, to the left on the southern. This apparent deflection is caused by the rotation of the earth's surface, which to an observer on the earth is the only plane of reference by which direction of motion can be determined. To an observer standing on the northern hemisphere the plane of the horizon rotates from right to left about a vertical axis with an angular velocity $\omega \sin \varphi$ where φ is the latitude and $\omega = \frac{2\pi}{86{,}400}$ radians per sec., the angular rotation of the earth about its axis. On the southern hemisphere the same rotation of the plane of the horizon occurs from left to right. Since the observer cannot perceive the turning of the plane of reference on which he is located, he observes the apparent deflection of the freely moving particle in the opposite sense. This deflection is observed directly in the Foucault pendulum experiment. Obviously the deflection is strongest at the poles and vanishes at the equator.

In order to account for this apparent deflection of a freely moving particle on the earth's surface, it is necessary to assume the existence of a deflecting force, the fictitious horizontal deflecting force, or Coriolis force. It is readily shown that the apparent acceleration of the freely moving particle, and therefore the force which must be assumed to act on each unit mass of moving air, is given by $a = F = 2v\omega \sin \varphi$, where v is the linear velocity relative to the earth's surface of the moving air. This Coriolis force acts always normally to v, to the right on the northern hemisphere and to the left on the southern, hence deflects but does not alter the speed of the wind.

The Geostrophic Wind Velocity.—In the absence of friction the horizontal motion of air relative to the ground is always controlled by at least the two forces, pressure gradient and Coriolis, so that the wind velocity adjusts itself to a total force $F = -\frac{1}{\rho}\frac{dp}{dn} + 2v\omega \sin \varphi$ per unit mass of moving air. A steady equilibrium velocity is reached when the total force vanishes, *i.e.,* when $2v\omega \sin \varphi = \frac{1}{\rho}\frac{dp}{dn}$, or $v = \frac{1}{2\rho\omega \sin \varphi}\frac{dp}{dn}$. This particular equilibrium wind velocity for which the sum of the pressure gradient force and the Coriolis force vanishes is called the geostrophic wind velocity. It is seen to be directly proportional to the horizontal pressure gradient (the distance between isobars on a constant level chart) and inversely proportional to the air density and to the sine of the latitude, so that no geostrophic wind balance is possible at the equator. The geostrophic wind velocity is readily computed for any observed conditions. It is a useful tool to the weather forecaster in the absence of complete wind observations.

Since the direction of the pressure gradient force is always normal to the level surface isobars toward lower pressure, for this force to be balanced exactly by the Coriolis force the latter must be directed normal to the isobars toward higher pressure. This condition requires that the geostrophic wind blow parallel to the isobars, with the direction such that on the northern hemisphere the higher pressure is to the right, on the southern hemisphere to the left, of an observer standing with his back to the wind. This relationship between wind direction and pressure gradient in the free atmosphere is frequently referred to as Buys Ballot's law. It is satisfied very closely under steady conditions in the absence of friction.

The Gradient Wind Velocity.—Since the equilibrium wind velocity, in the absence of friction, parallels the isobars, it follows that if the isobars are curved. as they normally are to some extent on any constant level weather map, then the wind is constrained to move in a curved path. This introduces a third force, the centrifugal force due to the curvature of the path, into the balance of forces. The centrifugal force amounts to $\frac{v^2}{r}$ per unit mass of moving air, where r is the radius of curvature of the isobar at the point where v is observed. Consequently for curved isobars the equilibrium wind velocity is given by $F = -\frac{1}{\rho}\frac{dp}{dn} + 2v\omega \sin \varphi \pm \frac{v^2}{r} = 0$. The particular velocity v for which this condition is satisfied is called the gradient wind velocity. The centrifugal force, like the Coriolis force, always acts at right angles to v and consequently cannot affect the wind speed. In the case of isobars that are curved around a centre of low pressure (cyclonic circulation) the pressure gradient force is always directed in toward the centre of low pressure, so that the Coriolis force as well as the centrifugal force are directed outward to balance the pressure gradient. In the case of an isobar which is curved around a centre of high pressure (anticyclonic circulation) the pressure gradient force is directed outward to lower pressure, the Coriolis force must then be directed inward, so that the pressure gradient force is balanced by the difference of the Coriolis and the centrifugal force. Consequently the positive sign with the centrifugal force term must be used for cyclonic, the negative sign for anticyclonic circulation.

With increasing intensity of the cyclonic or anticyclonic circulation (high or low) the velocity v usually increases as the radius of curvature r of the isobars decreases, so that the centrifugal force increases much more rapidly than the Coriolis force. In the low, where the pressure gradient force is balanced by the sum of the other two forces, there is no limit to the intensity of the cyclonic vortex that may develop under gradient wind equilibrium, as witness the small and extremely intense tropical hurricane (see Formation of Tropical Hurricanes, below). But in the anticyclone a limiting intensity is quickly reached beyond which the centrifugal force becomes so nearly equal to the Cori-

olis force that the pressure gradient force cannot be balanced by their difference, and no gradient wind equilibrium is possible. This difference between the cyclonic and the anticyclonic gradient wind balance accounts for the fact that there cannot exist in the free atmosphere any small highs which even remotely approach the intensity that is occasionally observed in small lows.

The direction of the Coriolis force, to the right on the northern hemisphere, and to the left on the southern, requires that the geostrophic and the gradient wind blow parallel to the isobars with lower pressure to the left on the northern hemisphere and to the right on the southern, standing with the back to the wind. Consequently the wind must blow clockwise around a high and counterclockwise around a low in the northern hemisphere, and vice versa in the southern. The fact that this sense of cyclonic and anticyclonic circulation on either hemisphere is observed without exception confirms the significance of the fictitious Coriolis force in any equilibrium wind balance on the rotating earth.

It follows from the balance of forces in the geostrophic and in the gradient wind equilibrium, that the geostrophic wind velocity computed by neglecting the centrifugal force must always be greater in a cyclonic circulation and less in an anticyclonic circulation than the gradient wind velocity computed from the gradient wind balance of forces. The difference between the computed geostrophic and gradient wind velocities is always small in the anticyclonic circulation, where an equilibrium balance is possible only when the centrifugal force is a small fraction of the Coriolis force. Even in the ordinary extratropical low pressure circulation the difference is usually not large, but in a small intense cyclonic circulation at low latitudes (tropical hurricane) the centrifugal force may outweigh the Coriolis force roo to 1 in the gradient wind balance. The computed geostrophic velocity is correspondingly larger than the gradient velocity. Obviously it is always the gradient velocity rather than the geostrophic which should correspond to the wind velocity observed in the free atmosphere in the absence of frictional retardation. Since the difference between the two is usually small, and since the geostrophic velocity is so much more conveniently computed from a weather map, the tendency is to use the geostrophic rather than the gradient velocity in most practical forecasting from weather maps.

The Effect of Friction on Atmospheric Winds.—Wind Velocity at the Ground.—It is a fact of observation, to be noted 'on any sea-level weather map, that the wind velocity near the ground departs significantly from the gradient or geostrophic velocity nhich corresponds to the existing pressure gradient. The sense of the circulation, except in cases of strong local interference, is always that required by the gradient wind equilibrium, but the observed speed is substantially less than the gradient speed, and instead of blowing parallel to the isobars, the wind is observed to blow at an appreciable angle across the isobars toward lower pressure. Thus the air at the ground moves spirally into a low and out of a high, with the proper clockwise or counterclockwise sense of rotation.

This observed departure of the surface wind velocity from the gradient value is evidently caused by surface friction. The frictional force of retardation acts always in direct opposition to the wind velocity at the ground, and is proportional to the velocity and to the roughness of the ground surface. It is evident from the gradient wind balance of forces that the Coriolis force and the centrifugal force are both diminished when the wind velocity v is decreased, but the horizontal pressure gradient force is independent of v and remains unchanged. Consequently the pressure gradient force is no longer balanced by the other two forces, so that the more v is reduced by friction, the greater is the angle at which the wind blows across the isobars in response to the unbalanced pressure gradient force. If the pressure gradient remains unchanged by this deflection of the wind, a steady state may be reached in which the wind blows at a constant angle across the isobars with less than gradient speed, and the retarding force of friction, acting in direct opposition to v, is added to the Coriolis and centrifugal forces to balance the pressure gradient force. Under this condition the horizontal pressure gradient accelerates the speed of each particle of air moving toward lower pressure by an amount that exactly compensates the retardation by friction.

The frictional character of the retardation of the surface wind is evidenced by the difference between normal surface winds over land and over the relatively smooth sea surface. Although wind conditions are quite variable, especially over land, nevertheless surface winds'are observed to average over the land roughly 40% of the gradient speed at an average angle across the isobars of approximately 4j°, whereas over the open sea the corresponding average values are approximately 65% of the gradient speed at an angle of some 30° across the isobars. With increasing wind velocity the departure of the surface wind from the gradient speed and direction tends to decrease, but at all velocities the difference between observed wind and gradient wind at the surface averages less over water than over land.

The Vertical Distribution of Wind Velocity in *the* Surface Frictional Layer.—The change of the horizontal wind velocity in the atmosphere with increasing height above the ground, *i.e.*, the vertical wind shear $\frac{dv}{dz}$, depends upon the internal friction (viscosity) of the atmosphere between the layers within which the shear occurs. Obviously if the internal friction is small, there is little frictional drag between overlying strata of the atmosphere, hence the surface wind is strongly retarded by friction at the ground, for it suffers little acceleration from the freely moving gradient wind layers aloft. Under this condition the frictional retardation of the surface wind is greatest, the depth of the surface frictional layer is least, the vertical wind shear is most rapid, and the full gradient wind velocity is attained at the lowest elevation in the free atmosphere. If the internal friction is large, then the reverse conditions hold, *i.e.*, the surface wind, in spite of strong frictional drag at the ground, is accelerated strongly by the faster moving air layers aloft to a velocity closer than usual to the gradient value, the depth of the surface frictional layer is greatest, the vertical wind shear is most gradual, and the full gradient wind velocity is first attained at an exceptionally high elevation above the ground. In the first case, of small internal friction, the total retardation of air movement by the ground is small, in the second case it is large.

It was pointed out in the discussion of molecular and turbulent transport in the atmosphere, that molecular exchange of momentum and consequently the coefficient of internal molecular friction, is completely negligible in its effects compared with turbulent transport and the coefficient of internal eddy or turbulent friction. Consequently this internal friction of the atmosphere on which the vertical wind structure of the surface frictional layer depends, is a matter entirely of the turbulent state of the frictional layer of vertical wind shear at the ground. The condition of strong turbulence and large internal friction of the lowest atmosphere with the corresponding characteristic vertical distribution of wind is effected by the following factors:

(1) Strong heating of the atmosphere by the ground surface to produce a steep lapse rate and thermal convective turbulence.

(2) A high wind velocity to produce strong mechanical turbulence and a steep lapse rate by mechanical mixing.

(3) A rough or hilly terrain, which in the case of a prevailing wind operates to increase mechanical turbulence.

Wind Velocity Profiles *in the* Surface Frictional Layer.—A great variety of vertical wind velocity profiles are observed through the surface frictional layer of the atmosphere, corresponding to a variety of combinations of the three controlling factors as listed above. The depth of the surface frictional layer (the height in the atmosphere to which the effects of surface friction are observed to reduce the wind velocity appreciably below the gradient value) ranges from only roo or zoo ft. in cases of very light winds and extreme thermal stability, to heights of 5,000 or even 10,000 ft. in cases of extreme thermal instability. When the frictional layer extends to appreciably more than 5,000 ft. it is rarely possible to distinguish the upper limit of the layer

because the vertical wind shear becomes insignificantly small and the ,horizontal pressure gradient and the corresponding gradient wind may change considerably from the values given by the sea-level isobars. When the surface thermal influence is markedly stabilizing. however, the surface frictional layer is usually clearly defined. Even in cases of strong wind and rough terrain, the depth of the turbulence layer in that case is unlikely to exceed some 4,000 ft., while the top of the layer is usually bounded by a sharp temperature inversion, frequently with a strato-cumulus cloud layer beneath the inversion.

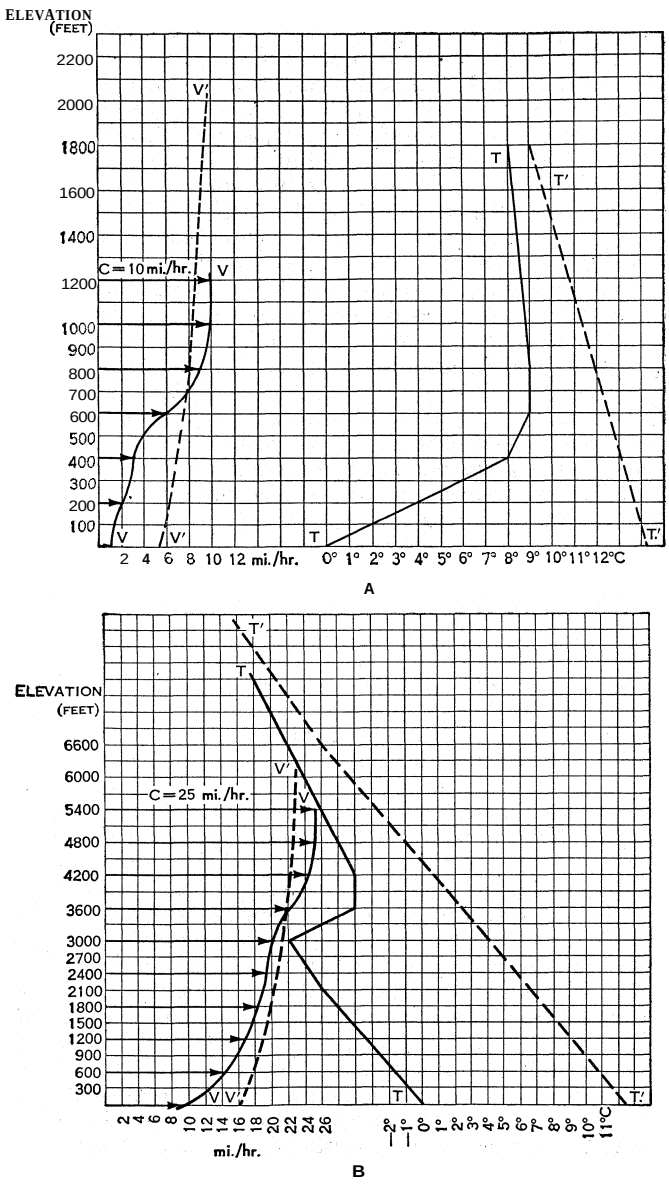


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FIG. 2.—VERTICAL PROFILES OF WIND VELOCITY AND TEMPERATURE IN THE FRICTIONAL LAYER ABOVE THE GROUND

Fig. 2 represents some typical wind velocity profiles over land for cases of light wind (fig. 2A, gradient wind velocity $c=10$ m.p.h.) and fresh wind (fig. 2B, gradient wind velocity $c=25$ m.p.h.). Wind speeds against height above the ground are represented by the curves VV and V'V'. Corresponding typical vertical distributions of temperature are represented by the curves TT and T'T'. It may be assumed that the direction of the actual wind velocity v approaches the direction of the gradient wind c as the speed of v approaches c with increasing height.

The curves VV and TT in fig 2A represent typical nocturnal conditions with clear skies, prevailing light minds and radiational cooling of the ground. The wind at the ground becomes almost calm, and dew, frost or even ground fog are formed. The vertical wind shear in the stable atmosphere is large. so that a light breeze is observed at an elevation of a few hundred feet, and the full gradient wind velocity may be encountered at 1.000 ft. or occasionally as low as at 500 ft. above the ground. The curves V'V' and T'T' represent the effect on the nocturnal conditions of strong diurnal insolational heating of the ground. The temperature is raised most at the ground, where the relative humidity drops correspondingly and any condensation forms are evaporated. The depth of the frictional layer is greatly increased, with a marked decrease of the vertical wind shear as the surface winds are accelerated and the winds at higher levels retarded by the increased vertical exchange of momentum by turbulent transport. This typical diurnal variation of the wind velocity profile over land during settled weather conditions is reflected in a normal wind regime such that the highest velocities at the ground are observed during the warmest part of the day, the lowest velocities during the coolest part. The regime at moderate elevations and at mountain-summit stations is reversed.

The curves VV and T T in fig. 2B represent a typical distribution of wind velocity and temperature above the ground after prolonged surface cooling but with a prevailing wind that is too strong to permit the formation of any inversion of temperature at the ground. In this case the turbulence layer is much deeper, topped by an inversion of temperature beneath which a strato-cumulus cloud layer is to be expected, but the relative humidity at the ground is far short of saturation. The vertical wind shear is gradual, being most pronounced at the ground and in the stable upper boundary of the frictional layer. Prolonged and strong heating of the atmosphere at the ground tends to produce a vertical distribution of uind velocity and temperature as represented by the curves V'V' and T'T', respectively. No clear definition of the frictional layer remains. The strato-cumulus clouds are dissipated or converted into the unlimited convective forms, cumulus or cumulo-nimbus. The diurnal wind regime at the ground and at higher levels is present in the same sense that occurs with the light wind in fig. 2A, but the diurnal variation is less pronounced.

Smooth flying conditions (the atmosphere relatively free of turbulence) occur always just above the surface frictional layer when the upper edge of the layer is sharply defined by marked thermal stability of the atmosphere. Thus in fig. 2A the conditions represented by curves T T and VV indicate smooth flying throughout the lower atmosphere, whereas the curves TT' and VV' suggest localized thermal convective bumpiness, without much general wind roughness. In fig. 2B the conditions represented by curves TT and VV indicate marked wind roughness of the air up to 3,000 ft., but smooth flying conditions above some 3,600 ft., whereas the curves TT' and V'V' indicate general wind roughness and strong thermal convective bumpiness of the air at all levels.

The Vertical *Distribution* of *Wind* Velocity in the Free *At*mosphere.—In the free atmosphere above the surface frictional layer the observed wind velocities not infrequently depart to some extent from the gradient wind values, but very rarely to a degree that even approaches that which is usually observed at the ground. It must be remembered further that wherever a horizontal temperature gradient exists in the atmosphere. the horizontal pressure gradient, and consequently the gradient wind velocity, change with elevation in direct proportion to the temperature gradient. This vertical wind shear in the free atmosphere is usually small compared to that which exists in the surface frictional layer. Furthermore, the eddy viscosity of the air is likely to be smaller in the free atmosphere, so that departure of the observed wind from the gradient mind due to frictional accelerations is usually insignificant. It should be noted that the frictional acceleration in the free atmosphere produces supergradient as readily as subgradient mind velocity, for the frictional acceleration of each air particle is the combined effect of the frictional drag of the air layer above and of that below. Therefore it is the second derivative of the velocity with height, or the sign

of $\frac{d^2v}{dz^2}$ at each level, that determines whether the frictional acceleration of the gradient wind is positive or negative. In the surface frictional layer $\frac{d^2v}{dz^2}$ is nearly always negative (except perhaps in the stable upper boundary of the layer), hence the frictional acceleration is nearly always one of retardation of the gradient wind, but in the free atmosphere this is by no means the case.

In general the pressure pattern (the isobars on any constant level chart) and wind pattern are in a state of constant change, or flux. When these changes take place slowly, so that relatively steady conditions of pressure gradient and wind velocity prevail, then there is opportunity for the gradient wind equilibrium to become well established in the free atmosphere, and only the minor frictional accelerations remain to produce departures of the observed wind from the gradient value. But when rapid changes are occurring, as indicated by the rapid movement and the deepening or filling of pressure centres, then there are accelerational fields present which may be much stronger than the frictional, and correspondingly large departures of wind velocities from the gradient values are observed. However, large departures of this type are usually rather localized on the pressure charts and of relatively short duration, for the tendency toward mutual adjustment of the pressure field and the wind field to the gradient equilibrium is always active.

The change with height of the horizontal pressure gradient, and of the gradient wind, as a result of the horizontal temperature gradient, is such that the pressure gradient is steepened, and the centre of lowest pressure is displaced, in the direction of the coldest air. A gradient of increasing pressure is steepened, and the centre of highest pressure is displaced in the direction of the warmest air. Consequently, in general, west winds increase with height and east winds decrease with height at any point in the atmosphere where a poleward temperature gradient exists. This condition applies normally throughout the troposphere in middle and higher latitudes. West winds decrease with height and east winds increase with height at any point in the atmosphere where an equatorward temperature gradient exists. This condition applies normally at the base of the stratosphere in most latitudes, in the upper troposphere in the tropical and subtropical latitudes, and to some extent even in the lower troposphere in the tropical latitudes of either hemisphere during its summer season.

Since the coldest air is usually found to the north and west of a centre of low pressure at sea level in middle latitudes, and the warmest air to the south and west of a high-pressure centre, it follows that such a centre of low pressure at sea level tends to be displaced westward and northward with increasing height, finally opening out as a trough of low pressure toward the pole at high elevations. Similarly the high-pressure centre at sea level tends to be displaced westward and southward with increasing height, finally opening out as a ridge of high pressure toward the equator at high elevations. Thus, especially in winter, when the horizontal temperature gradients in middle latitudes are strongest, the normal east-west sequence of closed highs and lows which are observed in the sea-level pressure pattern in these latitudes tends to open out at the 10,000, 15,000 or 20,000 ft. levels into a trough and ridge wave-pattern of isobars more or less concentric about the pole. Correspondingly the closed cyclonic and anticyclonic gradient wind circulations observed at sea level open out aloft into a wave pattern of motion within one great circumpolar cyclonic vortex. Hence in general the west-east component of wind motion tends to increase with height relative to the north-south component. In summer, at least on the northern hemisphere, the horizontal temperature gradients are much weaker than in winter, so that the circumpolar cyclonic vortex aloft is relatively weak, and the closed cyclonic and anticyclonic circulations extend higher in middle latitudes. On the southern hemisphere, corresponding to the greater coldness of the antarctic, the circumpolar vortex aloft is stronger throughout the year even than it is on the northern hemisphere in winter.

ATMOSPHERIC CIRCULATIONS

All of the wind circulations of the troposphere, which directly or indirectly cause most of the weather of the lower atmosphere, are to be explained by the principles outlined briefly in section V. However, the complexity of most of these large-scale atmospheric phenomena is such that there exists only the most imperfect understanding of the mechanics of their genesis, maintenance and decay. Consequently the following discussion of the mechanics and of the weather characteristics of these circulations can be at best only crudely qualitative and descriptive.

For purposes of systematic discussion the atmospheric circulations are classified by size and by principle of maintenance, insofar as the latter is understood. The primary, or general circulation, comprises that world-wide complex of wind systems by means of which is effected the latitudinal transfer of heat that maintains the heat balance of the atmosphere. The secondary circulations are the large-scale cellular units which are contained within the general circulation and which constitute an essential part of the general circulation. These are the cyclonic and the anticyclonic centres of high and of low pressure which are observed to occur with greater or lesser frequency and intensity on every sea-level weather map. The tertiary circulations are the small-scale local disturbances which occur in a variety of forms within most of the larger circulations, but unlike the secondary circulations they do not contribute appreciably to the general circulation. The tertiary circulations include glacier winds, fohn winds, land and sea breezes, thunderstorms, tornadoes, etc. In the following discussion the atmospheric circulations are considered in turn, proceeding from the over-all general circulation to the small-scale tertiary circulations The secondary circulations are discussed first in connection with their role in the general circulation and then as important weather phenomena in themselves.

THE GENERAL CIRCULATION

The Direct Thermal Drive.—Basically the general circulation of the earth's atmosphere is maintained by the horizontal temperature gradient between tropical and polar latitudes. If there were no complicating factors, the general circulation would consist of one large thermally direct cell on either hemisphere, circulating in the sense outlined in The ***Principle*** of Thermal *Circulation,* above. In such cells the atmosphere slowly subsides over the polar half of the earth's surface with equatorward outflow of cold air in the lower half of the troposphere, and slowly ascends over the equatorial half of the earth's surface with poleward outflow of warm air in the upper half of the troposphere. Each of these large thermally direct cells tends to reach a steady equilibrium intensity of circulation in which it operates with a certain definite efficiency, thereby consuming a definite part of the thermal energy received in the tropical heat source of the atmosphere to overcome frictional resistance. The balance of the thermal energy received in the tropical heat source is delivered to the polar cold source, the amount of this heat transfer being exactly that required to maintain the existing heat balance of the atmosphere. A change in the latitudinal heat balance of the atmosphere on either hemisphere, such as that which occurs between the summer and the winter seasons, accelerates the affected circulation cell to the equilibrium intensity required by the changed heat balance, an intensity which must be greatest during the winter season when the tropical-polar temperature contrast is strongest.

Essentially the drive of the general circulation follows exactly this thermally direct pattern, which is purely meridional (north-south) in character. Actually the general circulation as it is observed to exist is radically altered by the effect of the earth's rotation and by the contrasting thermal influences of continents and oceans, factors which superpose such large zonal (east-west) and cellular components on the circulation that the basic meridional component is almost lost to sight (for a full description of the observed features of the circulation see WINDS, GENERAL

CIRCULATION OF). The following explanation attempts in a rough qualitative fashion to account for some of these observed features of the general circulation.

Effect of the Earth's Rotation. — The effect of the earth's rotation on a thermally direct circulation cell of the type outlined above must be, in accordance with Buys Ballot's law, to establish straight zonal west winds in the upper troposphere and zonal east winds in the lower troposphere in either hemisphere. This wind distribution represents an impossible steady state of the general circulation, partly because there is none of the necessary meridional circulation other than the small frictional nongradient component of the air motion, and partly because the earth and the atmosphere cannot rotate at different speeds at the frictional boundary between them, *i.e.*, in the long run, averaged over the entire earth, there must be as much zonal west wind as zonal east wind at the ground.

It is necessary only to assume that there exists a large-scale meridional circulation on the rotating earth to account for the observed distribution of zonal wind in the general circulation. The latitudinal transfer of angular momentum by any meridional circulation from the high values of the equatorial latitudes to the low values of the polar latitudes imparts a relative eastward motion to the atmosphere over the polar half of the earth's surface, and a relative westward motion over the equatorial half.

The action of the Coriolis force in these two zonal wind belts must establish a compensating pressure gradient in the form of a belt of high pressure on either hemisphere at approximate latitude 37°, the parallel which divides either hemisphere into two equal areas, with equatorward and poleward pressure gradients on either side. The mean zonal winds which are observed at the earth's surface on either hemisphere fit this pattern very closely. The principal deviation occurs in the form of a shallow cold-air anticyclone over either polar cap, presumably the result of extreme surface cooling of the atmosphere in the polar regions. This cold polar anticyclone in either hemisphere reverses the prevailing westerlies of higher latitudes in a shallow layer of the atmosphere to a distance of some 25° of latitude from the poles. Hence a mean trough of minimum pressure is observed in the vicinity of the 65th parallel on either hemisphere, poleward from which light east winds normally prevail. As would be expected from the strong poleward temperature gradient, the direction of the pressure gradient and wind is normally reversed at a height of only 2 or 3 km. above the ground, so that essentially the entire troposphere in middle and higher latitudes rotates faster than the earth in one great circumpolar cyclonic vortex.

As a result of the surface easterly winds in the polar regions, the subtropical boundary between zonal easterlies and zonal westerlies is displaced moderately equatorward from the 37th parallels, usually lying in the mean between latitudes 30° and 35° on either hemisphere. In winter the poleward temperature gradient in these latitudes is quite pronounced, hence a marked equatorward displacement of the high-pressure belt is observed with increasing elevation above the ground, such that in the upper troposphere west winds are observed to overlie the easterlies to as close as 15° from the equator. In summer a meridional temperature gradient in latitude 35° is almost nonexistent, consequently the boundary between easterlies and westerlies tends to be nearly vertical, *i.e.*, there is almost no displacement of the high-pressure belt aloft.

The Cellular Character of the General Circulation. — The zonal component of the general circulation as outlined above is readily observed in mean or normal pressure and wind patterns, but it makes no allowance for the essential meridional circulation. other than the small and quite inadequate nongradient frictional component of the wind, nor does it give any indication of the irregular short-period fluctuations of the general circulation pattern. An inspection of seasonal mean or normal pressure and wind charts indicates that the zonal pressure and wind belts are to a considerable extent broken into cells which change their character and location from season to season. The cellular character of the general circulation pattern, as well as the seasonal changes, are much more pronounced on the northern than on the southern hemisphere.

It is obvious from the difference between the two hemispheres, and from the seasonal fluctuations of the position and intensity of these high- and low-pressure cells, or secondary centres in the general circulation, that they are maintained and controlled in the mean by the contrasting seasonal thermal influences of the continents and oceans. On the northern hemisphere the subtropical high-pressure belt is broken into two very large high-pressure cells in summer over the relatively cool North Atlantic and North Pacific oceans while pressure is relatively low over the heated continents. In winter the subtropical high-pressure cells extend far northward over the cold continents, while two very strong cyclonic cells, the so-called Icelandic and Aleutian lows, centred over the northernmost warm ocean areas, in the circumpolar belt of low pressure, dominate the circulation pattern at high latitudes, except for the northward extension of the ridges of relatively high pressure over the colder parts of Asia and North America. In summer the Icelandic and Aleutian lows tend to disappear as separate cells, or to be displaced inland over the warm continental areas in the circumpolar low-pressure belt.

On the southern hemisphere there are three subtropical high-pressure centres, over the south Atlantic, Pacific and Indian oceans respectively. The unbroken sweep of cold ocean around the Antarctic continent causes the southern hemisphere circumpolar low-pressure belt to exist as a continuous deep trough of low pressure without any distinct cell formation, around the strong polar anticyclone over the antarctic continent. This strong zonal circulation, and the temperature gradient that maintains it, undergo only minor seasonal fluctuations. The arctic polar anticyclone is relatively weak, for it is not based on any extensive glaciated continental area.

At elevations of from 10,000 to 20,000 ft. these seasonal thermal cells of the general circulation pattern tend to open out, as would be expected, into the general circumpolar cyclonic vortex. The cold anticyclonic cells at sea level tend to become ridges of high pressure aloft which are displaced usually westward over adjacent regions of surface heating and warm cyclonic cells at sea level. These cyclonic cells in turn become troughs of low pressure aloft that are displaced usually westward over adjacent regions of surface cooling and high pressure at sea level (see WINDS, GENERAL CIRCULATION OF).

It is evident that this surface cellular and upper-level wave pattern (troughs and ridges) of isobars and winds accounts to a considerable extent for the meridional component of the general circulation. This pattern maintains large-scale and persistent east-west pressure gradients which make possible correspondingly large-scale meridional components of the gradient wind. The importance of the role played by these secondary thermal cells in the genera1 circulation and in the latitudinal heat balance of either hemisphere is indicated by the difference between the northern and the southern hemisphere. In the southern hemisphere, where the secondary thermal cells are practically nonexistent in middle and higher latitudes, the meridional circulation and the poleward transport of heat is apparently significantly weaker than that on the northern hemisphere. This fact is indicated by the stronger latitudinal temperature gradients, the much more intense zonal circulation of the southern hemisphere and the greater uniformity of the circulation throughout the year, relative to the conditions of the northern hemisphere. However, it appears that also the relatively short-lived migratory frontal cyclones and anticyclones play an important part in the meridional circulation between subtropical and polar latitudes.

The Role of Frontogenesis and Frontal Cyclogenesis in the General Circulation. — The circulation of the semipermanent thermal cells effects meridional transport of air within each cell, but to complete the meridional exchange of air masses between polar and tropical latitudes there is required an effective mechanism for the exchange of air masses between polar and tropical cells or, in the absence of thermal cells, between the zonal wind systems. This mechanism is found in frontogenesis (the formation of frontal zones) and in frontal cyclogenesis (the development of lows on the fronts). Frontal zones are formed

and maintained in the general circulation wherever the circulation of the semipermanent cells leads to the large-scale horizontal convergence of air currents (air masses) of markedly different properties. Such convergence occurs most effectively between two anticyclonic cells. Intertropical fronts, of small air-mass contrast, are formed in the equatorial belt of low pressure between the subtropical highs of the northern and those of the southern hemisphere. Polar fronts, of the most important air-mass contrast, are formed between two subtropical highs, and in winter between a cold continental high and a warm maritime subtropical high. Arctic fronts, also of large air-mass contrast, are formed between the zonal easterlies of either polar cap anticyclone and the warmer anticyclonic cells of middle latitudes.

The occlusion process which marks the normal development of an intense migratory low on an arctic or polar front (see the discussion of secondary circulations of the dynamic type below) is characterized by the rapid advance of cold air at the ground around the deepening low, while warm air aloft flows into the region which is evacuated by the cold air. Essentially the occlusion of a frontal low is marked by an extensive breakdown of the frontal transition zone between a warm and a cold cell of the general circulation, mith an extensive outflow of cold air at the ground from the cold into the warm cell, and the ascent of warm air from the warm cell into the upper levels of the cold cell. Even the necessary vertical component of the meridional circulation of the atmosphere is present in such an exchange of air masses. Hence the interaction primarily of polar and tropical air masses in the course of the occlusion of a typical migratory low in the frontal zone between two semipermanent cells of the general circulation, ie., the customary wintertime sequence of warm and cold waves in middle latitudes, forms the final important link in that complex of circulations which constitutes the general circulation of the atmosphere.

Frontogenesis and cyclogenesis on the southern hemisphere are not quite as definitely localized as they are between the semipermanent cells of the general circulation of the northern hemisphere, but both processes occur quite extensively in the form of arctic fronts between the strong zonal westerlies and the polar easterlies and in the form of polar fronts between the subtropical high-pressure cells. These cells show a tendency to stronger eastward migration than is observed in such cells on the northern hemisphere. But even with the assistance of these migratory frontal systems, the meridional component of the general circulation of the southern hemisphere remains considerably weaker than that of the northern hemisphere.

Fluctuations of the General Circulation Pattern. — From the preceding discussion of the general circulation of the atmosphere, the following conclusions may be drawn concerning its seasonal fluctuations:

(1) The entire circulation system, both the zonal and the meridional components, is weaker during the summer than during the winter season. This difference is much more pronounced on the northern than on the southern hemisphere, corresponding to the difference in the seasonal variation of the poleward temperature gradient on the two hemispheres.

(2) The zonal pressure and wind belts are shifted poleward an average of 5° to 10° on either hemisphere during the summer season. This displacement corresponds to the seasonal shift of the thermal equator (the belt of maximum equatorial temperatures) and to the summertime contraction of the polar cap zones of extreme cooling of the atmosphere.

(3) The cellular pressure and wind pattern is greatly modified, especially with respect to the continental cells in middle and higher latitudes.

(4) Corresponding to the seasonal changes in the position, intensity and sense of circulation of the semipermanent cells of the general circulation, there occur resultant shifts in the positions of the frontal zones which are displaced poleward and which become weaker and less active in the formation of migratory lows in summer.

In addition to the normal seasonal fluctuations of the general circulation pattern, there occur even more striking irregular large-scale changes of the circulation during the same season within one year and from one year to another. These irregalar changes are most extreme in their effects on world-wide weather conditions during the winter season when the general circulation is strongest, but their consequences are more serious during the crop-groning seasons. The most striking of these fluctuations tend to run in irregular periods which vary in length from two or three weeks to two or three months, but much longer period fluctuations of smaller amplitude also occur. These fluctuations explain the great variety of persistently anomalous, or abnormal weather conditions, which occur and recur in most parts of the world for periods of weeks. months or even years. Typical of such conditions is the occurrence of a very severe winter in one region with a mild winter in another, or an extended period of severe winters over an entire continent, or a prolonged summer drought over a vast area of the earth's surface while another area receives excessive rains. Essentially these persistently anomalous weather conditions stem from an excessive or deficient intensity of either the meridional or zonal or of both components of the general circulation, with the concomitant dislocations of the normal cellular circulation pattern. This dislocation produces a corresponding displacement of the principal frontal zones, and hence of the normal storm tracks, of the number and intensity of storms in any particular region and of the prevailing air-masses. An abnormally strong zonal circulation tends to establish settled and moderate weather conditions in middle and lower latitudes. mith a maximum of storminess at higher latitudes and excessive coldness in the polar regions. An abnormally strong meridional circulation tends to establish a persistent condition of contrasting extremes of temperature, with a maximum of severe storminess in middle and lower latitudes. Persistent severe cold is experienced in middle and lower latitudes in those regions dominated by the equatorward-moving polar air-masses, while persistent abnormal warmth is experienced in middle and higher latitudes in those regions dominated by the poleward-moving tropical air-masses. Little or nothing is known of the operation of the physical factors which control these irregular long-period fluctuations of the general circulation. This is one of the primary problems in meteorology which remains to be solved, a problem which probably must be solved before dependable long-range weather forecasts will be feasible.

THE SECONDARY CIRCULATIONS

The secondary circulations, whether anticyclonic or cyclonic, are characterized by one or more isobars closed around centres of high or of low sea-level pressure, respectively. Consequently highs and lows are essentially localized areas of excess or deficit, respectively, of the mass or weight of the overlying atmosphere. The effect of friction at the ground was seen to be such that the steady surface wind blows spirally into a low and spirally out of a high. Hence the effect of surface friction is to dissipate the centres of high or of low pressure which constitute the secondary circulations through the transport of air by the frictional cross-gradient component of the surface wind. It follows that any high or low that holds or increases its intensity as observed in the sea-level isobars must be maintained by some active process that effects sufficient horizontal convergence or divergence of air at upper levels into the area of closed isobars to compensate or overcompensate the frictional divergence or convergence near the ground. Consequently the atmosphere slowly sinks and spreads horizontally in the lower portion of a high, and slowly ascends and converges in the lower portions of a low. This difference of vertical motion and its effect on the temperature lapse rate accounts for the typical difference between the settled weather and clear skies of the high-pressure area in contrast to the extensive rain-or showers and unsettled weather of the low.

The secondary circulations are classified, according to the nature of the process which maintains them against the dissipative action of friction, as thermally direct and as dynamic or forced. The thermally direct highs and lows are formed by localized cooling or heating, respectively, of the lower atmosphere. The coldness of the high and the warmth of the low reverses the direction

of the pressure gradient and the sense of the circulation at those upper levels where the inflow or the outflow is located, which compensates the effect of surface friction. The dynamic highs and lows are formed by the mechanical interaction of major air currents of the general circulation one with another or to a lesser extent with topographical barriers, but the mechanics of the development of these dynamic secondary circulations is comparatively little understood. The dynamic highs and laws are frequently relatively warm and relatively cold, respectively. in which case the intensity of the circulation increases with height in the troposphere, unlike the thermally direct variety.

The thermally direct secondary circulations include the seasonal semipermanent cells of the general circulation called monsoons after the Arabic word for season *(see* MONSOON), and the tropical hurricane, called typhoon in the far east *(see* HURRICANE; TYPHOON).

The Monsoon Circulations. — The term monsoon was applied originally to the seasonal wind, normally the strongest such wind on the northern hemisphere, which prevails over the Arabian sea as one branch of the Asiatic thermal cell of the general circulation. More recently the term monsoon has come to be applied to any circulation which is essentially seasonal in character, hence it applies in general to the semipermanent cells of the general circulation which are maintained by the seasonal thermal contrasts of the continental and ocean surfaces. Since the seasonal monsoon contrast is greatest over continents in middle latitudes, the effects of the North American and of the Asiatic monsoons on the climates of those two continents, the largest land masses in middle latitudes, are considered briefly as typical of the extreme monsoon influence.

In North America the summer continental low and the winter continental high appear in the seasonal mean or normal pressure and wind charts, but they are frequently obscured or temporarily obliterated by the day-to-day sequence of migratory highs and lows. However, their seasonal influence is clearly demonstrated. In winter the predominant air-flow east of the continental divide is one of an intermittent sweep of cold continental polar air-masses from Canada southward and southeastward to the gulf and Atlantic coasts of the United States, between the continental high in the west and the North Atlantic low in the east. Thus a northerly wind component and a cold dry climate predominate over the central and eastern part of the continent. At the same time frontogenesis and cyclogenesis between this cold polar air-flow and the subtropical high-pressure cell over the Atlantic leads to considerable storminess and winter precipitation along, and to some distance inland from, the gulf and Atlantic coast lines. On the Pacific coast, between the continental and the North Pacific low, the prevailing wind direction has a southerly component and the predominant winter weather type is warm, wet and stormy. In summer the prevailing flow pattern is just reversed, between the high pressure areas covering most of the oceans, and the relatively low pressure over the continent. The prevailing air-mass flow over the eastern and central part of the continent has a southerly component, carrying warm moist tropical air from the Gulf of Mexico northward, thus accounting for the predominantly warm sultry weather with scattered thunderstorm activity and occasional widespread convective rains east of the continental divide. On the west coast the prevailing air-mass flow is anticyclonic of maritime polar air from the northwest around the Pacific high, the predominant weather type correspondingly cool and dry.

Asia, representing a land mass some two and one-half times in area that of North America, produces correspondingly the strongest strictly monsoon circulations in the world. They are approximately three times the extent and intensity of the North American monsoons, they are never obliterated or rarely even obscured by the day-to-day migratory pressure centres, and they completely dominate the winter and summer weather patterns over most of Asia. Asia differs from North America also in the fact that the great mountain ranges, extending eastward from Asia Minor in the west through the towering Himalayas just north of the Indian peninsula into northern Burma and southern China, interpose a major obstacle to any such free northward or southward movement of air masses as occurs in central and eastern North America.

In winter the circulation over most of Asia and the adjacent ocean areas is dominated by the great symmetrically centred Asiatic anticyclone. All of Asia north of the southern mountain barrier is dry and extremely cold, with temperatures over the low-lying plains of northeastern Siberia averaging in January the lowest that are known in the world near sea level. The extremely cold continental polar air is shallow, a result of surface cooling and subsidence aloft in the monsoon anticyclone. Consequently the southern mountain barrier completely blocks the flow of this shallow cold air to the Indian ocean in the manner that cold waves in North America reach the Gulf of Mexico. The prevailing northeast winds over southern coastal Asia in winter are dry, and moderately warmed by downslope movement from the mountains and by insolational heating. The winter monsoon season in this area is almost rainless and quite mild in temperature. Frontal and storm activity is held at a distance by the strength of the predominant anticyclonic monsoon circulation.

In summer central Asia is dry and intensely heated, even Siberia becomes quite warm, as the continent is dominated by the vast monsoon low which is centred in the hot dry region northwest of India. The prevailing strong southwest and southerly winds that blow across the northern Indian ocean into southern and eastern Asia deposit excessive amounts of precipitation on the south coast and along the exposed southern slopes of the great mountain barrier, where the heaviest rainfall in the world occurs during the summer monsoon. The moisture is so completely removed from the maritime tropical air-masses in the course of their ascent over the mountains, that central Asia remains quite arid during the hot summer season, unlike the condition in North America where the maritime tropical air from the Gulf of Mexico and Caribbean sea has easy access to the interior of the continent.

The summer maximum temperatures in the region of the heavy monsoon rains of southern Asia are somewhat depressed by the cloudiness and precipitation, so that in these areas the highest temperatures occur during the intermonsoonal periods in April and May in the spring, and in October and November in the autumn.

The Asiatic monsoon circulations, like the other semipermanent cells of the general circulation, vary appreciably from year to year in their exact location, intensity and duration. Correspondingly large variations occur in the time of onset, intensity and distribution of the monsoon rains, which are of vital importance to the subsistence of the dense agricultural populations of southern Asia. Consequently much attention has been paid by the British and Indian meteorologists to the development of suitable statistical long-range weather forecasting techniques that might be applied to the seasonal variations of the Indian monsoon as related to other features of the general circulation, but as of 1946 the success of such forecasts had not proved very impressive.

Formation of Tropical Hurricanes (Typhoons). — The hurricane is a thermal convective cyclonic circulation of great intensity which is maintained entirely by the latent heat liberated by the condensation of excessive amounts of water vapour. Release of latent heat is doubtless a contributing factor in the maintenance of many extra-tropical migratory lows (of the dynamic frontal type), but the best quantitative estimates indicate that this source of energy is of only secondary and often of negligible importance in the extra-tropical cyclones. Since there can occur no correspondingly localized cooling of the atmosphere by evaporation, the tropical cyclone has no anticyclonic counterpart.

Since the hurricane is generated and maintained essentially by the convection of excessively moist air to great heights, its initial development is restricted to regions of markedly warm ocean surface and prevailing light wind, both conditions favouring surface instability, and of general air-mass convergence, which favours instability of the atmosphere aloft. Hurricanes never form over land, in regions of a prevailing fresh to strong wind or of markedly anticyclonic circulation, nor within some 6° of the equator,

where the Coriolis force becomes too small to establish cyclonic circulation. The ideal conditions and the principal genesis of hurricanes are observed to occur in general between roughly the 6° and 25° latitude circles in the equatorial doldrum belt (intertropical frontal zone) on either hemisphere in late summer and early autumn when this belt has its maximum poleward displacement, and in other tropical convergence zones between cells of the subtropical highs. On the northern hemisphere such favourable zones include the Caribbean sea and Gulf of Mexico, the region of the Philippines and the China sea, the doldrum belts off Cape Verde and off the west coast of Central America, and the Bay of Bengal and the Arabian sea only during the intermonsoonal periods.

The initial formation of the hurricane takes place slowly, in a region of unstable showery conditions, light variable winds and slightly lowered pressure—conditions that are typical of the doldrum belts or of any other zone of convergence of tropical air masses. Cyclonic circulation in the disturbed area of hurricane genesis is established usually only after a lapse of several days, owing to the slow action of the Coriolis force at low latitudes. Meanwhile slow inflow of air into the convectively unsettled area takes place at all levels, thus preventing the appearance of any clearly defined centre of low pressure. But once the cyclonic sense of circulation is finally established, the inflow is restricted to the surface layer of the warmest and most humid air which thus feeds the convection from below. From this point in the development the pressure can fall rapidly at the centre, for in the contracting vortex the increasing pressure gradient is balanced by the rapidly increasing cyclonic spin which is produced by the conservation of angular momentum. In a very short time, sometimes within 24 hr., assuming the continued supply of sufficiently warm and moist air, a small and very intense hurricane vortex is established. The convection is fed by the warm moist air at the ground, which spirals upward with the release of excessive latent heat in the vortex. The compensating outflow, as indicated by the movement of the high clouds, is located in the upper troposphere, and usually takes place ahead of, in the direction of movement of, the vortex. Normally in this early intense stage of the hurricane, the entire vortex is only 30 to 50 mi. in diameter, the circulation and the cloud forms may extend upward to a height of 50,000 ft. or more (to the top of the troposphere), the sea-level pressure at the centre of the storm is lowered by from 50 to 100 millibars or even more, winds of from 100 to 200 m.p.h. velocity drive a blinding curtain of heavy rain, and incessant lightning is frequently observed. At the centre of the vortex there always occurs a small central calm, the so-called "eye" of the storm, from 5 to 10 mi. in diameter, in which the rain ceases and the clouds frequently are dissipated. These effects are produced by the downward movement and adiabatic heating of air from the upper atmosphere into the partial vacuum at the centre of the vortex.

Movement of Hurricanes.--Once formed, the hurricane tends to drift with the prevailing winds aloft, as indicated, for example, by the isobars and winds at the 10,000 ft. level. In tropical latitudes this drift is normally westward with a slight poleward component, at a speed of some 10 to 15 m.p.h. At some point between the 20° and 30° latitude circles the hurricane usually recurves poleward at reduced speed through some low-pressure trough or breaks in the subtropical high-pressure belt, subsequently moving northeastward or eastward with increasing speed as it reaches latitudes of increasing zonal west winds aloft. Some hurricanes, if they do not move inland, survive long enough as a severe storm after recurvature to cross the full width of an ocean, thereby attaining a total life span of from two to three weeks. The movement of individual hurricanes may be quite abnormal and erratic, as a result of abnormal wind patterns aloft. Particularly in the autumn the circulation of a strong migratory polar anticyclone occasionally catches a poleward-moving hurricane and reverses its direction of movement. In general, except in the northern Indian ocean, the mid-season hurricanes (August-September on the northern hemisphere, February-March on the southern) are the most frequent, are formed and recurve farthest from the equator, are the most intense and experience the longest life and the longest trajectories of any of the hurricanes.

As hurricanes move to higher latitudes, during and after recurvature, they usually increase in size, sometimes to a diameter ten times that of the early intense stage. At the same time they lose something of their intensity, the circulation normally does not extend so high in the atmosphere, and some of their vortical symmetry is lost as they come in contact with polar air masses and begin to develop air-mass contrasts. In other words, the hurricane becomes more like the larger and less intense extratropical lows with their air-mass contrasts and asymmetrical distribution of precipitation and other elements. However, as long as the storm remains active over the ocean it may retain hurricane intensity with winds in excess of 75 m.p.h. When the hurricane moves inland the increased surface friction and decreased supply of moisture allows the storm to disintegrate very rapidly, so that winds of hurricane velocity seldom persist at the ground three hours after the storm centre crosses the coast line.

One of the most destructive features of the hurricane is the high water that the storm brings with it as it advances against a shelving coast line. All of the heavy loss of life in hurricanes is caused by drowning rather than by wind destruction. As the hurricane approaches a coast line over shallow water, the water is carried by the frictional drag of the wind far inland on the right of the storm centre and forced offshore on the left. As a result, violent currents that sweep everything before them are driven from right to left, parallel to the shore line in front of the advancing storm. In particular at the head of a shallow bay the water may be piled up to a depth of 30 ft. above normal high tide, and be driven miles inland by the wind. Such coastal inundations have cost thousands of lives in a single hurricane in many parts of the world. See also TROPICAL STORMS.

Secondary Circulations of the Dynamic Type.—Minor low-pressure centres or troughs in the sea-level isobars are formed in the lea of major mountain ranges, as for example on the eastern flank of the continental divide in western North America, by the barrier action of the mountain mass against a strong cross wind. A corresponding weak centre or ridge of high pressure is frequently observed on the windward side of the mountain barrier. These weak orographically-produced secondary circulations rarely extend their influence to very high levels in the atmosphere, nor to any great distance from the locality in which they are formed. Their direct effect on the weather is relatively slight.

The important group of secondary disturbances of the dynamic type are those which originate as waves on the polar (or arctic) fronts, and which develop into the typical active migratory lows of middle latitudes. The development of these frontal disturbances, and the attendant weather phenomena, depends very much on the characteristics of the air masses which interact at the front. The air masses determine not only the weather which occurs in the frontal zone of interaction, but also the weather which is to be expected in the great area covered by each air mass individually, outside of the frontal zone. Therefore it is necessary to consider briefly the significance of the air mass properties.

The Characteristic Properties of Air Masses.—Air masses consist essentially of those extensive air currents of polar or tropical origin which constitute an important part of the meridional component of the general circulation. The important air masses all originate in polar or in subtropical latitudes; the middle latitudes constitute essentially a zone of modification, interaction and mixing of the polar and tropical air masses by the general circulation.

An air mass is characterized by relative uniformity, or horizontal homogeneity of properties, in contrast to the frontal zones where conditions change very abruptly in the transition from one air-mass type to another. The horizontal homogeneity of an air mass is acquired in an extensive uniform source region, and in the uniform modification of the source properties of the air mass as it journeys to other latitudes. The four basic air-mass source types are continental polar (cold and dry, especially in winter), maritime polar (cool and moist), continental tropical (hot and dry, especially in summer), and maritime tropical (warm and moist).

The important modifications of the properties of an air mass as it moves from the source region concern primarily the vertical lapse rate on which depends the type of any condensation forms that may occur. The lapse rate in the surface frictional layer depends upon the heating or cooling of the air mass as it moves over a warmer or colder surface, and upon stirring by frictional turbulence. The lapse rate above the surface turbulence layer is determined primarily by dynamic influences, notably by the stabilizing effect of subsidence caused by extensive horizontal divergence in regions of strong or increasing anticyclonic circulation or of rising pressure in general, and by the unstabilizing effect of ascent caused by extensive horizontal convergence in regions of strong or increasing cyclonic circulations, of frontogenesis or of falling pressure in general.

The cold dry continental polar (cP) air mass in minter is likely to be stable at all levels and characteristically free of condensation forms. When heated or moistened from the ground, or with strong wind turbulence, this air mass develops the limited convective strato-cumulus cloud forms with scattered light snow showers. When this modification occurs over the Great Lakes or other similar bodies of water in a strongly cyclonic circulation, the unlimited convective cumulo-nimbus clouds with moderate snow showers or occasionally even heavy local convective snowfall may occur. In this case the cP air mass becomes locally maritime polar in character. In summer the strong continental heating rapidly modifies the coolness and dryness of the cP air mass as it moves to lower latitudes. Daytime building of cumulus clouds is the rule, but the upper level stability of the air mass is usually such as to prevent the formation of cumulo-nimbus clouds or showers.

The cool moist maritime polar (mP) air mass in winter is strongly heated and moistened as it moves to lower latitudes over the warm ocean surfaces. In regions of marked anticyclonic circulation this maritime influence produced the limited convective strato-cumulus clouds and possible scattered light showers, but in areas of cyclonic or frontal activity cumulo-nimbus clouds and moderate or heavy showers characterize this air mass. In summer the ocean surface is relatively cool and the circulation over the oceans in middle latitudes is predominantly anticyclonic rather than cyclonic. Consequently the mP air mass is characterized only by strato-cumulus clouds at the top of the surface frictional layer, with occasional light drizzle showers. Unlimited convective condensation forms are definitely the exception rather than the rule.

The hot dry continental tropical (cT) air mass originates in arid or desert regions in middle or lower latitudes principally during the summer season. This air mass is typically strongly heated with superadiabatic lapse rates during the daytime which may extend to a height of 10,000 ft. or more, but the moisture content is so low that the intense dry convection normally fails to reach the condensation level. Occasionally very high convective condensation forms appear. Of all the air masses, the cT is the most limited in extent and plays the smallest role in world weather.

The warm moist maritime tropical (mT) air mass is at all seasons of the year the most important moisture-bearing and rain-producing mass. In winter as it moves poleward it is cooled by the ground surface, and consequently is characterized by fog or low stratus or strato-cumulus clouds with drizzle and poor visibility, depending upon the wind velocity. A steep lapse rate aloft in regions of frontal or cyclonic activity assures the occurrence of heavy frontal and convective rains. In anticyclonic circulations, especially in the subtropical highs in the source regions, only the lower stratified or limited convective condensation forms appear. Above the subsidence inversion the air mass is as warm and dry as the cT air mass at corresponding levels. In summer the characteristics of the mT air mass over the oceans and in zones of frontal or cyclonic activity are essentially the same as in winter. But over warm continental areas the air mass is strongly heated so that instead of fog and low stratus clouds, widely-scattered and locally-heavy afternoon thunderstorms occur in this air mass in all regions in which unlimited convection is not checked by strong subsidence inversions aloft.

The Characteristics of Fronts.—A significant front, such as the usual polar front, consists of a sloping transition zone which sometimes approaches a true discontinuity in character between two air masses which differ sharply in temperature and moisture content. From simple hydrostatic considerations it is evident that the front must slope so that the cold air lies in a wedge under the warm air. When the front between a warm and a cold air mass is in motion, the warm air may either be forced to ascend over the cold wedge, which constitutes an active front and produces condensation forms if the ascending air is moist, or the warm air motion may parallel or descend the slope of the cold wedge, a condition which constitutes an inactive front in that it is usually free of condensation forms.

When the front advances so that warm air displaces cold air at the ground and is forced to ascend over the cold wedge with the ensuing development of active condensation forms, the front is referred to as an active warm front. When cold air displaces warm air at the ground, the front is referred to as a cold front. Only when the cold air advances faster at the ground (normal to the front) than the warm air aloft is the warm air forced to ascend with the formation of active cold front condensation forms The slope of an active cold front is usually significantly greater than that of a warm front near the ground, because a rapidly moving wedge of cold air is retarded at the ground by surface friction in such a manner that the advancing cold air mass is piled up in the form of a blunt nose at the forward edge. This nose forces the warm air to ascend suddenly and violently. Hence the cold-front passage is likely to be marked by a violent convective squall, while the warm-front passage is relatively mild and marked primarily by the cessation of warm-front precipitation as the advancing warm current makes itself felt at the ground. Since the gradient wind velocity must, by reason of the prevailing temperature gradient, increase with elevation in the warm air mass at a front in middle latitudes, it follows that the warm air mass aloft usually moves faster than the cold air beneath. Consequently at the typical warm front the warm air at high levels advances to great distances ahead of the surface front. The foremost cirrus clouds of the advancing warm front cloud system may appear from 500 to 1,000 mi. ahead of the warm front at the ground. At the active cold front, on the other hand, the lifting of warm air by the advancing cold wedge usually extends to only a relatively short distance behind the surface cold front. Further behind, at greater heights over the advancing cold wedge, the rapidly moving warm air normally moves downslope, so that the high cloud forms in the warm air aloft normally terminate a relatively short distance behind the cold front, usually within 200 mi. Convective cloud forms within the lower cold air mass may continue much further behind, if the air mass is moist and unstable, as in the case of maritime polar air in winter.

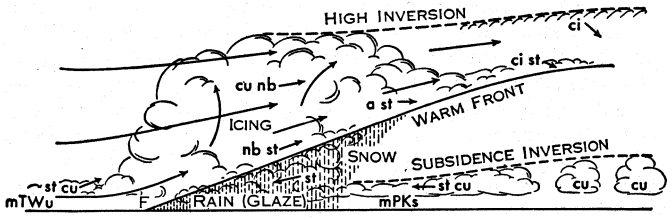
Figs. 3 and 4 represent in schematic cross sections normal to the front the typical condensation forms at an active warm front and at a rapidly-moving active cold front, respectively. The long arrows indicate the horizontal and vertical components of the air motion in the cross section, the short arrows attached to the abbreviated names of the cloud forms indicate the horizontal direction, by compass points, of cloud movements.

In fig. 3 the cold air mass beneath the advancing warm front is assumed to be subsiding moist maritime polar air, with limited convective cloud forms beneath the subsidence inversion. If it were dry continental polar air these condensation forms would be missing. The overrunning warm air is assumed to be maritime tropical air, cooled at the ground but with typical frontal instability aloft, so that the frontal condensation forms are heavy and convective. If the air mass were less moist, or were stable aloft, the condensation forms would be much more restricted.

In fig. 4 the warm air ahead of the cold front is assumed to be the same as that in fig. 3, with a full assortment of limited convective cloud forms at the ground and of unlimited convective forms aloft in the cold-front squall, but with the high cloud system extending only a limited distance above the cold front. The cold air mass behind the cold front is assumed to be subsiding

cold dry continental polar air. If it were moist and unstable maritime polar air, there would occur extensive cumulo-nimbus shower formation within the cold air, instead of only scattered cumulus clouds.

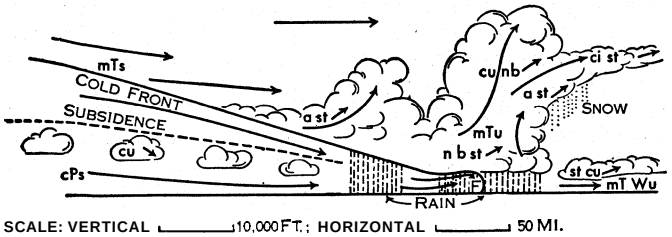
When the polar front between a cold polar and warm tropical



SCALE: VERTICAL ——— = 10,000 FT.: HORIZONTAL ——— = 100 MI.

FROM "DESCRIPTIVE METEOROLOGY" BY HURD C. WILLETT (ACADEMIC PRESS)

FIG. 3. — TYPICAL WARM FRONT CONDENSATION FORMS



SCALE: VERTICAL ——— 10,000 FT.; HORIZONTAL ——— 50 MI.

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FIG. 4. — TYPICAL COLD FRONT CONDENSATION FORMS

current remains relatively stationary (quasi-stationary) and meteorologically inactive, a perfectly definite condition of dynamic equilibrium must be satisfied. Otherwise the force of gravity acting at the sloping frontal discontinuity of air density operates to change the slope of the front, thereby producing vertical motions and displacement of the surface front. There is a marked tendency for extensive fronts to adjust themselves to attain such a condition of quasi-stationary dynamic equilibrium. This equilibrium is attained when the isobars and the gradient wind on either side of the front are parallel to the front and exhibit at the front just that discontinuity of gradient and corresponding wind velocity which are required hydrostatically by the existing slope of the front and the air-mass density contrast at the front. In other words, it is the gradient wind which in balancing the discontinuity of the horizontal pressure gradient at the front balances the effect of gravity on the frontal contrast of density.

The Development of Disturbances on Fronts. — The typical migratory low of middle latitudes originates as a wave disturbance of the dynamic equilibrium of a quasi-stationary front. Important disturbances never develop on a rapidly-moving front, although the development of a strong disturbance on a front usually sets portions of the front into rapid motion. Disturbances of the dynamic equilibrium at a quasi-stationary front may be affected by anything that affects directly the discontinuity of the wind, the pressure gradient or the temperature. The disturbance of the wind field by an orographic barrier, of the pressure field by an upper level front or pressure wave, and of the temperature by the close proximity to a cold front of a warm source region—any one of these disturbing influences may lead to a localized movement and readjustment of slope of the front accompanied by vertical motion at the front. The front recedes at one point and advances at another, so that an undulation is set up which travels as a wave along the front. This is the form in which most of the frontal migratory lows first appear. The wave progresses eastward along the front with a speed which varies considerably with the dimensions of the wave and the wind field at the front.

The shorter wave disturbances of only 100 to 300 mi. in wave length which are produced by minor disturbances of the frontal equilibrium usually continue to move as waves which are gradually, after 24 to 36 hr., damped out by friction. They remain very weak low-pressure centres, with only one or two closed isobars. These minor wave disturbances affect the weather adversely only in the immediate vicinity of the front, giving rise to a narrow zone of warm-front weather at the forward edge of the wave, and of cold-front weather in the rear (see fig. 5(A)). The passage of the wave leaves the frontal equilibrium essentially unchanged from the initial condition. The energy of this minor circulation is derived principally from the kinetic energy (in the horizontal shear) of the frontal wind field.

Frontal wave disturbances of longer wave length, corresponding to major impulses of disturbances of the frontal equilibrium, follow a radically different course of development. Theoretical conditions indicate, and observation verifies the fact, that such medium-long frontal waves are unstable. The wave character of these stronger disturbances usually breaks down in what is known as the process of occlusion, with the development of a large intense cyclonic circulation. The essential character of the occlusion process is represented in fig. 5. Fig. 5(A) represents the disturbance in which the undulation of the front is of small amplitude relative to the wave length, the warm and cold fronts represent only minor displacements of the initially quasi-stationary front, and the centre of low pressure at the crest of the frontal wave has only one or two closed isobars. Fig. 5(B) represents the active process of occlusion, the classical Bjerknes model of an actively-deepening migratory low of middle latitudes. The cold air, as represented by the cold front, is beginning to sweep actively around the deepening low-pressure centre, tending to overtake the warm front and to narrow the warm sector. This spreading of the cold air at the ground and the replacement of cold air by overrunning warm air aloft constitutes occlusion. It represents essentially a lowering of the centre of gravity of the air-mass system in the occluding disturbance, or a loss of potential energy of the system. It is primarily this loss of potential energy which supplies the kinetic energy of the increasing cyclonic vortex and of the horizontal pressure gradient, although the release of large amounts of latent heat from the frontal precipitation sometimes contributes significantly to the ascent and outflow of warm air from the cyclonic vortex. In this stage all of the condensation phenomena of the typical warm front and cold front, as represented in figs. 3 and 4, may be observed in the respective frontal zones of the deepening low.

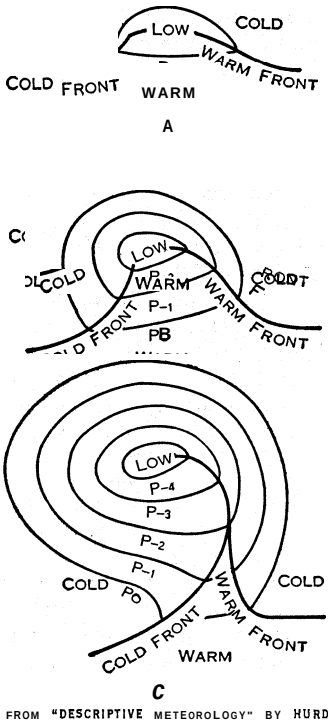

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FIG. 5. — OCCLUSION OF A WAVE ON A FRONT

Fig. 5(C) represents the intense cyclonic circulation when occlusion at the ground is practically completed, *i.e.*, the surface warm and cold fronts with their respective condensation phenomena have joined to form an occluded front in the central portion of the low. Warm moist air continues to be lifted aloft at the occluded front, but the amount of the lifting, the transformation of potential to kinetic energy, and the condensation of water vapour begin to diminish at the point at which occlusion is completed at the ground. Consequently the cyclonic vortex, or the sea-level pressure centre, usually reaches its maximum intensity at this point, followed by a slow filling of the low under the influence of friction as the chief source of energy of the deepening disturbance is exhausted. It is evident that the net effect of intense cyclogenesis by the occlusion process is to break down completely the initial frontal equilibrium and air-mass distribution. The polar air mass, following the cold front, is swept to lower latitudes and into regions previously dominated by the tropical air mass, which in turn is carried to higher latitudes in the upper atmosphere, thus contributing to the meridional component of the general circulation of the atmosphere (see Wind, above). The cold front, after

the impulse of one such development, may again come to rest in quasi-stationary dynamic equilibrium and the process be repeated in lower latitudes, unless the cold air has been spread so thin by the previous development that there remains insufficient potential energy to develop another occlusion. Most major polar-front systems develop a sequence, or family, of occluding and non-occluding wave disturbances in the course of the completion of one major cold-air outbreak from polar to tropical latitudes.

The migratory anticyclones that follow the migratory frontal cyclones in sequence are essentially effects of the cyclonic circulations. They accompany the wedges of cold air between frontal disturbances. On the other hand, one vast polar anticyclonic cell usually pushes slowly southward with each major polar outbreak of cold air. The polar front, with its entire sequence of migratory highs and lows, is a boundary or interaction phenomenon between such an extensive cold polar anticyclonic and a major warm subtropical anticyclonic cell.

THE TERTIARY CIRCULATIONS

Although the small-scale local or tertiary circulations play no role in the general circulation of the atmosphere, a number of those which are thermally direct constitute independent locally significant weather phenomena in themselves, while a number of those which are forced are among important weather phenomena associated with the cyclonic secondary circulations. Among the thermally direct tertiary circulations those selected for brief mention in the following discussion include (1) the mountain breeze and glacier winds which are caused by local cooling; (2) the valley breeze, dry thermal convection and cumulus convection which are caused by local heating; (3) thermal convective showers and thunderstorms and the land and sea breeze, which are caused by simultaneous adjacent local heating and local cooling. Among the forced tertiary circulations those selected for discussion are (1) large-scale vertical eddies, (2) fohn minds, (3) orographic and frontal showers and thunderstorms, and (4) tornadoes.

Local Circulations Produced by Cooling (Drainage Winds). — Wherever air is cooled at the ground at high elevations, the tendency exists for the cold heavy air to drain down-slope as a gravity or drainage wind, collecting in the lower valleys or other topographic basins. With clear skies and prevailing light winds, conditions which favour radiational cooling at the ground, this is the phenomenon which produces frost and minimum temperatures at low-lying points. Under such favourable conditions the cool mountain breeze which descends from exposed mountain ridges or upland plateaus develops during the night from a light breeze only 200 or 300 ft. deep in the bottom of the drainage valley early in the evening, to a moderate wind of 12 or 15 m.p.h. velocity which by morning extends with decreasing velocity to the top of the drainage valley, perhaps several thousand feet deep. After sunrise insolational heating of the valley walls and upland slopes rapidly reverses the mountain breeze, thereby establishing the valley breeze. The strongest drainage winds descend from extensive glaciers or glaciated plateaus. Such glacier winds in their most extreme development in winter may reach destructive violence. Great masses of air which have been cooled to extremely low temperatures are set in motion by a gradient wind and cascade downward from the edge of the plateau through suitable drainage channels. This phenomenon is best developed in fjords, river valleys, canyons or passes which cut deep into glaciated plateaus, the outbreaks occur from the cold continental interior to the warm coastal area. Particularly noted for such violent cold drainage winds are the fjords of Alaska (where the squalls are called williwaws), Greenland and Norway; the edges of the antarctic ice plateau, the Rhône valley of southern France, the northern Adriatic sea (see WIND: Coastal Slope *Winds*), the Columbia River gorge of Washington, the Santa Ana canyon of California and many others.

The drainage minds are heated adiabatically by their descent, hence the violent ones inevitably arrive quite dry at lower elevations, but they must arrive also much colder than the air which they displace, for it is only their relative coldness that causes their violence. This relative coldness is possible only because of the initial extreme coldness of the descending air. In this respect they are the exact opposite of the similarly violent descending fohn wind, a forced tertiary circulation.

Local Circulations Produced by Heating. — For the most part the tertiary circulations produced by local heating are not as readily observed at the ground as are the drainage winds, for intense surface heating causes instability and vertical convection in the free atmosphere rather than surface winds. An exception is the valley breeze, the reverse of the mountain breeze, which by midafternoon of a day with strong insolational heating may attain a velocity of 15 to 20 m.p.h. up steep rocky slopes at the head of a deep valley. But except where the terrain slopes steeply upward, intense localized insolational heating produces corresponding thermal updrafts which are perceptible only in the free atmosphere. The local updrafts form principally over dry rocky or sand surfaces which are free of vegetation, particularly over sand dunes or rocky hills.

Dry thermal convection in arid regions, such as deserts, may extend with considerable violence to a height of 10,000 ft. or even more, and be quite imperceptible to the observer on the ground. On the other hand, such vertical columns of rising heated air not infrequently acquire a spin which makes them visible as dust or sand whirls (dust devils, sand devils). The larger of these sand devils, which appear as nearly stationary thin vertical columns that may persist for an hour or more, are destructively violent vortices within a small radius. In more humid regions the individual convective elements are rendered visible by the cumulus cloud formation at the condensation level, which depends, as already explained, on moisture content of the surface air. It should be noted, however, that when the cumulus formation develops into the cumulo-nimbus shower cloud, the circulation ceases to be that of a simple thermal convective cell.

Local Circulations Produced by Adjacent Heating and Cooling. — When cumulus convection extends into cumulo-nimbus with the development of a thermal convective shower or thundershower, as soon as precipitation commences falling from the base of the cloud the cooling by evaporation of the relatively dry underlying atmosphere rapidly forms an extensive mass of cool air. This cool air mass within the shower sinks and spreads out in all directions, thus forming a cool descending branch of the convective shower circulation which frequently becomes rather violent in heavy convective thundershowers, accounting for a number of the characteristic features of these weather phenomena. It causes the strong squall of cold wind which breaks with the heavy rain in intense newly-formed showers, but which may run far ahead of the rain in older disintegrating showers. The wind squall cloud, or typical low roll cloud of the violent thundersquall, is formed between this outrushing cool air mass and the preceding light inflow of warm air that maintains the thunderstorm convection. The sudden drop of temperature, the shift and increase of wind velocity, and the rise of atmospheric pressure which accompany the wind squall have all the features of a cold-front passage, so that it may be impossible to decide whether the shower is merely thermal convective, or of the cold-front variety, until the permanence of the change is observed after the passage of the shower.

Thundershowers of the thermal convective variety in middle latitudes are essentially a summer afternoon phenomenon over land, attaining their maximum frequency in regions that are primarily readily accessible to moist air masses, and secondarily characterized by the rough or mountainous terrain that favours thermal convection. A secondary maximum of thermal convective thunderstorm frequency occurs during the late night hours over extensive warm lakes and coastal waters, where the water surface is relatively warm at night, as well as in certain inland localities where the diurnal variation of the gradient wind advection appears to favour nocturnal instability. The most regular occurrence of heavy afternoon convective thunderstorms throughout the year occurs in the tropics, particularly over tropical islands which are open to maritime tropical air at all times, and which are located in tropical or intertropical zones of air-mass convergence.

Tropical islands lying in regions of marked anti-cyclonic divergence and subsidence may be quite arid and barren. In middle and higher latitudes a marked winter maximum of convective shower activity, which rarely reaches thunderstorm intensity, occurs over the relatively warm ocean areas which are accessible to cold air masses.

The land and sea breeze is the most obvious and simple of the tertiary circulations produced by simultaneous adjacent local heating and cooling. The sea breeze blows from cold water to heated land with maximum strength at midafternoon in late spring and summer, and is noted wherever it occurs for its marked cooling action.

The land breeze blows from the cold land to warm water, with maximum strength during the early morning hours in late autumn and winter. It is rarely observed or noted even when well developed; consequently it requires no further comment.

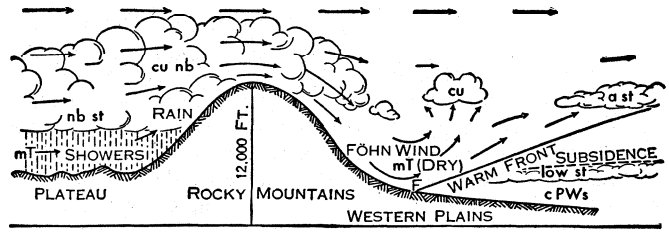
On a favourable day with light winds the sea breeze usually starts along the immediate coast as a light breeze only a few hundred feet deep blowing directly onshore. Overhead a light offshore wind in to be expected. By midafternoon at its maximum strength the sea breeze becomes a moderate wind of 12 or 15 m.p.h., with a vertical depth of perhaps 1,000 ft., extending some 15 mi. inland and an equal distance offshore. By late afternoon or early evening the sea breeze diminishes in intensity and tends to blow more nearly parallel to the shore as the Coriolis force gradually makes its influence felt. The breeze may extend as far as 30 mi. inland and offshore. During the evening the breeze rapidly disappears, frequently becoming a light land breeze before midnight. The principal significance of the sea breeze is its marked cooling action.

In some coastal localities, where particularly cold water lies offshore, the arrival of the sea breeze also frequently carries inland coastal fog or low stratus clouds which are formed over the cold water offshore.

Large-Scale Vertical Eddies.—When a strong wind blows across a major orographic barrier, a variety of violent turbulent eddy phenomena are produced. The most dangerous of these formations are the large eddies, with horizontal axes, which are formed in the lee of major mountain ridges by the crowding of the wind stream lines over the crest of the ridge. These eddies are observed in some detail by drifting pilot balloons, by fog or cloud movements and occasionally by aircraft or manned balloons. Vertical velocities in excess of 1,000 ft. per min., in persistent eddies of from 3,000 to 5,000 ft. in diameter, have been observed with strong winds in mountainous terrain. It is evident that such eddy formations constitute a serious hazard to low flight by aircraft of any type in mountainous terrain during the occurrence of strong winds.

The **Föhn** (Chinook) **Wind.**—The föhn wind is essentially a large-scale eddy turbulence phenomenon. When a strong warm wind aloft blows across a major mountain range and is deflected downward in the lee of the mountains by frictional drag, the warm current reaches the lower elevations as an extremely warm dry gusty wind, which blows erratically depending upon turbulent action. The most extreme fohn effects are felt on the inland side of major mountain ranges, when warm maritime air blowing inland forcibly displaces cold continental air in the lee of the mountains. Under these conditions an oscillating quasi-stationary warm front is maintained dynamically in the lee of the mountains, the temperature fluctuating by as much as 50° F. at the sharp boundary between the warm and the cold air mass. The development of heavy orographic precipitation on the windward side of the mountains may add considerable latent heat to the warm current, but the condensation forms are dissipated completely in the descending fohn wind. The warmth and dryness of a strong föhn east of the continental divide in North America are such that the wind may melt and evaporate as much as 2 ft. of snow in 24 hr., hence the name chinook (Indian for "snow eater") which has long been applied to the phenomenon in that region.

Fig. 6 represents schematically the circulation and the condensation forms that are typical of a strong föhn wind development on the eastern slope of the Rocky mountains between warm maritime tropical air from the west coast and cold continental polar air in the interior of the continent. This region is noted for some of the most extreme föhn wind contrasts in the world, but föhn wind conditions only slightly less extreme in character are observed north of the Alps in western Europe, north of the Himalaya mountains in central Asia east of the Andes in the southern portion of South America and in many other regions. It is to be noted that the fohn wind is always a warm wind whose descent is dynamically forced by frictional turbulence, in contrast to the cold gusty drainage winds whose descent is gravitational.



FROM "DESCRIPTIVE METEOROLOGY" BY HURD C. WILLETT (ACADEMIC PRESS)

FIG. 6.—FÖHN WIND CIRCULATION WITH CONDENSATION FORMS

Orographic and Frontal Showers and Thunderstorms.—The difference between the thermal convective showers and thundershowers and the orographic and frontal variety lies in the fact that in the former the vertical convection is initiated by the thermal instability of the lowest atmosphere, whereas in the latter the vertical motion must be forced at least up to the condensation level of the rising air. Above that level conditional instability of the atmosphere maintains the saturated convection exactly as it occurs in the thermally direct variety.

In winter, shower and snow shower activity is greatly increased where conditionally unstable air masses, particularly those of the maritime polar variety, are forced upslope against mountains or rugged coast lines. In summer, when the prevailing winds are normally lighter and insolational heating stronger, the orographic influence on shower activity is more likely to be thermally direct in character, but even in summer orographic forcing is the prime cause of locally heavy convective rains in parts of the subtropical easterly and monsoon wind systems.

Heavy precipitation which is convective in character and locally variable in intensity is a normal part of active frontal weather. In the tropics the great majority of the showers and thunderstorms are thermally convective or orographic in character, but in middle and higher latitudes probably half of the summer thunderstormsarefrontal, while nearly all are in winter. The warm-front type of thundershower is rather distinctive in character in that the thunderstorm activity, unlike that of most other thunderstorms, is restricted entirely to the upper levels, being shielded from the ground by the passive layer of cold air beneath the warm front. Thus while the thunderstorm is in progress aloft, the weather at the ground may be foggy and cold, in winter even freezing, sleeting or glazing, conditions which are not ordinarily associated with thunderstorm activity.

The ordinary cold-front thundershowers, which accompany nearly every active cold front in summer and occur not infrequently in middle latitudes also in winter, are very similar to the thermal convective thundershowers, in that they usually build up from the ground ahead of the cold front. The thunderstorm often breaks with the front passage in a manner which is very similar to the breaking of the wind squall of an intense thermal convective storm. The occurrence of cold-front thunderstorms is markedly favoured by the advance of a cold front upslope against a mountain range, while conditions are relatively unfavourable on the lee side of the range.

Occasionally an overrunning form of cold front develops which is of special significance for the occurrence of frontal convective squalls. When the cold air mass that follows a rapidly moving cold front is only moderately cold, it may happen that the rapidly-moving cold air above the surface frictional layer overrides the warm air to some distance, *i.e.*, the cold front advances more rapidly aloft than at the ground. If the air-mass stratification produced in this way is very unstable, then convective overturning takes place in a line along the front, just in advance of the position of the front at the ground. This condition is evidenced by a rapidly-moving narrow line of violent convective squalls, the so-called line squall.

When the stratification is less unstable, the upper cold air layer may advance as much as 100 to 200 mi. ahead of the surface front, causing a zone of marked convective instability and of extremely sharp vertical cyclonic wind shear. Tornadoes are formed by vertical convection of warm moist air from the ground through the layer of cyclonic wind shear. The cyclonic vortex established by such convection is very intense and extremely destructive, but usually less than half a mile in diameter near the ground. Heavy hail or other local convective precipitation usually occurs with the accompanying thunderstorm. When favourahle conditions are established in this manner, a number of tornadoes are likely to occur. They usually move at moderate speeds from southwest to northeast, drifting with the warm current ahead of the cold front. One tornado may last from a few minutes to an hour or more, leaving a path of intermittent destruction of a few hundred yards up to 40 or 50 mi. in length as the vortex repeatedly dips down to the ground and withdraws again from the surface.

WEATHER FORECASTING

Modern weather forecasting depends essentially upon the synoptic representation of the prevailing state of the atmosphere. A weather forecast consists of an estimate of the future state of the atmosphere. This estimate may apply to the conditions at a fixed point in the

atmosphere or to an extended portion of the atmosphere, and it may apply to the conditions at a given moment of time, to the sequence of change of conditions during a period oi time, or to the average or mean conditions during a period of time. But in any case the basic problem of the weather iorecaster is to extrapolate'in some manner from an initial (recent) state of the atmosphere to some subsequent (future) state. The first prerequisite for such an extrapolation is an adequate representation of the initial state. It is this adequate representation of the current state of the atmosphere which the customary synoptic weather charts (both maps and diagrams) are intended to supply. The rapidity with which atmospheric conditions change requires that any consistent representation of the state of the atmosphere be as nearly as possible synoptic, *i.e.,* based on weather observations which are taken at the same moment of time at all points. For a full discussion, see the article WEATHER FORECASTING.

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METER, ELECTRIC: *see* INSTRUMENTS, ELECTRICAL MEASURING.

METER, GAS: *see* GAS METER.

METHANE (MARSH GAS) is a colourless, odourless gas occurring abundantly in nature as the chief component of natural gas, as a constituent of firedamp in coal mines and as a product of the anaerobic bacterial decomposition of vegetable matter under water (hence its alternative name. marsh gas). Methane is also produced industrially by the destructive distillation of bituminous coal in the manufacture of coal gas and coke-oven gas. The activated-sludge process of sewage disposal produces a gas which is also rich in methane.

Methane is the first and simplest member of the paraffin hydrocarbons, having the chemical formula CH_4. It is lighter than air, and has a specific gravity of 0.554 in relation to air. It is only slightly soluble in water, but much more soluble in ethyl alcohol and ethyl ether. Methane burns readily in air, forming carbon dioxide and water vapour. The flame is pale, slightly luminous and very hot. Methane is, in general, a very stable material. However. a mixture of methane and air, with the methane content between 5.3% and 13 9% by volume, is highly explosive. Such explosions have been a frequent occurrence in coal mines and collieries.

Although there are a number of well-known methods of preparing methane in the laboratory, such methods are of only academic interest. In most parts of the world, methane is readily available commercially in steel cylinders under pressure. Its chief source is natural gas, which, after extraction of natural gasoline, contains from 75% to 95% methane depending on the source. It is easily separated from other hydrocarbons by special processes. Methane is also produced commercially from bituminous coal. One method, previously mentioned, consists of the destructive distillation of coal. A newer method is coal carbonization. which gives yields of 25%—30% methane. These methods of manufacture are important in locations where natural gas is not plentiful. The coal carbonization process is particularly important in that it has made the coal industry a part of the petrochemical field. The process also looks toward the future when natural gas sources have become depleted.

Since commercial natural gas is composed largely of methane, their uses may, for all practical purposes, be considered as identical. Because of its abundance, low cost, ease of handling and cleanliness, its chief use has been as a fuel for producing heat and power in industrial and commercial establishments and in homes.

In the United States, natural gas is distributed through thousands of miles of pipelines to all parts of the country, and, since World War II, has made great inroads into the fuel market, particularly at the expense of coal.

Another important use is in the manufacture of carbon black (*q.v.*), although this application has been diminishing since 1950 because of the increasing price of natural gas. When methane is decomposed at high temperatures in the presence of a limited supply of air, carbon is cracked out. This fluffy product of colloidal fineness is called carbon black, and is used chiefly as a reinforcing pigment to make rubber tough and wear-resistant, qualities particularly important in automobile tires.

Methane also has definite usefulness in the important field of petrochemicals, although it is not so valuable in this field as certain other paraffin hydrocarbons. For example, methane can be made to react with steam at high temperatures (800°–1,000° C.) in the presence of catalysts to form hydrogen and carbon monoxide; the latter then reacts with additional steam to form more hydrogen and carbon dioxide. This process is useful as a source of industrial hydrogen in the manufacture of ammonia, which in turn is used to produce fertilizer and explosives. Other valuable products obtained from methane are methanol and formaldehyde, both of which are produced in an oxidation process. hlethanol is used as an antifreeze and formaldehyde as an organic intermediate. Successive chlorination of methane leads to methyl chloride, methylene chloride, chloroform and finally carbon tetrachloride. By nitration. nitromethane is formed: this material is a solvent. a refrigerant and a basis for the synthesis of other petrochemicals. (R. K. E.)

METHODISM is a term used to describe a section of the Christian church which emphasizes the doctrines of assurance, conversion and holiness. and lays special stress on personal experience and fellowship in Christian service. The movement began with the evangelistic work of John and Charles Wesley and George Whitefield in the 18th century. (See WESLEY (FAMILY); WESLEY, JOHN; WHITEFIELD. GEORGE.) The epithet Methodist, originally applied contemptuously to extremists of various kinds, was then attached to a little circle of Oxford students who met together to share their Christian experience in a typical centre of contemporary rationalism. John Wesley, a fellow of Lincoln college. was, like his brother, a clergyman of the Church of England and became leader of the group. The exact regularity of their lives and their strict observance of religious obligations was greeted, at first, with derision, but they accepted the title as an honourable description. Eventually John Wesley himself referred to the members of his "societies" as "the people called Methodists."

The movement began as a direct result of a vivid personal experience, a spiritual metamorphosis, which came to the two brothers in May 1738, and is sometimes called their evangelical conversion. At once they dedicated themselves to the "spreading of Scriptural holiness over the land."

There was no intention originally of founding a separate denomination. John Wesley was anxious to uphold the church of his fathers, but he was even more concerned with infusing new life and spiritual energy into its being. He and his folloners accepted most of the Thirty-nine Articles of Religion and the Book of Com-

mon Prayer. The doctrines of the Trinity, the Incarnation and the Atonement in its Arminian interpretation were rigidly maintained. A strong emphasis was placed on assurance, conversion and holiness or Christian perfection which was defined as "the loving God with all our heart, mind, soul and strength. This implies that no wrong temper, none contrary to love, remains within the soul, and that all the thoughts, words and actions are governed by pure love." The doctrinal standards were contained in Wesley's *Notes on the New Testament* and in his *Sermons*. Methodism has continued for more than two centuries to proclaim a freedom of the spirit as opposed to the bondage of an organization, and its appeal has been based on the reality of a personal experience of spiritual emancipation through faith in Christ.

When many ecclesiastical authorities banned the Wesleys and their preachers from occupying their pulpits, they continued the work in the open air. Field preaching became an important medium for spreading revival. Meetinghouses were licensed. Local preachers, following their normal occupations during the week. gave much of their leisure to preaching in their own neighbourhood, but gradually a new order of traveling preacher or itinerant came into being and eventually a regular, full-time ministry was established.

The Methodist people were gathered into "classes" for Christian fellowship under the pastoral oversight of a lay leader. A number of Anglican clergy, sympathizing with Wesley, co-operated with him in many ways. It became obvious that the Methodists were not hostile to the national church and could not logically be called dissenters. In general they refrained from holding meetings during statutory service hours, and many came to Holy Communion in their parish churches.

In 1744 John Wesley held his first conference which certain Anglican clergymen and Methodist preachers attended. The conference became an annual event. At first it consisted only of preachers and functioned as an advisory body, though later laymen were admitted, and by the mid-20th century the numbers were equal. In 1789 there were 56,195 members of Methodist societies in Great Britain, but by 1815 the number had increased to 181,709.

Separation From the Church of England. — At the time of John Wesley's death (1791) the Methodist societies were independent of the Church of England, but the relationship was not unfriendly and there was no definite technical separation. The position was anomalous, and though the majority seemed content to let things remain as they were, it soon became obvious that complete detachment was inevitable. The main issue was the celebration of the sacraments. If Methodists wished their ministers to officiate, then these preachers must be duly ordained. But Wesley had already claimed his right as a presbyter to ordain preachers, first for America and then for certain places in Britain. It was not until 1836, however, that the Methodist conference decided its preachers should receive regular ordination. From that time the use of the Ordination Office has been obligatory, and the conditions for the acceptance of candidates for the ministry, their training and the completion of a period of probation have been faithfully kept. Only after they have confirmed their acceptance of the polity, doctrines and discipline of Methodism are they ordained.

Divisions in British Methodism. — The death of John Wesley ended a benevolent autocracy. His rule had been patriarchal, and it was unlikely that a successor could maintain the same type of administration. He had created a body of preachers, known as the Legal Hundred, and these became the constitutional authority in Methodism. Wesley himself had selected the first members of this body but they were subsequently elected by the whole conference. As the organization of the societies developed and the movement became a church, some felt that its evangelistic fervour cooled. It was feared that its guerrilla forces were being regimented. Actually it was more true to say that they had become a disciplined brigade in the army of God. Fear of the growth of an ecclesiastical authority and an objection to liturgical usages caused uneasiness that eventually led to some leaving the parent body and forming new denominations. It is noteworthy that none of these divisions was caused by doctrinal differences.

The first schism came when a group, led by Alexander Kilham, demanded the complete democratization of the church courts. The majority of Methodists refused to agree to these drastic proposals, and Kilham was expelled from the conference of 1796. Five thousand members joined him in forming the Methodist New Connexion in 1797. It was to this branch of Methodism that William Booth belonged until in 1861 he withdrew to form the Salvation Army.

The development of democratic feeling in many Methodist groups was hastened by the dominance of Jabez Bunting (*q.v.*), a strong and able leader, conservative in his outlook and criticized for what many felt to be his autocratic administration. In spite of growing opposition he was four times elected president of the conference, but his critics, many of whom were anonymous, became more numerous and more bitter. Continued agitation resulted in the loss of 100,000 members. Various new groupings emerged, among them the Wesleyan Reformers, the Protestant Methodists and the Wesleyan Methodist association. In 1857 the Wesleyan Reformers and the Wesleyan Methodist association joined to form what was then called the United Methodist Free Churches.

However harshly Jabez Bunting may have been judged, time has shown that there was some gain in the opportunity for changed emphases afforded to these smaller bodies, each of which played a part in contemporary Christian witness.

What was believed by some to be a decline in the evangelistic motif of Methodism led to other divisions. In 1806 several small groups united to form a strongly evangelical body called Independent Methodists. A remarkable evangelist, William O'Bryan, led a series of campaigns in the west of England. His followers were organized in 1831 and became known as the Bible Christian Church. Their roots were in Methodism and their separation was not by way of rebellion so much as an attempt to concentrate on evangelism in the idiom which attracted the people of the west country. The establishment of Primitive Methodism in 1811 was a heavy loss to the parent church. The separation was caused by the conviction that Wesleyan Methodism was not reaching the poorer section of the community, especially in rural areas. The first Primitive Methodist conference was held in Hull in 1819. By 1860 its membership was 132,114 and it was exercising a great influence in many industrial centres. In the north of England some of the early leaders of organized labour came from Primitive Methodism. (*See* PRIMITIVE METHODISTS.)

New Social Emphasis. — In the mid-19th century Wesleyan Methodism was in danger of becoming conventional and somewhat self-centred. It numbered many prosperous industrialists among its members and they tended to be conservative in their churchmanship. Suddenly a new, dynamic leadership changed the whole situation. The personality of Hugh Price Hughes (*q.v.*) made the Forward movement, inaugurated by Charles Prest, a force to be recognized by the nation as well as the church. The conscience of Methodism was quickened, and social evils, sweated labour, poverty and squalor were realized as the concern of Christian people. The Wesleyan Methodists built great central mission halls, from which many social institutions were maintained. Hugh Price Hughes became the first superintendent of the West London mission in 1887, and made plain the pattern of an evangelisni which was concerned with the well-being of the whole man, body, soul and spirit.

Movements Toward Methodist Union. — During the second half of the 19th century the trend toward more democratic church government and the determination to apply the principles of Christianity to social problems lessened the differences between the various sections in Methodism. The possibility of reunion was becoming a live issue. In 1907 the United Methodist Free Churches, the Bible Christians and the Methodist New Connexion combined to form the United Methodist Church. Finally in 1932 the larger union was effected when the Wesleyan Methodists, the Primitive Methodists and the United Methodists were consolidated and the Methodist Church, with a membership of 800,000, was legally constituted by an act of union. After a century and a half of division, Methodism, with the exception of some small bodies including the Independent Methodists and the Wesleyan Reform

union, was again an entity.

Methodism in the United Kingdom.—In Wales John Wesley had co-operated with George Whitefield and Howel Harris in the Evangelical revival. Most of the early Welsh Methodists joined *Yr Corff,* the Calvinistic body which became known as the Presbyterian Church of Wales *(see* CALVINISTIC METHODISM), but a minority remained true to their Arminian beliefs, and the Welsh Methodist assembly (established in 1898 in close relationship with the British conference) became the administrator of Welsh affairs.

In Scotland Methodism has only a small membership, partly, perhaps, because temperamentally the Scottish people are reserved and do not respond to the English type of class meeting. There are, however, certain centres where strong Methodist churches maintain a witness to the need for stressing evangelical doctrine, and this is a definite contribution to Scottish religious life.

Irish Methodism, established by the Wesleys in the face of fierce opposition, has always been virile, especially in its enthusiastic support of missionary enterprise. Though it has its own conference, delegates are appointed, as in the case in Scotland and Wales, to the parent conference meeting annually in England.

Expansion **Overseas.**—Methodism was brought to Newfoundland by one of Wesley's converts in 1765, and in 1787 William Black, who had been working independently in Nova Scotia, was appointed by the American Methodists to superintend missions in that area and in New Brunswick and Newfoundland. Methodism came to eastern Canada through preachers from the New England states but, in 1799, was under the English conference. In Quebec and Upper Canada Methodism was introduced by soldiers in the army of Gen. James Wolfe.

When the United States of America achieved independence English and American preachers worked together among the settlers, but the first circuits formed were linked with conferences in the U.S. (See *Methodism* in *the United States,* below.) Several branches of Canadian Methodism came into existence during the next few years but in 1874 these were united in the Methodist Church of Canada. Fifty years later a larger union was effected when, in 1925, Canadian Methodists and Congregationalists combined with approximately 70% of Canadian Presbyterians to form the United Church of Canada.

Methodism in Australia began with the formation of class meetings by Thomas Bowden, a London Methodist living in Sydney. The Methodist organization and genius were specially suitable for the needs of a new and rapidly developing colony. Adapting its procedure to local conditions, the Methodist Church grew quickly. In New Zealand missionaries going to minister to the Maoris in 1822 began work which spread among the English and Scottish colonists so that Methodism became a considerable force in the life of the uhole country. The most spectacular example of Methodist missionary enterprise was seen in the conversion, within a single generation, of the people of Fiji and the Friendly Islands. Today the great majority are attached to the Methodist Church. (In New Zealand and Australia Methodist union has long been an accomplished fact, though in each country there is autonomous church government. The expansion of Methodism in this part of the world was so rapid that by 1910 returns shoned that one person in every nine in Australasia was a declared Methodist.)

The father of Methodist overseas missions was Thomas Coke (*q.v.*), an Irishman who joined the Methodists in 1776. He was one of the founders of the Methodist Church in the West Indies, and visited America nine times on ecclesiastical business. It was his great desire to take the Methodist witness to the far east, hut he died at sea on his way to Ceylon in 1814, a year after the Wesleyan Methodist Missionary society had been formed. The six companions who had sailed with him made his dream reality by establishing Methodism in Ceylon, whence it spread to India and made considerable progress, not least among the outcastes and "untouchables." The creation of the Church of South India (1947), uniting Anglicans and Free Churchmen, was an achievement in which Methodism played a notable part.

It was in 1811 that a Methodist missionary and three schoolmasters came to Sierra Leone, bringing Methodism to Africa. For many years it has exerted a powerful influence in Nigeria, the Gold Coast and French West Africa. In South Africa the increasing number of settlers was a challenge to the Methodists who had begun modestly in 1806. The work developed quickly, over a wide area, and in 1882 a South African Methodist conference was created to administer affairs south of Rhodesia.

The first Methodist work in Bunna began in 1887. In China the lonely pioneering efforts of George Piercy, beginning with his preaching to British soldiers in Hong Kong and Canton, was soon sponsored by the Wesleyan Methodist Missionary society and grew steadily, while mission stations were established by the United Methodist Church in north and south China. Methodism has given of its best to bring Christianity to the Chinese people and in the 1950s many of them were bearing sacrificial witness to their faith.

See also WESLEYAN METHODIST CHURCH.

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Consult also the bibliographies to the articles WESLEY, JOHN and WESLEYAN METHODIST CHURCH. (L. F. C.)

METHODISM IN THE UNITED STATES

The Methodist movement had been under way in England for 25 years before it made its appearance in the new world. It was introduced by local preacher immigrants without the knowledge of John Wesley. Robert Strawbridge (? –1781), an Irish local preacher, settled in Maryland about 1760, and Philip Embury (1729-1775), also a local preacher from Ireland, went to New York with a number of Methodist relatives in 1760. Both began preaching, Strawbridge probably in 1764 and Embury in 1766, and Methodist societies were formed. Capt. Thomas Webb. a British soldier and lay preacher, was sent to New York in 1766 by British authorities as a barracks officer, and immediately became active in helping organize Methodist societies. By 1768 little groups of Methodists were meeting in New York. New Jersey, Pennsylvania and Maryland, following the pattern of Wesley's societies in England. Wesley, informed of these happenings, sent two of his English preachers in 1769 to help establish societies. In 1771 two others were sent. one of them Francis Asbury (*q.v.*). In 1773 Wesley appointed Thomas Kankin (*c.* 1738–1810) to superintend the growing work, and under his direction the first American Methodist conference convened in Philadelphia, Pa., in June of that year. The return of all the English preachers except Asbury to England soon after the beginning of the Revolutionary War gave opportunity for an able group of native preachers to assume leadership under Asbury's direction

In its early years the Methodist movement was largely confined to Delaware. Maryland and Virginia, where Anglicanism was strongest. There it was greatly aided by Devereux Jarratt, an evangelical Anglican clergyman in south central Virginia who traveled widely throughout the adjoining counties surrounding his parish to administer the sacraments to the Methodist people.

Because so few Anglican clergymen would co-operate with the Methodists, thereby depriving them of the sacraments, a movement was begun in 1779 among the Virginia preachers to with-

draw from all connection with the Anglicans and form a new ecclesiastical body. They met in a conference in Fluvanna county, where several of the Methodist preachers were ordained. For a year these preachers administered the sacraments to the Virginia Methodists. Asbury and the other preachers north of Virginia opposed this independent movement and fortunately were able to persuade their Virginia brethren to suspend their administration of the sacraments until Wesley could be heard from. Thus, a division among Xmerican Methodists was avoided. During the Revolutionary War the number of Methodists increased from 4,921 (1776) to 14,988 (1784) and the number of preachers from 24 to 83, Eighty-nine per cent of the Methodist membership was south of the Mason and Dixon line.

Organization of the Methodist Episcopal Church.—The winning of independence brought with it the necessity of forming the Xmerican Methodists into an independent ecclesiastical body. This was speedily accomplished by John Wesley's appointment of Coke, already in Anglican orders, to go to America in 1784 as his representative, bringing with him Wesley's instructions and plans for the new church. On Coke's arrival in America, Asbury informed him that the American preachers must be summoned in a conference to pass on all matters pertaining to the new church, since Independence had made them unwilling to accept even Wesley's dictum in regard to American affairs.

The conference. known as the Christmas conference, convened in Baltimore, Md., on Dec. 24, 1784. There the Methodist Episcopal Church was organized. Asbury and Coke were chosen joint superintendents (later assuming the title of bishop). A discipline was adopted and also a Sunday service, prepared by Wesley, abbreviated from the Book of Common Prayer of the Church of England, together with Twenty-five Articles of Religion likewise abbreviated from the Thirty-nine Articles.

At first there was but one annual conference for the entire country, composed of all the traveling preachers, at which the preachers were assigned to their circuits. As the church expanded geographically and numerically, this plan became increasingly unwieldy, and in 1796 the country was divided into six annual conferences. In 17y2 a general conference was formed, meeting every four years, as the lawmaking body of the church. which in 1808 became a delegated body.

Early Controversies and Divisions.—Though there were a number of schisms in American Methodism, none was caused by doctrinal differences. The first, that of James O'Kelly, came in 1792. It arose over the question of the appointing power of the bishop and resulted in the withdrawal of O'Kelly and a number of other preachers with several thousand members who took the name of Republican Methodists. Most of them eventually merged with the followers of Barton W. Stone to form the Christian Church (later united with the Congregationalists). A more serious division occurred in 1830 and resulted in the formation of the Methodist Protestant Church. Starting as a movement to restrict the power of the bishops, the agitators took the name Methodist Reformers. and advocated a wider democracy in the administration of the church. After the general conference of 1828 had rejected all of their petitions, memorials and appeals, the Reformers began to withdraw, and in 1830 the Methodist Protestant Church was formed in Baltimore as a nonepiscopal body with equal lay and clerical representation in its governing body. Strongest in Maryland. Pennsylvania and adjoining states, within four years the Methodist Protestants had 14 annual conferences and 26,587 members. Many of the reforms they advocated were later incorporated in the Episcopal Methodist bodies.

Slavery Controversy.—At the organizing conference in 1784 slavery was outlawed in the Methodist Episcopal Church. Because of laws against the freeing of slaves in the slave states, however, it soon became necessary to modify the antislavery position of the church. As a result of the agricultural revolution which took place in the south following invention of the cotton gin, slavery was fastened upon the cotton-growing south and gradually became an accepted institution in all the southern churches. The abolition movement in the north found numerous adherents among New England and New York Methodists particularly, and their denunciation of slavery as a sin and all slaveholders as sinners aroused increasing resentment among southern Methodists.

In the general conferences of 1836 and 1840 the moderates of the north combining with the southern delegates outvoted the abolitionists by a large majority and imposed a "gag rule" on the church, shutting out antislavery discussion in all Methodist conferences. This action led to withdrawal of the most extreme abolition wing of the church, under the leadership of Orange Scott (1800–1847), LeRoy Sunderland (1802–1885) and L. C. Matlack (1816–1883), and the formation of the Wesleyan Methodist Church (Connection) of America in 1843. Centring principally in New England, New York and Michigan, the new church had about 20,000 members by 1845. This secession brought about a shift among the moderates in the north when they saw that in their attempt to avoid a proslavery secession they had precipitated an antislavery division.

The most serious division over slavery came as a result of the action taken by the general conference of 1844. The issue was brought to a head by the marriage of Bishop James O. Andrew to a slaveholding wife. Since Methodist bishops exercised episcopal authority throughout the church and presided in turn over all conferences, north and south alike, a slaveholding bishop would not be acceptable to the northern conferences. After 11 days of debate, a motion to suspend Bishop Andrew was passed by a substantial majority. A few days later a plan of separation was adopted by an almost unanimous vote, to provide a way for a friendly division if separation became necessary. The southern leaders immediately took advantage of this plan and called a meeting of representatives of all the southern conferences to meet in Louisville, Ky., in May 1845. There the Methodist Episcopal Church, South, was organized. The first general conference of the new church met in Petersburg, Va., in May 1846. The doctrine, polity and discipline of the southern church was identical with that of the Methodist Episcopal Church, even retaining the identical rule on slavery. The southern church began with a membership of 460,000, of whom 124,961 were Negroes and 2,972 Indians.

Following the schism there was a series of controversies over publishing property. In spite of this, however, both churches grew rapidly in the years following division, the southern church redoubling its interest in work among plantation Negroes. U'ith the coming of the Civil War the two Episcopal Methodisms took opposite sides, the southern church being enthusiastically Confederate and the northern church equally loyal to the Union cause.

Methodists in Education.—By 1860 the Methodists had established 34 permanent colleges in the United States and at the close of the Civil War both northern and southern churches entered upon a new period of educational expansion. In 1867 Drew Theological seminary was opened in Madison, N.J. (Two Methodist theological seminaries had been opened previous to the Civil War—one in 1846 which grew into Boston university school of theology and Garrett Biblical institute in Evanston, Ill., in 1854.) In 1869 Boston university was chartered and in 1870 Syracuse university was established in Syracuse, N.Y. In 1873 the southern Methodists opened Vanderbilt university (Nashville, Tenn.), and in later years three other universities were established in the south—Emory university in Oxford (later moved to Atlanta), Ga., Duke university at Durham, N.C., and Southern Methodist university at Dallas, Tex., all of which attained high rank among the universities of the south.

By mid-20th century the Methodist Church had 128 educational institutions affiliated with it, including 9 universities, 10 schools of theology and 68 colleges.

Negro Methodists—Previous to emancipation there were no independent Negro churches in the south. since Negroes were compelled to worship under white supervision. In 1860 there were 207,766 Negro members of the Methodist Episcopal Church, South. In the north two independent Negro churches had been formed previous to the Civil War, the African Methodist Episcopal (1816) and the African Methodist Episcopal, Zion (1820). Both arose out of friction between white and Negro members attending the same churches. Neither had any members in the south previous to the Civil War, but with the war's end both entered the

south and began a successful campaign for the winning of the southern Negro. Between 1866 and 1876 the African Rlethodists increased from 70,000 to 391,044, while the Zion Methodists grew from 42.000 in 1866 to 164,000 in 1868. This growth was largely the result of draining of the Negro membership from churches of their former masters. A third large Negro Methodist Church arose in the reconstruction years made up of the Kegro members of the Methodist Episcopal Church, South. which took the name Colored Methodist Episcopal Church, and which was renamed at the general conference of 1954 the Christian Methodist Episcopal Church.

The Methodist Episcopal Church had a Negro membership from its beginning and at the close of the war it too entered the south through its Freedmen's Aid society, formed in 1866, with a program of evangelization and education for the Negro. Negro conferences were formed and Negro schools and colleges established, including Clark college, Atlanta, Ga . Claflin college in Orangeburg, S.C.. Rust college in Holly Springs. Miss.. Wiley college in Marshall, Tex., Bennett college (for Kegro women) in Greensboro, N.C., Meharry Medical college in Nashville, Tenn., and Gammon Theological seminary in Atlanta, Ga.

Missions.—U.S. Methodism from its beginning was imbued with a missionary purpose, and Methodist itinerants worked among Negroes and Indians before the formation of the Methodist Missionary society in 1819. The first foreign missionary, Melville B. Cox, went to Liberia, Africa, in 1833 and a second to South America in 183j. Work was begun in China in 1847.

By 1939, when the three large Methodist churches united to form the Methodist Church, the combined churches were maintaining 1,065 missionaries in Asia, 152 in Africa, 225 in South America and 12 in Europe, totaling 1,454. Methodist church membership in these mission fields was 679,320 including probationers. Besides these missionary churches there were autonomous Methodist churches in Japan (after World War II the Methodists in Japan became part of the United Church of Christ in Japan, with a membership of about 300,000), Korea, Mexico and Brazil. By mid-20th century there were two Methodist resident bishops in Europe, seven conferences in Africa. six conferences in India, three episcopal areas in China and eight missionary conferences in Latin America, besides the independent churches in Mexico and Brazil.

Although World War II seriously disrupted missionary activity. particularly in Japan, China and Korea, the work was strongly resumed after peace was declared. Besides the missionary work carried on under the Methodist Church, the three large Negro Methodist Episcopal Churches maintained missions in Africa. the West Indies and in northern South America

Lay Control and Organizations.— Until the close of the Civil War the two Episcopal Methodisms were under complete clerical control. In its first general conference following the war the Church, South, adopted equal lay and clerical representation in its general conference and partial lay representation in its annual conferences. In 1868 the Methodist Episcopal Church voted partial lay representation in the general conference which later becaine equal representation, and in later years equal lay representation in its annual conferences. Since lay representation was one of the principal issues in the formation of the Methodist Protestant Church in 1830, full lay representation was adopted as a matter of course by the Methodist Church after the union in 1939 *(see* below).

A development of the 1870s and 1880s was the rise of young people's societies in the Methodist churches. In 1889 five such societies consolidated to form the Epworth league, and the next year the Church. South, also authorized formation of an Epworth league.

Numerous new church boards also were formed in the post-Civil War years, including the Church Extension society, the Woman's Home and Foreign Missionary societies, the Freedmen's Aid society, and the board of education.

Other Activities.— No other U.S. church developed its publishing interests comparably with the Methodists. The Methodist publishing house was established in 1789 to supply Christian literature for the people. Methodism pioneered in the publication of weekly periodicals and in 1831 its oldest weekly paper, *The Christian Advocate and Journal,* which began publication in 1826, had the largest circulation of any weekly journal in the world. In 1841 the Methodist Book concern began publication of the *Ladies Repository and Gatherings of the West,* one of the first woman's literary magazines in the U.S. Besides numerous weekly papers the church began the publication of a quarterly in 1818 called the *Methodist Review.* When division came in 1844, the Church, South, also began publication of a *Quarterly Review.* With union the two were merged into a new review called *Religion in Life.*

During the last quarter of the 19th century U.S. Methodists began the establishment of hospitals and homes for the sick and unfortunate. The first Methodist hospital was opened in Brooklyn, N.Y., in 1881, while the first southern Methodist hospital was that at Emory university (1905) in Atlanta, Ga. By mid-20th century there were 70 Methodist hospitals in the United States, 51 homes for the care of the aged and 46 homes for the care of children.

In addition, the Methodist Woman's division of Christian Service owned and operated 50 institutions, such as business girls' homes, rest homes and hospitals.

An institution begun by Methodists, but later interdenominational, which has spread throughout the United States is the Goodrvill Industries. Begun in Boston. Mass., in 1907 the plan was to give handicapped people without employment a chance to earn a living by revamping castoff clothing, shoes and furniture and selling the repaired product to the poor.

The Union of U.S. Methodism.— The first step toward healing the major Methodist division, that between the north and the south. took place in 1870, when northern Methodist delegates were received by the general conference of the southern Methodists. From that time until the end of the century there was little progress other than exchange of fraternal delegates. In 1905 a joint hymnal and order of worship was adopted by the two Episcopal Methodist bodies. Since Methodist divisions were not caused by doctrinal differences it was not necessary to reconcile different theological points of view. Between 1906 and 1925 a movement for merging the Methodist Protestants and the two Episcopal Methodisms uent forward slowly. The first plan of union voted upon, that between the northern and the southern Episcopal Methodisms in the middle 1920s, was adopted by the Methodist Episcopal Church but failed to receive the necessary majority in the Church, South.

The large Negro membership in the Methodist Episcopal Church was the principal stumbling block in gaining sufficient support among the southern Methodists.

In the 1930s a new plan of union, comprising the two Episcopal Methodisms and the Methodist Protestants, received the necessary support in all three churches concerned. At a uniting conference held in Kansas City, Mo., in May 1939 the Methodist Church was formed, involving a larger number of Protestants than had ever before come together in a reunion body.

METHODIST THEOLOGY AND ORGANIZATION

Wesleyan influence was largely responsible for turning English theological currents away from the prevailing Calvinism of the 17th century. Anglican high churchmen were the original English Arminians—the tradition in which the Wesleys were reared. The Methodists preached the gospel of universal redemption and the appeal of the love of God to the free will of men, as against the predestination of the Calvinists. The Wesleys' hymns were also heavily freighted with these doctrines. Methodists, however, have never been strongly theologically minded, although they have consistently maintained through the years a more or less definite theological point of view. Their theology may be characterized as realistic and idealistic, but they have never stressed a rigid system. That Methodism abandoned the older fundamentalism without much theological strife has been credited to the influence of Bordon P. Bowne (1847–1910), a Methodist philosopher-theologian.

Methodism and **Ecumenicity.**—The fact that John Wesley held that there was no one form of church polity prescribed in Scripture led Methodists to adopt different forms of church government in various parts of the world. The additional fact that Methodism never developed a rigid doctrinal position naturally led to broad tolerance of other points of view and of other religious bodies. It was natural therefore that Methodism should take an active part in all interchurch movements, such as the Federal Council of the Churches of Christ in America and in the World Council of Churches.

Organizational Structure. — From the beginning Methodism has been notable for its efficiency and its highly centralized government. The same functions exercised by Wesley in Great Britain were assumed by Asbury in America, the most important being that of assigning preachers to their charges, a function now assumed by the bishops. A second distinctive organizational feature is the conference system. Every ordained Methodist preacher is a member of an annual conference. A delegated general conference meets every four years and is the law-making body. The United States is divided into six jurisdictions, each with its jurisdictional conference, whose main function is to elect bishops for each jurisdiction. The program of the church is carried on by 16 agencies or boards, each with a permanent staff. The three most important boards are missions, education and publications.

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METHODIUS (c. 825–885), the apostle of the Slavs, was a native of Thessalonica, probably by nationality a Graecized Slav. His father's name was Leo. and his family was socially distinguished; Methodius himself had already attained high official rank in the government of Macedonia before he determined to become a monk. His younger brother Constantine (better known as Cyril, the name he adopted at Rome shortly before his death) a-as a friend of Photius, and had earned the surname "the Philosopher" in Constantinople before he withdrew to monastic life. Constantine about 860 had been sent by the emperor Michael III to the Khazars, a Tatar people living north-east of the Black Sea, in response to their request for a Christian teacher, but had not remained long among them; after his return to within the limits of the empire, his brother and he worked among the Bulgarians of Thrace and Moesia, baptizing their king Bogoris in 861. About 863, at the invitation of Rastislav, king of "Great Moravia," who desired the Christianization of his subjects, but at the same time that they should be independent of the Germans, the two brothers went to his capital (its site is unknown), and, besides establishing a seminary for the education of priests, successfully occupied themselves in preaching in the vernacular and in diffusing their translations of Scripture lessons and liturgical offices. Some conflict with the German priests, who used the Latin liturgy, led to their visiting Pope Nicholas I, who had just been engaged in his still extant correspondence uith the newly converted Bulgarian king. The pope's death (in 867) occurred before their arrival, but they were kindly received by his successor Hadrian II. Constantine died in Rome (in 869), but Methodius, after satisfying the pope of his orthodoxy and obedience, went back to his labours in "Moravia" as archbishop of Syrmia (Sirmium) in Pannonia. His province appears to have been, roughly speaking, co-extensive with the basins of the Raab, Drave and Save, and thus to have included parts of what had previously belonged to the provinces of Salzburg and Passau. In 871 complaints on this account were made at Rome, nominally on behalf of the archbishop of Salzburg, but really in the interests of the German king and his Germanizing ally Swatopluk, Rastislav's successor; they were not, however, immediately successful. In 879, however, Methodius was again summoned to Rome by Pope John VIII, after having declined to give up the practice of celebrating mass in the Slavonic tongue; but the pope, contrary to all expectation, ultimately decided in favour of a Slavonic liturgy, and sent Methodius (880) back to his diocese with a suffragan bishop of Neitra, and with a letter of recommendation to Swatopluk. The closing years of the life of Methodius were embittered by continual ecclesiastical disputes, in the course of which he is said to have laid Swatopluk and his supporters under the ban, and the realm under interdict.

Methodius is said to have died at Hardisch on the March, on April 6, 885.

The Greek Church commemorates St. Cyril on Feb. 14 and St. Methodius on May 11; in the west both are commemorated on March 9. Their canonization (by Leo XIII in 1881) is noteworthy, in view of the fact that several popes condemned them as Arians. After the death of Methodius much of his work was undone; his successor Gosrad, a Slav, was expelled, with all the Slav priests, and the Latin liturgy supplanted the vernacular.

METHODOLOGY: see SCIENTIFIC METHOD.

METHUEN, SIR ALGERNON METHUEN MARSHALL (1856–1924), British publisher and founder of Methuen & Co. Ltd., was born at Southwark on Feb. 23, 1856, his surname being Stedman. While conducting his own school at Godalming, Surrey, he wrote more than 20 educational works in Latin, Greek and French, which he used to form the nucleus of his own publishing house in 1889 under his name Methuen. In 1895 he gave up teaching, formally changing his surname to Methuen in 1899, and in 1910 the firm became a limited liability company. By 1914 it had become one of the largest and most successful of British publishing houses, with such authors as H. G. Wells, Arnold Bennett, Henry James, Stanley Weyman, Conan Doyle, Anthony Hope and Marie Corelli on its list.

Methuen was created a baronet in 1916 and died at Haslemere, Surrey, on Sept. 20, 1924. (J. A. W.)

METHUEN, JOHN (d. 1706), English diplomat and lord chancellor of Ireland, was born in Bradford, Wiltshire, England. He studied law and practised as a lawyer for some years. In 1690 he was elected to parliament as representative from Devizes, Wiltshire, and the following year was appointed envoy to Portugal, remaining in that country until the death of the lord chancellor of Ireland in 1696 left a vacancy in that position. Methuen was appointed to the post in Jan. 1697. He later returned as ambassador. to Portugal, where he died.

Methuen is best known for the Methuen treaty, concluded with Portugal on Dec. 27. 1703. It provided that in return for Portugal's allowing the importation, previously prohibited, of British woollens, Great Britain would levy a duty on Portuguese wines one-third less than that on French wines. This treaty was not only designed to benefit the two countries involved but to harm France, which was allied with Spain against, among other countries, Portugal and England. The result of it was both to kill any Portuguese woollen industry that might have grown up and to change the wine-drinking tastes of the English people from French wines to the Portuguese port, a trend which received enormous impetus from the Methuen treaty.

METHUSELAH, eighth in the list of antediluvians, Genesis v, is credited with the longest life, 969 years. Methushael, a similar name, appears in the list of Genesis iv. In both cases a Lamech is cited as son. Attempts—for which see the commentaries—have been made to find etymologies for the name, and to equate it with a name in similar Babylonian lists.

METHVEN, a village and civil parish, Perthshire, Scotland, 6 mi. W.N.W. of Perth at the southaestern end of the valley of Strathmore. Pop. of civil parish (1951) 1,669. Only an aisle remains of the collegiate church founded in 1433 by Walter Stewart,

earl of Atholl. Methven castle (1660) occupies a fine situation in a park in which stands the Pepperwell oak, 18 ft. in circumference. Trinity college is $4\frac{1}{2}$ mi. N.W. of Methven in Glenalmond, and is usually called by the latter name. It was the first public school on the English model in Scotland and was opened in 1847.

METHYL ALCOHOL, methanol, carbinol, wood alcohol, wood spirit, occurs throughout the vegetable kingdom in the form of esters, such as methyl salicylate (oil of wintergreen) and as complex ethers in many alkaloids, natural dyes and the lignin portion of wood. Discovered in 1661 by R. Boyle, and studied in greater detail in 1831 by Jean Baptiste Dumas and Eugène-Melchior Péligot, its synthesis by M. P. Berthelot from methane through methyl chloride followed in 1858.

Methyl alcohol, CH_3OH, the simplest alcohol known, is the first of a long series of aliphatic alcohols. The name methyl (from the Greek words for wine and wood) is descriptive of the original source of commercial methanol. From the time of its discovery until 1930, substantially all methyl alcohol was obtained by the destructive distillation of wood. Methanol from this source was largely replaced and exceeded by synthetic production. The U.S. wood distillation industry, which formerly produced more than 5,000,000 gai. of methyl alcohol annually, was producing less than 3,000,000 gal. at mid-20th century.

Many attempts were made, without success, to commercialize Berthelot's process for producing methyl alcohol from methane via methyl chloride. Paul Sabatier in 1905 stated the possibility of combining carbon monoxide and hydrogen to produce methanol, but he never succeeded in achieving the synthesis. The thermochemical equation $CO + 2H_2 \rightleftarrows CH_3OH +$ 32,100 cal. shows that the forward reaction will be favoured by increased pressure and also by diminishing temperatures, provided that a suitable catalyst is found. The problem was solved 15 years later by G. Patart, a French chemist, although the Badische company in Germany was the first to develop the process commercially. In the modern method of preparing methanol either natural gas or coal is used to obtain the synthesis gas, $CO + H_2$, which is caused to react in the presence of a reduced zinc oxide and chromic acid catalyst at a temperature of about 400° C. and a pressure of 200 atm. The methanol synthesis closely resembles the Haber process for making ammonia. Indeed, either product can be made in the same plant by changing the reactants and catalysts and by making minor additions. Synthetic plants of this type were established in England, France; Germany, Czechoslovakia, the U.S.S.R., India, China, Norway, Canada and the United States.

The growth of the synthetic methanol industry in the United States was very rapid after its introduction in the late 1920s. By mid-century the annual production of synthetic methanol in the U.S. was approximately 150,000,000 gal. In contrast with the impure product produced by the wood distillation industry, synthetic methanol is substantially a chemically pure material.

Methyl alcohol is a colourless liquid boiling at 64.5° C. and solidifying at −97.8° C. Its density at 25° C. is 0.78641. Methanol forms explosive mixtures with air and burns with a non-luminous flame. It forms azeotropic mixtures with many liquids, such as chloroform, acetone, carbon disulphide, benzene and carbon tetrachloride. The azeotropic mixture of methanol and acetone finds limited use in industry as a solvent under the name of methyl acetone. With certain inorganic solids, methyl alcohol forms addition compounds, such as $CaCl_2, 4CH_3OH$.

Methanol is a violent poison. Many cases of blindness or death have been caused by drinking mixtures containing it. Blindness and serious poisoning may also result from prolonged exposure to its vapours. Commercial usage of methanol and its esters, as industrial solvents, is greatly restricted by their poisonous nature.

The economic production of a pure product by the synthetic process greatly increased the industrial uses of methyl alcohol. Methanol is an important starting material in chemical synthesis. Its derivatives are used in great quantities for building up a vast number of compounds, among them many important synthetic resins, dyestuffs, drugs and perfumes. Large quantities are converted to dimethylaniline for dyestuffs and formaldehyde for synthetic resins. Methanol is also used in automotive antifreezes; about 40,000,000 gal. were being consumed annually in the U.S. at mid-20th century. *See* ALCOHOL; *see* also Index references under "Methyl Alcohol" in the Index volume. (D. G. Z.)

METOCHITES, THEODORE (THEODORUS METOCHITA), (c. 1260–1332), Byzantine scholar, author, patron of learning and statesman, some of whose writings are of historical value. He was grand logothete (chancellor) under Andronicus II (1282–1328). With the fall of Andronicus he was banished for a time from Constantinople but returned in 1331 to live as a monk in the Chora monastery which he had restored. Metochites' writings, some of which are lost, some still unpublished, include works on natural history, philosophy and astronomy, as well as rhetorical pieces, letters and poetry.

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METONIC CYCLE, in chronology, a period of 19 years during which there are 235 lunations, so called because discovered by Meton, an Athenian astronomer (fl. 432 B.C.). Computation from modern data shows that 235 lunations are 6,939 days, 16.5 hours; and 19 solar years, 6,939 days, 14.5 hours. The relation between integral numbers of months and years expressed by Meton's rule therefore deviates only two hours from the truth. Since 19 Julian years make 6,939 days, 18 hours, the relation errs by only 1.5 hour when the Julian year is taken. *See* also CHRONOLOGY.

METONYMY (Gr. *metonymia,* "change of name"), a form of metaphor in which the name of a thing or person is exchanged for the name of another associated with it. Examples: "twirler" (*i.e.,* curver), baseball pitcher; Knickerbocker, New Yorker; Old Dominion, Virginia. *See* FIGURES OF *SPEECH: Figures of Relationship.* (G. W. A.)

METRE. Aristotle in his *Poetics* declared metres to be "manifestly sections of rhythms." Basically the word "metre" signifies measurement, but what element or elements in the rhythmical structure of a poem do we measure? During the Renaissance, English rhetoricians borrowed both their theory and terms from Greek and Latin prosody (or metrics), and these have persisted down to the present time, though many prosodists have questioned their usefulness.

In traditional English prosody, thus derived, syllables are designated as "short" or "long" according to their phonetic make-up and the time required (at least theoretically) to pronounce them. The repetition of short and long syllables constitutes the metre, which can be scanned (or measured) by using the breve (⏑) to indicate a short and the macron (–) to indicate a long syllable.

The four basic metres are: iambic (⏑–); trochaic (–⏑); anapaestic (⏑⏑–); and dactylic (–⏑⏑). The spondee (––) was an important variant in Greek and Latin poetry, and less common were the pyrrhic (⏑⏑), the tribrach (⏑⏑⏑) and the amphibrach (⏑–⏑). These last four are occasionally found in English verse.

Each recurrence of these basic metrical units is called a "foot." Thus if the verse, or single line, of the poem contains only one foot, it is called monometer; two feet, dimeter; three feet, trimeter; four feet; tetrameter; five feet, pentameter; six feet, hexameter; seven feet, heptameter; eight feet, octameter; etc., though the count seldom goes above six.

Since the 14th century classical prosody has predominated in English verse, though some traces of the older alliterative practices of Anglo-Saxon survived. One difficulty with the adoption of the metrical system was that it did not entirely fit the English language, which is Germanic in origin, with strong expiratory stress on certain more or less fixed syllables. Greek and Latin were also highly inflected languages, with case endings to indicate grammatical functions. Even by the time of Chaucer most of these inflections had been lost in English, and either word order (subject, verb, object or other complement) or prepositions took their place. These practices affected the number and position of the short

syllables and the degree of stress on the long ones. In Chaucer's language a vestige of the inflection survived as an indefinite terminal -e, often already mute, sometimes pronounced as the a in "sofa," or as the *ee* in "see" when stressed as the rhyme sound, as in the beginning of "The Pardoner's Tale":

In Flāun|drĕs whīl|ŏm wās| ă cōm|pănyē
Of yŏng|ĕ folk,| that haūn|tĕdēn| fŏlyē, . . .

The regularity of Chaucer's verse was partly the result of the French influence on English, which caused a more even stress on all syllables than in earlier or later English. By the 16th century the basic Germanic inheritance of the English language had reasserted itself, with a return to strong tonic stress on accented syllables and relatively light stress, usually with rapid pronunciation (*i.e.*, shorter duration of sound), on the unaccented syllables.

One school of prosodists has argued since the 16th century that what constitutes rhythm in English verse is still the pattern of accents, or stressed syllables. Actually, a long syllable in Latin or Greek did not always have exactly twice the duration of a short syllable, but the long and short syllables could be defined with more precision than in English. Furthermore, as inflectional endings were lost, the unstressed syllables in English words were spoken less distinctly and more rapidly. These facts support the accent prosodists in abolishing the use of the breve and the macron, and using symbols to indicate stressed (′) and unstressed (ˣ) syllables, as in:

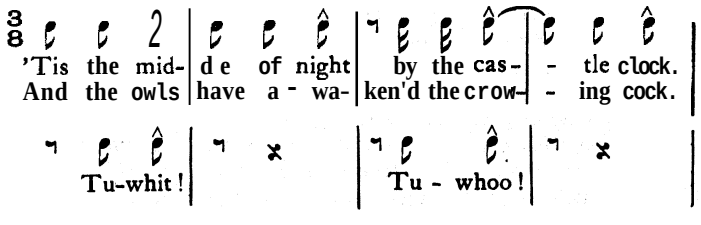
Whĕn wín|tĕr wínds| ăre piérc|ing chíll, . . .

Degrees of stress can be indicated by the use of additional symbols, such as secondary accent (ˋ), or ueak accent (ˋˋ), and the like. But usually the Latin terms (iambic, trochaic, anapaestic, dactylic) are retained, and the difference in metrical analysis is one of degree rather than kind. For example, the metrical stress (a lightly stressed syllable in a position where the metrical pattern calls for a stress) can be indicated by the breve over the macron (⏑), and each reader can use his own judgment as to degree of stress:

Ŏf Mān's| First Dĭs|ŏbē|dĭĕnce, ănd| thĕ Frūit

(The syllables *-di-ence-*, with two joining unstressed vowels, are elided.)

The other school of prosodists, which has also existed since the 16th century, is that of the timers. They insist that time is the basis of all rhythm in poetry, and that therefore what must be measured is the recurrence of sounds in time patterns. They find in musical terminology a ready-made technique of analysis. If a note is assigned to each syllable, the stressed syllable may receive a half note, the more lightly stressed syllable (or secondary accent) a fourth note, the unstressed (short) syllable an eighth note. This technique can be applied readily to iambic or trochaic metre, read in $\frac{3}{4}$ time. Sidney Lanier read the irregular, 4-stress verse of Coleridge's Christabel (intended to be accentual rather than metrical) in $\frac{3}{8}$ time. Here the pauses (silences) can be more neatly indicated by "rests" than by any conventional metrical notation:



The chief objection to musical scansion is that it is highly subjective, especially in the observance of pauses. It is also likely to result in artificial reading because each measure covers precisely the same time (duration). Yet two readers, no matter how competent, seldom read a poem with exactly the same degree of stress on words and syllables or the same duration of pauses. The musical analogy works best with lyric poems, especially those that come nearest to actual song; it is least satisfactory for narrative or dramatic verse.

The acoustics of verse can be accurately measured by the oscillograph and other scientific instruments. By such means it is possible to determine exact pitch (frequency of vibration): volume (loudness), timbre (resonance) and time (duration). Without scientific instruments it is not possible to define the exact meaning of stress or accent (or long or short syllables). A stressed syllable usually differs in volume and duration from an unstressed syllable; and it may also, though not always, differ in pitch.

Actually, on the oscillograph the sounds of spoken verse are continuous, with differences in degree of the four qualities of sound named above, so that syllables, words and metrical feet do not exist in this measurement. Furthermore, acoustics, being concerned only with sound, does not take into account symbolic or linguistic meanings of the sounds, whereas the words of a poem do have meanings aside from their music (sound effects), and the syllables exist also as linguistic units. Thus as an imprecise but still roughly approximate indication of the rhythmical structure of verse, the old method of arbitrarily counting feet and marking the syllables as long or short (or stressed and unstressed) is still useful and convenient.

It is important to understand, however, that English verse is not consistently metrical. The chief value of metrical analysis is to explain the rhythmical structure of an existing poetic work, not to prescribe how a poem should be written. However, metrics can set limits to variations and substitutions in the metre; these variations must not be so frequent that the basic metre is unrecognizable, or even in doubt. An irregularity often encountered is the substitution of one metrical foot for another:

Thē gŏds| tŏ-dāy| stănd frĭēnd|lў, thăt| wĕ măy,
Lŏvĕrs|ĭn peāce,| lĕad ōn| ŏur dāys| tŏ āge!

Substitution is common in the first foot, and not unusual after the caesura, or at the end of the line. Least substitution is found in trochaic metre; most in anapaestic, with which iambic combines easily, as does also trochaic with dactylic. The spondee in the hexameter (*q.v.*) is not a variation but part of the conventional pattern, like rhyme in English. It is substituted in iambic and trochaic metres to give weight and emphasis. Note Pope's illustration of dullness by the use of spondees:

Ănd tēn| lōw wōrds| ŏft crēep| ĭn ōne| dūll line.

John Donne, on the other hand, used heavy stresses for emphasis of meaning and emotion:

Ŏne short; slēep pāst,| wĕ wāke| ĕtĕrn|ălly
Ănd Dēath| shăll bē| nŏ mōre:| Death, thou| shălt dĭē!

English verse can be light as well as heavy. In fact, blank verse (*q.v.*) frequently has only three or four genuinely stressed syllables in the ten, often when an article, a preposition, an unemphatic monosyllable or an unaccented syllable of a polysyllabic word stands in the stressed position. Another not uncommon irregularity is an extra unaccented syllable in blank verse. When this comes after the caesura, usually in the second or third foot, it is called an epic caesura; at the end of the line it is called extra metrical. This variation is frequent in Shakespeare's later blank verse, and Milton permitted the epic caesura. Nearly all English poets, in fact, have composed by ear, not by counting syllables; but, except in free verse (*q.v.*), the underlying pattern of the rhythms is metrical. ***See*** also ALLITERATIVE VERSE; VERSE.

BIBLIOGRAPHY.—For the influence of classical metre on English verse, *see* Gilbert Murray, *The Classical Tradition in Poetry,* ch. iv, "Metre" *(1927,* 1957). For survey of theories, *see* Pallister Barkas, *A Critique of Modern English Prosody (1880–1930)* (1934); Rene Wellek and Austin Warren, *Theory of Lzterature,* ch. xiii, "Euphony, Rhythm, and Meter" (1949); Karl Shapiro, *Essay on Rime,* in blank verse (1945). For scientific approaches, *see* Sidney Lanier, *The Science of English Verse (1880); W.* L. Schramm, *Approaches to a Science of English Verse* (1935). General works are Paull Franklin Baum, *The Principles of English Versification* (1922); Enid Hamer, *The Metres of English Poetry* (1930); *T. S.* Omond, *A Study of Metre* (1920); George Saintsbury, *A History of English Prosody, 3* vol. (1906); Paul Verrier, *Essai sur les principes de la métrique anglaise* (1909). New

approaches are discussed in "English Verse and What It Sounds Like," a group of studies, *The Kenyon Review,* vol. xviii, pp. 411–477 (summer 1956). (G. W. A.)

METRIC SYSTEM: see WEIGHTS AND MEASURES and PHYSICAL UNITS.

METROCLES (fl. late 4th century B.C.), a Cynic philosopher, born of a good family at Maroneia in Thrace, was, like his sister Hipparchia, a pupil of Crates of Thebes (*see* CRATES), having previously studied under the Peripatetic Theophrastus, whom he found excessively attached to the conventions of well-to-do society. He is the first philosopher recorded to have made a collection of instructive anecdotes and sayings, a common form of literary activity among later moralists. (F. H. SH.)

METRODORUS, the name of several ancient Greek philosophers. Three of them must be distinguished:

1. The elder Metrodorus of Lampsacus (jth century B.C.), a pupil of Anaxagoras, is remembered for his allegorical interpretation of Homer's *Iliad* and for having represented the Olympian pantheon as an image of the human body (each god having his seat in a separate organ).

2. Metrodorus of Chios (fl. 4th century B.C.), a pupil of Democritus, may have tried to reconcile his master's atomism with Eleatic views but was also known as a sceptic.

3. The younger Metrodorus of Lampsacus (c. 330–278/277 B.C.) was a pupil and friend of Epicurus.

METROLOGY, a term designating the science of measurement. This science is of fundamental importance in many human activities, especially those concerned with the acquisition and application of scientific knowledge and the regulation of trade by legal systems of weights and measures. As Lord Kelvin once remarked: "I often say that when you can measure what you are speaking about and express it in numbers you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knon-ledge is of a meagre and unsatisfactory kind" (*Popular Lectures and Addresses,* vol. 1, p. 80, Macmillan, 1891). Metrology has extensive ramifications and applications (*see* GEODESY; INSTRUMENTS, ELECTRICAL MEASURING; MEASURES AND WEIGHTS; MENSURATION; PHYSICAL UNITS; SURVEYING; WEIGHING MACHINES). This article outlines the scope and organization of metrology; defines units and standards of measurement and their functions in the fundamental process of measurement; discusses random and systematic errors of measurement; provides a table of accuracies at present attainable in some of the more fundamental operations of metrology; and gives detailed descriptions of the standards of length and mass and how they are maintained. The subject of the time standard (*see* TIME MEASUREMENT) remains an astronomical one, but the second of time is now based on the tropical year instead of the mean solar day because of the established uncertainties in the diurnal period of the earth's rotation. Eventual supersession of the astronomical by an atomic standard was foreshadowed for the measurement of time intervals by the establishment, in 1955, of a cesium beam frequency standard capable of providing a more conveniently accessible as well as a more accurate standard for the second based on a natural period of the atom.

Scope and Organization. — Because of the primary need in the early stages of the economic development of any politicosocial organization to create, and later to maintain, an acceptable system of weights and measures for the conduct of trade, the practice of metrology is often thought to be restricted to measurement of the three fundamental quantities, length, mass and time, from which all the other mechanical quantities, *e.g.,* area, volume, density, velocity, acceleration, force, pressure, energy and power, are derived. Such a limitation cannot be accepted in science for the reason so aptly stated by Lord Kelvin. Because of the dependence of continued economic progress upon proper utilization of the discoveries of science and the need to apply scientific metrology over a wider field than that already indicated, it is essential that any comprehensive system of practical measurement should include at least three other basic quantities. These enable the mechanical system to be extended to the measurement of temperature and related quantities; electric and magnetic quantities; and photometric quantities.

Accordingly, in 1954, the tenth General Conference of Weights and Measures formalized the following six basic quantities and units of a practical international system of measurement (the symbols for the units are given in parentheses):

Quantity	Unit
Length	metre (m.)
Mass	kilogram (kg.)
Time	second (sec.)
Thermodynamic temperature	degree kelvin (° K.)
Intensity of electric current	ampere (A)
Luminous intensity	candela (cd.)

Since 1887 many standards laboratories have been set up to undertake, for national purposes, the establishment and maintenance of standards of measurement throughout the whole field indicated above. These duties apply not only to the six basic quantities but also to their systematic derivatives as well as to the associated test and verification work for science and industry. As examples of such laboratories may be mentioned the national bureau of standards (NBS) in the United States, the National Physical laboratory (N.P.L.) in the United Kingdom and similar laboratories in many commonwealth countries. Some laboratories, notably the NBS, incorporate the national office of weights and measures and are therefore also concerned with legal metrology, but in the United Kingdom this work is the duty of the board of trade standard weights and measures department.

The international metric organization created by the Metric Convention of 1875 (amended in 1921) also has a central laboratory, the International Bureau of Weights and Measures, Sèvres (near Paris), with duties analogous to those of the national laboratories but concerned especially with international co-ordination of all scientific work relating to the maintenance and improvement of the metric system. This organization, representing 35 nations, acts under the authority of the General Conference of Weights and Measures, meeting every six years, with the aid of an elected executive body, the International Committee of Weights and Measures, meeting every two years. This committee manages the affairs of the bureau in between general conferences and makes recommendations relating to units and standards of measurement with the help of various expert advisory committees.

Units and Standards of Measurement. — It is important to distinguish between units and standards of measurement. The process of measuring any quantity consists essentially in ascertaining the ratio of that quantity to another fixed quantity of the same kind, known as the unit of that kind of quantity. A unit is essentially an abstract conception and cannot be utilized as a basis of measurement until it has been defined in one of two ways: by reference either to arbitrary material standards, or to natural phenomena, including in the latter physical constants and the properties of specified substances. Both methods have been used at different times. For example, in the metric system the unit of length is defined by the separation of two lines on a particular metal bar, but is likely to become referred to a certain number of wave lengths of a particular spectrum line; the unit of mass, once the mass of a certain volume of water, is now the mass of a particular cylinder of platinum-iridium. The unit of time has long been defined by reference to natural phenomena; and temperature is scaled by reference to certain natural temperatures, such as the triple point and boiling point of water.

Some kind of comparison is always involved when a measurement is made. This is usually accomplished by comparing the quantity to be measured with a standard whose value is known in terms of the unit of that quantity, although the presence of the standard in any particular measuring instrument may not be so easily recognized as it is in instruments described as "comparators." The standard in its turn must have its value ascertained in terms of the unit; this is ultimately the duty of the standards laboratory.

Random and Systematic Errors. — No measurement is ever absolutely correct; some degree of experimental error is always present. Experimental error may be random or systematic. Random error is mostly due to uncontrolled and erratic minor disturbances of the conditions; *e.g.,* temperature, in which any given

measurement is conducted. Such disturbances lead to a series of observed values having, for instance. a Gaussian distribution about the true value. The extent to which the reliability of the final result is affected by random errors can then be readily assessed by well-established methods of statistical analysis.

It is possible in principle for a measurement to be free from significant random error and yet be subject to an appreciable systematic error which, by reason of its elusive nature. remains undetected. Only by rigorous examination of all the processes involved in a measurement can the possible sources of systematic error be traced and steps taken to eliminate or evaluate them. For instance, where an observer has a physiological bias in the interpretation of readings it can often be arranged that the bias operates an equal number of times in opposite directions. Evaluation of systematic error is best done by the observer himself from his personal knowledge of all the experimental conditions in which his measurements are made. The most satisfactory way of assuring that the measurement of a physical standard or constant is free from unsuspected systematic error is to make two or more determinations by entirely different methods, if possible in different laboratories and with different observers. If each determination gives the same result within the limits of the independently assessed experimental errors, then the probability is that the major systematic errors have been eliminated, on the assumption that the causes of systematic disturbance are unlikely to be the same in the various experiments

Accuracies of Measurement Attained. — The present achievements in accuracy for a representative list of quantities, including the six basic quantities already mentioned, are given in Table I. Understandably. the tendency is for the best measurements to be concerned nith maintaining the standards of physical quantities or of obtaining more precise knowledge of certain natural phenomena, and the assessments relate to the accuracies attained in this field. An important distinction is preserved between the fundamental group—length, mass and time—and the three other basic and eight other derived quantities. The main characteristic of a fundamental standard, apart from its arbitrary nature and the need that it should not change secularly, is the accuracy of comparison, or the degree of precision attained when copies are compared mith their prototype. A derived standard—the other three basic standards are in some sense derived standards—is characterized by two qualities: accuracy of realization and accuracy of comparison. The first, representing the accuracy of evaluation of the standard (or reference) derived either solely in terms of the fundamental standards. or partially in terms of one or more of these standards mith the aid of certain arbitrary theoretical considerations, is usually inferior to the second, representing the accuracy of comparison for two samples of the same standard. For each item appearing in Table I there is a value, or a range of values, for which measurement is most precise, and the highest accuracy attained in the most favourable circumstances, as indicated in the appended notes, is quoted.

TABLE I.—*Accuracies*

Quantity	Standard or reference	Nature	Accuracy of realization, parts per 000,000	Accuracy of comparison, parts per 000,000
Length* . . .	international metre	material	—	0.2†
	wave length of light	natural	0.01‡	0.005§
Mass*	international kilogram	material	—	0.001‖
Time*	mean solar second	natural	—	0.01¶
	ephemeris second	natural♀	—	0.002
	quartz clock	material	—	0.001δ
Frequency	quartz oscillator	material	—	0.0001
	cesium atomic beam	natural	—	0.0001□
Volume . . .	litre	derived○	1	—
	cubic decimetre	derived	0.5▲	—
Velocity .	velocity of light	natural	2+	—
Acceleration	earth's gravitational acceleration	natural	5	0.05⊕
Pressure . . .	standard barometer	material**	10	—
Temperature* . .	thermodynamic scale	theoretical	50††	0.5‡‡
Electric resistance .	ohm	theoretical	10	1
Electric current* .	ampere	theoretical	10	1§§
Quantity of heat .	joule	theoretical	20	—
Luminous intensity*	candela	natural ‖ ‖	2,000	1,000
Sound pressure . .		derived	10,000¶¶	—

*These are the six basic quantities of the international system of measurement, †0.1 for modern line standards (metre or yard) in a standard microscope comparator and possibly 0.05 or better when compared by impersonal photometric or photographic means. ‡By means of derived end standards (metre or yard); possibly 0 05 or better by means of derived line standards of modern construction. §Interferometric comparison of end standards :metre or yard). ‖Comparison of kilograms. ¶Since 1885 the mean solar day (=86 400 mean solar seconds) has been subject to variations ranging through 7 parts in 10^8, with a general tendency to become longer. ♀The ephemeris second (now designated the second) is the fraction 1 /31,556,925.9747 of the tropical year for 1900.0 at 12^h ephemeris time; the accuracy quoted is considered by astronomers to be obtained in due course irom current observations of the motion of the moon over a period of one to two years. δWeek-by-week stability of quartz clocks. □By comparison with quartz clocks. ○Derived from the kilogram of water; 1 litre = 1000.028 $cm.^3$ ▲Reproducibility of interferometric measurements of an accurately constructed cube with 9-cm. side. +Reproducibility of measurements made at optical and microwave frequencies. ⊕Accuracy of relative comparisons, completed in a few hours, between stations situated within a few miles of one another; for stations situated in different parts of the earth the accuracy of comparison is 0 j. **Involving length and density of a mercury column, and the earth's gravitational acceleration. ††In 1954 the thermodynamic scale of temperature was defined by assigning to the triple point of water the value a73.16° K. exactly (the ire point is 0.01° K. lower); the experimental uncertainty of realization is about 0.01° K. ‡‡Reproducibility of the triple point of water. §§The relative comparison is not of amperes but of volts. ‖‖In the sense that the temperature of the black body whose luminance determines the unit of luminous intensity is the freezing point of a pure metal, namely platinum; in determining the luminous intensity of a source differing in spectral energy distribution from the standard, account must he taken of the relative luminous efficiencies at different wave lengths, the values of which have been internationally agreed. ¶¶Representing the accuracy to which standards of sound pressure are maintained at the N.P.L. in the calibration of standard microphones; in the most favourable cases this accuracy could probably be improved upon, ii required, by a small factor.

STANDARDS OF LENGTH

Types of Standard. — Cnder carefully specified conditions a length may be defined by the distance between: (1) two parallel lines engraved upon a material standard bar (a line standard); or (2) two flat and parallel end surfaces of a similar bar (an end standard). Alternatively, reference may be made to a natural phenomenon or standard. For example, the length of a pendulum beating seconds at sea level in the latitude of London was legally specified as the means of re-establishing the standard yard of 1834 (see MEASURES AND WEIGHTS) should its replacement eventually become necessary. The metre was originally defined to be equal to one ten-millionth part of the earth's meridional quadrant. Both these attempts to define a unit of length in natural terms were unsuccessful because the accuracy of realization attainable was far lower than that possible in the comparison of material standards constructed to serve as convenient representations of the prototype reference. The present standards are the imperial standard yard, a bronze line standard established in 1856, and the international prototype metre, a line standard of platinum-iridium (90% Pt. 10% Ir) which, in 1889, replaced the platinum end standard (the *mètre* des *archives*) that superseded the original natural definition. Other materials used for the construction of length standards are nickel, nickel-steel alloys including invar, and fused silica.

The Light-Wave Standard. — During the development of the wave theory of light. J. Eabinet suggested, in 1828, that the wave length of light might serve as a standard of length. It was not until 1893, however, when A. A. Michelson and J. R. Benoît made the first direct determination of the metre in terms of wave lengths of the red radiation of cadmium, that the suggestion was shonn to be realizable in practice. During 1905–06 Benoît, C. Fabry and A. Perot repeated the determination, using improved methods and apparatus. Their originally announced value of the cadmium wave length λ_R in terms of the metre, namely 0.64384696μ(1 micron, symbol μ, = one-millionth of a metre) in air under specified conditions, confirmed the earlier value within the experimental accuracies assigned to the two determinations.

In 1927 the seventh General Conference of Weights and Measures gave formal sanction. as an interim measure, to determinations of length being made hy reference to this value of the wave length of the cadmium red line as an alternative to direct reference to material standards; the reciprocal in terms of the metre was given as $1{,}553{,}164.13\lambda_R$.

The importance of the two independent determinations of the metre in wave lengths lay in their indication that a natural standard of length was independently reproducible within an accuracy at least as high as that attainable in the comparison of material standards. Further confirmation of the reproducibility of the wave-length standard was obtained from the results of seven subsequent determinations of the metre which are listed in Table II together with those of the two earlier experiments.

The values of λ_R all refer to dry air, containing 0.03% by volume of carbon dioxide, at 15° C. and under standard atmospheric

pressure (1,013,250 dynes per square centimetre). The value originally announced by J. R. Benoît *et al.* was subsequently amended to that given in the table to take account of subsequent

TABLE II.—*Wave-Length Determinations*

Date	Observers	Wave length λ_R (unit = 1 micron)	Number of waves in 1 metre
1892–93	A. A. Michelson and J. R. Benoît	0.64384691	1,553,164.25
1905–06	J. R. Benoît, C. Fabry and A. Perot	0.64384703	1,553,163.96
1927	N. Watanabe and M. Imaizumi	0.64384682	1,553,164.46
1933	J. E. Sears and H. Barrell	0.64384713	1,553,163.71
1933	W. Kösters and P. Lampe	0.64384689	1,553,164.29
1934–35	J. E. Sears and H. Barrell	0.64384720	1,553,163.81
1934–35	W. Kösters and P. Lampe	0.64384693	1,553,164.27
1937	W. Kosters and P. Lampe	0.64384700	1,553,164.03
1940	XI. F. Romanova, G. V. Varlich, A. I. Kartachev and N. R. Batarchukova	0.64384687	1,553,164.34
	Mean values	0.64384696	1,553,164.12

conclusions regarding the values to be attributed to the metre standards employed by these observers. By happy chance the mean of the nine values of λ_R is identical with that adopted for spectroscopy and, provisionally, for metrology. It is to be noted, furthermore, that no evidence of any systematic change in the length of the international prototype metre is shown, over a period of nearly 50 years, compared with the wave length of light; also the greatest departure of any individual result from the mean is less than 3 parts in 10,000,000, which is much the same as the accuracy associated with the measurement of length in terms of the national copies of the metre available during that period.

At the ninth General Conference of Weights and Measures a resolution was adopted recognizing the possibility of defining the metre eventually in terms of wave lengths of a radiation of a pure isotope of even atomic number and even mass number (or zero nuclear spin), such as krypton-86, krypton-84, mercury-198 or cadmium-114. In 1953 an advisory committee of the International Committee of Weights and Measures recommended that favourable consideration be given to basing a new definition of the metre on the wave length in *vacuo,* continuity with the existing metre unit being preserved through the intermediary of the mean value, quoted above, of the wave length of the cadmium red radiation in air. This recommendation was accepted by the tenth General Conference in 1954. Although the particular radiation to serve as the ultimate standard of length remained to be selected, attention was directed in 1956 to two lines in the spectrum of krypton-86 which appeared to be the finest available. One of these, the orange-red, was slightly favoured and the hope mas that the experimental data required for a formal definition[1] on the metre on some such basis as this would be ready for consideration when the General conference assembled in 1960. In the meantime the definition of the metre would remain unchanged.

The Yard-Metre Relationship.—The need for an ultimate standard of length based on a stable natural phenomenon is emphasized by the history of the imperial standard yard. This bar and its parliamentary copies are made of a particular kind of bronze known as Baily's metal, and it has long been suspected from indirect evidence that each member of this family of standards may have shortened by about 0.0002 in, during the early years of its existence. No direct evidence of further changes among the members of the family was brought to light by the statutory decennial intercomparisons of the standards carried out as required by the Weights and Measures act of 1878. Unimpeachable evidence of secular instability was derived from a series of determinations of the ratio of the imperial and metric standards of length, the results of which are summarized in Table III.

TABLE III.—*Metre-Inch Relationships*

As the prototype metre has remained constant to within 3 parts in 10.000,000 in relation to the wave length of light during roughly the same period, Table III indicates that the standard yard (= 36 in.) steadily decreased in length by about 2 parts in 1,000,000 between 189; and 1947, equivalent to a rate of about 0.000001 in. per annum. The legal relationship between the metre and the yard is that embodied in the result for the year 189;. To establish stability in scientific and industrial measurements of length made in terms of the yard in the United Kingdom, the lengths of standard gauges, geodetic surveying tapes and other measures of precision verified at the N.P.L. are based on the length of the imperial standard yard in 1922, using as control the ratio between the yard and the metre determined at that epoch, namely, 1 yd. = 0.91439841 m. or 1 m. = 39.370147 in.

The United States Yard.—By an act of congress, 1866, which legalized use of the metric system in the U.S., the United States yard is described as the ratio 3,600/3,937 of the metre, *i.e.,* 1 yd. (U.S.) = 0.91440183 m., 1 m. = 39.37 in. (U.S.), 1 in. (u.s.) = 25.400051 mm., and this ratio is accepted as the definition in the Mendenhall order of the U.S. treasury issued in 1893.

An International Yard.—A proposal to redefine the yard as exactly equal to 0.9144 m. (or 1 in. = 25.4 mm. exactly) was put forward by the Royal Society Empire Scientific conference in 1946. In 1951 the Committee on Weights and Measures Legislation, set up by the board of trade under the chairmanship of Sir Edward Hodgson, recommended in its report the adoption of this relationship (as an alternative to a recommendation for full adoption of the metric system in an obligatory fashion) and advised that consultations with the United States be instituted to assess the possibility of introducing legislation both in the United States and the British Commonwealth to fix the value of the yard once and for all in terms of the metre. The adoption of this proposal would bring into exact agreement the U.S. and British yards. which at present differ by from three to five parts in 1,000,000 according to the basis of conversion used.

Line Standards: Mode of Comparison.—The standard method for the comparison under microscopes of two line standards is as follows: the bars are placed side by side, each on one of two parallel girders contained in a water bath mounted on a carriage capable of being moved in a direction perpendicular to the length of the bars. This arrangement is known as a transverse comparator. Each bar is supported on two rollers so spaced that the distance between the defining lines, which are ruled on the exposed neutral plane of the bar, has its maximum value. Two micrometer microscopes (*see* MICROMETER; PRECISION GAUGES AND COMPARATORS) are rigidly held in brackets supported in such a manner as to he unaffected by the motion of the carriage. Each girder has independent adjustments by means of which the defining lines can be brought into focus in the two microscopes. In the best modern comparators each microscope is capable of rotation through 180° about its optical axis and its objective lens is enclosed in a cell with an optically flat glass window at its base which is submerged below the surface of the water in the bath. The water is continuously stirred and the temperature read by means of accurately calibrated thermometers.

Readings are taken by means of the microscopes alternately on the two defining lines of each bar and then again with the microscopes rotated through 180° to minimize the effect of any asymmetries in the illumination and in the sectional profiles of the defining lines. The comparison is repeated with each of the bars turned end for end on the two girders and the whole operation then repeated once more in a symmetrical fashion. In an important determination. several bars (six or eight) may be included, and each will be compared against all the others.

Subdivision.—The divisions of a scale are calibrated in a similar way, except that the carriage of the comparator moves in the direction of the length of the bar. that is. longitudinally. The microscopes are fixed successively at a series of suitable intervals apart. *e.g.,* 1 dm., 2 dm., 3 dm., etc., for a metre scale divided in decimetres, and each interval of 1 dm., 2 dm., etc., is with every other interval of the same magnitude throughout the

[1] In 1957 the recommendation mas made to define the nietre as equal to 1,650,763.73 wavelengths *in vacuo* of the orange-red radiation of the krypton-86 atom.

scale. By computation from the results so obtained the value of each decimetre is determined in relation to the whole length of the scale. Smaller intervals are calibrated in a similar manner.

Other Developments. — To improve the accuracy of comparing line standards and scales two impersonal methods were, in 1957, being developed at the N.P.L. Both would be more precise than that depending on visual observations through microscopes and both could be applied to the direct interferometric determinations of such standards in terms of light waves. In one, special camera microscopes replace the usual two microscopes in the transverse comparator and record on two plates the relative positions of the corresponding defining lines on the two standards under comparison. An analysis of the gradients of optical density in magnified images of the lines. recorded on the photomicrographs in this manner, demonstrated the possibility of defining their positions to an accuracy of 0.00005 mm. (0.000002 in.) or better. A suitable machine accordingly mas designed as an accessory to the photographic comparator in which this densitometric procedure is applied, using a photoelectric cell as detector, to measure the relative positions of the line images on each photomicrograph.

In the other method a photomultiplier cell replaces the function of the human eye in a special design of microscope. The image of the defining line produced by the microscope objective is caused to oscillate across a slit in front of the cell, and the variation of cell current is transformed electronically into an indication of the line position, with a sensitivity of 0.00002 mm. or better for settings on good quality lines. Other forms of the photoelectric microscope with similar performance are also under development elsewhere for application in the transverse and longitudinal types of comparator.

Measurements of Longer Distances. — The invar tapes and wires used for measuring long base lines and other distances in geodetic surveys, or for civil engineering purposes, are verified under microscopes on a long measuring bench in the standards laboratory by a process depending on addition, commencing from line standards representing the fundamental units of length. In the first place a bar, 4 m. or 12 ft. 6 in. long and graduated in metres or yards and fractions thereof, is compared metre by metre, or yard by yard. etc., with the standard line bar in a large transverse microscope comparator. The bar is in turn compared either with suitable reference marks engraved on inetal plates let into the masonry base of the measuring bench (usually 50 m long) at intervals corresponding to the length of the bar, or else directly with the divisions of the graduated tape to be verified, nhich is suspended in single or multiple catenary (and sometimes supported on a flat surface) under tension. In the best work an accuracy of 1 part in 2,000,000 is achieved in the standardization of a 24-m. tape The tapes after verification either directly, or by comparison nith the bench marks. are used in catenary suspension to determine base lines in the field by comparing them against temporary bench marks set up at distances apart roughly equal to the length of the tape. Although invar is the material commonly used for the construction of geodetic standards of length because of its low thermal expansivity. the mechanical properties of invar (including its secular stability) are poor and the tapes require careful manipulation in use to avoid damage. Some precise surveying has been done nith steel tapes (having a much higher thermal expansivity but better mechanical properties, including stability) for which the relation betneen length and electrical resistance, determined in the laboratory over a wide range of ambient temperatures, is used in the field to determine length from measurements of electrical resistance.

Light-wave interferometry has been successfully employed to establish the distances between the datum marks on a 50-m. measuring bench in the laboratory and even for distances up to nearly 1 km. under suitable atmospheric conditions in the field. (See INTERFEROMETER.) Interferometry over distances of several metres, using radio microwaves in the millimetre range of wave lengths, was applied by K. D. Froome to determine the velocity of propagation of electromagnetic waves.

An instrument known as the geodimeter, originally developed by E. Bergstrand in Sweden to measure the velocity of light, has been successfully applied to the measurement of geodetic base lines to an accuracy of about 2 parts in 1,000,000. The method is based on the classical toothed-wheel experiment used by A. H. L. Fizeau to determine the velocity of light. It depends on measuring, by electronic means controlled by a quartz crystal frequency standard. the time taken by high-frequency light pulses, generated in a beam transmitter situated at one end of the base, to travel to a mirror placed at the other end (say 20 km. away) and back to the transmitter. As the velocity of light is known to 2 parts in 1,000,000 the distance traveled can be calculated to a similar order of accuracy provided the effect on velocity of the atmospheric conditions along the base can be properly assessed. Another method of measuring long bases, depending on the principle of the radar transponder used for aircraft recognition, was introduced in South Africa during 1956.

End Standards: Mode of Calibration. — The most familiar form of end standard is the slip or block gauge made of hardened steel with highly finished. flat and parallel measuring faces first introduced by C. E. Johansson (Sweden) in 1896. In sizes up to 4 in. (100 mm.), the rectangular section of this form of gauge has been found particularly suitable for a wide variety of measurements in precision engineering. Greater lengths than 4 in.. up to 1 yd. or 1 m and larger, are more convenient to construct and use in the form of cylindrical steel rods or bars with only the ends hardened.

An interesting feature of block gauges and end gauges is that it is possible to "wring" two or more gauges together, by bringing their cleaned faces into extremely close contact with a combined sliding and twisting motion, to form additive combinations which are strongly adherent. This adherence is due to molecular forces of cohesion mhich are much enhanced if a minute amount of liquid. such as paraffin oil (kerosene), is introduced between the surfaces. The minimum thickness of a liquid film between two polished, flat surfaces in good wringing contact was measured at the N.P L by two methods which both yielded a value of the order of 0.0000002 in. (0.000005 mm.). This wringing property of the end standard is of great utility to the precision engineer and the standards laboratory, for it provides the means of building up a large number of combination standards by selection from a set containing a limited number of gauges arranged in a suitably graded series of sizes.

Measuring machines of different types and varying sensitivity are available for comparing end standards by contact measurement. In these the standard is measured between two opposed anvils, one of which may be fixed, or may be movable by means of a micrometer scren, while the other is capable of a small movement operating some form of sensitive indicator. This indicator amplifies small movements by means of a mechanical, optical, electrical or pneumatic principle. or a combination of two or more of these principles. The two standards to be compared are inserted between the anvils. and if the whole difference between them is sufficiently small, the movement of the indicator over a calibrated scale suffices to determine it. If the difference is greater, the indicator is brought to a fixed mark by an adjustment of the moving anvil, the difference in length being then ascertained by the difference in reading of the micrometer drum.

As the fundamental units of length are defined by line standards, an essential operation in the calibration of reference end standards is that of transfer from line to end measure by means of a classical metrological procedure too lengthy to describe here. The process of determining end standards representing fractions of the fundamental units is accomplished by comparing together, in suitable highly sensitive comparators or end measuring machines, wrung combinations of equal nominal size. Analogously with the process of subdivision already outlined, the basic end standard (36 in.) is compared with a combination of two 18-in. standards or of three 12-in. standards. Intercomparison of the two 18-in, standards or the three 12-in. standards then provides information enabling the size of each of the smaller standards to be expressed in terms of the 36-in. standard. When extended to smaller fractions, the process becomes laborious and is now largely superseded, for sizes less than 0.5 yd. (18 in.) and 0.5 m.

(50 cm.), by interferometric methods of calibration.

Interferometry of Length. — One basic form of an interferometer for the measurement of length consists of two opposed, semitransparent mirrors separated by the distance to be measured. These are set either parallel. as in the Fabry-Perot interferometer. or nearly parallel, as in the Fizeau (or wedge) interferometer. Reduced to its simplest terms, the process of interferometry is as follows: a beam of monochromatic light waves incident on the interferometer is divided by one of the mirrors into two coherent parts which are then reflected and transmitted in such a manner that the path difference, *i.e.*, the extra distance traveled by one part in relation to the other. is equal to twice the mirror separation. Subsequently, the two parts are recombined and give rise to a pattern of alternate bright and dark bands because the two trains of light waves mutually interact or interfere. If the positions of these bands or fringes are suitably measured in, say, four monochromatic beams of different wave lengths known in terms of the yard and the metre, information is obtained enabling the distance between the mirrors to be evaluated in numbers of waves, from mhich the mean value of the distance is derived. A variant of the above types of interferometer. more convenient for measuring end standards, is that in which one of the mirrors is fully reflecting and the other acts as the beam divider. In the basic form of the Michelson interferometer, both mirrors are fully reflecting and a suitably disposed semitransparent mirror serves as the beam divider.

Owing to their optical perfection of finish. the terminal faces of an end standard can serve as interferometer mirrors and thus provide the means of indicating their relative positions. The interferometry of an end standard would be more convenient if both ends faced the same way. In the Kosters-Zeiss and N P.L.-Hilger designs of gauge-measuring interferometer, which are used for routine standardizations of the highest qualities of block gauges to an accuracy of 0.000001 in. (0.000025 mm.), this convenience is achieved by wringing one end of the gauge to the centre of a flat, reflecting base plate of larger area so that the projecting margins then face the same may as the other end of the gauge. The cornposite mirror thus constituted replaces one of the usual mirrors in the standard forms of interferometer. By utilizing the earlier mentioned sources of monochromatic light in which pure isotopes are the emitters, the range of direct measurement is extended to 18 in, and 50 cm., with an accuracy of 1 part in 10,000,000 or better. The principles used for the interferometry of greater length are the same as, or are developments of, those introduced for the determinations of the metre in light waves. Interference cornparators are available in which the difference in length between any two end standards of the same nominal size is simply evaluated.

STANDARDS OF MASS

General Description. — The kilogram was originally defined to be equal to the mass of a cubic decimetre of water under certain conditions, and its first material representation was the kilo*gramme* des *archives*, a solid cylinder of platinum constructed in the late 18th century. Here again, practical realization of the definition proved inconvenient and insufficiently precise, and the specification in natural terms became superseded by the platinum standard: this in its turn was replaced in 1889 by the international prototype kilogram, also a solid cylinder, of height equal to its diameter, made of the same platinum-iridium alloy as the international metre.

In the British system the imperial standard pound — representing the avoirdupois pound (symbol lb.) of 7,000 grains (symbol gr.)— was constructed in 1844 in the form of a solid cylinder of platinum. In the United States the pound (U.S.) is defined as 0.4535924277 kg., from which 1 kg. = 2.20462234 lb. (U.S.). This ratio was, in fact, determined in 1883 by the board of trade standard weights and measures department in co-operation with the International Bureau of Weights and Measures, but when given legal sanction in the United Kingdom by order in council (S.R. and O., 1898, No. 411) for use as a conversion factor for purposes of trade, the rounded value, namely 1 lb. (U.K.) = 0.43'359243 kg. (equivalent to 1 kg. = 2.2046223 lb. [U.K.]) was adopted. Subsequent determinations of the ratio of the pound (U.K.) to the kilogram gave the results: 1 lb. (U.K.) = 0.453592343 kg. (1922) and 0.453592-338 kg. (1933). These are in very close agreement but differ by about 1 part in 5,000,000 from the result obtained in 1883, the change probably being due to abrasion caused by subsequent excessive use of the standard. As for the yard and metre, a recommendation was made to redefine the pound in terms of the kilogram, using a relationship acceptable in the United States and the British Commonwealth. The values under consideration are: 1 lb. = 0.45359237 kg. or 0.4535923 kg., both being exactly divisible by 7 so that exact relations with the grain are derivable.

Materials. — The choice of platinum and platinum-iridium, and particularly the alloy, for constructing the ultimate standards was fortunate. The degree of consistency, within 2 parts in 100,000,-000, with mhich recomparisons of various national copies of the kilogram have in general repeated the original determinations, convincingly demonstrates the suitability of the standards as well as the perfection of the balances used in the comparisons. The folloning results nere obtained for the British copy (no. 18) at the International Bureau of Weights and Measures:

Year	Mass (kg.)	Year	Mass (kg.)
1889	1.000000070	1933	1.000000058
1924	1.000000051	1948	1.000000071

The recommended materials for reference standards of mass (usually designated as weights) of nominal value greater than 0.5 g. (6 gr.), are, in order of preference with regard to stability: (1) platinum-iridium (90110); (2) platinum; (3) austenitic stainless steel (25% chromium, 20% nickel); (4) nonmagnetic nickel-chromium (80120); and (5) brass, plated to a minimum thickness of 0.015 mm. (0.0006 in.) with rhodium, platinum or chromium over a suitable underplating, or with tin-nickel alloy (65/35). Pure nickel is not a suitable plating material because of its magnetic properties and its liability to "fog" in service. For smaller weights; materials (1), (2), (3) and (4) above are preferred, with the addition of (6) gold alloy, (7) tantalum and (8) aluminum (for standards of 0.1 g., 1 gr. and smaller).

Buoyancy Corrections. — In the comparison of two .standard masses in air, allowance must be made for the upward buoyant effect oi the volumes of air they respectively displace. The upthrust experienced by each standard is proportional to its volume and the density of the air. If M is the weight of a standard of density ρ, obtained by weighing in air against a mass standard oi density ρ_w, its mass is $M + M\rho_a[(1/\rho) - (1/\rho_w)]$, where ρ_a is air density. In practice, each member oi a set of weights, including the fractional weights, is standardized on the basis of balancing, in air of density 0.0012 g./ml. (gram per millilitre), a standard of the same nominal mass having a suitably rounded value of density representing that of the larger members of the set, namely. 8.4 g./ml. ior nickel-chromium and brass, and 8.0 g./ml. for stainless steel. In service, these values of density should be used, as appropriate, in the assessment of buoyancy corrections when significant. For many purposes the representative value of the air density quoted above is suitable, but if high accuracy is required, allowance should be made for variations of air density irom that value. This procedure is much simpler than that of calibrating weights according to their true masses, which involves a knowledge of the actual density of each weight and the individual application of its buoyancy correction.

Methods and Technique of **Weighing.**—In all methods of weighing, either a null method is used or allowance is made for small changes in the inclination oi the beam oi the balance irom weighing to weighing. In the iormer, the load on one arm is adjusted so as to achieve a certain reproducible position oi the beam, indicated by the pointer position or graticule reading. In the latter, when the deflection of the beam has been made small by adjusting the weights, the change in load necessary to achieve some fixed arbitrary position of the pointer is calculated irom the deflection by using the sensitivity, which is separately determined.

In the most commonly practised method of weighing on an orthodox balance, complete equality of the arms of the balance is assumed, and the weight oi an object is assumed to equal the weights added to one pan in order to balance the addition of the object to the other. The effect of inequality oi the arms is eliminated by using either the method of substitution (ascribed to J. C. Borda) or the method of double weighing (ascribed to K. F. Gauss). In substitution weighing the object to be weighed is first counterbalanced by means of accessory weights; other weights are then substituted for the object and are equal to it when they have been adjusted so that the first position of the beam has been regained. In double weighings, the ordinary single weighing is repeated with the loads in the two pans interchanged,

thus eliminating the effects of asymmetry of the beam or of the temperature. This principle of weighing can be extended to eliminate the effects of progressive changes of rest point by repeating the weighings in reverse order; such weighings are described as "double-double" and are usually reserved for the work of the very highest precision on specially well-adjusted balances. If the balance is of the free-swinging type, time is saved by using the method of swings. To a first approximation the effective rest point is midway between successive extremities of swing, but in refined work one more extremity is taken into account.

Elaborations of construction and manipulation of a balance are required for the accurate comparison of primary standard's. It is necessary to take great care to preserve constancy of temperature in the balance room to maintain a steady relationship between the arm lengths of the balance, and the observer should work outside the room. all the manipulations of the balance and the standards being effected by remote controls. Movements of the balance beam are observed either through a telescope or by noting the movement across a scale of a spot of light reflected by a small mirror attached to the beam.

For weighing very small quantities, microbalances, usually made of fused silica, are used and are often constructed with the beam torsionally supported on a fine, horizontal, silica fibre at right angles to the beam and with the pans supported from its ends by means of silica fibres fused directly to it. Differences in load on the two pans are compensated by suitable rotation of one end of the torsion fibre, the amount of rotation being observed by means of an accurately divided torsion head observed optically. Loads as small as 0.1 g. are weighed to an accuracy of 1 part in 10,000,000.

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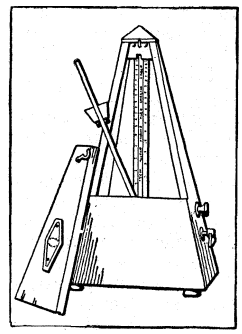
METRONOME, an instrument for denoting the speed at which a musical composition is to be performed. Its invention is generally ascribed to Johann Nepomuk Maelzel, a native of Ratisbon (1772–1838), but erroneously, since its actual inventor was a Dutch musician named Winkler. It consists of a pendulum swung on a pivot; below the pivot is a fixed weight, and above it is a sliding weight that regulates the velocity of the oscillations by the greater or less distance from the pivot to which it is adjusted. In its simplest form the metronome is put in motion by hand and allowed to go on swinging to and fro of its own momentum till it comes to rest. It has a scale of numbers marked on the pendulum, and the upper part of the sliding weight is placed under that number which is to indicate the quickness of a stated note, as M M. (Maelzel's Metronome) ♩=60, or ♩=72, or ♩=108, or the like The number 60 implies a second of time for each single oscillation of the pendulum — numbers lower than this denoting slower, and higher numbers quicker beats. A more complicated metronome is actuated by clockwork, makes a ticking sound at each beat, and continues its action till the works run down; while a still more intricate machine has also a bell which is struck at the first of any number of beats.



BY COURTESY OF CARL FISCHER

METRONOME WITH FRONT OFF TO SHOW PENDULUM

METROPOLITAN, in the Christian church, the title of a bishop who has the oversight over bishops of subordinate sees. In the western church the metropolitan is practically the same as the archbishop (*q.v.*); in the eastern church he ranks above the archbishop. but below the patriarch.

METSU (METZU, METSUE), **GABRIEL** (1630–1667), Dutch painter of everyday subjects, was the son of Jacob Metsu, a painter of Leyden, by his third wife, Jacomina Garnyers. According to Arnold Houbraken, Metsu was taught by Gerard Dou. He was registered among the first members of the painters' corporation at Leyden, and he was still a member in 1649. In 1650, or soon after, he settled at Amsterdam. Marrying in 1658, he became a citizen of Amsterdam in 1659. He died there in 1667 and was buried on Oct. 24 of that year.

Among Metsu's early work were pictures on religious subjects, painted under the influence, successively, of Jan Steen and Rembrandt, but sacred art was ill suited to his temper. and he turned to other subjects for which he was better fitted. That at one time he was deeply impressed by the vivacity and bold technique of Frans Hals can be gathered from the surprising success with which he depicted the low life of the market and tavern; in contrast, with wonderful versatility, he painted with equal success incidents of high life and the drawing room. In no instance, however. no matter what the subject, do the artistic lessons of Rembrandt appear to have been lost upon him.

In the United States samples of Metsu's work may be seen at the National Gallery of Art, Washington, D.C. ("The Intruder"), and at the Metropolitan Museum of Art, New York city ("The Music Lesson" and "The Artist and His Wife"), among other galleries. The National gallery, London, has Metsu's "The Duet" and "The Music Lesson" (or "Music Party"), and other of his pictures are at Buckingham palace.

METTERNICH-WINNEBURG, CLEMENS WENZEL LOTHAR, PRINCE (1773–1859), Austrian statesman and diplomatist, was born at Coblenz, May 15, 1773. His father, Count Franz Georg Karl von Metternich-Winneburg zu Beilstein (d. 1818), was a diplomatist who had passed from the service of the archbishop-elector of Trier to that of the court of Vienna; his mother was Countess Maria Beatrix Aloisia von Kagenegg. At the time of Clemens Metternich's birth, and for some time subsequently, his father was Austrian ambassador to the courts of the three Rhenish electors, and the boy was thus from the first brought up under the influence of the tone and ideas which flourished in the small German courts that lay within the sphere of influence of the France of the *ancien régime.*

In 1788 he went to the University of Strasbourg, but the outbreak of the French Revolution caused him to leave after two years.

Metternich was a witness of the excesses of the mob in Strasbourg, and he ascribed his lifelong hatred of political innovation to these early experiences. In 1790, by way of striking contrast, he was deputed by the Catholic bench of the Westphalian college of counts to act as their master of the ceremonies at the coronation of the Emperor Leopold II at Frankfurt, a function which he again performed at the coronation of Francis II in 1792. The intervening time he spent at Mainz, attending the university and frequenting the court of the archbishop-elector, where his impressions of the Revolution were strengthened by his intercourse with the French *émigrés* who had made it their centre. The outbreak of the revolutionary war drove him from Mainz, and he went to Brussels, where he found employment in the chancery of his father, at that time Austrian minister to the Government of

the Netherlands. Here, in Aug. 1794, he issued his first publication, a pamphlet in which he denounced the "shallow pates" of the old diplomacy and argued that the only way to combat the French revolutionary armies was by a *levée en masse* of the populations on the frontier of France—singular views for the statesman who was destined to be the last great representative of the old diplomacy.

After a long stay in England, where he made the acquaintance of the prince of Wales (afterwards George IV.), Metternich went to Vienna; and on Sept. 27, 1795 he married at Austeflitz the Countess Eleonore von Kaunitz, a grand-daughter of the Austrian chancellor of that name. This alliance not only brought him great estates in Austria, but introduced him into the most exalted circles of Viennese society. Here he was well qualified to hold his own by reason of his handsome presence, the exquisite courtesy of his address and a certain reputation for gallantry. In Dec. 1797 he was chosen by the Westphalian counts as their representative at the Congress of Rastadt, where he remained till 1799. In Jan. 1801 he was appointed Austrian envoy to the elector of Saxony, and he then came into touch with many Russian and Polish families of importance. In Nov. 1803 his serious diplomatic career began with his appointment as ambassador at Berlin. His diplomacy here was not very successful although Prussia ultimately (1805) signed a treaty with Austria and Russia; but he had made himself personally so agreeable to the French envoy that after his appointment as ambassador to Petersburg, Napoleon requested that he might be sent to Paris, where he took up his residence as ambassador in Aug. 1806. His influence in European politics grew rapidly henceforward. At first he ingratiated himself everywhere at the French court and in society, notably with Talleyrand and Caroline Murat, Napoleon's sister. In 1809, however, war broke out between France and Austria, as Metternich had personally urged in his court. He was arrested as a reprisal for the action of the Austrian Government in interning two members of the French embassy in Hungary, and in June, on Napoleon's capture of Vienna, he was conducted there under military guard.

In July he was exchanged at Komárom for the French diplomatists, and was present with Emperor Francis at the battle of Wagram. On July 8, he succeeded to Stadion's place, and became minister of State on Aug. 4. He was absent at the peace conference at Altenburg when the emperor signed the Treaty of Schonbrunn on Oct. 14, 1809, and thus had nothing to do with this document, although on Oct. 8 he had been appointed minister of foreign affairs, a post he held for 40 years.

The position of Austria, reduced as she was by the Treaty of Schonbrunn to the level of a second-rate power, was one of great difficulty and danger, and of this Metternich was fully conscious. Up to this time, his policy had not been wholly free from emotional impulse; but henceforward it was nothing but calculation, caution and a mechanical balancing of chances. His first ambition was to gain time, and to separate Napoleon from the tsar. The power which seemed to him best worth courting was Austria's late enemy, although he was determined not to lose his freedom of action by any too great concessions. Napoleon's request for the hand of the Archduchess Marie Louise, whether due to Metternich's initiative or not, fitted his plans admirably. He accompanied the archduchess to Paris on March 13, 1810. The definite concessions which he established for Austria were, indeed, small; Napoleon declared that anything further must depend on Austria's attitude in the Franco-Russian War which he now stated to be inevitable. Yet Metternich had restored Austria's freedom to move. He hurried back to Vienna on Oct. 10, just in time to stop the strong pro-Russian party at the Austrian court from compromising this liberty by concluding an alliance with Russia, and to win over the emperor for his policy of armed abstention. With the approach of the Franco-Russian War, this policy became increasingly difficult to maintain in its entirety; but although Metternich concluded an alliance with Napoleon on March 14, 1813, promising him military assistance in return for considerable concessions which France was now obliged to offer, he at once informed Russia that Austria's troops would only act on the defensive, and held out a prospect of a renewal of the old alliance of the conservative powers. When Napoleon suffered by catastrophe in Russia, Metternich extricated Austria from her alliance, alleging that it had been abrogated by Napoleon's own act; reverted to neutrality; and had soon manoeuvred his country into the position of arbiter of Europe. Napoleon's signature of the armistice of Pleiswitz gave Austria time to complete her armaments. When Metternich visited Napoleon at Dresden on June 26, he still posed as the impartial "mediator," assuring the emperor "on his honour as a German count" that Austria was still free of "engagements." Yet he already had in his pocket the draft of the second treaty of Reichenbach (which was not, indeed, signed till the following day), whereby Austria contracted with Russia and Prussia to put 150,000 men in the field, and not to make peace without the consent of her allies, should Napoleon reject the ultimatum which was to be put to him. Metternich's object was, in fact, only to gain an txtension of the armistice, till Austria was ready to take the offensive. As for the terms offered to Napoleon, his acceptance of them need not hamper the plans of the allies, while his rejection of them would be a blow to his waning popularity in France.

In the war that followed, although Metternich signed a fresh treaty with Russia at Toplitz (Sept. 9), committing Austria more closely to the policy of the allies, he mas chiefly anxious to ensure that the balance did not swing too far, nor strengthen overmuch either Russia or Prussia. The course of events forced him, against his wishes, to agree to the restoration of the Bourbons, but in other respects the Treaty of Chaumont (March 1, 1814) was a real triumph for him, since it laid down that at the final settlement Germany was to be reconstituted as a confederation of sovereign States, and also did much to temper the fear of a Russian dictatorship by consecrating the principle of that concerted action of the Great Powers, in affairs of international interest, which after Napoleon's fall governed the European system.

On April 10, Metternich arrived at Paris, ten days after its occupation by the allies. He was now at the height of his reputation; on Oct. 20, 1813, two days after Leipzig, he had been created an hereditary prince of the Austrian Empire; he now received from the Emperor Francis a unique honour: the right to quarter the arms of the house of Austria-Lorraine with those of Metternich. At the same time (April 21) the countship of Daruvar was bestowed upon him. On May 30, Metternich set his signature to the Treaty of Paris, and immediately afterwards accompanied the Emperor Alexander and King Frederick William on a visit to England. On July 18, he was back in Vienna, where the great congress was to meet in the autumn. The dignity of a Hungarian magnate was bestowed upon him.

At the congress Metternich's charm of manner and great social gifts gave him much personal influence; the ease and versatility with which he handled intricate diplomatic questions, too, excited admiration; at the same time he was blamed for his leaning to intrigue and *finesse* and for a certain calculated disingenuousness which led to an open breach with the Emperor Alexander.

Whatever the real wisdom of the decisions, he reached a settlement in Germany and Italy precisely in accordance with his wishes and emerged from the congress, of which he had been unquestionably the greatest figure, wholly content with his work. He was destined to spend most of the remainder of his life in an attempt to stabilize and make permanent the situation which he had so largely helped to create. The key-note of his policy henceforward was his attempt to use the European concert as an instrument for ensuring the "stability" of Europe by suppressing any "revolutionary" movements. Both Austria's multinational character, and her central position in Europe caused him to follow a policy that was essentially European. *"C'est* que *depuis longtemps l'Europe a pris pour moi la valeur d'une patrie,"* he said to the Duke of Wellington in 1824; and to his wife he wrote: "I have become a species of moral power in Germany, and perhaps even in Europe." In part this was due, no doubt, to personal vanity, but he had also arranged his system so that it must feel the shock of any disturbance even in the remote parts

of Europe, much more in Germany, Italy or Austria itself. So in his system of diplomacy by congress, Metternich, everywhere the central figure, busied himself in repressing liberty, whether in Germany, Spain or Italy. At first his dominance was unquestioned, especially after he had finally won the Tsar Alexander' over to his side; it was weakened first by the ascension to office of Canning in England, and still further by the revival of the Eastern Question (*q.v.*) in the shape of the Greek revolution, which left Austria isolated in the Near East. The revolutions of 1830 seemed to threaten Metternich's system, yet gave it, at least, a temporary new lease of life. The Berlin convention of Oct. 15, 1833, which reaffirmed the divine right of intervention was a fresh triumph for Metternich's diplomacy, yet it was his last conspicuous intervention in the general affairs of Europe. Although he himself hardly realized it, his system had already passed away.

In domestic affairs Metternich was not, indeed, the wholehearted reactionary for which he was often taken. He was too intelligent not to see the abuses inherent in the Austrian governmental system, and would gladly have remedied some of them. The real author of the incredibly reactionary and aggressive *régime* in Austria in the opening half of the 19th century was the Emperor Francis I. Metternich declared himself more than once, and possibly believed himself to be a liberal. But in any case, he lacked the moral courage to urge the reforms which he felt to be necessary, and he certainly misjudged the forces of his time. His mind was essentially 18th century, and he thought in terms of the State not the nation. He saw that nationalism was fatal to Austria's position in Germany, Italy and at home, and for this reason struggled against it; but he totally miscalculated its real strength, and so the work of his later years, and even at the Congress of Vienna, failed completely to secure the stability which he preached. Although for many years chancellor of Austria, he was not, indeed, primarily interested in internal policy, not mainly responsible for it, and probably could not have reformed it greatly. After the death of Francis I. he was, in any case, too old to change. He was too experienced not to realize the sickness of the State, but he was content to veil it from himself and to attempt to veil it from others. The world was not deceived; but it was not until the Vienna mob, in 1848, was thundering at the door of his cabinet that Metternich himself realized the truth to which he had tried to blind himself. With his fall his system also fell; and his flight from Vienna was the signal for the revolutions of 1848.

The resignation of Prince Metternich, handed in on March 13, 1848, was accepted by the emperor on the 18th, and the prince and his family at once left for England. Here he lived in great retirement, at Brighton and London, until Oct. 1849, when he went to Brussels. In May 1851 he went to his estate of Johannesberg; in September he returned to Vienna. The events of 1848 had not shaken his self-complacency; they seemed to him rather to confirm the soundness of his own political principles. He died on June 11, 1859.

Probably no statesman has, in his own day, been more beslavered with praise and bespattered with abuse than Metternich. By one side he was reverenced as the infallible oracle of diplomatic inspiration, by the other he was loathed and despised as the very incarnation of the spirit of obscurantism and oppression. The victories of democracy brought the latter view into fashion, and to the liberal historians of the latter part of the 19th century the name of Metternich was synonymous with that of a system in which they could recognize nothing but a senseless opposition.

The later reaction against this view found its fullest expression in the work of Srbik (see below); but Srbik's own estimate has been questioned. Of the "technique" of diplomacy Metternich was a master. His despatches are models of diplomatic style. They, are, indeed, sententious, over-elaborate and excessively lengthy, yet their phrase-making was often the result of astute calculation.

In private life Metternich was a kind, if not always faithful, husband and a good father, devoted to his children, of whom he had the misfortune to lose several before his death. He was three times married. His second wife, Baroness Antonie von Leykam, Countess von Beilstein, died in 1829; his third wife, Melanie, Countess Zichy-Ferraris, died on March 3, 1854. Of his sons three survived him: Richard Clemens Lothar (1829–95), his son by his second marriage, who was Austrian ambassador in Paris from 1859 to 1871; Prince Paul (1834–1906) and Prince Lothar (1837–1904), his sons by his third marriage. His grandson Prince Clemens (b. 1869), son of Prince Paul, married in 1905 Isabella de Silva Carvajal, daughter of the marquis de Santa Cruz.

BIBLIOGRAPHY.—A vast mass of unpublished material for the life of Prince Metternich exists in public and private archives; to some of those in the F.O. Records references are given in the bibliography to chap. 1. of vol. x. of the *Cambridge Mod. Hist.* Of published documents the most important are in the collection *Aus Metternichs nachgelassenen Papieren* (1880–84), edited by his son, Prince Richard Metternich. There is a complete French translation issued contemporaneously, and an English version, of which only five volumes (down to 1835) have been published, under the title *Memoirs, etc.* (London, 1880–82). These *Memoirs,* especially the autobiographical parts, must be read with considerable reserve; even the official letters and documents, which are their most valuable contents, have been to a certain extent "edited." Fedor von Demelitsch's *Fürst Metternich* und *seine auswärtige Politik,* vol. i., to 1812 (Munich, 1898), is an elaborate and useful analysis of Metternich's foreign policy, based on a large mass of unpublished archives. A very full modern biography is that by H. von Srbik, *Metternich, der Staatsmann und der Mensch* (Vienna, 1925).

METZ, a town of France, capital of the department of Moselle, on the Moselle, 99 mi. N.W. of Strasbourg by rail, and on the through route from Paris to Mainz and Frankfort. Pop. (1936), 83,119.

History.—Metz, the Roman *Divodurum,* was the chief town of the Mediomatrici, and was also called by the Romans Mediomatrica; Metz is a contracted form. Caesar describes it as one of the oldest and most important towns in Gaul. The Romans, recognizing its strategical importance, fortified it, and supplied it with water by an imposing aqueduct, the remains of which still exist. Under the Roman emperors Metz was connected by military roads with Toul, Langres, Lyons, Strasbourg, Verdun, Reims and Trier. Christianity was introduced in the 3rd century. In the middle of the 5th century the town was plundered by the Huns under Attila; later it came into possession of the Franks, and was made the capital of Austrasia. On the partition of the Carolingian realms in 843 Metz fell to the share of the emperor Lothair I as the capital of Lorraine. Its bishops, whose creation reaches back to the 4th century, now began to be very powerful. Metz became a free imperial town in the 13th century, and soon became prosperous. Having adopted the reformed doctrines in 1552 and 1553, it fell into the hands of the French and was defended against Charles V by Francis duke of Guise. It now sank to the level of a French provincial town, and its population dwindled from 60,000 to about 22,000. At the peace of Westphalia in 1648 Metz, with Toul and Verdun, was formally ceded to France. It was taken by the Germans in 1870 and ceded to them in 1871. It was retroceded to France after World War I.

Buildings, Industries, etc.—The general appearance of the town is quaint and irregular, but there are several handsome modern streets. The Moselle, which is here joined by the Seille, flows through it in several arms, and is crossed by 14 bridges. Of the ten city gates the most interesting are the Porte des Allemands on the east, a castellated structure built in 1445, and the Porte Serpenoise, flanked by turrets belonging to the old ramparts, on the south. The cathedral, 13th to 16th centuries, with huge pointed windows, slender columns and numerous flying buttresses, belongs to the period of the decadence of the Gothic style. St. Vincent, 13th and 14th century Gothic, has a Renaissance façade, and St. Eucaire, 12th–15th century restored, has a pilgrimage chapel. The public library contains an extensive collection of works relating to the history of Lorraine. Metz is the seat of a bishopric, of a prefect, of the VI military region and XXXV army corps, of tribunals of first instance and of commerce, of a board of trade-arbitrators and of a chamber of commerce. The chief industries are the manufacture of shoes and metal-goods and the preserving of fruits and vegetables. There is a national tobacco factory. Trade is in wine, grain, cattle and garden produce.

As a fortress, Metz has always been of the highest importance,

and throughout history down to 1870 it had never succumbed to an enemy, thus earning for itself the name of La pucelle. The original town walls were replaced by ramparts in 1550, and the citadel was built a few years later. By 1674 the works had been reconstructed by Vauban. Under Napoleon III. the fortress was strengthened by a circle of detached forts, which, after 1870, were modified and completed by the Germans, who treated the fortress as the pivot of operations against France.

BATTLES AROUND METZ, IN THE FRANCO-GERMAN WAR, 1870

Colombey-Borny (August 14).—The French army under Marshal Bazaine was in and about Metz. The German I. and II. Armies, on the march from the Saar, were heading for the Moselle between Metz and Pont-&-Mousson, and on the morning of Aug. 14 the German I. Army (I., VII. and VIII. Corps, under General v. Steinmetz) lay on and east of the French, with outposts well to the front, watching the French camps east of Metz, which were little more than 1m. to the front. Steinmetz had received from headquarters overnight instructions that on Aug. 14 the I. Army would maintain the positions occupied during the 13th, and merely passed on these orders to his corps commanders. In Metz, meanwhile, Bazaine had decided to retreat. The II. Corps (Frossard) and VI. (Canrobent) began to retire about midday, the III. (Leboeuf), IV. (Ladmirault) and Imperial Guard (Bourbaki) were to follow. These preparations being observed, the German outposts got under arms. Goltz, in command of the VII. Corps determined at 3 P.M. to advance to the ridge between Colombey and Borny (which was still occupied by French outposts), in order to clear up the situation. The ridge was easily captured, but the sound of the firing at once set all the neighbouring troops in motion, and fortunately so, for the French had immediately retaliated on Goltz. Between 4 and 6 P.M. there was continuous heavy fighting on the front from Borny to Mey, held by Leboeuf's corps, as both sides brought fresh troops into the field, and the troops engaged rapidly slipped frpm all superior control. Shortly before 6:30 Ladmirault's corps came up, endangering the right flank of the Prussian I. Corps (General v. Manteuffel). Meanwhile Steinmetz had been sending peremptory orders to the battlefield to stop the battle, but neither of the corps commanders was able to enforce them. Fortunately for the Prussians, Bazaine had issued similar orders to his subordinates, who, having their men better in hand, were able to obey; and as night began to close in the French broke off the action and retired under the guns of the Metz forts, convinced that at last they had "broken the spell" of German success. In this action the Germans brought only 30,500 on to the battlefield out of more than 100,000 which could have been engaged before darkness. Bazaine actually deployed 50,700 to oppose them. He might, however, had he been so minded, have struck with his whole army—nearly three times this force, and, judging from the course events actually took, we can have little doubt as to the result of such a blow. The losses on either side were in killed and wounded—French 3,600, Germans 4,800.

The Battle of Vionville—Mars-la-Tour (August 16).—On the following day (15th) the German II. Army approached the Moselle above and below Pont-à-Mousson, with a view to overtaking and heading off Bazaine in his presumed retreat to the Meuse (see FRANCO-GERMAN WAR). So far, however, from being ahead of the Germans on the road to Verdun, the French were actually, late in the afternoon of Aug. 15, bivouacked on the plateau of Rezonville, and there their outposts were placed, not where they could see the surrounding country, but at the regulation distances of 600 to 1,000 paces from the bivouacs. At daybreak on the 16th, no Prussians being reported in sight by the outposts, the troops began nonchalantly to prepare for the resumption of the march. On the Prussian side, Alvensleben's Corps (III.) shortly after daybreak was moving north-westward from the Moselle in two columns, on Vionville and Mars-la-Tour, Alvensleben himself riding in advance. The 6th cavalry division was ordered to precede the right column and scout towards Rezonville. No one was aware of the dangerous proximity of the French army.

About 9 A.M. the 5th cavalry division, with two horse artillery batteries (flank guard of the X. Corps from Thiancourt), and accompanied by Caprivi (chief of staff, X. Corps, and afterwards chancellor of the German Empire), were trotting up the western slopes of the ridge which runs between Tronville and Vionville. Reaching its summit they suddenly found themselves in face of at least 40,000 encamped French troops. The temptation proved too great for the artillery, who promptly fired into the midst of the nearest camp. This gave the alarm and Frossard's II. Corps at once stood to arms and advanced, encountering the Prussian 6th cavalry division, which promptly bore away to cover. Meanwhile Alvensleben himself had seen the surprise of the French camps. The sound of the heavy firing coming from the eastward convinced him of what had been gradually dawning on him—that with barely 30,000 men he was in the presence of the whole French army.

In a few moments his decision was taken. Calling on the X. Corps, away to the south-westward, for support, he determined to screen his own weakness by a vigorous attack. By universal consent this is approved as the boldest resolution arrived at by an independent commander throughout the war. His 5th infantry division had already encountered the advancing French as it came out of the defile leading from Gorze up to Rezonville. Now the 6th infantry division, at this moment between Puxieux and Tronville, was ordered to wheel in to their right and attack. Under the onset of this division the French began to retire eastward. Bazaine had meanwhile arrived on the scene, and ordering forward fresh troops to relieve (not to reinforce) those already engaged, he rode forward to watch the operations—and narrowly escaped capture.

After an ill-advised French cavalry charge had been shattered by the Prussian infantry volleys, for about two hours there was a lull in the fighting, which the Prussians utilized on their right in bringing up reinforcements through the Bois des Ognons. On their left, however, no fresh troops were as yet available, and on being informed, about 2:30 P.M., that French cavalry seemed to be about to charge the exhausted 6th division, Alvensleben ordered Bredow's cavalry brigade to charge, and if necessary to sacrifice itself, to save the infantry. Bredow's command (six squadrons of the 16th Ulans and 7th Cuirassiers) moved off in line of squadron columns and ascended the gentle incline which still hid them from their enemy. Arrived at the summit, Bredow sounded "line to the front" but the men, no longer to be restrained. dashed forward, before the line could be completed, almost due east against long lines of infantry and artillery which they now saw for the first time about 1,200 yards in front of them.

This distance was covered at the fullest extended speed of the horses, and reaching the infantry they swept over them "like hounds over a fence"—in the words of an eyewitness. So sudden had been their onset that very few were hit until the infantry had been passed; then the latter, recovering from the shock, turned and fired into the cavalry from behind, whilst a whole fresh division of French horsemen charged them in flank. After a desperate melée of some minutes, the survivors, breaking their way a second time through the French infantry, eventually reached the shelter of their own lines, having lost rather more than half their numbers, but having saved the situation momentarily.

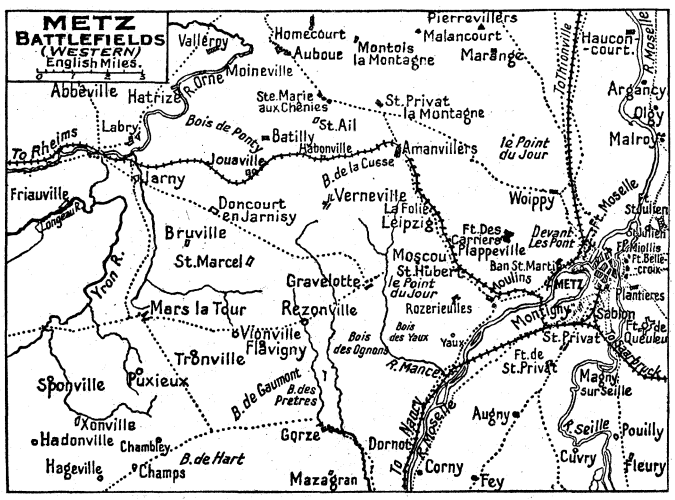
Meanwhile, unknown to Alvensleben, a fresh storm was brewing on his left, where Ladmirault's Corps had arrived from St. Privat—on his own initiative, not Bazaine's intention—and reached a position north of the Tronville copses whence his guns could fire into the left rear of the long line of Prussian guns on the heights above Vionville and Flavigny. Their fire threw the latter into serious confusion and he had decided to attack with his nearest division (de Cissey) in the direction of the steeple of Vionville, when the sudden apparition of a closed mass of Prussian troops detaching itself from the low dust-cloud of a slow-moving infantry column, and forming to the south of Mars-la-Tour, arrested his attention. Unanimously he and his staff agreed that this fresh enemy could only be the advanced guard of a large Prussian force, and delay occurred while the situation was investigated. Actually this body consisted only of the 38th brigade (Wedell), forming part of the X. Corps. In equal ignorance of the situation it moved diagonally across the front of Cissey's division, which, catching sight of them, opened a devastating fire

upon their left flank, and then charged, rolling up their line. The 1st Guard Dragoons, however, rode down the pursuers and by their self-sacrifice relieved the remnants of the infantry.

This was the scene which for the moment held the attention of Prince Frederick Charles when at length he reached the battlefield from Pont-à-Mousson. All along the rest of the line the Prussians were still holding their own, and on the extreme right fresh troops from the IX. Corps were streaming up through the woods against the French left wing. But on the left there was every sign of incipient disaster, and to avert this only the cavalry were at hand. Sending, therefore, hasty orders to the 5th and 6th cavalry divisions to concentrate to the west of Mars-la-Tour, the prince ordered them from there to sweep round on the right rear of the French army. The same idea had, however, occurred to Ladmirault, and he had called on the two nearest French cavalry divisions to put it into execution, and as the Prussians began to reach the plateau west of Mars-la-Tour and the Yron brook from the south, the French were deploying across it some two thousand yards to the north.

Then followed a duel—the one great cavalry duel of the war—between upwards of two thousand horsemen a side. But it was delivered by both sides in a series of regimental charges, and was singularly indecisive. For about half an hour great crowds of riders, hidden by dense clouds of dust, drifted aimlessly about the plain, till at length the charge of a single squadron delivered on the outer French flank, brought the whole mass into motion north-eastward, and, both sides sounding the rally, the engagement gradually ceased. It was now about 7 P.M. and night was coming on. Seeing the dust-clouds drifting away northward, and noting the lethargy which seemed to have settled over the whole French line, Prince Frederick Charles decided to assert his own independent will to conquer by a final assault along his whole front. Guns, cavalry, infantry, everything that could still stand were to take part in it. But the troops! soon lost direction in the smoke dusk and became involved in the direst confusion; and exhaustion put an end to the Prussian advance.

Thus closed the hardest fought battle of the Franco-German War. From 9 A.M. to 3 P.M. only 23,700 rifles, 8,100 sabres and 126 guns had been brought into action by the Germans against 59,100 rifles, 6,700 sabres, and 300 guns on the French side, and



even at the close of the day the former had only deployed 47,100 rifles, 8,300 sabres and 222 guns against 83,000 rifles, 8,000 sabres and 432 guns including 24 mitrailleuses. The chief characteristic of the day's fighting was the terrible effectiveness of the Prussian artillery, which was handled in masses and not, as on the French side, by batteries. The latter arriving singly on the field, were quickly reduced to silence. Deprived of their support, the gallant counter-attacks of the French infantry were repeatedly shattered, after rolling back the opposing infantry. As for the cavalry, on both sides, although they several times intervened to avert a menace, they proved altogether incapable of affecting the decision.

Gravelotte-St. Privat (August 18).—The position on to which the French army fell back from the field of Vionville is formed by a ridge some six miles long running from Rozerieulles almost due north to Roncourt, and connected with the general plateau between the Meuse and Moselle by a gentle saddle running from Amanvillers west towards Doncourt. North of this saddle the slopes are passable by troops of all arms in close order. To the south the rivulet of the Mance forms a formidable obstacle. Scrub and woods with dense undergrowth line both its banks, and, except by the great chaussée from Metz to Verdun, access to the French side becomes impossible to troops in ordered bodies. It does not appear that the position had been systematically examined or apportioned to the several corps. The army merely swung backwards, pivoting on its left wing. No lines of march were assigned to the several units, consequently the confusion became great; and, arriving late, many of them had so little idea of the generai situation that they actually placed outposts to the north and east, whilst the whole enemy army lay south and west.

Fortunately for the French the Germans were too exhausted by the battle of the 16th to attempt to interfere with these movements. At daybreak on the 18th the royal headquarters (which now for the first time arrived at the front) still had no certain knowledge as to whether the French main army was in retreat, or in a position for a fight. Hence the orders issued overnight on the presumption that the main force of the French was retreating to the north and west were allowed to stand, and the whole II. Army (Prince Frederick Charles) moved off in échelon from left to right, the I. Army under Steinmetz, being left in observation of the troops visible on their front and of the garrison of Metz itself. And it had only the VII. Corps immediately available if the enemy counter-attacked. But Steinmetz had not ordered, nor had Zastrow, the corps commander, undertaken any preparations to meet an emergency. About 10 A.M. the corps of the II. Army had reached the following positions: VIII. Corps, Rezonville; IX. near St. Marcel; Guard approaching Doncourt; XII. towards Jarny; the III. and X. still in their bivouacs preparing to move. The cavalry of the Saxons had established the fact that the French had not retreated northward, but though scouts from the Guard had already seen the enemy on the heights of St. Privat, this information had not yet reached headquarters, nor had it been transmitted to the IX. Corps, which it most closely concerned.

Shortly after 10 A.M. Moltke, still under the impression that the French right extended no farther than La Folie (zm. north of the Metz road), determined to attack with the IX. and VIII. Corps whilst the Guard executed a turning movement via Habonville against the French right. The IX. Corps was to engage, but not to push its attack home until the Guard could co-operate. The XII. Corps was left to its own devices, but fortunately the crown prince of Saxony, who commanded it, had ridden forward and, seeing the French force towards Roncourt, had issued orders which in the event proved decisive. In pursuance of his instructions Manstein, commanding the IX. Corps, set his two divisions in motion towards La Folie and the Bois de la Cusse, and advanced to reconnoitre the French position. Suddenly coming in sight of the camp of a whole French corps (the 4th), he decided to execute an artillery surprise on a grand scale. At noon, just as the French infantry were falling in for midday roll-call, sufficient guns were in position, and suddenly opened fire. But the effect was disappointing. The French infantry ran to their arms, and moved forward to attack, while their artillery also took up the challenge, and from the heights near St. Privat the 6th Corps, whose presence was unsuspected by the Prussians, joined in. The batteries on the extreme Prussian left were saved by the timely arrival of companies of Hessian infantry. An obstinate fight ensued.

Prince Frederick Charles now brought forward the 2nd division of the Guard to the Hessians' assistance, while the 1st division attacked Ste. Marie. Meantime the crown prince of Saxony (XII. Corps), with a better view than his superior, was already aware that the French position extended to Roncourt at least, and had despatched a whole division down the valley of the Orne to outflank them. No news of this movement, however, appears to have reached Prince Frederick Charles. The Prussians rushed Ste. Marie but became disordered, and more than an hour passed

before the troops could be re-organized. With the Hessians and the IX. Corps the action still dragged; the 3rd brigade of the Guard had become involved in the fight, and notwithstanding the arrival of the corps artillery of the III. Corps the situation was still critical.

About 4:30 P.M. the prince therefore had to consider how long it would take to obtain a decision. To postpone it till the morrow seemed undesirable; to achieve it before nightfall was only possible at the cost of immediate effort. He therefore decided to assault St. Privat with all the Guards available, and called up the III., X. and Saxons to assist them. The 4th brigade of the Guards now received their orders to attack Jérusalem (a hamlet a little south of St. Privat), and the 1st division was ordered to assault St. Privat itself. Pape, commanding the division, after pointing out his lack of artillery support transmitted the order. The deployment of his and brigade was hindered first by the gardens of Ste. Marie and then by the overlapping of the 4th brigade, so that it had to wheel half-left in mass before it could gain room to deploy. Almost as the commands were given, the French suddenly opened an overwhelming long-range fire and their bullets swept like hail through the crowded mass of the German troops. Nevertheless the wheel was effected, the fresh direction taken, the troops extended for attack, and then the whole brigade dashed towards their objective. Meanwhile the 1st brigade had moved round the north of the village and carried out its extension without serious hindrance. The whole line then raced forward to reach the effective range of their very inferior weapons, which were about equal at 200yd. to the French rifle at 600. But the losses of the 2nd brigade, particularly in officers, had been too heavy, and the rush died out.

It was now about 6 P M. and a long pause ensued, while the 220 guns, which by degrees had unlimbered behind them, brought these villages under fire. About 7P M the Saxon turning-movement took effect; their infantry from the Orne valley attacked Roncourt from the north, and about 7:15 the village was carried. With the III. and X. Corps now coming up, Prince Frederick Charles, although still unaware of the capture of Roncourt, decided to call on the whole of his force to attack. He was in the act of issuing his orders when a psychological wave swept through the fighting-line, and the men rose and rushed the village at the point of the bayonet. It was now about eight o'clock, and the light was failing.

The confusion in and around St. Privat, where troops from four corps were all intermingled, became so extreme that no further infantry-advance could be attempted; so under cover of a fierce artillery duel the remnants of the unfortunate French 6th Corps drifted away towards Metz down the many ravines leading into the river valley. The "annihilation" of the Guard at St. Privat has become historic. Yet, heavy as were the losses of the 1st Guard division they were not excessive compared to those previously endured—roughly one-third of their effectives had fallen. But the legend cannot be justified when the facts are compared with the slaughter of the Seven Years' War, of Napoleon's battles, the Crimea, and the American Civil War.

In the southern sector of the battlefield, where an entirely independent engagement had been raging all the afternoon; when Manstein's guns had opened fire opposite Amanvillers, Goeben's VIII. Corps and Zastrow's VII. Corps had promptly moved "to the sound of the guns," and his support. Both corps took as their primary objective the farms of St Hubert and Point du Jour, standing just above the defile made by the Verdun-Metz road where it climbs out of the Mance ravine towards the French position. About 3:30 P.M. St. Hubert was carried and Steinmetz, believing the main French position to have been pierced, ordered the 4th cavalry division to cross the ravine by the *chaussée* and pursue. Simultaneously Zastrow had ordered his corps artillery to advance and Goeben, also, pushed up reserves.

All these columns converged upon the defile and a hopeless entanglement ensued. Here, exposed to all the random bullets and shells of the French, a panic ensued, thousands of men breaking away and flying in wildest confusion through Gravelotte towards the west. Hardly had they melted away when the French made a most brilliant counter-attack from their main position between the farms of Leipzig and Moscow. This was stopped almost entirely by the Prussian artillery fire; but the news of its coming sent another wave of panic through the mass, many thousands bolting right upon the front of their own batteries, thus masking their fire at the most critical moment, and something like a crisis in the battle arose. Fortunately the II. Corps was now rapidly approaching (about 6 P.M.) and the king, against Moltke's advice, now ordered Steinmetz to attack again with all his forces. Darkness and a third panic delayed the preliminary movements, but at length the II. Corps, together with all of the VII. that could be collected, moved down into the valley. Just as the leading German troops were approaching St. Hubert the French again began to fire, their bullets plunging down among the fresh arrivals, who knowing nothing of what had taken place about St. Hubert (where the remnant of their own infantry were still offering a desperate resistance) opened fire into the backs of their own men, and a fourth panic began which soon spread to the stragglers crowding the Mance ravine. Fortunately, by the superb gallantry of some of the company officers and men, the new arrivals were induced to recognise their mistake, and by degrees about 10 P.M. the whole of the II. Corps succeeded in reaching the plateau between St. Hubert and Point du Jour, where the débris of VII. and VIII. Corps had gathered. But in the darkness and confusion no forward movement against the French (only 400yd. to their front) could be initiated, therefore the whole mass passed the night where they stood until daylight disclosed the French retreat,

Meanwhile the king, Moltke and Bismarck, had ridden back behind Gravelotte where they passed two hours of intense anxiety. From the flash of the rifles it was clear that the French main position was still intact, and as every body of troops within thirty-six hours' call had been engaged there seemed little prospect of renewing the struggle next morning. No news too had come from Prince Frederick Charles. About midnight tidings of the capture of St. Privat arrived, and all anxiety ended.

The Investment of Metz (Aug. 19–Oct. 28).—During the night following the battle of Gravelotte the French army withdrew within the line of the forts round Metz. The 6th Corps only was severely shaken, the 4th (the best of the whole army), though it had fought hard twice within forty-eight hours, losing nearly 30% of its strength, was still well in hand, and the 3rd, 2nd and Imperial Guard were almost intact After a fresh issue of ammunition and food they would have been capable of an attempt to thrust aside the I. German Corps, the only one in their direct path, and then fight their way across the communications of the II. and III. German Armies until they regained touch with the French railways to the south-west about Troyes. And although the latter army would have been a difficult obstacle, the chance of success was fair.

Bazaine, however, withdrew entirely under cover of the forts, and set about the reorganisation of his troops in the most leisurely manner. The Metz forts, though insufficiently armed and some incomplete, were nevertheless too formidable for any field army to attempt without the aid of a powerful siege train, which for the moment was not available. Hence the Germans decided from the first to reduce the place by hunger, calculating that with the extra 150,000 men thrown back upon the fortress, its food supplies could not last very long On the morning of the 19th the German army was far too exhausted for further efforts. In the course of the afternoon the royal headquarters, creating a new army under the crown prince of Saxony for field operations towards the Meuse, assigned the remainder of the II. Army, and the whole of the I. Army to Prince Frederick Charles as commander-in-chief of the army of investment. Steinmetz was shortly afterwards relieved of his command and returned to Germany. This brought the strength of his command to eight corps, numbering some 220,000 men; an enormous mass to feed.

For the moment the chief care of the Prince was to guard against an attempt of the French army to break out to the westward. The encircling positions were fortified with a light outpost line, behind which was drawn a main position on which every art of the engineer was expended. The water-supply of the town was promptly interrupted, but the river water was quite drinkable.

Meanwhile the French in Metz had been diligently at work. There was no real deficiency of ammunition and stores in the fortress, and provisions for forty days were reported in hand. Bazaine issued orders for a break out to the northward by the right bank of the river, but at the last moment he wavered. Calling a council of war on the heights of Fort St. Julien, he asked the opinion of his subordinates, who were unanimously against the proposed sortie, principally because the artillery "had only ammunition enough for a *single* battle!" Besides, the Germans had long since become aware of the movement in progress, and all chance of surprise was past. It was also raining very heavily. Accordingly the scheme was abandoned. On August 29 Bazaine, receiving word of MacMahon's move to his relief. determined to renew the attempt.

At this moment (Aug. 31) the positions of Manteuffel's command (I. Corps and 3rd Landwehr division) were most dangerously extended, and a surprise at daybreak might have had far-reaching results. But the habit of excessive bugling and band-playing betrayed the French design even before daybreak. This time he adhered to his decision, but the concentration was not complete until 1:30 P.M., and not till 4 P.M. did the attack open (battle of Servigny or Noisseville); his opportunity had been allowed to slip, and though his first onset overwhelmed the German outposts, their main line held good, and masses of guns unlimbering over a front of some 4m. rendered all further attempts to break the German cordon abortive. Next morning the fighting was renewed, but the whole French army was disheartened. It was obvious that what they had failed to do by surprise was hopeless now that twenty-four hours had been given in which the Germans could make counter-preparations. Therefore about noon a general retirement under the guns of the forts took place, and the last serious hope of the French army had vanished. Some 120,000 men with 528 guns had been engaged against 60,000 Germans with 222 guns, and had been beaten off with a loss of 3,500 men. The Germans had lost about 3.000.

The investment now resumed its regular course, and as time wore on the conditions in Metz and the surrounding camps became deplorable. Towards the close of September rations had to be reduced, and the troops began slaughtering the cavalry horses for food. Probably to cheer the men by a semblance of activity Bazaine attempted a large sortie on Oct. 1 in the direction of Ladorchamps, and fighting continued into the 2nd, but without prospect of success, and the profound depression following on defeat sent up the sick list rapidly. One other sortie towards Noisseville followed on the 7th, but it was beaten off with the utmost ease by the investing troops, who were well fed and cared for. By this time even the gun-teams had followed the cavalry horses to the slaughter-house, so that the French as an army had ceased to exist. On the recognition of this fact negotiations for capitulation were begun on Oct. 13, and on the 28th the Army of the Rhine surrendered. Had it held out even 48 hours longer events before Paris and Orleans might have taken a different turn. The investment of Metz had lasted 54 days, and the death roll of the civil population had risen to 3,587 against 1,200 in the corresponding period of a normal year. The army itself had only lost from sickness 2,600 men.

MEUDON, a town of northern France, in the *département* of Seine-et-Oise, 6 mi. E. of Versailles by rail and about 2½ mi. S.W. of Paris. Pop. (1954) 23,869. The remains of a castle (17th century) burned during the siege of Paris in 1871 have since been adapted as an observatory. In the 16th century the cardinal, Charles of Lorraine, built at Meudon a magnificent château destroyed in 1803.

MEULEN, ADAM FRANS VAN DER (1632–1690), Flemish painter of battle scenes. was born at Brussels. He was a pupil of the battle painter Peter Snayers, and was called to Paris about 1666 by Jean Colbert. at the instance of Charles Le Brun, to fill the post of battle painter to Louis XIV. His paintings during the campaigns of Flanders (1667) so delighted Louis that from that date Van der Meulen was ordered to accompany him on all his expeditions. In 1673 he was received into the French Academy. He attained the grade of councilor in 1681, and died at Paris in 1690. He is best represented by the series of 20 paintings, executed for Louis XIV. now in the Louvre.

MEUNIER, CONSTANTIN (1831–1905), Belgian sculptor and painter who chose most of his subjects from the life and surroundings of farmers and workers, was born at Brussels on April 12, 1831. He was a pupil at the academy there. His first exhibit was a plaster sketch, "The Garland." at the Brussels Salon in 1851. Soon afterward, on the advice of the painter Charles de Groux. he gave up sculpture for painting. Influenced by Jean François Millet, he began to absorb socialistic ideals. About 1880 he was commissioned to illustrate those parts of Camille Lemonnier's description of Belgium in *Le Tour du Monde* which referred to mines and factories. After a visit in 1882 to Spain, where he painted "The Tobacco Factory at Seville" (Brussels gallery), he was appointed professor at the Louvain Academy of Fine Arts and in 1885 returned to sculpture, producing, among other works, "The Puddler," "The Hammerer" (1886). "The Mower" (1891), "The Glebe" (1892), the "Puddler at the Furnace" (1893) and "The Horse at the Pond." He collaborated with Charles van Stappen in 1893, in the scheme for the decoration of the Botanic garden at Brussels. The "Monument to Labour." an unfinished work for the Brussels gallery, comprises four stone bas-reliefs. "Industry," "The Mine," "Harvest" and the "Harbour," four bronze statues, "The Sower," "The Smith," "The Miner" and "The Ancestor," and a bronze group, "Maternity." Meunier died at Brussels on April 4, 1905.

See C. Lemonnier, *Constantin Meunier* (1904); *A.* Fontaine, *Constantin Meunier* (1923). (A. K. McC.)

MEURICE, PAUL (1818–1905), French dramatist, was born in Paris on Feb. 7, 1818. In 1848 he became the editor of the *Evénement,* founded by Victor Hugo, and in 1869 he was one of the promotors of the *Rappel,* a journal on similar lines. He was the literary executor of Victor Hugo, and edited his works (1880–85). In collaboration with Auguste Vacquerie and Théophile Gautier, he produced *Falstaff* (1842), a play in imitation of Shakespeare, and in 1843 an imitation of the *Antigone;* and with Alexandre Dumas a *Hamlet* (1847). He also wrote *Benvenuto Cellini* (1852), *Schamyl* (1854), *Struensée* (1893), and a dramatic version of *Les Misérables* (1878). He died on Dec. 12, 1905.

MEURSIUS (JOHANNES VAN MEURS) (1579–1639), Dutch classical scholar and antiquary, was born at Loosduinen, near The Hague. At the age of 16 he produced a commentary on the *Cassandra* of Lycophron. Political disturbances caused him to leave Leyden, where he was professor of Greek, for Sorö in Denmark, where he died on Sept. 20, 1639. Many of his classical editions and treatises are printed in Gronovius's *Thesaurus Antiquutatum.* Scaliger called him "pedant" and "ignoramus," which he hardly deserves.

Complete edition of his works by J. Lami (1741–63). *See* Van der Aa's *Biographisch Woordenboek der Nederlanden* (1869), and L. E. Sandys, *Hist. of Class. Scholarship,* vol. ii, p. 311 (1908).

MEURTHE-ET-MOSELLE, a department of northeastern France. formed in 1871 out of those parts of the old departments of Meurthe and Moselle which continued French. Before 1790 it belonged to Lorraine. or to one or other of the bishoprics of Toul, Metz and Verdun. Pop. (1954) 607,022. Area 2,038 sq. mi. It is bounded east by Lorraine, north by Belgium and the grand duchy of Luxembourg. west by the department. of Meuse. and south by that of Vosges. The department is formed of the basins of Meurthe and Moselle near Nancy, but not of the part of the Moselle basin focussing on Metz. for the department was reconstituted after that city had been taken by the Germans in 1871 It extends northward to the frontier of Luxembourg along the scarp of the Côtes de Moselle (Oolite). including the Haute Plaine de la Woëvre within its borders. The department is hilly and rises to 2.041 ft. in the southeast near the Vosges. Summers are hot and winters severe. The mean annual temperature is between 48° and 49°. The annual rainfall averages between 28 and 32 in. The chief crops are cereals and potatoes. clover. mangel-wurzels, tobacco, hops and beetroot. The vine is cultivated; the best vintages are in the Toul district. Fruit trees include pear, apple. walnut, cherry and plum. Oak and wych-elm are most frequent in

woods in the west, beech and fir in the Vosges. The French school of forestry has its seat at Nancy. Horse-rearing is important. The salt-workings (chiefly between Nancy and St. Nicolas), and the iron-mines (round Nancy and Longwy) of Meurthe-et-Moselle are very important. Industries include manufacture of boots and shoes, straw and felt hats, pottery, tanning and brewing, cotton and wool spinning, and the manufacture of cotton goods, hosiery, embroidery, chemicals, soap, crystal, mirrors, glass, army clothing and paper. The Eastern railway from Paris to Strasbourg goes through Nancy. The main waterway is the canal between the Marne and the Rhine, communicating with the Moselle, which is navigable from Frouard downwards, and with the Eastern canal, which unites the Meuse and the Moselle with the Saône and the Rhone. The department constitutes the diocese of Nancy, under the archbishop of Besançon, has its court of appeal at Nancy, and forms a part of the district of the VI. (Metz) and the XX. (Nancy) army corps, and of the académie (educational division) of Nancy. There are three arrondissements (Nancy, Briey and Lunéville), with 29 cantons and 600 communes. The principal towns are Nancy, the capital, Lunéville, Toul, Longwy, Pont-à-Mousson and St. Nicolas.

MEUSE, a *de'partement* of France, formed out of a part of Lorraine and Champagne. Pop. (1954) 207,106. Area 2,409 sq.mi. It is bounded north by Belgium and the *de'partement* of Ardennes, east by that of Meurthe-et-Moselle, south by those of Vosges and Haute-Marne and west by those of Marne and Ardennes.

Oolitic rocks outcrop over most of the surface, and the department has the impervious lower Cretaceous clays beyond its western border and the Lias beyond its eastern one. The Meuse river crosses it from south-southeast to north-northwest. beneath a limestone scarp on the west (1,388 ft. in the southwest). and a ridge rises rapidly on the east (Côte de Meuse) to the high plain of the Woëvre. To the northern part of the western scarp the name of Argonne is given. The east of the Woëvre drains to the Moselle via the Orne and the Made, the valleys of which thus give access to the Meuse from the northeast; this gave St. Mihiel and Verdun very special significance in World War I. West of Verdun the hills of the Argonne diminish rapidly in height northwards. Most of the department save the northwest is over the 600 ft. level.

Its winters are less severe than those of the Vosges, but it is not so temperate as the Seine region. The average annual rainfall is about 30 inches. The chief crops are wheat, oats. rye, barley, clover, potatoes and mangel-wurzels. The vine is grown to some extent, notably at Bar. The forests, occupying more than a quarter of the area, are mainly of oak and are rich in game, as are the rivers in fish. Baskets are made in the Argonne. Mineral wealth includes good freestone (Euville, Lérouville). It has iron and steel works, wire-works, and manufactories of files. hardware and edge tools. Ligny-en-Barrois manufactures scientific instruments. There are cotton-spinning. wool-weaving. and hemp, flax and jute factories, sawmills. carriage works, leather manufactures, glassworks, paper mills, distilleries and flour mills. The *département* is served by the Eastern railway, the principal lines being that from Paris to Strasbourg through Bar-le-Duc and Commercy, that from Paris to Metz through Verdun and the branch line of the Meuse valley.

The chief waterways are the canal connecting the Marne with the Rhine and the Eastern canal along the Meuse valley; together they are 145 m i long.

The *de'partement* forms the diocese of Verdun under the archbishop of Besançon; it has its court of appeal and *académie* (educational division) at Nancy, and forms part of the district of the VI army corps (Metz). There are 3 *arrondissements*—Bar-le-Duc, Commercy and Verdun—a8 cantons and 586 communes. The principal places in the *de'partement* are Bar-le-Duc, the capital, Commercy, Verdun and St. Mihiel.

MEUSE (Flem. *Maes,* Du. *Maas*), a river, 590 mi. long, rising at Pouilly, 1 j mi. N. of Langres, France, and flowing northward across the zone of Upper Jurassic rocks which are largely calcareous and give a steep-sided valley of some depth. On this section are the war-scarred St. Mihiel and Verdun, the latter where a line of relatively low land going from the Moselle to the Paris basin crosses the line of the Meuse valley. After passing Mézières the river crosses the lower Palaeozoic rocks of the Ardennes in a narrow valley, entering Belgium north of Givet to proceed to Namur. Here it is joined by the Sambre (left) and, now known as the Maas, turns eastward along the Belgium coalfield to Liège where it again turns north to pass Maastricht, forms the frontier for some distance and enters Holland below Maeseyck. After passing Roermond and Venloo it flows into the Waal channel of the Rhine and near Gorinchem it divides into two branches, the northern flowing due west to join the Lek (Rhine) above Rotterdam and the southern turning south passes along the canalized channel of the New Merwede and enters the Hollandsch Diep. It is also canalized between Liége and Visé and below Maastricht.

MEUSE LINE, the chain of French forts which prior to World War I were intended to close the passage of the Meuse between Verdun and Toul. The total length of the line was 31 mi., and the *forts d'arrêt* were disposed along the right bank. Between Toul and Épinal the frontier districts were designedly left open, and at Épinal the Moselle Line began. These lines formed part of the defensive scheme adopted by France in 1873–75.

MEW, CHARLOTTE (1870–1928), English poet. Her work appeared at first in various periodicals, but in 1917 a collection of 17 poems was issued by the Poetry Bookshop. An enlarged volume appeared under the title of *The Farmer's Bride* in 1920, and there are perhaps 20 more in existence. She was extremely critical of her own work, and the very small proportion of it which she allowed to be published is of a high quality. She died on March 24, 1928.

For some time before her death she had been in receipt of a Civil List pension granted by the prime minister.

MEXBOROUGH, an urban district in the Dearne Valley parliamentary division of the West Riding of Yorkshire, Eng., 13 mi. N.E. of Sheffield by road. Pop. (1951) 18,972. Area 2.3 sq.mi. It is on the Don river and on the Dearne and Dove canal which affords water communication with Sheffield, Doncaster, Goole and the Humber.

Encircled by collieries, Mexborough's population is largely employed in and about the coal mines and railways. The town is also a shopping and educational centre with a technical college. Castle hill is crowned with earthworks of uncertain date.

MEXICAN WAR, THE, began in the last week of April, 1846, with a series of skirmishes between troops of the United States and Mexican forces on the north bank of the Rio Grande. The war came to an end 21 months later with the negotiation of the treaty of Guadalupe-Hidalgo, signed in a suburb of Mexico City. The entire history of the war was closely associated with the expansionist movement in the United States. The war resulted in a decisive victory for the Cnited States, and as a result the United States acquired a vast expanse of territory stretching from the Rio Grande to the Pacific ocean.

Relations between the two countries had been strained for at least 15 years before the outbreak of war. Unstable political conditions in Mexico created a continuing menace to the lives and property of foreigners. Before 1830 claims of U.S. citizens for losses incurred as a result of civil strife in Mexico had become a subject of diplomatic contention. The evasive tactics of the Mexican authorities caused increasing irritation in the United States; and the government of the United States several times considered the use of reprisals in an effort to compel Mexico to negotiate a settlement.

After a series of prolonged negotiations, beginning in 1839, Mexico agreed to pay claims in excess of $2,000,000; but after paying the accumulated interest on this sum early in 1843, it failed to continue the stipulated payments.

In the meantime, a revolt in the Mexican province of Texas, led by natives of the United States, resulted in the establishment of the independent Republic of Texas (1836). Almost immediately there began a move for the annexation of Texas by the United States. This proposal was favoured by a large majority in Texas, commanded widespread support in the United States, and intro-

duced a highly explosive issue into the already tense relations between Mexico and the United States, for Mexico refused to accept the loss of Texas as a permanent fact. For six years the Cnited States took no positive action respecting Texas, other than to recognize its independent status.

In 1843, Pres. John Tyler made the annexation of Texas a major objective of his administration. A treaty to accomplish this was rejected by the U.S. senate, and annexation became the principal issue in the presidential election of 1844. The candidate who was most outspoken in favour of annexation was James K. Polk. His victory was interpreted as a mandate for the early annexation of Texas, which was accomplished on March 2, 1845. By this action, the United States not only offended Mexico, which broke off diplomatic relations with the U.S., but also fell heir to a boundary dispute between Mexico and Texas. Mexico asserted that the boundary mas the Nueces river, while Texas claimed to the Rio Grande, more than 100 mi. W. of the Nueces.

Polk hoped to settle the outstanding issues with Mexico by peaceable means. The situation was complicated, however, by his undisguised desire to acquire California, which was then a part of Mexico.

At the close of 1845, Polk sent John Slidell (*q.v.*) to Mexico City to negotiate a settlement of the questions in dispute and, if possible, to purchase California. Public opinion in Mexico was not favourable to compromise, and a shift in the government brought to power a party that appeared to favour war. The Mexican authorities refused to receive Slidell, and the situation appeared to have reached an impasse.

When Polk learned that the Slidell mission had failed, he ordered U.S. troops, under Gen. Zachary Taylor, into the disputed zone between the Nueces and the Rio Grande (Jan. 13, 1846). When, in April, Mexican troops were sent to the Rio Grande it appeared that hostilities could not be avoided. On April 24, a Mexican detachment crossed the Rio Grande. On the following day it fought a skirmish with a small party of U.S. troops, in which several of them were killed. In the ensuing two weeks there was desultory fighting on the north bank of the Rio Grande, culminating in the battles of Palo Alto and Resaca de la Palma (May 8, 9, 1846).

On May 9, before news of the first skirmish on the Rio Grande reached Washington, Polk and his cabinet canvassed the tense situation. The president and a majority of his cabinet favoured a declaration of war on the grounds of the unsettled claims and the rejection of Slidell.

After the meeting adjourned, Polk learned that fighting had already begun, and he immediately prepared a message to be sent to congress recommending a declaration that war existed by action of Mexico in which U.S. blood had been shed on U.S. soil. Polk recognized that there would be opposition in congress and feared his recommendation would be rejected. Congress, however, quickly responded with the desired declaration.

The action of Polk in sending Taylor to the Rio Grande and his willingness to recommend war before he knew that Mexican troops had crossed that river caused some of his contemporaries to question his motives and has led historians to debate the justification of his policy. The conduct of Mexico was admittedly irritating, but Polk's determination to acquire California—an acquisition not possible of accomplishment by peaceable methods—has been widely regarded as his true objective. The issue was obscured by the fact that Texas had entered the union as a slave state, and it mas generally assumed that slavery might be extended into any territory taken from Mexico.

Polk was a southern slaveholder, and northern antislavery groups accused him of precipitating the war for the benefit of his fellow slaveholders. For more than half a century this view was commonly accepted by historians. Later research has indicated that Polk's action resulted partly from exasperation with the conduct of Mexico and partly from a desire to add California to the United States.

The original plans for the military conquest of Mexico mere relatively simple. The army on the Rio Grande, under Taylor, was to invade the heart of Mexico, while a second force under Gen. Stephen Kearny was to occupy New Mexico and California. The navy was to blockade Mexico and to support the forces occupying California. The campaign into New Mexico and California encountered little effective opposition, and the residents of both provinces appeared to accept U.S. occupation with a minimum of resentment.

The plan to invade Mexico from the north was a disappointment. Taylor fought several engagements south of the Rio Grande, captured the important city of Monterrey, and defeated a major Mexican force at the bloody battle of Buena Vista (Feb. 22–23, 1847). He appeared to have no enthusiasm for a major invasion of Mexico and on several occasions he failed to pursue the Mexicans vigorously after defeating them. In disgust, Polk revised his war strategy.

Early in 1847, Polk ordered Gen. Winfield Scott to take an army by sea to Veracruz, capture that key seaport, and march inland to Mexico City. Scott took Veracruz after a siege of three weeks (March 7–29, 1847), and began the march toward Mexico City. He defeated the Mexicans in a battle at the mountain pass of Cerro Gordo (April 18) and continued inland. Despite some stiff resistance from the defenders, Scott's campaign was marked by an unbroken series of successes and he entered Mexico City on Sept. 14, 1847. This entry concluded the significant military operations of the war.

Polk had favoured a declaration of war; he was equally anxious to conclude peace whenever Mexico was willing to accept his terms. These included, as a minimum, the cession of New Mexico and California. To facilitate the early negotiation of a peace, Polk sent with Scott's army a special envoy, Nicholas Trist, who was authorized to conclude a peace as soon as Mexico would negotiate on Polk's terms. This negotiation was not easy, for despite. the obvious military superiority of the United States, public opinion in Mexico was opposed to a cession of territory, In the meantime, expansionist elements in the United States were demanding that Mexico be required to yield more territory than Polk had originally contemplated.

After considerable delay, Trist and representatives of Mexico signed the treaty of Guadalupe-Hidalgo on Feb. 2, 1848. By this treaty, Mexico ceded to the United States nearly all of the territory now included in the states of New Mexico, Colorado, Utah, Nevada, Arizona and California. The United States agreed to pay Mexico $15,000,000 and to assume the claims of U.S. citizens against Mexico. Polk was more interested in bringing the war to a close than in holding out for a cession of additional land, and he accepted the treaty.

The treaty was a political victory for Polk, but it satisfied few others. Antislavery groups opposed the acquisition of any territory as a result of a war that they regarded as unjust. Expansionists regretted that the President's terms had been so modest,

The treaty was ratified because it was the only practical means by which the war could be brought to a formal conclusion.

No foreign war of the United States except the War of 1812 with Great Britain so divided public opinion in the United States. The opposition to Polk's policies continued unabated throughout the war. In part, this was the product of partisan politics; but more significant was the attitude of the antislavery groups in the north. Antislavery congressmen repeatedly sought to force through congress a resolution excluding slavery from any area, taken from Mexico. This question was unresolved at the close of the war, and became the principal issue in postwar politics. The prolonged and bitter debates over the organization of the territory ceded by Mexico gave slavery a greater political prominence than it had hitherto commanded, and set in motion a chain of crises which led a dozen years later to the American Civil War.

BIBLIOGRAPHY.—The standard history of the Mexican War is Justin H. Smith, *The War with Mexico,* 2 vol. (1919), based on extensive research, but so argumentatively biased in favour of the United States as to be lacking in objectivity. A more recent useful account, also favourable to the United States and a strong defense of Polk, is Robert Selph Henry, *The Story of the Mexican War* (1950). An older but better balanced work is George L. Rives, *The United States and Mexico,* 2 vol. (1913). A well written brief account may be found in Nathaniel W. Stephenson, *Texas and the Mexican War,* in "Chronicles

of America," xxiv (1921). J. S. Reeves, ***American Diplomacy under Tyler and Polk*** (1907) is critical of those presidents. (H. W. BY.)

MEXICO, a ftderal republic of North America. though belonging partly to Central America in the geographical sense, extending from the United States southward to Guatemala and British Honduras. Its northern boundary line follows the Río Grande del Norte (Rio Bravo) from its mouth northwestward to lat. 31° 47' N., thence on that parallel westward for 100 mi., thence south to lat. 31° 20' N., thence due west to the 111th meridian, thence in a straight line. nearly west-northwest, to a point on the Colorado river 20 mi. below the mouth of the Gila river, thence northward to the mouth of the Gila, and thence nearly due west along the old line between upper and lower California, to a point on the Pacific coast one marine league south of the southernmost point of San Diego bay, this line having a total of 1,550 mi. The boundary line with Guatemala and British Honduras is even more arbitrary, beginning at the mouth of the Suchiate river on the Pacific coast, and following that stream to its source, thence determined by the peaks of Tacaná, Buenavista and Ixbul, from there following a parallel to the Chixoy river, which is really the Upper Csumacinta. to a point on the Gsumacinta itself about 16 mi. S. of Tenosique (Tabasco). thence due east to the San Pedro Mártir river, thence north to lat. 17° 40′ N., which it fallows eastward to the border between British Honduras and Guatemala, thence north to the Hondo river which it skirts to Chetumal bay. The length of this border line is approximately 5jo mi.

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I. PHYSICAL GEOGRAPHY

In its location. appearance and physical structure Mexico is a land of transition. It overlaps the juncture between the continent of North America and the bridge region of Central America, which in turn leads to the continent of South America. The North American continent does not end at the Rio Grande, nor does it extend into Central America. Where one puts its southern limits depends on the criteria chosen. The Mexican Volcanic axis (see below) and the Isthmus of Tehuantepec are equally eligible continental limits. and both are in Mexico.

The physical make-up of Mexico is somewhat complex, but it is not difficult to understand. In the north its core is a high plateau rimmed by mountains on the east. west and south. and by lowlands beyond the mountains. In the south and east the low Isthmus of Tehuantepec ties the structural basin of central Chiapas and its associated highlands to the Oaxaca plateau and the Sierra Madre del Sur. Two peninsulas complete the picture: Baja California. with a backbone of faulted mountains, and Yucatan, a limestone plain.

1. Central Plateau. — The outstanding feature in the physical geography of Mexico is the great plateau (Meseta Central) that makes up the northern and central parts of the country. It covers about a third of the total area, and is in a very real sense the heart of Mexico. In the north this upland begins without a break as an extension of the high plains and basins of the western interior United States. It is really a tilted block. rising from elevations below 3.600 ft. near the U.S. border to more than 8,600 ft. along part of the southern rim. Some parts of its surface are flat, especially the alluvial bottoms of local basins of interior drainage, but in many places there are hills and even mountains of varying degrees of relief. The local highlands are sometimes arranged in roughly parallel ranges with lower areas between them — typical basin-range topography caused by faulting and differential uplift — and sometimes in the roughly circular form of bolsons.

The most important bolson is the Valley of Mexico itself. by nature a basin of interior drainage, which originally contained several lakes. Only Texcoco lake. the lowest and saltiest of these, occupies a considerable area today. especially after the summer rains. Drainage of the basin was begun in the 17th century with the construction of ditches and a tunnel through the higher country to the north, permitting the gradual emptying of the lakes into a tributary of the Panuco river. The partial dehydration of the water-logged lacustrine deposits has brought about a gradual but unequal lowering of the basin floor, with grave consequences for Mexico City, which was built in large part on this spongy formation.

In addition to the Valley of Mexico (elevation 7,400 ft.), the Basin of Puebla (elevation 7,100 ft.) to the east and the Basin of Toluca (elevation 8.600 ft.) to the west deserve special mention, for they too are important centres of population and highland agriculture. Somewhat farther north the Bajio (elevation 6,100 ft.), a lsrge and fertile basin which spreads over parts of the states of Guanajuato, Queretaro, Michoacán and Jalisco, is one of the most notable and productive regions of alluvial land on the Meseta Central. In northern Mexico the bolsons of Mapimí and Mayrán (elevation 3,700 ft.) are noteworthy, the latter including the celebrated Laguna district, devoted mainly to irrigated cotton production.

2. Mountains. — The Central plateau is bounded on the west by a great complex of parallel ranges and escarpments about 800 mi. long, known collectively as the Sierra Nadre Occidental. Steep-sided canyons *(barrancas)* occur in various places, some of them rivaling in depth the Grand canyon of the Colorado. The average height of the mountains is about 7,300 ft.. with a few peaks approaching 10.000 ft. in elevation. Convenient passes through the mountains and canyons are almost completely absent.

The Sierra Madre Oriental on the eastern edge of the plateau is a much less serious barrier to communications. For the most part it is merely the deeply incised and dissected edge of the plateau, without separate orogenic development. Only in the states of Tamaulipas and Nuevo Leon are there major independent ranges not specifically associated with the plateau edge.

The highest mountains of Mexico are found in the Volcanic axis, which crosses the country transversely from coast to coast along the southern rim of the plateau, simultaneously cutting off the two Sierra Madre systems which follow the western and eastern plateau edges. The Volcanic axis, called by some Mexican geographers the Cordillera Neo-Volcánica, follows a line of crustal weakness along which volcanic activity still occurs. Not only

have volcanic cones of all sizes been built up, but great fissure flows of lava and widespread deposits of volcanic ash have been common, nhich through weathering have formed fertile volcanic soils over hundreds of thousands of square miles.

From east to west the outstanding volcanic cones are San Martin (5,085 ft.), Pico de Orizaba or Citlaltkpetl (18,696 ft.), Cofre de Perote or Nauhcampatépetl (14,048 ft.), La Malinche (13,474 ft.), Iztaccihuatl (17,338 ft.), Popocatkpetl (17,887 ft.), Nevado de Toluca or Xinantecatl (15,016 ft.), Paricutin (1,194 ft.) and the twin peaks Kevado de Colima (14,21y ft.) and Volcán de Colima (12,795 ft.). Those active within the last century include San Martin, Popocatkpetl, Paricutin and Volcán de Colima. The most famous is undoubtedly Popocatépetl, which is often climbed because of its proximity to Mexico City and its relatively easy ascent. Its crater is 620 ft. deep as measured from the lowest point on the rim, and 1,560 ft deep as measured from the highest; it has a circumference of more than 1½ mi. The Pico de Orizaba is the third highest mountain in Korth America, with an almost perfect conical shape reminiscent of Fujiyama in Japan or Mt. Osorno in Chile. The most recent volcano to appear on the mainland of Mexico is Paricutin, whose birth dates from 1943 and whose activity completely ceased by 1952. In its short lifetime the cone grew to more than 800 ft. above its surroundings.

The Sierra Madre del Sur lies along much of Mexico's southern coast. Extending southeast from Cape Corrientes, it is roughly 60 mi. wide and averages about 7,000 ft. high. In the state of Oaxaca it merges with the broad, maturely dissected Oaxaca plateau and with the so-called Sierra de Oaxaca, which is considered by some an extension of the Sierra Madre Oriental Several peaks in these southern mountains exceed 11,000 ft in elevation, the most famous being the isolated Zempoaltepec (meaning 20 peaks), roughly halfway betneen the city of Oaxaca and the Isthmus of Tehuantepec. The lowest pass across the isthmus lies just under 800 ft. above sea level To the southeast begins the Sierra Madre de Chiapas. also known as the Sierra de Soconusco. which rises gradually toward the Guatemalan border. culminating in the volcanic peak Tacaná (13,417 ft) which marks the beginning of the Volcanic axis of Central America

3. Earthquakes. — The Pacific region of Mexico is particularly subject to earthquakes, especially the southern district from San Blas to the Guatemalan border. The states of Guerrero and Oaxaca are most commonly affected. In 1907 the town of Chilpancingo was reduced to a mass of ruins. A violent tremor lasting more than 40 seconds occurred in the region from Mexico City to Acapulco on July 28, 1957, killing more than 60 persons, injuring hundreds, and doing damage in Mexico City alone estimated at 200,000,000 pesos The lowlands of the Gulf of Mexico have earthquakes only rarely.

4. Coastal Region. — The lowlands, or *tierra caliente* regions, which lie between the sierras and the coast, consist of sandy and marshy deposits near the sea, but some sections of the coastal lands. where alluvial deposits from higher up have accumulated, may reach an altitude as great as 3,000 ft., while on the Pacific coast, mountain spurs may extend donn to the littoral (Cape Corrientes, Cerro de León). In Tabasco and in southwest Campeche the lowlands cover a much vaster extension and are made of the alluvial deposits of the Usumacinta and Grijalva net of rivers. The low Yucatan peninsula north of the Petén is formed almost entirely of white limestone and is characterized by many sinkholes and the prevalence of subterranean drainage.

The difference betneen the aspect of the Atlantic (Gulf of Mexico) coast and that of the Pacific is as great in Mexico as it is in the United States. The former. 1,080 mi. long, is generally low and sandy, and shous no bay of commercial importance except the shallow Tamiahua lagoon, the relatively deep Laguna del Carmen (the only one that has a natural harbour owing to the protection afforded by the islands of Carmen and Puerto Real) and those on the eastern coast of Yucatan, of which almost no use is made because the region itself is still undeveloped. The general lack of secondary articulations, characteristic of the Gulf coast, and the fact that all the rivers ahich have their mouths there are obstructed by sand bars, explain why the good ports on the Gulf of Mexico are artificial; and it must also be remembered that this coast is by far the most important in respect to international communications. The leading ports are Tampico and Veracruz; the former, which is a river port. has been considerably improved by the building of breakwaters or jetties. while the latter is almost entirely man-made. Coatzacoalcos (Puerto Mexico) on the river of the same name—a port whose future on account of its situation could hardly be doubted—has been improved in the same way as Tampico. Large boats can go as far up the river as Minatitlán, 26 mi. from the coast. Progreso, the henequen (sisal hemp) port, has taken the place of old Sisal, but can accommodate small vessels only and is losing depth on account of the slow rising of that part of Yucatan Tuxpan, notwithstanding its modest importance in connection with the oil business, has not been much improved. Frontera, in spite of its favourable location at the entrance of a large river, is almost useless on account of a bar, nhile Campeche, at the head of a small, artificial harbour, is almost entirely silted.

The Pacific coast. 2,860 mi. long, rugged and much better articulated, has excellent bays, one of which. that of Acapulco, is truly magnificent, though they are all cut off from the interior by the Sierra Madre del Sur and the Sierra Madre Occidental. The only important ports are those connected with the interior by railway; viz., Guaymas. Topolobampo, Mazatlán, Altata, Manzanillo and Salina Cruz. Baja California has some excellent natural bays, such as those of Ensenada de Todos Santos and La Magdalena on the Pacific coast, and Santa Inés and La Paz on the Gulf of California.

There are no islands of great importance belonging to Mexico. El Carmen with the port of the same name, on the Gulf of Mexico, Isla Mujeres and Cozumel on the east coast of Yucatan are the only ones worthy of mention on the Atlantic coast, and the Tres Marías in the Pacific near San Blas are used as a penal colony.

5. Rivers. — One would hardly expect that a country consisting mostly of a high denuded plateau and enjoying but a scanty rainfall would be provided nith important rivers It was. in fact, on that account that Mexico found it necessary to develop an efficient net of railways. On the Gulf side, where rivers are all obstructed with bars, we find first the Rio Grande del Norte or Rio Bravo. a river that is much more American than Mexican if we take into consideration the official boundary and the fact that its 1,800 mi. of length is mainly in United States territory. Ending in a small delta it has lost all the commercial importance it formerly possessed. Its leading branch on the Mexican side is the Conchos. Farther south the Soto la Marina river hardly deserves mention because of the undeveloped region it traverses. The Pánuco river is one of the relatively important streams of Mexico oning to its numerous branches and to the fact that its mouth, thanks to a system of jetties, has been much improved, in order to facilitate the considerable commerce of Tampico. It now drains the lakes of the Valley of Mexico. The Papaloapan, whose headwaters are in the mountains of Oaxaca, and the San Juan. shich flows through one of the richest regions of the *tierra caliente*, finally unite in the lagoon at Alvarado. The Coatzacoalcos, in the isthmus region, owes its importance to the works that have been constructed to improve its entrance, as a means of improving in turn the port of Coatzacoalcos. It is navigable as far as Minatitlan, where there is a large oil refinery.

The Grijalva and the Usumacinta unite in a common delta but nothing has been done to prevent the forming of a bar and, as a result, the port of Frontera has not developed as much as one might have expected, bearing in mind the splendid region the two rivers and their many branches pass through. The Grijalva, called Chiapas in its upper course, rises in western Guatemala and is navigable for yo mi.. its total length being 350 mi. The Usumacinta, which rises in the Altos region of Guatemala and is navigable as far as Tenosique, is a powerful river of majestic aspect gathering in the waters of tno important branches, one of uhich. the Rio de la Pasión, has its headwaters in British Honduras. Its total length is said to be 330 mi. The Yucatan peninsula has few superficial streams, the whole country being made of a porous limestone through which the rain penetrates and forms subterranean rivers opening either into the coastal lagoons or into the

gulf itself, sometimes at quite a distance from the littoral. As a consequence, all the important villages are near some of the holes, or natural wells, called cenotes or rather *tzonotes*, through which one can reach the subterranean water, sometimes at a depth of as much as 400 ft. However, the southeastern part of the peninsula, the geological constitution of which is somewhat different, has a relatively important river whose source lies in Petén and whose sluggish course has been chosen as the border between Mexico and British Honduras.

Some of the rivers of Mexico's north Pacific slope, while of negligible importance for navigation, are of great significance as sources of irrigation water. Most of these rivers have a highly variable flow because of the long dry season. but some of the more important ones have been dammed. The mouth of the Colorado belongs entirely to Mexico, and its waters are being used to irrigate the important commercial cotton area south of Mexicali, a certain minimum flow being guaranteed to Mexico by treaty with the United States. Similarly the Rio Yaqui is furnishing water to an irrigation district near Ciudad Obregon, the population and agricultural production of which expanded rapidly in the early 1950s. Much the same may be said for the Río Nazas, which rises in the Sierra Madre Occidental but which flows eastward into the dry interior of northern Mexico, never reaching the sea. It finally ends in the Bolsón de Mayrán, where it provides the irrigation water for the cotton grown in the Laguna district, which has already been mentioned.

The Rio Lerma has its source in the Bolsón de Toluca, then flows across the southern part of the plateau into Lake Chapala. It issues from the lake as the Rio Grande de Santiago, drops over the Juanacatlán falls (70 ft. high; 524 ft. wide) near Guadalajara, and then acts as the master stream draining the barranca country of the southern end of the Sierra Madre Occidental. It reaches the Pacific some distance north of the old port of San Blas. The Rio Balsas has its source on the plateau in the state of Tlaxcala. It drains the great structural trough (Balsas depression) south of the Volcanic axis and finally breaks through the Sierra Madre del Sur to reach the ocean near the colonial town of Zacatula.

Since the end of World War II, Mexico has built numerous dams for irrigation, flood control and hydroelectric power. Especially noteworthy are new dams on the Río Bravo (Falcon dam, shared with the U.S.), Río Conchos, Rio Yaqui and Rio Papaloapan and its tributaries. The last-named is a completely integrated system patterned after the Tennessee Valley authority.

6. Lakes.—Lake Chapala is the largest lake in Mexico, its normal dimensions being 51 by 19 mi. In the late 1940s its surface area diminished greatly, leaving lakeside dock installations far from the water. The reasons for this occurrence were a succession of dry years and increasing use of Rio Lerma water upstream. Since rapidly growing Mexico City is now depending more and more on the Rio Lerma for its water supply, it is possible that Lake Chapala will not regain its former extent, although torrential rains in the mid-1950s caused the lake to rise. Some of the exposed lake bed has been converted to agricultural use. Lakes Pátzcuaro and Cuitzeo in the state of Michoacán are most picturesque and have become tourist attractions. The several freshwater lakes formerly occupying parts of the Valley of Mexico are only memories today because of the progressive desiccation of the basin since the final completion in 1900 of the artificial drainage channel. Only after sudden rains do they briefly reassert themselves because of the slow runoff. Salty Lake Texcoco still exists, but its size is greatly diminished.

Northern Mexico contains many shallow lakes, some of them large, some intermittently dry (playas), most of them brackish or salty. They represent the final evaporating pans of rivers in basins of interior drainage. They are especially common in the states of Chihuahua, Durango and Coahuila. Frequently their gently sloping alluvial shores are used for irrigation agriculture.

7. Geology.—The high plateau of Mexico, the country's dominant feature, is composed mainly of Cretaceous limestones and Cenozoic volcanics. Extensive areas of its surface are covered with detritus and alluvium, collected, as we have seen, in basins of interior drainage. These basins are commonly separated from one another by scattered block mountains. The eastern lowlands are largely composed of recent sedimentaries, whereas the bulk of the region east of the Isthmus of Tehuantepec is made up of folded Cretaceous and Tertiary strata interspersed with eruptive formations. Yucatan is an immense limestone slab of Tertiary age. Western and southwestern Mexico is geologically complex.

The state of Sonora displays an involved series of Paleozoic and Mesozoic limestones and clastic strata invaded by intrusives of varying age and composition. mostly strongly faulted. displaced and tilted into typical hasin-range topography. The Sierra Madre del Sur is composed of crystallines of Archean or Paleozoic age, in part exposed, in part overlain by Mesozoic limestones and in part intruded by granodiorite batholiths which are now locally uncovered The northern half of Baja California as well as the extreme south consists mostly of Cretaceous sedimentaries and metamorphics with granitic intrusives, whereas most of the rest of the peninsula consists of volcanics and of Tertiary and Quaternary sedimentaries.

From the point of view of economic geology Mexico has been well endowed, especially in metallic ores. Although only limited amounts of gold have been found. Mexico may well have produced more silver in the last four centuries than any other country in the world. Most of the silver veins are found in the central plateau, the Sierra Madre Occidental, and the Sierra Madre del Sur. Silver is still being produced in quantity in the mid-20th century, but base metals such as lead, zinc and copper have become relatively more important. Iron is found in reasonable amounts, the main commercial ore body being in the Cerro de Mercado near the city of Durango.

The mineral fuels and other nonmetals are also significant. Moderately plentiful coal deposits of Cretaceous age are found in Coahuila. Combined with Durango iron they form the basis of Mexico's iron and steel industry Tertiary oil and gas pools in the eastern lowlands have long been known. The main producing districts are around Reinosa, Matamoros. Tampico, Tuxpan, Poza Rica and Minatitlán. After World War II vast sulfur deposits were proved on the Isthmus of Tehuantepec. and Large-scale mining by the Frasch process nas under way by the 1950s.

8. Climate.—Two causes contribute to make the climate of Mexico among the most varied on earth: one. the great longitudinal extension of the country. which stretches through 17 parallels of latitude with the Tropic of Cancer crossing it about midway; and the other, the fact that the larger part of the country consists of a very high plateau. To give an accurate account of Mexico's climate. we resort to the old division into three vertical zones, tierra caliente, tierra templada and tierra fria, which, although applicable to other countries such as Guatemala and Colombia, finds its best application in Mexico.

The tierra caliente rises from sea level to an altitude of about 3,000 ft. and includes the coastal zone, 30 to 40 mi. aide, the Yucatan peninsula, all of Tabasco, part of Chiapas, the Isthmus of Tehuantepec and a relatively small part of Oaxaca, its mean temperature ranging from 77° to 82° F., rarely falling to less than 60° but reaching 105°, 110° and even higher on many points of the Pacific coast, especially Guaymas (max. 119° F.), Mazatlán, Manzanillo and Acapulco. though on the Atlantic coast. even in Yucatan, regular breezes make the heat somewhat less oppressive. The maxima, observed anywhere in Mexico, are not higher, however. than those recorded in some parts of Texas and Arizona.

The tierra templada, or subtropical zone, rises to an elevation of from 5,500 to 6,000 ft. and comprises the greatest portion of Coahuila, Nuevo León. San Luis Potosi. nearly half of Tamaulipas, a small part of Veracruz, nearly the whole of Chiapas and Oaxaca, and a large portion of Guerrero, Jalisco, Sinaloa and Sonora. Its mean annual temperature is 7j° F. and it has justly been called the best of the three zones, even to Europeans, on account of its lacking the anemiating influences that are found at higher altitudes. Orizaba and Jalapa in the state of Veracruz are typical stations.

The so-called tierra fria, which ranges from about 5,500 to 9,000 ft., comprises all the higher parts of the plateau, and its

average temperature is about 63° F. At such altitudes there is never any real heat, nor are winters cold, although a slight frost during the night is a frequent occurrence. Once in about ten years a feu- snowflakes may be seen falling on Mexico City; hut during the winter there is a great difference in temperature in the same house between the rooms exposed to the sun and the others less favourably situated, and foreigners find it impossible to stay in the latter without artificial heat. Its climate may be compared to that of Tuscany, but the maxima of heat and cold that can be observed in Florence are never experienced on the Mexican high plateau. In Mexico City the coldest months are December and January while the warmest are April and May.

Some climatologists consider a fourth zone, the *tierra helada,* or frozen land. It is found above the third one and is made of all the mountains and peaks above the high plateau. The term is exaggerated when applied to its lower parts where forests are found and where cereals are cultivated, but it is evident that at a very high altitude polar conditions are encountered. Such zones are, of course, uninhabited except in rare cases, the ranch of Tlamacas on the Popocatépetl, the altitude of which is 12,500 ft. and which is inhabited the whole year round, being one of them. The succession of climates represented by these different zones can be experienced in a few hours by going on the train from Veracruz to Mexico City. Where the plateau is cut by deep valleys, one can admire the marvelous spectacle offered by the three zones in succession with their wheat fields. maize, coffee trees. light green patches of sugar cane and finally the banana plant in its finest development.

9. Rainfall. — As has been mentioned in another part of this article, the annual rainfall is very heavy in the tierra caliente, south of the 'Tropic of Cancer, while near the border on the west side there is almost none. In certain parts of northern Chiapas, in Tabasco and in Veracruz the annual rainfall reaches 80. 100 and even 150 in. (northwest Chiapas). In most of Mexico it is the absence or the presence of the rain that marks the changing seasons. As is the case in various other parts of Latin America, the dry season is usually called *verano,* even though it includes the winter, and the net season is called *invierno,* although it is actually summer. This inverted nomenclature was probably introduced by the Spaniards in the 16th century, because the seasonally dry climate uith which they were most familiar, that of Spain, has a dry summer and a wet winter. The annual precipitation of Mexico City totals only 23 in.. and most of it falls in the months from May to October. Parts of the Colorado desert in northwest Mexico receive less than *2* in. of rainfall a year.

II. PLANT AND ANIMAL LIFE

1. Vegetation. — The immense diversity that Mexico offers in environment and climate is the natural explanation of its remarkable variety in plant life. from the desert flora of the north to the luxuriant tropical one. Although three leading divisions nould he expected, corresponding to the different climatic areas, it is more accurate to adopt four — one for the plateau and the arid coastal zones, another for the tierra templada and the tierra fria, a third for the tierra helada and the fourth for the humid tierra caliente. No fixed limit can be set, however, between one flora and another, since local conditions, determined by a varying amount of sun radiation, wind and humidity, may bring about deviations from the general rule.

The arid regions, especially the desert zones of the north, have their peculiar vegetation, such as yucca trees, hundreds of species of cacti and many types of agave and mesquite bushes. A few drops of rain change the whole aspect of the country for some days, the whole desert being almost suddenly covered with flowers of the most brilliant colours. Among the cacti the most interesting, perhaps. are the gigantic *pitahaya,* which bears excellent fruits, the strange *drganos* (various *Cereus* species) and the commoner varieties, yielding the ever-present *tuna* whose alternate green, yellow and red colours correspond to the successive seasons. Less numerous but economically more important are the agaves, of which the *Agave atrovirens,* from which the pulque is extracted, is the most popular, while other varieties give different types of mescal. Some plants of the *Agave atrovirens* are said to yield 2,000 lb of sap in six months. Most vegetable fibres used in Mexico come from some kind of agave. the *ixtle* fibre being produced by *Agave lechugilla,* whereas the *Agave fourcroydes* yields the famous henequen or sisal hemp. This particularly valuable variety of agave is gronn in the Yucatan peninsula and in the state of Tamaulipas only.

On the central and southern parts of the high plateau, or tierra fria, where there is a greater degree of humidity, relatively abundant trees are found on the slopes of the mountains, cereals of Eurasian origin can be cultivated, and all kinds of fruit trees may be grown, together with the local maize. It is hard to say where the exact limit between the tierra fria and the tierra helada may be determined because the deforestation of the high plateau has allowed the pine trees of the higher altitudes to invade relatively warmer regions. In ascending the slopes of the mountains, one finds an intermediate zone uhere different varieties of oaks (*Quercus crassifolia,* Q. *reticulata,* etc.) are found, together with a pine tree of high altitude (*Pinus oocaspa),* the ocote pine. long and short leaved pines and the *oyamel (Abzes relzgiosa).* On the slopes of the mountains around the Valley of Mexico forests can be seen of the superb *ahuehuete* (*Taxodium mucronatum*). The extreme upward limit of trees seems to be between 12,500 and 13,500 ft., but juniper bushes occur as high as 14,000 ft.; above that, small plants are found until one reaches the lower limit of the snow field. The same thing may be said of the limit between the tierra fria flora and that of the tierra templada. It is only gradually that one passes from the former to the latter and it is only in the presence of the banana, coffee and orange trees that one can feel sure of having reached a lower level. For a long stage the ocote pine and many varieties of oaks are found together, especially on the eastern slopes, with the addition of magnolias, acacias, myrtles, mimosas and bamboos. There are still cacti when the level is reached where the first palm trees appear, but it is only when the latter are found in abundance that one is in the real tierra caliente.

The vegetation of the tierra caliente is of such variety as to bewilder the stranger. Trees of hundreds of species, thickly interspersed among palms and ferns of all kinds, form the frame on which hang closely interwoven curtains of lianas and epiphytes, while saprophytic and parasitic plants of infinite diversity are found at the foot and on the trunks of the trees, or on the decaying vegetable matter that litters the soil of the forests. To open a way through such an entangled mass, even with a machete, is a slow and painful process, more especially. perhaps. because of the oppressive semidarkness that surrounds the explorer. In the forests of Chiapas are found more than 50 species of cabinetnood, including the ebony, the mahogany, the rosewood and the Spanish cedar. Other valuable trees of the tierra caliente are the log-mood (*Hematoxylon campechianum*), the dividivi tree (*Caesalpinia coriaria*) and the *chicozapote (Achras sapota),* exploited in Campeche and Chiapas for chicle. There are not less than 17 oil-bearing plants in Mexico and a much larger number of medicinal ones. yielding jalap, annatto, ginger, licorice, sarsaparilla, ipecac and various gums.

Many of the crop plants grown in Mexico today were domesticated by the pre-Columbian Indians out of the native flora, for southern Mexico and western Central America nas one of the world's eight or ten important and more or less independent centres of plant domestication. Plants probably domesticated there include maize, kidney and lima beans, squash, red pepper and upland cotton, all occurring in many varieties adapted to different environmental conditions. Also native to the region, though only slightly changed from their wild ancestry, are cacao, vanilla, papaya and avocado. Each of these lists could be greatly expanded. The Mexican Indians had an anareness of the qualities and potential uses of their native plants that amounted almost to genius. Introduced plants important in Mexican agriculture today include wheat, rice, sugar cane, mangos, bananas and citrus fruits. These were all brought over from the old world in colonial days.

2. Fauna. — Since Pliocene times — that is to say, since the two Americas were united — the two faunas have merged, and the

Mexican fauna of today includes animals from South and North America, with predominance of the latter. The high plateau at. tracted the North American fauna (Sonorian fauna: wolf, coyote, buffalo, bear, beaver, etc.) while the lowlands, on both sides and to the south, forced the South American fauna (jaguar, puma, five species of monkeys, etc.) toward and into the United States. Besides the above-mentioned, the Mexican fauna includes the ocelotl, a typical Aztec name, the lynx, badger, otter, raccoon, tapir. two species of peccary, the skunk, several species of opossum, the sloth, two species of ant bears, the armadillo. at least three species of deer, the Mexican bighorn (still found in Chihuahua and Baja California), the fur-bearing seal and many different kinds of small rodents. Bats are numerous, among them the dangerous vampire. which makes it so difficult to keep horses in some parts of Chiapas and Campeche.

Mexican birds are extremely numerous and comprise many beautiful species, while a few (notably the *zenzontle* or mockingbird) are songsters, the latter being identified with the cold and temperate zones. In the warm zone. on the other hand, as well as in the temperate, are found many varieties of parrots, parakeets and macaws, besides toucans. spoonbills, boatbills, ducks, pelicans, cormorants. sandpipers, curlews, grackles. ever abundant chachalacas (*Ortalis* vetula), woodpeckers, jays. cuckoos, turkeys, partridges, quail and doves (sometimes seen in immense bevies), buzzards, especially the black zopilote which is protected by the Mexican laws as the scavenger of the country, and many hummingbirds (*chupaflor, chupamiel*). The gorgeous quetzal (*Pharo*machrus *mocino*) has almost disappeared from Mexico and is now rarely found even in Guatemala where its love of freedom has made it the emblem of the country.

Reptiles of many species can be found throughout Mexico. All tropical rivers and lagoons abound in caymans. while the sea gives abode to enormous turtles and the swamps to tortoises and iguanas. One species of iguana, the black one, is largely arboreal. Lizards of many varieties are found everywhere; snakes are equally abundant, some. such as the *palanca* (fer-de-lance of Martinique), the naoyaca and 13 out of the 15 species of American rattlesnakes, being much dreaded. Many interesting varieties of amphibians are also to be found, as. for example, the remarkable tree-climbing frogs — toads and the famous axolotl.

Despite an abundance of fish, Mexico's commercial fishing industry remained in its infancy. Foreign fishing boats, especially those of U S registry, are active on the continental shelves beyond territorial limits. Shrimp and prawn fishing became a big enterprise in the 1950s.

In the tropical parts of Mexico man's greatest and most dangerous enemies are the insects, especially the many varieties of garrapatas or ticks, nigua or chigoe (*Tunga* penetrans), jején or gnat, mosquitoes and fleas, the first of these having in some instances wiped out cattle and horses from certain districts. Numerous species of ants are also found, the most famous being the leaf-cutting variety. The most destructive type of insect, however, is the so-called white ant or termite. (G. C. E.; H. J. Bn.)

III. SOCIAL AND ECONOMIC CONDITIONS

1. Population. — Demographic trends in Mexico include an expanding population, increased urbanization and continued mixture of ethnic stocks; immigration and emigration have been negligible. Historically the growth of the Mexican population has been slow. An estimated aboriginal population of between 4,000,000 and 11,000,000 in 1520 had given way to a mixed group of 12,632,427 when the first modern census was taken in 1895. Though slowed for a decade by the Mexican revolution. expansion thereafter was rapid. Later census tabulations were as follows: (1921) 14,334,780; (1930) 16,552,722; (1940) 19,653,552; (1950) 25,791,017. The 1960 census was 34,625,903.

Mexico's gro th is by natural increase. With a crude birth rate of 45.9 per 1.000 population (1960) and a crude death rate of 11.7 per 1,000 population (1960). it stands near the top in both respects, with one of the highest rates of natural increase. Though still high, the infant mortality rate had dropped to 10% by mid-20th century and the death rate was diminishing about 3% annually. Population pressures put an enormous strain on Mexico's modest social and agricultural resources.

In 1910 approximately 80% of the Mexican population was rural; this dropped to 57.4% in 1950. In 1960 the largest cities in Mexico were Mexico City, 2,697,994; Guadalajara, 734,346; Monterrey, 600,609; Puebla, 285,284; Mérida. 177,405; Torreón, 159.358; San Luis Potosi, 173,886; León, 148,081; Ciudad Juárez, 220.000; and Veracruz, 121,408. Several other cities passed the 100,000 mark in the early 1960s.

TABLE I.—*Population of Mexico, 1950 and 1960**

Political units	Area in square miles	Pop. 1950	Pop. 1960	Density 1960
STATES (capitals)				
Aguascalientes (Aguascalientes)	2,118	188,075	236,574	112.7
Baja California (Mexicali)	27,655	226,965	520,913	18.8
Campeche (Campeche)	19,672	122,098	164,256	8.3
Chiapas (Tuxtla Gutierrez)	28,732	907,026	1,215,475	42.3
Chihuahua (Chihuahua)	94,831	846,414	1,235,891	13.0
Coahuila (Saltillo)	58,068	720,619	896,509	15.4
Colima (Colima)	2,010	112,321	157,339	78.3
Durango (Durango)	47,691	629,874	750,220	15.7
Guanajuato (Guanajuato)	11,805	1,328,712	1,728,358	146.4
Guerrero (Chilpancingo)	24,887	919,386	1,189,085	47.8
Hidalgo (Pachuca)	8,058	850,394	983,161	122.0
Jalisco (Guadalajara)	31,296	1,746,777	2,402,884	76.8
México (Toluca)	8,268	1,392,623	1,883,201	227.8
Michoacán (Morelia)	23,202	1,422,717	1,862,568	80.3
Morelos (Cuernavaca)	1,915	272,842	381,346	198.9
Nayarit (Tepic)	10,445	290,124	391,970	37.5
Nuevo León (Monterrey)	25,136	740,191	1,063,399	42.3
Oaxaca (Oaxaca)	36,375	1,421,313	1,675,926	46.1
Puebla (Puebla)	13,125	1,625,830	1,957,380	149.1
Querétaro (Querétaro)	4,432	286,238	354,154	79.9
San Luis Potosi (San Luis Potosí)	24,417	856,066	1,054,206	43.2
Sinaloa (Culiacan)	22,582	635,681	790,679	35.0
Sonora (Hermosillo)	70,484	510,607	771,663	10.9
Tabasco (Villa Hermosa)	9,783	362,716	471,808	48.2
Tamaulipas (Ciudad Victoria)	30,734	718,167	1,009,800	32.9
Tlaxcala (Tlaxcala)	1,555	284,551	347,334	223.4
Veracruz (Jalapa)	27,759	2,040,231	2,749,235	99.0
Yucatán (Mérida)	14,868	516,899	612,047	41.2
Zacatecas (Zacatecas)	28,361	665,524	798,232	28.1
TERRITORIES (capitals)				
Baja Caliiornia Sur (La Paz)	27,979	60,864	83,433	3.0
Quintana Roo (Chetumal)		26,965	52,312	2.7
FEDERAL DISTRICT	19,440	3,050,442	4,829,402	8,428 3
Total	760,333†	25,791,0171	34,625,903s	45.5

*Preliminary. †Includes 2,077 : g mi. oi uninhabited islands ‡Includes 11,763 residents temporarily out of the country §According to source: includes 1,054 persons in foreign service, and 4,089 persons for which place of residence is not available.

The Mexican census bureau divides the country along state boundaries into five broad regions. The Central district, consisting essentially of the southern part of the Meseta Central, was the most densely populated in 1950, having 47.8% of the total population but only 14% of the area. This district is the economic and historic core of Mexico, and is dominant in all phases of national life. North of about 22° N. latitude there are two districts, the North Pacific with 21% of the area and 6.6% of the population, and the North with 40% of the area and 20.2% of the population. Here is the most sparsely populated part of Mexico because of the paucity of rainfall, but favoured spots are growing rapidly, as witness such cities as Monterrey, Mexicali and Ciudad Obregón. The more strongly Indian parts of Mexico in the south, including the South Pacific region and the Gulf coast, have densities that are average for the country as a whole (South Pacific, 12% area, [1950] 13.4% population; Gulf coast and Yucatan, 12% area, [1950] 12.0% population).

Modern Mexicans are the end products of innumerable ethnic and cultural breeds from four main stocks that blended to form a common nationality. Onto a congeries of Indian tribes of heterogeneous cultures and types were grafted somewhat diverse Iberian peoples, mixed with a significant but various African element and a less important northern European contribution. Crossbreeding among these elements and their hybrid offspring for many generations, as well as cultural interchanges, created such a complex situation that in 1921 Mexican census officials gave up the traditional terms of Indian, white and mestizo (mixed blood) as meaningless and misleading.

In 1940, less than 7.5% of the people spoke no Spanish and

were fluent only in Indian languages. Another group of about equal size were bilingual in Spanish and native idioms. The largest of the identifiable and linguistically definable Indians at that time were villagers on the Mesa Central who continued to speak the ancient language of the Aztecs, the Nahuatl dialects; they numbered 360,071 persons. Other main language stocks are encountered chiefly in southern Mexico, with a sprinkling in western Mexico. In 1940 the number of monolingual Indians of the main stocks were Mixteco, 124,994; Maya. 114,011; Zapotec, 104,661; Otomi, 87,404; Totonac, 59,242; Mazatec, 55,743, with the remaining 27 languages being spoken by less than 50,000 each, tapering off to Yaqui, 307, and Papago, 91, in northern Mexico. Originally there may have been more than 200 stocks of languages and tribes, of which these are vestiges. The official language of Mexico is Spanish, spoken habitually by more than 90% of the people.

The term Indian is often loosely applied to about half the Mexican population comprised of rural persons who have a relatively lo material standard, are generally illiterate, go barefoot or wear sandals, sleep on the ground or in hammocks, dress in pajamalike costumes or modified native dress and have as their main items of diet maize and beans. The other half of the Mexican people sleep in beds, dress in European-American style, eat wheat bread and in general consider themselves "modern." Thus the social-cultural spectrum in Mexico stretches from isolated Indian families to sophisticated strata in the national capital where live some of the world's outstanding intellectuals and artists, fluent in five or six tongues.

Class lines rather than blood lines tend to set one portion of the Mexican people apart from another. There is an enormous lower or "popular" class, a small but growing middle class and a tiny, unstable upper class that has changed its composition since the Mexican revolution. Each social class may be subdivided into rural and urban; differences between country folk and urbanites of any social class are probably more significant than the thin lines between classes. Under impact of urbanization and improved agrarian programs both the urban and rural middle classes have been growing at the expense of the popular sector, which embraces nearly all the Indian and transitional groups mentioned above. In 1950 it was estimated that around 25% of the Mexicans could be considered middle class. A study published by the Mexican sociologist José E. Iturriaga in 1951 indicated some of the significant changes that had been occurring by a comparison of social classes in 1895 and in 1940. Vocational status, income level and social outlook proved to be more meaningful classifications for Mexicans than Indian, mestizo and white. Though at comparable social level, there is considerable difference between the impoverished but "modern" group of servants, unskilled and semi-

TABLE 11.—Social Classes of Mexico

Social classes	1895		1940	
	Persons	Per cent	Persons	Per cent
Total	12,698,330	100.00	19,653,552	100.00
Urban	2,625,879	20.75	6,896,669	35.09
Rural	10,072,451	79.25	12,756,883	64.91
Upper	183,006	1.44	205,572	1.05
Urban	49,542	—	110,868	.57
Rural	133,464		94,704	.48
Middle	989,783	7.78	3,118,958	15.87
Urban	776,439	6.12	2,382,464	12.11
Rural	213,344	1.66	736,494	3.75
Popular	11,525,541	90.78	16,329,022	83.08
Urban	1,799,898	14.17	4,403,337	22.40
Rural	9,725,643	76.61	11,925,685	60.68

Adapted from José E. Iturriaga, *La estructura social y cultural de México* (Mexico, 1951)

skilled workers and marginal vendors in towns and cities and semi-Indian agriculturalists hacking a poor living out of the reluctant earth; in aggregate all form the popular class. Backbone of the rural middle class are independent farmers, often termed *rancheros*, while in the cities their counterparts are bureaucrats, professional people and various educated persons; the upper classes are ill defined, but include a few large landholders, large industrialists, great merchants and important military and political families risen through revolutionary activity.

2. Political Organization. — Mexico is governed by the political constitution that resulted from the Mexican revolution of 1910. Promulgated by executive decree on Feb. j, 1917, it summed up a long list of personal and civil liberties, as well as the anticlerical proclivities of the earlier constitution of 1857. It also provided a framework for continuing revolutionary and evolutionary changes in the social and economic spheres as well as altering previous political organization. It provided for free, compulsory, democratic elementary education (article 3, amended 1942) from which religious organizations were excluded, and in articles 27 and 123 outlined a broad program of agrarian and labour reform as well as asserting national sovereignty over subsoil rights; the latter provision gave rise to many international controversies, as it conflicted with sanctity of property and contract guaranteed in article 14. Largely because of the revolution, Mexico developed a system of government *sui generis*, and successive administrations after 1920 emphasized one or another element in the often contradictory constitution. A chief peculiarity of the system from 1929 was a single monopolistic political party, to which all members of the government belonged. Known from 1946 as the Party of the Institutionalized Revolution (*Partido Revolucionario Institucional*) it generally received from 85% to 90% of the votes and unfailingly elected its presidential candidate and slate of senators; from time to time smaller opposition parties, chief among them the National Action party (*Partido de Accidn Naczonal*, founded 1942), elected members to congress, though at any one time no more than 12 opposition deputies have occupied seats in the chamber. Extremist groups, notably Communists and reactionary *Sinarquists*, together total less than 1% of the electorate. Reform legislation in 1946 and 1952 reorganized electoral machinery by providing for permanent national parties and by placing registration and polling supervision in the hands of technical boards on which congress, the executive and the parties are represented. Five major parties entered the national campaigns of 1952, while registered voters increased from 5,000,000 to 6,000,000.

The constitution provides for national executive, legislative and judicial branches to govern the nation, a federal republic of sovereign states each with a constitution modelled on the national one. Upon admission of the new state of Baja California Norte (Lower California North) in 1952 there were 29 such states, whose governors stand in relation to municipalities or other local divisions much as the president of the republic does to the states. The Federal District, in which the national capital, Mexico City, is located, and two national territories (Baja California Sur; Quintana Roo) are dependent on the national government for their administration, though represented in congress.

There is no vice-president. The president, as chief executive, has wide constitutional prerogatives. These include freedom from impeachment for political actions, a wide scope of decree legislation, powerful veto privileges, the right to initiate laws that take first priority in congress, sweeping appointive privileges and command of all armed forces. His cabinet varies in number and is subject to confirmation by congress. The president must be native-born and at least 35 years old. He is directly elected for a six year term that begins on Dec. 1 after the July of his election; for certification of this, congress becomes an electoral college. The president may not succeed himself. As leader of the official party, he has many extraconstitutional powers sanctioned by usage. Dominance of the executive has overridden checks and balances among the co-ordinate branches stipulated by the constitution for the national government and undermined the theoretical autonomy of state governments.

Legislative powers are vested in a bicameral congress whose houses have very nearly the same constitutional mandates. The lower house, chamber of deputies, is elected for a three-year term by universal suffrage at the rate of 1 member for each 150,000 people or fraction over 75,000; on the basis of the 1950 census there were 161 electoral districts. Each state, as well as the Federal District, is assured a minimum of two deputies, and each territory is allowed one. Each must have resided in his district

six months before election and may not immediately be re-elected; deputies and senators must be at least 2j years old, native-born and be free of certain offices. The senate has 60 members, 2 for each state and for the Federal District. Congress sits from Sept. 1 to Dec. 31. and during the recess period a permanent commission of 14 senators and 1j deputies, appointed by the respective houses. acts in its stead. On nomination from the executive, the senate appoints the judiciary.

After experimenting with an irremovable federal judiciary and a bench filled for short terms by elections, Mexico in 1950 reached a compromise whereby members of the supreme court have life tenure, while lesser justices serve probationary terms. The Mexican legal system follows Hispano-Roman traditions and many French models rather than Anglo-American patterns and common law. It is noted particularly for a special writ, *amparo*, developed in Mexico to protect individual rights against administrative encroachments. The civil service is protected by law. Administrative expenses account for about 5% of the national budget and in 1952 amounted to about 200,000,000 pesos.

Under the doctrines developed by the Mexican Revolution, state intervention and leadership in economic and social matters is enjoined on the government. Programs of nationalization brought about half the land under direct state ownership, with consequent growth of a number of agencies to furnish credit, advice and direction to holders of grants to plots for usufruct (*ejidos*). In 1937 many of the major railways of Mexico mere nationalized. and subsequent purchases placed in government hands all lines longer than 100 mi. Domestic telegraph lines early became a state service and in 1949 at the lapse of concessions to foreign companies, international cable and telecommunications reverted to national control. Major petroleum producers were expropriated in 1938 and their holdings consolidated in a government monopoly that subsequently purchased all but two minor companies not nationalized in 1938. Semiautonomous agencies, in which the government owns controlling stock, administer railways and petroleum. In addition, there are numerous special banks and investment trusts to foster economic development, foreign commerce, urban housing and a variety of other activities.

Two semiautonomous government agencies aiding economic development are the Bank of Foreign Commerce and the Nacional Financiera; the one in stimulating commercial agricultural production and the other, an investment trust, in developing industry.

3. Public Finance. — Mexico's basic monetary and accounting unit is the peso, divided into 100 centavos. By international agreements in 1954 its value mas stabilized at 12.5 pesos to the U.S. dollar, so that one peso equals 8 cents. Nickel and copper small coins and silver ones in 1 and 5 peso denominations circulate! as do banknotes of 1 peso or more. In late 1954 the total money supply, including checking accounts (47%), was 8,705,000,000 pesos. Founded in 1925 by the national government (which owns 51% of its capital stock) the Banco de Mexico does business only with other banks; under a system modeled closely on the United States federal reserve system, it performs central banking functions, including management of the currency supply. Mexico's gold and foreign exchange reserves were about $78,000,000 in 1948. They increased markedly in the 1950s, jumping by 54% between June and Dec. 195j, and amounting to $430,000,000 by Aug. 1956. Among the underlying causes were good yields of export crops, high coffee prices, rapid industrialization, increasing foreign investments and American tourism.

Mexico's funded internal debt on Jan. 1, 1950, amounted to 2,041,200,000 pesos capital and 1,275,100,000 pesos interest; this was reduced by application of budgetary surpluses in 1950 and 1951. To canalize savings to productive enterprises, small government bonds! doubling their investment value in 10 years, were bought by the public during 1950–51 to amounts of 87,864,000 pesos (half maturity value). In Feb. 1952 Mexico was current on payment of international obligations; on Jan. 1, 1950, its foreign debt amounted to 806,300,000 pesos capital plus 554,400,000 interest. In 1942 arrangements were concluded whereby ancient debts were scaled down from 2,471,000,000 pesos to 240,000,000, payable regularly in dollars or pesos through 1962 and 1968; a similar agreement in 1947 reduced the debt arising from nationalization of railroads in 1937 from 2,704,000,000 pesos to 245,000,000. Mexico liquidated sums due U.S. oil companies for their expropriated properties and in 1947 reached a settlement with British firms by which regular instalments would be paid through 1962 for their nationalized holdings. General and revolutionary claims similarly are punctually met. A notable development was Mexican borroning of long-term, low-interest sums for capital improvements in steel, electrification, communications. hydraulic works and other developinental projects. From 1934 through Jan. 1954, the Export-Import Bank of Washington extended credits amounting to $380,000,000. The International Bank for Reconstruction and Development, up to Feb. 1952, provided Mexico with additional lines of credit totaling $90,000,000 for specific projects. chiefly communications and electrification, but including $10,000,000 to aid small private Mexican business.

National public revenues rose in the general prosperity enjoyed by Mexico during and after World War II. National income increased from 6,000,000,000 pesos in 1939 to 84,000,000,000 pesos in 19jj; national taxation amounted to from 10% to 12% of this. Public revenues in 1952 amounted to 6,338,000,000 pesos, with income taxes representing the largest source (23%). followed by export taxes (12%) and import taxes (12%). The national budget grew from 836,800,000 pesos in 1942 to 3,996,000,000 pesos for 1952. Beginning in 1948, surpluses of revenue over budgeted expenditures were applied to developmental activities and reduction of national debts. In 1950, 1951 and 1952 the single largest item in the budget was service on debt (22%–24%), with defense (11%–13%) and administration (5%) making the fixed regular expense between 41% and 44%; 52%–56% was spent on economic and social items, chief of which were communications (17.4%), hydraulic works (10.5%), education (11%) and welfare (4.3%), with a contingency fund and direct government investments in key industries accounting for the remainder.

4. Defense. — The president is commander in chief of the armed forces and relies on the secretary of national defense and the secretary of navy to administer them. The republic is divided into 32 military zones, each with its commander and assigned to one of 9 military regions created in 1951. In 1949 the regular army consisted of 3,405 officers and 38.430 enlisted personnel. divided into 50 battalions of infantry, 40 regiments of cavalry (horse and mechanized), 2 regiments of military police, 2 regiments of artillery, 5 companies of marines and 3 detached companies. The autonomous air force consisted of 2 regiments of 3 squadrons each. with 51 planes. The navy had 3 sloops, 4 frigates, a training craft and 20 coast guard patrol vessels. As a consequence of World War II, every man became subject to compulsory universal military training at his 20th birthday and upon completion of a year's service would be part of the reserve of the army or national guard. The army was reorganized on the model of that of the United States, from which considerable lend-lease equipment was obtained to create a modernized, highly mobile force. In general the army acts as an internal police force and is active in numerous civic tasks such as road building, taking the census, reforestation and the like. Mexico's military industries manufacture powder, small and medium calibre cartridges. carbines and small (up to 150 lb.) aviation bombs. In addition to coast patrol work, the navy is encharged with the merchant marine, which in 1951 had a deadweight metric tonnage of 272,000. Mexico maintains an excellent array of military academies.

5. Education. — Article 3 of the constitution of 1917 prescribed the rules for education. Under national supervision private bodies may by permission establish schools, although article 3 orders that elementary schooling shall be free, compulsory and secular. Nominally. states and the national government have distinct roles and responsibilities, but the national government assumed nearly all the burden for primary education, while it. the states and private groups share in providing secondary and university training. The public education system is highly ramified from kindergarten through postgraduate training, with numerous special schools, but the great bulk of effort and expenditures falls on

providing good schooling within the primary levels. About 26,000 such schools. with nearly 55,000 teachers for about 4,000,000 pupils operated in 1952, though figures are not wholly in accord. In 1952 there were a total of 544 secondary schools, employing 14,-528 teachers for 85.663 students; 25% of the schools and about 45% of the teachers and pupils were in the Federal District; the number of schools was almost evenly divided among those supported by the nation. by the states and by private endowment though 52.7% of the pupils were in federal schools. The first federal secondary schools were authorized in 1926 and there were 284 of them by 1951, with 7,900 teachers and 73,000 students. As of 1952 there were also 1,068 kindergartens with 112,562 pupils, 80 preparatory schools with 22,714 students. 87 teacher training schools with 13,281 students, 158 vocational and technical schools with 37,068 students and 168 special schools with 22.485 students.

Mexican education makes a special distinction between urban and rural schooling. and the latter is the special creation and pride of the revolution. It is built around an "action" school reflecting regional needs. From 309 such schools, with as many teachers, in 1522, the number grew to 20,051 in 1952. To capitalize on Mexican experiences and to adapt them more widely, the Mexican government, the Organization of American States and the United Nations Educational, Scientific and Cultural organization in 1951 jointly opened the first regional centre of fundamental education at Patzcuaro, Michoacán for teachers from Latin America to study on government fellowships. Where rural schools are not feasible, traveling cultural brigades of educational and vocational specialists make extended stays in rural places. In the main Indian areas, 18 boarding schools which emphasize vocational preparation are maintained.

Crowning the formal educational system are 14 universities with 61 faculties and about 60,000 students in 1952. The Federal District and Guadalajara each have 2, and there are others in Michoachn, Nuevo León, San Luis Potosí, Puebla. Veracruz and Yucatan. All are state or nationally supported except one in Mexico City. The most important is the Autonomous Kational University of Mexico in Mexico City. moving in 1952 to the University City created for it on the outskirts of the metropolis. With more than 30 professional faculties and independent institutes, its enrollment is usually about 25,000; from 1940 to 1950 inclusive it graduated 62,584 students. A student body of comparable size attends the National Polytechnic institute in Mexico City and the several state and municipal affiliates that it supervises at various points in the republic, notably in mining and industrial sections. Local businessmen founded and endowed the Technological Institute of Monterrey (enrollment 1,300); in Zacatecas, Oaxaca and Chiapas older institutes of arts and sciences added "technology" to their titles.

Under a campaign launched in 1947, groups and individuals sponsored the construction of schools under department of education specifications; under private patronage 3.000 new schools were added within the next five years, with facilities for 1,000,000 children on double shifts. In 1944 a crusade to obliterate adult illiteracy was inaugurated and three years later became a permanent part of the system. In 1940 the adult illiteracy rate was 51.6%, a considerable drop from the 95.5% in 1824. Approximately 4,000,000 adults of the 6,600,000 illiterates of 1940 were taught the rudiments of reading and writing under legislation that required each literate person to instruct an illiterate one, and then by the 21,283 permanent and semipermanent centres subsequently established. Special programs for Indians and army personnel were devised. and the methods were widely copied. The 1950 illiteracy rate was about 40%.

6. Economy. — Long dependent on extractive industries and plantation crops for commerce and a relatively poor subsistence agriculture, Mexico in the first half of the 20th century proceeded rapidly in the direction of enlarging and changing its traditional concerns and developing an integrated modern system. Economically active populations grew from 5,800,000 in 1940 to 8,345 000 in 1950. In 1921, 83% of the population engaged primarily in subsistence agriculture; 58% was so employed in 1950, the remainder uorking in other lines. National income rose from 6,000,000,000 to 52,000,000,000 pesos between 1939 and 1952. Despite inflation and devaluation, real as opposed to money national income advanced from 4,800,000,000 pesos in 1940 to a 1950 figure of 7,800,000,000 pesos. Per capita income rose from 316 pesos in 1940 to 1,181 pesos in 1950; the real per capita incomes of the economically active over the same time went from 1,040 pesos to 1.2 50 pesos. With an expanding agricultural production, individual shares of subsistence items increased from 262 lb. annually in 1945 to 360 lb. in 1950.

Private banks had resources of 10,791,000,000 pesos, and during 1950 invested 1,182,000,000 pesos, of which 864,000,000 went into industry; in the first six months of 1951 bank reserves available for credit totaled 5,756,800,000 pesos, and of investments, 1,537,400,000 pesos went to industry. Total credit transactions grew from 478,000,000 pesos in 1940 to 5,200,000,000 in 1950, with savings accounts mounting from 27,000,000 pesos to 134,-000.000 pesos. Insurance firms increased their loans and investments from 95,000,000 to 507,000,000 pesos in the decade. In 1952, direct foreign investments were stated to be 6,302,135,000 pesos, about 80% U.S. and the remainder divided between Canada and the United Kingdom. They were distributed to mining 1,385,-943,000; agriculture 48,874,000; petroleum 56,053,000; industrial concerns 1,950,271,000; utilities 1,387,296,000; commerce 1,004,-257,000; transport 347,182,000; and miscellaneous 122,259,000. Mexican government purchase of remaining petroleum concerns and railways in 1951 and 1952 materially reduced these investments. but large sums flowed into indirect investments in Mexican industry and establishment of new manufacturing and assembling firms.

7. Agriculture. — The situation of Mexican agriculture, traditionally hampered by the small amount of arable land, inefficient production methods and generally low yields, improved markedly after 1940 through construction of irrigation and drainage works, improvement of seeds and use of hybrids, mechanization, use of fertilizers and the supplying of credit and communication through government means. Land under cultivation increased from 15,-400,000 ac. in 1546 to 22,200.000 ac. in 1951, while irrigated areas grew from 2,000,000 ac. in 1946 to 3,000,000 ac. in Sept. 1951 and actually exceeded a total of 4,000,000 ac. at the end of 1954. Crops raised on newly irrigated lands were valued at 1,826,000,000 pesos in 1950–51, and the lands themselves rose in value from 195,000,000 pesos to 2,435,000,000 pesos.

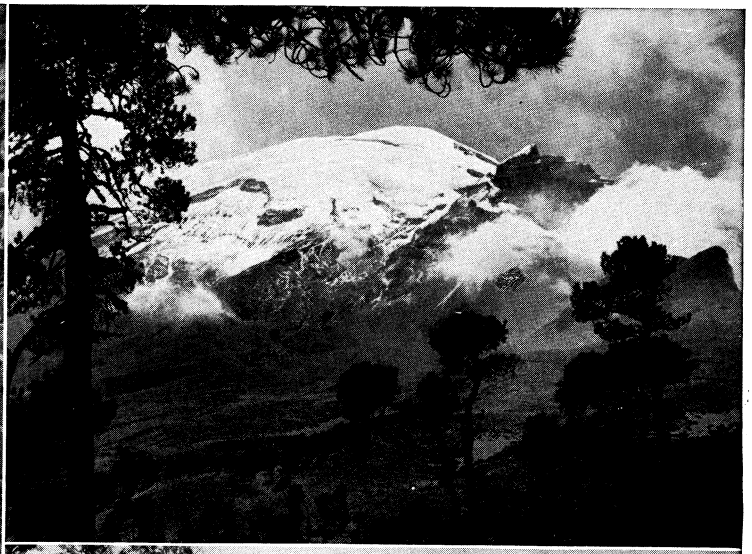
The Mexican irrigation program, in addition to creating about 4,000,000 ac. of irrigated land, also provided river control, soil conservation and production of hydroelectric power for Mexican industrial activities. Between 1947 and 1952 alone more than 1,000,000,000 pesos were expended in Latin America's largest hydraulic program.

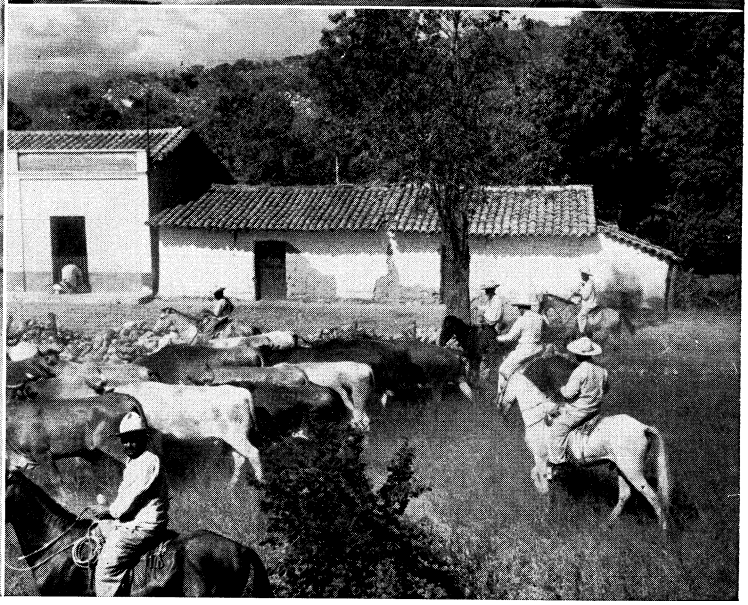
The Alemán dam in the Papaloapan river basin is one of the largest in the hemisphere.

TABLE III.—*Mexican Agricultural Products*
(in 000 metric tons)

Product	1910	1935	1940	1941–45 (average)	1948	1950	1952	1954
Maize	2,059	1,674	1,680	2,159	2,800	3,122	3,201	4,000
Beans	176	120	96	169	139	250	244	?
Wheat	258	291	430	402	477	587	512	830
Rice	?	70	106	111	108	187	151	162
Coffee	36	48	52	54	53	62	71	106
Henequen	113	85	125	116	122	101	97	?
Cotton	...	54	62	109	207	260	265	380
Tobacco	14	14	14	26	23	35	36	42
Barley	...	...	...	91	126	162	164	?
Chickpeas	...	...	...	84	110	84	83	?
Pineapples	...	...	...	60	110	140	?	?
Bananas	36	494	238	?	?	419	363	?
Tomatoes	...	...	...	?	?	355	350	?
Sugar	...	...	...	303	645	683	?	?

Under nationalized land programs that resulted from the revolution, about half the utilizable area is cultivated by government-sponsored co-operatives known as ejidos whose members enjoy usufruct. *Ejidos* vary in size and local arrangement and comprise about 3,000,000 rural families, whose average parcel is about six acres. **A** number of them, notably at La Laguna and in Yucatan, are large co-operatives dedicated to commercial crops.



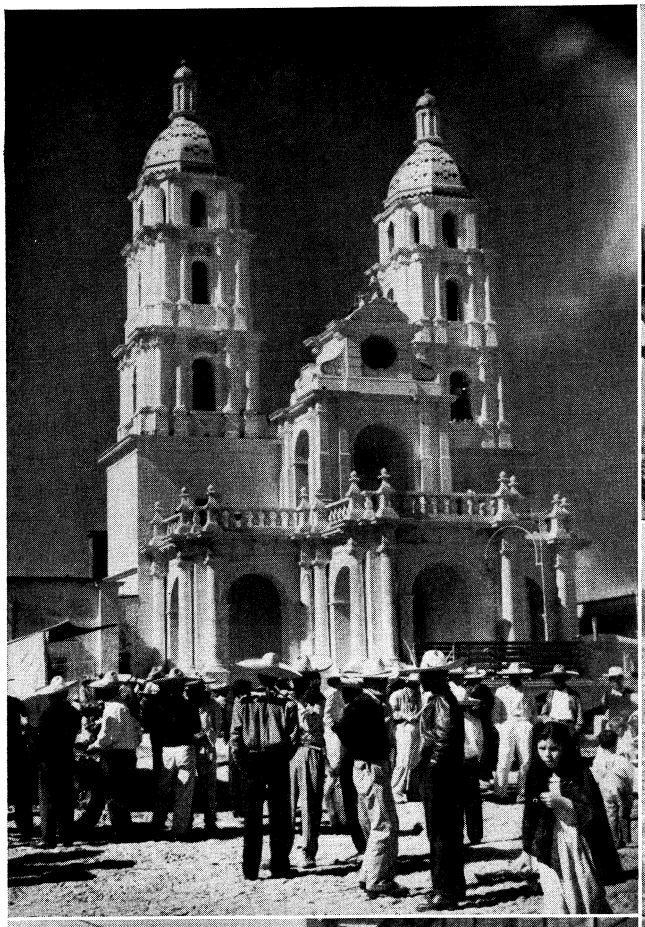


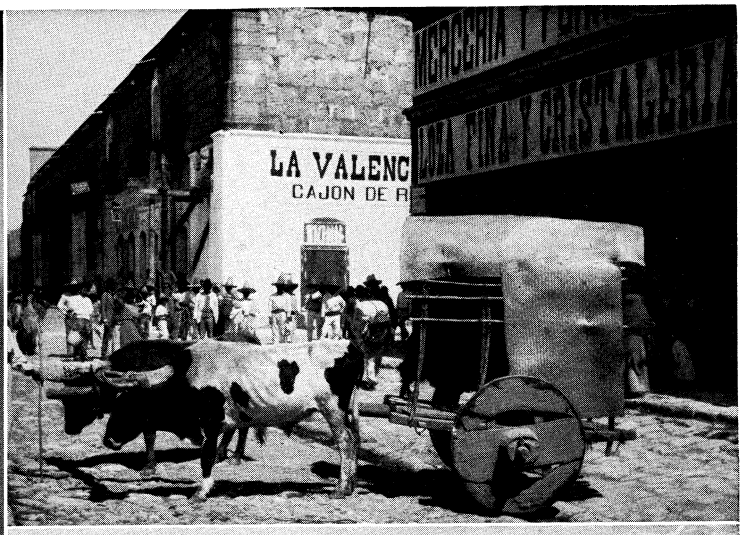
PHOTOGRAPHS, (TOP LEFT) KURT SEVERIN FROM BLACK STAR, (TOP RIGHT, BOTTOM RIGHT) EWING GALLOWAY, (CENTRE RIGHT) HERBERT LANKS—PIX FROM PUBLIX, (BOTTOM LEFT) PAIL S PHOTOS

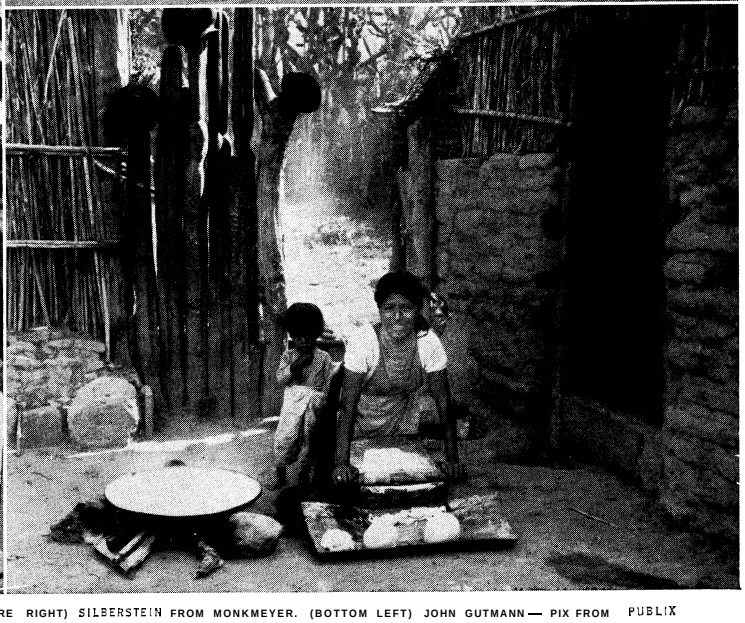
VIEWS OF MEXICO

Top ***left:*** Aztec pyramid temple El Castillo, Chichen-Itzá, Yucatán
Top ***right:*** Mt. Popocatepetl, in the state of Puebla
Centre ***right:*** Scene along the Paseo de la Reforma, Mexico city
Bottom ***left:*** Street scene in Taxco, with the dome of Spanish colonial church in the background
Bottom ***right:*** Cattle roundup at a ranch near Pijijiápam, Chiapas

MEXICO







PHOTOGRAPHS, (TOP LEFT, TOP RIGHT, BOTTOM RIGHT) EWING GALLOWAY, (CENTRE RIGHT) SILBERSTEIN FROM MONKMEYER. (BOTTOM LEFT) JOHN GUTMANN — PIX FROM PUBLIX

MEXICAN VILLAGE LIFE

Top *left:* **Farmers gathered in the plaza before the cathedral, Valle de Guadalupe**
Top *right:* **Oxen and covered cart, Oaxaca**
Centre right: **Net fishing in Lake Chapala near Guadalajara**
Bottom left: **Indian woman chatting with a grape vendor in a village market place**
Bottom right: **Woman of Mitla making tortillas**

Beginning in 1941, small holders of private lands (not under ejido programs) obtained certificates against expropriation of their lands, and the remaining large holdings are mainly grazing lands.

Staple crops for subsistence are primarily Indian corn (maize). beans, wheat. rice and potatoes. Until 1948 Mexico imported some maize, but thereafter became self-sufficient in all but wheat and began to export rice. Main commercial crops are fibres, mainly cotton and sisal hemp (henequen). Cotton culture grew rapidly until Mexico stood next to Egypt as a world supplier. Coffee culture began in 1940; by 1951 it led all exports, placing Mexico after Brazil and Colombia as world producers. On irrigated lands in Matamoros and Baja California, production of cotton and winter vegetables was expanded, while pineapples also became important. In 1950 the total value of agricultural production was placed at 5,093,000,000 pesos, and for 1951, at 5,695,000,000 pesos.

8. Mining. — Mexico since colonial days has been an important mining country. About 97% of the 32,000 mining enterprises at mid-20th century were in British and U.S. hands, producing chiefly for export. Mexico has a twofold significance as a mineral supplier: it mines precious metals, and its silver usually represents about 20% of the world production; at the same time it is an important purveyor of base metals (lead, zinc, copper, iron) and for domestic purposes is a coal producer. In addition there are industrial metals of strategic importance, including sulfur and uranium. Total value of the 1949 mining products was 1,748,000,000 pesos.

TABLE IV.—*Mineral Production of* **Mexico**
(in metric tons)

Mineral	1935	1940	1945	1950	1952	1953	1954
Gold	21	27	18	13	14	18	
Silver	2,351	2,570	1,900	**1,528**	1,566	1,403	1,510
Lead	184,193	196,253	205,315	238,678	246,082	221,549	216,624
Zinc	135,921	114,055	209,940	223,520	227,375	226,539	223,749
Copper	39,373	37,602	61,680	61,698	58,463	60,148	54,800
Iron	61,224	70,163	175,165	285,738	349,157	331,175	313,556
Antimony	4,510	12,387	18,542	14,460	3,532	3,687	4,134
Manganese	none	387			45,052	75,738	83,356
Mercury	216	402	167	130	301	401	589
Graphite	6,976	12,327	23,634	24,026	24,153	30,331	21,784
Cadmium	598	6	1,053	689	734	959	513
Sulfur	...		...	6,000	?	?	73,636

Reserves of coal and iron ore are found in various parts of Mexico, but commercial mining is limited to a few deposits. Most of the coal is produced in the Sabinas basin of the state of Coahuila, where by the mid-1950s about 1,400,000 metric tons of bituminous coal were being mined annually, mainly for conversion into metallurgical coke. In 1955 the known reserves of bituminous coal in and near the Sabinas basin were about 2,000,000,000 tons. Another 100,000,000 tons was estimated to be commercially available in the state of Oaxaca. The most important source of iron ore is the Cerro de Mercado near the city of Durango. The ore, produced in modern mechanized mines. is transported by rail to Monterrey, where much of Mexico's pig iron and steel ingot production is localized. Limestone for smelting is available near Monterrey, and the coke is shipped mainly from ovens at Monclova and Rosita in Coahuila. In 1955 iron ore production reached a record figure of 430,000 tons, and coke consumption was about 750,000 tons. Pig iron producing capacity in 1954 was roughly 480,000 tons, although only about 380,000 tons were actually produced. In the same year steel ingot production exceeded 620,000 tons, increasing to more than 700,000 tons in 1955. As Mexico's total annual steel requirement in the mid-1950s exceeded 1,000,000 tons, more than 300,000 tons a year had to be imported.

9. Petroleum. — During the first quarter of the 20th century Mexico produced nearly a quarter of the world's oil; subsequent opening of vast fields in Texas. Venezuela and the middle east reduced its contribution by mid-century to less than 2%, though it remained as sixth or seventh largest producer. After a labour controversy in 1937, the foreign-owned oil properties, dominated by three large concerns, were for the most part expropriated in 1938. With the nationalized property being administered by the semi-autonomous government agency Petroleos Mexicanos (Pemex), companies not originally expropriated were subsequently purchased. By agreements reached in 1943, U.S. companies received awards made by a mixed commission, and final payment by Mexico was made on these in 1950. Arrangements with the British government provided for liquidation of the expropriation debt by regular payments through 1963. Immediately after nationalization, production plummeted. Part of the task of reorganization confronting Pemex was the establishment of an internal distribution and refining system. Production in the 13 years after nationalization equalled that for the 13 years before, however. Nearly three-quarters of Mexican output ordinarily goes to the domestic market. Beginning in 1947, natural gas was increasingly utilized as an industrial fuel. and by-products of Pemex include sulfuric acid and fertilizers.

Production of crude oil had risen to 240,000 bbl. per day in 1956, with a scheduled 300.000 bbl. per day for 1957. Exploratory activities in northeastern and southeastern Mexico from 1946 encountered important new fields. and brought proved reserves to 2,427,000,000 bbl. in 1954. Well-drilling was proceeding at the rate of almost one a day in the 1950s. The sale of natural gas to Texas began in 1957.

10. Manufactures. — Industry mas stimulated markedly by World War II. Surveys made in that period uncovered many unsuspected resources. while development of communications and hydraulic works, together with modernization of agriculture and availability of capital at home and from abroad provided a foundation for industrial growth. Leading industrial centres are the Federal District, Monterrey, Guadalajara and Puebla, though in central, western and northern Mexico numerous towns form secondary hubs for national production.

From colonial times, output of consumer goods has been important. The main lines of manufacturing include cotton. woolen and synthetic fibre production, clothing, flour milling, beer, food processing and canning, vegetable oils, sugar, shoes, soap, cigars and cigarettes, matches, furniture and other domestic use items. Other products include cement, primary and secondary chemicals (acids and oils), fertilizer, paints and varnishes, plastics, farm machinery, railway cars, tires, tin cans, metal office furniture and a long list of minor objects. Nearly all principal European and U.S. automobile concerns maintain large assembly plants in Mexico which produce cars from imported parts; in the same fashion refrigerators, radios, television sets and electric appliances, electric motors and airplane engines were introduced on the local market.

Mexico was among the first Latin-American nations to introduce heavy industry and, as mentioned, continued to augment its iron and steel capacity, though neither kept full pace with rising demands. Although well supplied with coal and oil, Mexico's shortage of electric power hampered industrial expansion. A program ,of electrification begun in 1947 tended to offset this disadvantage, however. At the end of 1953, a total of 2,005 plants (private and nationally owned) had an installed capacity of 1,701,060 kw. Output for 1953 in kw.hr. (each equals 1.34 h.p.-hr.) was 5,702,800,000, of which hydro plants accounted for 2,621,986,000, and thermo plants (including diesel) for 3,080,816,000. The generation of electric power continued to increase markedly in the 1950s, reaching 6,300,000,000 kw.hr. in 1954 and an estimated 7,800,000,000 kw.hr. in 1956.

The estimated 1950 investment in manufacturing was placed at between 8,000,000,000 pesos and 10,000,000,000 pesos, and it employs about 15% of the total labour force. In Jan. 1952 the index of production, taking 1939 as 100, stood at 330.3, with industrial raw materials output at 541.9, power 185.2 and construction materials at 450.6, indicating that manufacturing had more than quadrupled since 1929 and increased more than sevenfold in value. In 1940 there were 12,711 establishments, each with more than 10.000 pesos capital investment. Estimates of 1952 placed the total number of concerns at about 60,000, ranging from small artisan-household shops to large modern plants.

11. Commerce. — Previous to 1940 Mexico maintained favourable balances by exporting large quantities of metals, petroleum and sisal hemp, while purchasing consumer goods, foodstuffs and luxuries. During and after World War II trade increased enor-

mously in volume and altered its composition. Manufactured items and new crops rose in importance as export items. while imports trended toward capital equipment for productive enterprises, chemicals and scientific instruments. Unfavourable trade balances were offset by "invisible" exports in the form of remittances from Mexicans working in the United States and a broadening stream of tourists. The dollar value of tourism grew from about $65,000,000 in 1945 to $550,000,000 in 1955 and became the most important dollar earner. New crops. especially cotton and coffee. as well as winter vegetables. joined metals as leading exports. Value of the latter was increased by semifinishing by Mexican manufacturers; oil is exported in quantities sufficient to cover expenses for expansion. Imports of basic foodstuffs ceased, and Mexico began to export sugar, beans and occasionally maize.

TABLE V.— *Foreign Trade of Mexico*
(in 000 pesos)

Year	Imports	Exports	Total Trade	Balance	
1935	406,136	750,292	1,156,428	+	344,156
1940	669,016	960,041	1,629,057	+	291,025
1945	1,604,404	1,271,878	2,876,282	−	332,526
1950	4,403,368	4,339,405	8,742,773	−	63,963
1955	11,045,729	9,484,267	20,529,996	−	1,561,462
1956	13,395,321	10,670,695	24,066,016	−	2,724,626
1957	14,439,413	8,729,249	23,168,662	−	5,710,164
1958	14,107,469	8,846,058	22,953,527	−	5,261,411
1959	12,582,614	9,006,863	21,589,477	−	3,575,751
1960	14,830,598	9,247,354	24,077,952	−	5,583,244

The United States remains Mexico's principal trade partner. Mexico ranks from first to third as the United States' chief Latin-American supplier and best customer. From 80% to 85% of Mexico's trade is with the U.S., even in face of directed effort to arrange barter and other deals with European areas. By some of these Mexico exchanged chickpeas with Spain for fishing boats; cotton with France and England for industrial machinery; oil and basic metals with western Germany for scientific and manuiacturing equipment. From 1949 European trade, almost evenly balanced between sales and purchases, rose sharply, though totaling only 8%–9% of total trade. In value, leading exports are raw cotton, coffee, silver, fish, zinc, textiles, copper and petroleum. In thousands of pesos (which varied in value during the period cited from $.20 to $.08), Table V summarizes the main trends of Mexico's commerce.

12. Transport and Communication.— Established by outside capital in the late 19th and early 20th centuries, the Mexican railroad net remained static and deteriorated through the civil wars of the Revolution and during reconstruction thereaiter until World War II. With technical and financial aid from the United States, a program of rehabilitation and enlargement mas started in 1944. This included standardizing rail gauges, replacing light with heavy track on trunk lines, purchase of diesel equipment in the United States and Europe, creation of maintenance and repair shops, relocation of terminals and construction of new lines. Most important of the latter were the connection of Baja California with mainland routes in Sonora (1948) and connection of southeastern mainland links with those on the peninsula oi Yucatan (1950). Important routes from Duranpo to Mazatlán and from Mexico City to Tuxpan were also begun. In 1953 Mexico had about 15,000 mi. of railways mhich carried about 23,000,000 metric tons of freight. As a result of government stock control earlier, then nationalization of the lines in 1937, and purchases of foreign-held enterprises during and after 1946, no route longer than roo mi. remained in private hands by 1952. Nationalized lines are administered by the semiautonomous agency, National Railways of Mexico, headed by a presidentially appointed director, after an experiment in worker administration had failed.

Between 1925 and 1950 the national government spent more than 2,000,000,000 pesos to create 15,000 mi. of national roads, while states and private organizations added an equal amount. By mid-century about 18.000 mi. were paved or "all weather." The Pan-American (also known as Inter-American) highway system (1,745 mi.) traverses Mexico from many points on the U.S. boundary to Guatemala. By the end of 1953, Mexico had 453,000 motor vehicles, a third of which were registered in the Federal District.

Maritime transport included a small merchant marine and a 20-vessel tanker fleet, whose 189,772 dead weight tons comprises most of the total tonnage of 272,000. Military and civil aviation grew in years during and after World War II. By 1952, a network of 36 main air, ports and nearly 250 auxiliary fields were serving domestic and international lines with about 37,000 mi. of scheduled routes. The airports of Mexico City. Monterrey, Guadalajara and Mazatlan could handle thr largest craft. All first-class mail is carried by air. Air passengers increased from 86.788 in 1940 to 1,183,364 in 1953, and air express from 8,200,000 lb. to 54,400,000 lb. From imported parts, Mexico produces airplane engines.

At the lapse of old concessions, international telegraph and cable facilities passed into national government hands in 1949, and for many years earlier domestic lines had been so operated. Addition of new equipment to existing telegraph and radio telegraph lines brought the total to an equivalent of 270,000 mi., which handled about 26,000,000 messages in 1950. There were 330,000 telephones in 1954. In 1953 there were 246 radio stations with 850,000 receivers; 6 main television transmitters and 10.000 receivers.

13. Ports and **Harbours.**—With slightly less than 5,800 mi. of coast, Mexico has 39 seaports but few important ones. Rivers emptying into the pulf have their mouths obstructed by sandbars and their port works are chiefly artificial. Most important are Tampico and Veracruz; other pulf ports include Tuxpan and Coatzacoalcos. On the Yucatan coast are Carmen. Campeche and Progreso, all minor. Pacific ports depend on rail connections to the interior and include Guaymas, Topolobampo, Mazatlán, Manzanillo and Salina Cruz Acapulco has a fine natural harbour but no rail connections.

In general, ports are far from significant population clusters to which they must be attached by expensive communication systems over rugged terrain, and port facilities are generally poor.

(HD. C.; H. J. **BN.**)

IV. COLONIAL PERIOD (1519–1821)

For ancient Mexico before the Spanish conquest see the articles AZTEC; and NORTH AMERICA: *Anthropology.*

The overthrow of the Aztec empire by a Spanish force under Hernán Cortés between 1519 and 1521, the execution of the last Aztec emperor. Cuauhtemoc. and the rapid extension of the Spanish conquest from Mexico City as a base. introduced the colonial period of Mexican history. Beginning in 1523 and continuing until the forced resignation of the last viceroy in 1821, New Spain was administered by royal governors until Dec. 1528, by *audiencias* from 1528 to 1j3j and by viceroys and *audiencias* after 1535.

In all. 61 individuals were appointed viceroys of New Spain, one of whom served a second term. Because of either the death or disability of a viceroy. the *audiencia* at Mexico City assumed administrative powers on 14 different occasions.

1. New Spain: **Extent.**—New Spain was one of the four viceroyalties comprising the overseas possessions of the crown of Spain known as the Kingdom of the Indies. As modified soon after its establishment in 1535, the viceroyalty of New Spain included and stretched northward from Central America above present Panama. It also included the Spanish West Indies. Venezuela for a number of years and the Philippines from 1j6j to 1584. The northeastern boundary of New Spain. by a treaty with England in 1670, was fixed just south of Charlestown. S.C.: at the same time its most northern occupied outpost was Taos, New Mexico.

Later. New Spain was delimited in the east by the English occupation of Georgia. and. farther n-est, between 1699 and 1763. by the French occupation of Louisiana. New Spain expanded greatly when Western Louisiana was ceded in 1763 by France to Spain, who held it until its retrocession to France in 1800. On the other hand New Spain suffered territorial loss in the east when Spain ceded Florida to England in 1763. Twenty years later Spain acquired West Florida and regained East Florida from England: both provinces were acquired by the United States between 1810 and 1819. In the west, California was occupied between 1769 and 1776.

New Spain was delimited on the north in 1776 when the provinces from Texas to California were erected into a military and political jurisdiction known as the *Comandancia General de las Provincias Internas,* administered by a commandant general. Many changes in organization were subsequently made.

2. Government and **Organization.**—The chief administrative subdivisions of the viceroyalty of New Spain at the close of the 18th century were the captaincies-general of Guatemala and Havana. The former included all of the present Mexican state of Chiapas and all of Central America north of Panama; the latter included the Spanish West Indies, Louisiana and Florida. Over the captains-general the viceroy exercised only general supervisory and administrative authority. The viceroyalty proper and the captaincies-general were subdivided for local administrative purposes into provinces. 'They were administered by governors. appointed by the king and responsible to him through either the viceroy or the captains-general. The only institution of semi-self-

government was the town council (ayuntamiento, or *cabildo*), composed of municipal judges (alcaldes ordinarios) and councilmen (regidores), but participation was mostly restricted to European or American-born Spaniards.

Aside from its administrative organization, New Spain was divided into four judicial districts, at the head of each of which was an audiencia, which functioned primarily as a court of appeals, but also exercised extensive administrative powers. The seats of the audiencias were Mexico City, Guatemala, Santo Domingo (moved to Puerto Principe, Cuba, after 1793) and Guadalajara. At Mexico City the audiencia served as a viceregal council, although the viceroy was not obliged to follow its advice. Similar relations existed between the *audiencia* and the captains-general at Guatemala. The *audiencia* of Santo Domingo exercised administrative authority over all of the Spanish West Indies until 1784, when it lost that authority over the captaincy-general of Havana; and in 1793, France came into possession of the entire island of Española (Haiti). This audiencia also exercised administrative authority over Venezuela for many years. The judicial authority of the audiencia of Santo Domingo extended over all of the Spanish West Indies, Florida, Louisiana after 1763, and Venezuela until 1786.

The audiencia of Guadalajara exercised administrative authority in the province of Nueva Galicia, and after 1776 exercised judicial jurisdiction over western and northwestern New Spain, including the *Provincias* Internas.

On the military side the viceroy of New Spain was captain-general of the entire viceroyalty. In practice, however, he exercised merely supervisory military authority in the captaincies-general of Guatemala and Havana.

In the *audiencia* districts of Mexico and Guadalajara he exercised direct military authority.

The powers of the subordinate or local captain-general were exercised by some provincial governors. At first the viceroy was in direct charge of the fiscal administration of New Spain. In 1786, however, a separate fiscal administration. dependent upon the viceroy, was introduced with the establishment of the intendancy system of twelve intendancies and three provinces. Each intendancy was ruled by a governor-intendant, who assisted in the collection of revenues and was charged with certain administrative, judicial and military authority.

3. The Church and the People.—The regular and secular clergy, particularly the former, supplemented the work of the conquerors. The Franciscans were the first regulars to enter New Spain with papal sanction, three of them arriving in May 1522. This order was noted for its charitable work among the Indians and missionary work on the northern frontier from Florida to California. Many other orders followed the Franciscans to New Spain, notably the Augustinians, the Dominicans, and the Jesuits. The last-named were transferred in 1572 from Florida to western New Spain where they were actively engaged until 1767 in missionary and educational work, and in advancing and holding the frontier. Each order had its own organization, the principal unit of which was the province, administered by a provincial. The various orders in 1805 were maintaining 254 convents in New Spain proper. Secular organization began with the nominal creation of the bishopric of Yucatan in 1519; actually it began with the creation of the bishopric of Tlaxcala in 1526.

The zealous Juan de Zumirraga arrived as first bishop of Mexico City in 1528; in 1547 Mexico City became the seat of an archbishopric. In 1805 there were in present Mexico one archbishop, eight bishops, and 1,703 parishes.

The Council of the Indies, a joint body of clergy and laity, exercised sovereign authority. Through special concessions of the papacy the king of Spain became virtually the administrative head of the colonial church. The Crown appointed to all ecclesiastical holdings, supervised the conduct of the clergy, and controlled ecclesiastical revenues.

The Church became immensely wealthy and early attained preponderant power and influence. Alaman states that its wealth in 1821 included not less than one-half of the real property and capital of the country. In 1644 the city council of Mexico petitioned Philip IV to stop the founding of new religious houses, to suspend ordinations because there were more than 6,000 unemployed clerics, and to suppress feast days because there were at least two each week. A tribunal of the Inquisition was established in Mexico in 1571.

The Church was delegated almost exclusive control over education, but, out of a population of about 6,000,000 at the beginning of Mexican independence, only 30,000 were said to be literate. The Church chiefly concerned itself with higher institutions of learning to equip young men of the upper classes for the priesthood and the practice of law, the Royal and Pontifical University of Mexico being inaugurated as early as 1553.

The Church also had charge of charitable institutions, as hospitals and orphanages.

Three distinct races were represented in New Spain—the European, the Indian, and the Kegro. The most important economically and politically was the small minority of European-born Spaniards, the gachupines. For the gachupines, in 1800 only about 15.000 in number, were reserved most of the political, commercial, and social preferments. The total number of Europeans in New Spain in 1800 probably was about 885,000, most of them being creoles, or American-born Spaniards who, though by then often wealthy, had few political privileges and were, with few exceptions, excluded from high posts in church, army, and Government. The native race remained the most numerous. In 1800, in New Spain proper, the Indians probably numbered 3,000,000, or approximately 50% of the total population.

Negroes were early brought to New Spain to work as slaves on the coastal agricultural lands. Prior to 1575 they probably outnumbered the whites, but by 1821 they had largely been absorbed or else had bought their freedom and had disappeared. Few Spanish women came to America at first, and at the close of the colonial period they probably did not total more than one-tenth of the European-born Spaniards. As a result, there were many classes of mixed blood, the most important being the mestizo (Indian and European), the sambos (Negro and Indian), and the mulattoes (Negro and white).

The number of persons of mixed race in 1800 was approximately 2,000,000. A few Chinese and Malays were settled on the Pacific coast.

On the theory that the Indians were its wards, the Crown felt obliged to protect, convert and civilize them, and justified in utilizing their labour. The chief means by which it was hoped to attain these ends was the *encomienda* system, first introduced by Cortés.

Allotments (*repartimientos*) were made to conquerors, to whom the Indians living thereon were given in trust (encomienda). Such a grantee (*encomendero*) was obligated to protect his Indians and to provide missionaries and teachers for them; he was also empowered to exact tribute of them. Not all Indians were given in encomienda, those living on royal lands being under overseers, appointed by the king, known as corregidores and alcaldes mayores. These officials after 1786 were replaced by assistants of the governors-intendant known as sub-delegates.

While the theory of the encomienda system was benevolent, it resulted, in practice, in the abject enslavement of many of the natives. Steps looking toward its correction and final abolition were taken in 1542 but it was not finally abolished in theory until the 18th century.

4. Expansion of the State.—For nearly three centuries the Spaniards of New Spain dramatically pushed the frontier northward, eager to arrest the advance of French and English settlers. For the first decade after the capture of Mexico City, the Spaniards, except for the founding of Panuco (Tampico) in 1522, confined their activities to the regions south and west of the capital. The creation of royal provinces in Central America between 1525 and 1527 cut off opportunities for expansion there. The heroic age of exploration was ushered in by the journey of Cabeza de Vaca from the Florida and Texas coasts to the Gulf of California between 1528 and 1536.

Soon afterward the Coronado and De Soto expeditions penetrated northern Mexico and the southern half of the present

United States; the Cabrillo-Ferrer expedition coasted as far north as Oregon; and the Villalobos expedition from New Spain to the Philippines gave Spain title to those islands.

For nearly two decades following the founding of Culiacán, Sinaloa, in 1531, the frontier of settlement extended in an irregular semi-circle, with the base resting on Guadalajara and Mexico City, from Culiacán, on the Gulf of California, to Pánuco, on the Gulf of Mexico.

Wealthy miners and cattle barons, adventurous military *adelantados,* leading motley throngs of settlers: rogues, mestizos, and Indian and Negro slaves and hirelings, pushed the outposts ever northward. Humble missionaries penetrated distant regions. By 1590 the frontier stretched from Cerralvo, on the lower Rio Grande, by way of Saltillo and San Bartolomé, to San Felipe at the mouth of the Sinaloa river.

Meanwhile, Florida had been permanently settled in 156j by a large expedition from Spain under Menéndez de Avilés. In 1598 the frontier of New Spain proper moved across 600 mi. of desert north of the line of 1590 and halted in the upper valley of the Rio Grande. New Mexico was made the base from which to try to anticipate other nations in the discovery of a supposed strait (North-west Passage) and to exploit the sedentary Pueblo Indians.

The fierce Pueblo Rebellion (1680–92) briefly halted permanent occupation.

Spanish advances in the later 17th and 18th centuries were due mostly to the fear of foreign aggression. The short-lived French settlement in Texas under La Salle (1684–87), prompted Spain to occupy temporarily east Texas (1690–93); English aggressions westward from South Carolina prompted Spain to found Pensacola, Fla., in 1698.

The founding and expansion of French Louisiana, beginning in 1699, made necessary the permanent occupation of Texas in 1716. The boundary between French Louisiana and Spanish Texas came to be regarded as the Arroyo Hondo, midway between Los Adaes, the capital of Texas, and Nachitoches, the westernmost French outpost on the Red river.

In north-western New Spain between 1591 and 1767 the Jesuits were chiefly responsible for the advance of the frontier into southern Arizona. and. beginning in 1697, into Baja California. After 1763, Western Louisiana having been acquired from France. it was necessary for the Spaniards to advance to the Mississippi and hold at that stream the Anglo-Americans all the way from New Orleans to and beyond St. Louis.

From the acquisition of the Floridas by treaty in 1783, until the retrocession of Louisiana to France in 1800, the frontier of settlement of Spain in America extended from St. Augustine, Florida, to New Orleans, thence north to St. Louis, and thence west, by way of Santa Fe, to San Francisco.

The leading events of the colonial period in New Spain proper can be given only in bare outline here. The first two brilliant viceroys, Mendoza and Velasco definitely determined the course of viceregal administration.

Mendoza's long administration (1535–so), was notable for the encouragement of exploration, the development of mining north of the line of settlement of 1531, an attempt to suppress the harsh *encomienda* system, the Mixton Indian uprising, and by a violent epidemic among the natives.

Viceroy Velasco ranks high as a humanitarian and an expansionist. By freeing 150,000 male Indian slaves and a large number of women and children, he earned the titles of "Liberator" and "Father of his Country."

The vanity of Martin Cortés, bastard son of the Conqueror, and the fear of the *encomenderos* that they would lose their rights, culminated in an abortive and disastrous attempt in 1566 to set up Cortés as king—the only 'separatist movement prior to the 19th century. The establishment of regular galleon service between Acapulco and Manila after 1571 made possible the development of an extensive commerce between Spain and the Far East across New Spain. This and the establishment of extensive woollen and cotton factories in the latter part of the 16th century redounded greatly to the material advantage of New Spain, even though Hawkins, Drake, Cavendish, and other Protestant patriotic freebooters, engaged in lucrative smuggling of goods into Spanish America and in even more lucrative preying upon Spanish commerce and coast towns.

The regular and secular clergy had early come into conflict, particularly over the tithes and the control of the Indians. The conflict reached a crisis and merged into one between Church and State during the viceregal administration of the Marqués de Gelves, 1621–24, who cornered the corn and wheat supply and sought other monopolies jealously guarded by the Church. Archbishop Serna placed Mexico City under an interdict, and excommunicated the viceroy, who had to hide from a mob.

During the reign of Viceroy Albuquerque (1702–11), which coincided with the war of the Spanish Succession, his chief concern was the defence of the coasts from British attacks and the fighting of pirates.

By the Treaty of Utrecht (1713) England secured commercial privileges which proved in practice to be an entering wedge for much illicit commerce. During the resultant war of Austrian Succession, the raids of Admiral Anson in the Pacific struck a hard blow at the commerce between New Spain and the Philippines. Spain entered the Seven Years' War in 1761, only to lose Havana and Manila to the British Florida was given to England in exchange for them at the close of the war. During the war of the American Revolution, the anti-English policy pursued by Bernardo Gálvez, Spanish governor at New Orleans, was of considerable aid to the colonists.

After Spain declared war against England (1779), he directed offensive operations against the British in the territory north of the Ohio river and personally waged successful campaigns against the British in West and East Florida, thereby obtaining them for Spain at the close of the war.

The reign of Viceroy Casafuerte (1722–34), one of the three New World creoles ever to be appointed as New Spain civil administrators, was made notable by the publication of the *Gaceta de México* and the *Mercurio de Mhxico,* and the rapid expansion of wealth and culture. A formidable Negro rebellion in Veracruz and a terrible epidemic among the natives were notable events of 1735 and 1736. Viceroy Ahumada (1755–63) is noted for his many administrative reforms

A few years later, a special royal visitor, clothed with supreme power, José de Gilvez, instituted many important administrative, economic, commercial, and fiscal reforms. Annual royal revenues from New Spain were increased from $6,000,000 to $20,000,000 nithout increasing taxes. At Gblvez's suggestion the *Comandancia General de las Provincias Internas* and the system of intendancies were established.

One of the notable events of the later 18th century was the expulsion of the Jesuits from New Spain, as from all of the Spanish dominions, in 1767, under orders of Charles 111—these being carried out in New Spain by Gálvez on the night of June 26. The Jesuits were arrested *en masse,* their property, estimated as high as 10,000,000 pesos, was sequestrated, and they were expelled, their place in the north-west being taken by the Franciscans The second Count of Revilla Gigedo (1789–94), like Casafuerte a creole. of all the viceroys of that century ranks as the greatest reformer, statesman, and promoter of industry and commerce His rule coincides with the "Golden Age" of the Spanish New World empire. From then on the forces of Separatism gathered headway.

5. The Independence of Mexico.—The European situation between the outbreak of the French Revolution in 1789 and the wave of liberalism that swept over the Mediterranean States in 1820 profoundly influenced the movement for the independence of New Spain. The revoiutionary doctrines of "liberty, equality, and fraternity" spread to Latin America and inspired hope among the creoles, who were ambitious to enjoy commercial, political, and social preferments on an equal footing with the gachupines, and among other classes, mestizos and Indians, for political and racial equality and economic liberation.

When Napoleon deposed the rightful king of Spain in 1808 and placed his own brother Joseph upon the throne, at once a small, politically ambitious minority in New Spain, acting on the theory

that with the deposition of Ferdinand VII. sovereignty had reverted to the people, demanded a share in the government of the viceroyalty. The viceroy, Iturrigaray, lent a willing ear to these suggestions and proposed the convocation of a national congress. Thoroughly alarmed lest they lose to the creoles some of their privileges through severante from Spain, the gachupines deposed Iturrigaray and took over the Government. They easily suppressed an abortive separatist movement initiated by the creoles in Michoacán in 1809, so that when the viceroy, Venegas, arrived in Sept. 1810, the hold of privileged autocracy never appeared stronger.

While the jealous gachupines and the ambitious creoles thus quarrelled in New Spain over the question of the extension of privileges, a great upheaval of the masses developed under the leadership of Father Miguel Hidalgo y Costilla, a member of the lower clergy who had been profoundly influenced by the doctrines of the French Revolution. He gave the "shout" (grito) of revolt in Dolores, Sept. 16, 1810, now celebrated as Independence day.

This movement advocated the extension of human rights and privileges to the great mass of Indians and mestizos, whose claim to such privileges was equally revolutionary to creoles, gachupines, and the higher clergy, and soon assumed the character of a race war under the patronage of the Virgin of Guadalupe.

Led by Hidalgo and Allende, a captain of cavalry, the revolters gained victories and ever more adherents until able to capture the wealthy city of Guanajuato, after which they threatened the capital. But the revolutionists were decisively defeated at Calderón in 1811 and soon afterward the leaders were executed.

Another liberal member of the lower clergy, Morelos, caught up the fallen banner. Although he met with serious reverses in the terrible siege of Cuautla in 1812, he rallied the south to his cause and in 1813 was able to convoke a congress in Apatzingán which, the following year, issued a declaration of independence and drafted a republican Constitution. Morelos was captured and executed at Mexico City in 1815, and the revolutionary movement disintegrated into guerrilla warfare. But when, in 1820, the liberal Spanish Constitution of 1812 was proclaimed after a military uprising in Spain the high clergy and the gachupines in Mexico feared that a liberal Government in the mother country would force upon them toleration and the loss of privileges, disestablishment and disendowment, all of which they had successfully opposed, first, in the period from 1808–10, when the ambitious creoles had demanded reforms, and second, in the period since 1810, when the social upheaval of the masses had largely caused the creoles and the gachupines temporarily to forget their differences. Accordingly the clerical, creole, and gachupin opponents of liberalism resolved upon the absolute separation from the Spanish monarchy as the only means of preserving their position.

The conservatives found a suitable military leader in the person of Agustin de Iturbide, a creole ex-officer in the Spanish Army, notorious for his ruthless executions of non-combatants, and who had been forced out of service because of misuse of funds. The unsuspecting viceroy sent him into the field against the rebels, led since 1815 by Vicente Guerrero. Without informing the viceroy, Iturbide treacherously signed with Guerrero on Feb. 24, 1821, the Plan de Iguala—a crude pronunciamiento which laid down as the bases of the new State the continuation of the Roman Catholic Church as the established church of hlexico, the establishment of an independent limited monarchy, and the equality of rights for Spaniards and creoles.

Thus the Plan de Iguala was, in theory, a compromise, to win the support of the various classes in New Spain. In the interest of the proposed plan, Iturbide first sought the co-operation of the viceroy, Apodaca, who refused, but was powerless to stem the flood of spontaneous support given the plan. When Juan O'Donojú, the last viceroy, arrived in July. he was unable to get beyond Veracruz, and, accordingly, recognized the independence of Mexico in the Treaty of Córdoba. Iturbide triumphantly entered Mexico City on Sept. 27, 1821.

The following day a provisional governing Junta, named by Iturbide, signed the "Act of Independence of the Mexican Empire," and appointed a regency of five, with Iturbide as its president. These acts marked the beginning of the national period of Mexican history.

V. INDEPENDENT MEXICO

Mexico has had a turbulent existence since independence. In 1823 the monarchy was repudiated in favour of a republic. From 1823 until 1860 a bitter contest was waged between adherents of federalism and centralism, the first gradually coming to represent the liberal anti-clericals, the trading classes, and the mestizo middle-class; the second, the clericals, the large landowners, the old and new creoles (non-Spanish), the conservatives, and the upper-caste military elements. A Federal republic was definitely established in 1857 but federalism was on the defensive for ten more years, first, in a three-year civil war and, second, during the period of the French intervention and the empire of Maximilian. Since 1867 there has been no organized opposition to federalism in Mexico, but for thirty-odd years the Diaz dictatorship prevailed in the guise of Federal institutions.

Indecision concerning the form of government was accompanied by political instability. Between 1821 and the rise of Diaz in 1876, there were two regencies, two emperors, several dictators, and enough presidents and acting or provisional executives to make no fewer than 74 governments.

Furthermore, the first 100 years witnessed approximately that number of revolutions, mostly political or personal in character. In fact, since 1810 there have been only three major upheavals in Mexico, socio-economic in character and more or less beneficent in their results.

The first, that of independence, begun in 1810 by Hidalgo, was soon appropriated by conservative elements. It represented a theoretical expansion of rights for all classes, but in practice substituted the creoles for the gachupines and resulted in greater power and wealth for the church, which in 1807 had been debarred from inheriting real estate.

The second, begun in 1854, disendowed and disestablished the church, but worked to the advantage of the great landowners.

The third, begun in 1910 and continuing down to the present time, was directed chiefly against the landed aristocracy and foreign capital, and is strongly nationalistic.

The Mexican empire was of short duration. In the first Mexican Constituent Congress, which met on Feb. 24, 1822, the republicans were in the majority and between them and Iturbide a conflict soon developed. This was terminated on May 18 by a military *pronunciamiento* in favour of Iturbide, and by his extra-legal election as emperor by a minority in Congress. Iturbide was crowned on July 21, 1822, but fresh conflicts broke out between him and the Congress which were only terminated by his forcible dissolution of that body. This arbitrary procedure reacted in favour of a republican armed movement, initiated by Santa Anna, a former royalist officer. Iturbide had to abdicate on March 19, 1823. The Congress deported him to Italy, and granted him a pension. He returned with political ambitions the following year, and on landing (having been previously outlawed) was arrested and executed (July 15, 1824). The Congress, left in absolute control after the abdication of Iturbide, created a provisional executive triumvirate; announced (June 12) the adoption of the federal form of government; and issued a decree (June 23) convoking a new Constituent Congress. This body drafted a Federal Constitution which was promulgated Oct. 4, 1824, and Guadalupe Victoria was inaugurated as first president.

1. The First Federalist Regime, 1824–34.—Confronted by manifold difficulties, the Federalists were able to remain in power for only one decade after 1824. At the outset, Centralist and Federalist organizations as such disappeared, their places being taken by two Masonic organizations. The Conservatives, Monarchists, and Centralists affiliated with lodges of Scottish-Rite Masons (Escoceses), and the Liberals, Republicans, and Federalists, encouraged by the American minister Poinsett, organized rival lodges of York-Rite Masons (Yorkinos).

The rival lodges kept the country profoundly agitated. An attempt at revolt by Vice President Bravo, the grand master of the Escoceses, was suppressed.

The thoroughly discredited and demoralized Escoceses thereupon refrained from naming a presidential candidate in **1828** and instead threw their support to Gómez Pedraza, the Liberal contender for the presidency with Vicente Guerrero, the grand master of the Yorkinos. Gómez Pedraza was declared elected, but as a result of an appeal to arms Guerrero was inaugurated for the second presidential term beginning April 1, **1829.**

Shortly afterward Spain made a final attempt to reconquer Mexico, but the invaders were repelled at Tampico by Santa Anna (Sept. **1829).** During the invasion, Vice President Anastasio Bustamante, a brutal turncoat royalist officer, seized the opportunity to depose Guerrero, who was treacherously seized in Acapulco, tried and executed (Jan. to Feb. **1831).**

The next year Santa Anna headed a successful revolution against Bustamante in behalf of Gómez Pedraza, thereby enabling him to serve the last three months of the term for which he had been elected in 1828. In the deferred elections, held early in **1833,** Santa Anna and Gómez Farias were elected president and vice president, respectively, for the term beginning April 1 of that year. During the greater part of the next **13** months Gómez Farias, as acting president, was responsible for many liberal changes, including the laicization of education, the relaxation of monastic vous, the discontinuance by the State of the collection of tithes, and the right of the State to appoint church officers.

These measures — "the **1833** Reform" — aroused the opposition of the Clericals and Conservatives, and Santa Anna, acting as their defender, assumed the presidency on April **24, 1834.** The following month, he dissolved Congress and the State legislatures, and substituted creatures of his own for the governors of the States and mayors. By such action he undid the liberal reforms of Gómez Farias and destroyed the federal system of which he had been the chief original defender.

The Conservatives and Clericals who thus came into power indirectly with Santa Anna retained contrcl until **1846** under a centralized form of government. A new Congress discarded federalism (Oct. **3,** 1835) and framed a centralist Constitution (Dec. 30, 1836), known as the *Siete Leyes* or Seven Laws. By it the States were converted into departments, ruled by governors appointed by the central authority, and popular representation was considerably reduced. Bustamante became the first Centralist president. When he failed to satisfy questionable damage claims of French nationals in Mexico a French fleet in **1838** blockaded the coast, bombarded the fortress of San Juan de Ulua, and temporarily occupied Veracruz. This gave Santa Anna the longed-for opportunity to pose as the country's defender, and in **1841** he joined a successful revolution against Bustamante.

The Plan of Tacubaya (Sept. **28,** 1841), put forward by the revolutionists, abolished all but the judicial provisions of the *Siete Leyes,* conferred upon Santa Anna power of reorganizing the administration, and provided for a new constituent assembly When it met in June **1842,** the Federalists were in the majority, much to Santa Anna's chagrin. He dissolved it and convened a hand-picked one which adopted an ultra-centralist Constitution (June 12, **1843).**

Santa Anna was inaugurated first president under it on Jan. 2, **1844,** but because of his mal-administration, extravagance, and profligacy, was overthrown before the end of the year and exiled. José Joaquin Herrera, who succeeded him (Dec. 1844), was a constructive statesman and adopted conciliatory foreign and internal policies but was overthrown (Jan. **1846)** by Ultra-Centralists, Monarchists, and anti-Americans led by Gen. Mariano Paredes. Seven months later, in order to solidify public opinion during the war with the United States, the Federalist Constitution of **1824** was restored (Aug. 5, **1846).**

Recalled from his exile to oppose the foreign invaders, Santa Anna was elected president (Dec. **1846)** under the Constitution which he had repudiated.

The substitution of a central for a Federal form of government in **1835** was the occasion for uprisings in various parts of Mexico, all of which were finally suppressed except that in Texas, which had been settled principally by colonists from the United States in consequence of contracts granted to immigration agents (*empresarios*) to introduce colonists. The first such contract was granted to Moses Austin, in 1821, and was carried out by his son Stephen.

Because of the incompatibility of Mexican and American settlers, Texas gradually drifted toward inevitable rebellion. Various specific grievances developed after **1826** that widened the breach, but the pretext for the rebellion of the Texans was the centralization policy inaugurated by Santa Anna in **1835.** A provisional revolutionary government, which professed to be acting in defence of the Constitution of **1824,** functioned in Texas from Nov. **3,** 1835, until March 1, **1836;** on the following day the unqualified declaration of Texan independence was issued. Santa Anna attempted to reduce Texas, showing great severity, but was eventually defeated and captured by Houston at the battle of San Jacinto.

There he signed an agreement pledging himself to work for the recognition of Texan independence upon his return to Mexico. The Mexican Government, however, repudiated Santa Anna, and a nominal state of war continued between Mexico and Texas, whose independence was recognized by the United States, Belgium, the Netherlands, France and England (1837–41).

2. War with United States, 1846-48. — The Texas question nas chiefly responsible for war between the United States and Mexico. Texas had applied for admission into the American Union in **1836** but annexation was delayed by those in the United States who were opposed to acquiring more slave territory. Fearful of British and French influence in Texas, however, the U.S. Congress early in 1845 adopted a resolution providing for annexation. On Dec. **29, 1845,** Texas was formally admitted to the Union. The Mexican minister withdrew from Washington following the adoption of the annexation resolution, and the United States minister was recalled from Mexico.

Nevertheless, President Polk was conciliatory, and late in **1845** sent Slidell to Mexico to attempt to settle all differences between the two countries — the chief ones arising from the disputed Texas boundary and the unsettled damage claims of U.S. citizens against Mexico — and also to purchase, if possible, California and New Mexico. Slidell's mission might have been successful, in part, but for the triumph of the war party in Mexico under Paredes.

President Polk then ordered American troops into the disputed region between the Nueces and the Rio Grande rivers. Hostilities inevitably followed and war was declared by the United States in May **1846.**

The original plans of the U.S. general staff called for (1) an invasion by Gen. Taylor of northern Mexico, to overawe the Mexicans and induce them to come to terms; (2) the military occupation by Gen. Kearny of the territory from New Mexico to California, to be held as an indemnity; and **(3)** the blockade of both coasts of Mexico by the U.S. fleet. The two last-named plans materialized fully; in addition, Gen. Doniphan led a side expedition from Santa Fe, New Mexico, to Chihuahua and Monterrey. But Gen. Taylor's campaign failed of its object.

The Mexicans, instead of submitting as the American Army advanced, put up a vigorous defence, and at Buena Vista, on Feb. 22 and **23, 1847,** Santa Anna opposed the Americans in the best-fought engagement of the war. When the spirit of the Mexicans was revealed, a campaign from Veracruz to Mexico City under Gen. Scott was decided upon. Veracruz was captured after a three-weeks' siege (March **7** to **29,** 1847), Santa Anna was decisively defeated at Cerro Gordo (April **18)** and Gen. Scott, with greatly superior forces fought his way into the Valley of Mexico, and entered Mexico City Sept. **13, 1847.**

Peace was formally re-established with the Treaty of Guadalupe Hidalgo, concluded on Feb. 2, **1848.** By it the Rio Grande was fixed as the southern boundary of Texas and the territory north of an irregular line extending from El Paso, by way of the Gila river to the Pacific ocean, was ceded to the United States; in return the United States paid Mexico $15,000,000 and assumed all claims of her citizens against Mexico.

3. The Constitution of 1857. — The Federalist President Herrera (1848–51), after the defeated Santa Anna left the country, attempted to reorganize the Government along Federalist lines,

restore order, and establish credit. The program was realized only in part, due to military and political disorders, but for the first time in Mexican history executive authority was peacefully and constitutionally transferred to President Mariano Arista. He soon gave way (Jan. 1853) before a movement promoted by Clericals and Conservatives, and after an interregnum (Jan.–March 1853) a group of militarists reinstated Santa Anna as president on April 20, 1853. He surrounded himself with Conservatives, and on Dec. 16 declared himself dictator, with the title of "most serene highness."

A few days later the sale of Mesilla valley (present Arizona, south of the Gila river) to the United States was negotiated. but the purchase money was soon dissipated. Santa Anna's zero hour, however, had already arrived. While Federalist and Centralist office seekers and doctrinaires wrestled for control after 1824, the mestizo and Indian masses, in social and economic degradation and misery, were either ignored or used as pawns. The church owned in 1854 a great part of all urban property, controlled or owned much of the rural property, had an annual income greater than that of the National Government, and acted as unofficial banker for the people. The gaze of the land-hungry masses fell upon this great domain. The revolution of Ayutla soon swept the faithless Santa Anna into perpetual political exile, and provided a liberal Constitution.

This revolution was initiated by the mestizo revolutionary patriot, Juan Álvarez, on March 1, 1854. It was soon joined by a future galaxy of heroes, including Comonfort, Juárez, and Diaz. Santa Anna had to leave the country in Aug. 1855.

On October 4, Álvarez was installed as provisionalpresident. He soon resigned and was succeeded by Comonfort, who served as provisional president.

The presidencies of Álvarez and Comonfort were signalized by the promulgation of two important laws and the adoption of the Constitution of 1857. The enactment (Nov. 23, 1855) of the first law was secured by Juarez, the Zapotec Indian minister of justice in Álvarez's cabinet, from whom it takes its name (Ley Juirez). By limiting the jurisdiction of ecclesiastical and military courts to offences of the clergy and military, the law for the first time provided for the legal equality of all citizens. Feeling that religion was being attacked. the Clericals opposed the law. Equally noteworthy was the Ley Lerdo (June 25, 1856), so called from its author, Miguel Lerdo de Tejada, minister of finance in Comonfort's cabinet. This law prohibited religious and civil corporations from acquiring or owning rural or urban property not used for the specific object of the corporation, and obliged corporations then owning such property to sell the same to the tenants or usufructuaries on reasonable fixed terms. Both laws were incorporated substantially in the new Federal Constitution (promulgated February 12, and effective Sept. 16, 1857) along with other clauses recognizing the natural and inalienable rights of man and providing for religious toleration and agrarian reform—all of which made the new Constitution appear extremely liberal in comparison with that of 1824.

Actually, the forced sale of church properties benefited speculators and promoted large landholding.

As the Constitution of 1857 went into effect, opposition increased. Comonfort, installed as constitutional president on December 1, within less than three weeks, vainly hoping to reconcile the two hostile political groups, accepted the Plan de Tacubaya (Dec. 17, 1857), which repudiated the new Constitution. Having used Comonfort. the Conservatives soon deposed and exiled him (Jan. 21. 1858) and named as his successor a thorough Conservative: Zuloaga. For the next three years Mexico was the prey of civil war between two rival Governments—the Constitutionalists at Veracruz under Juárez, who, as chief justice of the Supreme Court had succeeded Comonfort. and the Conservatives at the capital. The latter, better organized, early inflicted serious defeats upon the Constitutionalists.

Juárez won a great moral victory, however, when he was recognized by the United States (April 1859) and could thus obtain arms and volunteers. In July 1859, Juárez published decrees suppressing the religious orders, nationalizing ecclesiastical real property (estimated as worth more than $125,000,000, exclusive of churches, monasteries, schools, hospitals, libraries, and art treasures), establishing civil marriage and registration, transferring the cemeteries to civil control—in short, disestablishing and disendowing the church.

In 1859, each of the rival Governments made desperate transactions humiliating to Mexican sovereignty or provocative of future trouble. In return for promised aid, the Conservative president, Miramón, approved a treaty with Spain, which recognized unjust claims of Spanish natiqnals against Mexico. The same year, Miramón, pressed for funds, made a transaction with Jecker, a Swiss banker settled in Mexico, for a loan of $15,000,000 with a $16,800,000 liability.

Bonds to that amount were issued to Jecker who went into bankruptcy after he had delivered to Miramón only $1,470,000. Soon, he bribed French officials to press, in behalf of his French creditors, for the settlement of the bonds at their face value. Also Juarez, in the hope of securing a loan, and desirous of forestalling threatened European intervention, concluded a treaty which gave the C.S., in virtual derogation of Mexican sovereignty, rights of transit by diverse routes across Mexico, and unusual guarantees for U.S. nationals residing there. This treaty was not ratified by the U.S. Senate.

During the war both sides levied forced contributions on much foreign property, the Conservatives being the worst offenders. The United States withdrew-recognition from their Government in 1858; the following year outrages on British subjects caused the British minister to break off diplomatic relations. On Nov. 17, 1860, Miramón, under the plea of necessity, seized $660,000 which had been left under seal at the British legation. Until 1860 the Constitutionalists were on the defensive. In March of that year, however, the U.S. Government gave Juárez moral and material aid, and frustrated the plans of the Conservatives to attack Veracruz.

Henceforth, they were on the defensive. December 22 Miramón's forces were routed by the Juarist Gen. Ortega and his Government overthrown.

4. **European Intervention,** 1861.—Jubrez entered Mexico City on Jan. 11, 1861, and promptly expelled the intriguing Spanish minister, the papal legate, and members of the episcopate and steps were taken to enforce the decrees of 1859 disestablishing and disendowing the church. In return for British recognition Juarez acknowledged as valid British claims—including a new loan—totalling nearly $70,000,000. The financial difficulties, however, seemed insuperable. Mexico's acknowledged indebtedness to Europe alone exceeded $82,000,000. In addition there were the indefensible Jecker claims which the French Government now backed up. Juárez, however, would recognize as valid only the cash actually received by Miramón from Jecker.

Finally, the Congress decreed (July 17, 1861) the suspension for two years of interest payments on the external national debt. The French minister at once asked for his passports and the British minister suspended diplomatic intercourse with the Juirez Government. These events fitted in with the ulterior designs of Napoleon III, who was influenced by his Spanish wife, by the great landowners, and by the exiled Mexican Clericals to interest himself in the cause of centralized monarchy and the church; in addition, he was ambitious for political and commercial reasons to establish French hegemony in Spanish America. A convention between Great Britain, France, and Spain for joint intervention in Mexico was signed in London on Oct. 30, 1861.

In mid-December Veracruz was occupied by Spanish troops; the French fleet and troops arrived soon after, with instructions to seize and hold the Gulf ports until claims were satisfied by collection of duties; Great Britain sent ships. and landed 700 marines. A terrible epidemic broke out among the invading troops, and the convention of Soledad was concluded with the Mexican Government to permit the foreign troops to advance inland to more healthful sites pending a claims conference in April. But as the French harboured leaders of the Mexican Conservatives, pressed the Jecker claims, and showed an unauthorized disposition to interfere in Mexican domestic politics, Great Britain and Spain

withdrew their forces in April 1862. More troops were sent from France. Their advance was checked by Zaragoza and Diaz at Puebla on May 5 (battle of Cinco de Mayo); and in September 30,000 more French troops arrived under Gen. Forey. Wintering at Orizaba, they recommenced their advance (Feb. 17, 1863), reduced Puebla, and on June 7 entered Mexico City which had been abandoned by the Juárez Government.

A provisional government of Mexican Conservatives, nominated by the French minister Saligny, adopted monarchy and offered the cronn at Napoleon's instance, to Maximilian of Austria. brother of Emperor Francis Joseph.

5. Maximilian **Emperor.**—Maximilian, after being endorsed in a spurious Mexican plebiscite, accepted the Mexican crown, and reached Mexico City on June 12, 1864. The greater part of the country was already occupied by the French and reactionary troops, the Juárez Government finally being obliged to transfer to Paso del Norte on the Rio Grande. But the empire was unstable from the beginning and gradually Maximilian realized that he was little more than a pawn of a political faction sustained by foreign troops. Maximilian's efforts to conciliate the republican opposition and to form a coalition cabinet of Liberals and Monarchists, together with his refusal to restore the church property nationalized by Juárez, cost him the support of his original backers; and, when pressed for funds, he could obtain loans only on the most disadvantageous terms. No matter how hard pressed, Juirez was unyielding and the Republicans, defeated in open battle, resorted to guerrilla war. In desperation, Maximilian issued a decree on Oct. 3, 1865, which authorized the summary execution of any rebel and the fining and imprisonment of anyone aiding the rebel cause.

Maximilian's rule was short but primarily for reasons disassociated with Mexican internal affairs. With the Union triumphant in 1865, the U. S. Secretary of State, Seward, Feb. 12, 1866, delivered an ultimatum to Kapoleon that wrung from him a promise to withdraw his soldiers from Mexico. The anticipated commercial returns from the Mexican venture had not materialized and the French tax-payers were loudly protesting against its cost. Bismarck's aggressions against Austria also caused Napoleon to desire to have his troops at home. In desperation Maximilian vainly attempted to placate estranged Clericals. His wife, Charlotte of Belgium, undertook to dissuade Kapoleon from withdrawing his support. Finding Napoleon obdurate and the pope, to whom she appealed, unable to aid her, she became permanently insane, dying in 1927. With the last of the French troops withdrawn early in 1867, Diaz pushed north to Mexico City while the forces of Juárez besieged Maximilian in Querétaro. There, betrayed attempting to flee, Maximilian was captured (May 15, 1867). He was court-martialled and executed on June 19, 1867.

6. Juárez President.— The downfall of Maximilian made possible the re-establishment of a republican and Federal iorm of government. Juarez was re-elected in 1867, but his proposal for an extra-legal amending of the Constitution met with popular disapproval; his attempts to enforce the religious provisions of the 1857 constitution aroused new clerical opposition; and his reduction of the army aroused discontent among the soldiery. A crop of revolutions followed, with only partial restoration of order. A claims convention was signed with the United States (July 4, 1868) and friendly relations were resumed with some European nations. When Juirez stood for re-election in 1871, he was accused of seeking to make himself dictator, and when, after an indecisive election, Congress declared him president, one of the defeated candidates, Diaz, appealed to arms. His revolution was unpopular and had been virtually suppressed when the sudden death of Juárez removed its chief raison *d'être* (July 18, 1872). Sebastián Lerdo de Tejada, as president ad interim, granted general amnesty and called a special presidential election, in which he overwhelmingly defeated Diaz.

During his administration, commendable progress in suppressing banditry was made and several clerical revolts were put down. The Veracruz-Mexico City railroad was opened, the Juárez measures disendowing the church and separating it from the State were incorporated in the Constitution, and diplomatic relations were renewed with France and Spain. In 1876, when Lerdo sought to re-elect himself, Diaz again appealed to arms, declaring in the Plan de Palo Blanco for the sanctity of the Constitution and the principle of no re-election. After a dramatic campaign that culminated in the battle of Tecoac (Nov. 16, 1876), Lerdo, though declared re-elected, was forced into exile together with the president of the Supreme Court, Iglesias. After a short provisional term, Diaz was installed as president on May 5, 1877.

7. Diaz President.— Except for the term of González (1880–84). Diaz was president until 1911. He thus violated one of the fundamental bases of the Plan de Palo Blanco, but not without first having the Constitution conveniently amended. With Diaz a nen era was unconsciously ushered in. In addition to political instability, economic progress had been slow. The number of rural holdings had only increased since 1810 from 14.382 to 19,500; there were only 430 mi. of railroad in the country; financial conditions were deplorable. Eighty-five per cent of the population of 10,000,000 were Indian and Indian-like people. Only 350,000 children were in the public schools and fully 75% of the population was illiterate.

In marked contrast to the political instability of the past, the history of Mexico from 1876 to 1910 was almost void of politico-military strife. Diaz's policy was to keep down disorder; to centralize authority in his own hands; to foster railway development and economic progress—in large measure by attractive concessions to foreign capital; to develop native manufactures by protective tariffs; to introduce new industries; to promote forestry; and, above all, to place the national credit on a sound basis. By 1910 most of these aims had been realized. Summary extra-legal executions of malefactors and political conspirators—notably a group of alleged conspirators in 1879—and the policing of the country by a ruthlessly efficient rural gendarmerie maintained iron rule. Formidable uprisings of Indians—as the Mayas in Yucatán and the Yaquis in Sonora—were suppressed with great severity, and many survivors sold into distant peonage at so much a head by high officials. Centralization was effected by Diaz assuming the right to nominate directly or indirectly, for all Federal, State and municipal offices; by his influence upon bills while being drafted and considered in Congress; and by the deference to his wishes of the members of the Supreme Court in all cases affecting the Government or political matters. Railroad mileage increased to more than 15,000 mi by 1910. Textile factories in 1910 numbered 135 and employed 33,000 hands. Mexico's foreign trade in 1910, totalling more than 450,000,000 pesos, was nearly ten times that of 1873; the modern harbour of Veracruz was finished in 1902; nearly a billion dollars of gold were mined between 1870 and 1909; in 1910 Mexico ranked second in the production of copper; the oil industry at the close of Diaz's administration was expanding. In the realm of public finance notable progress was made. Foreign obligations were adjusted and refunded; the tariff was made protectionist; the monetary standard was changed from silver to gold; the hated tax on sales (alcabala) was abolished; the budget was balanced, reserves created and new loans effected.

Finally, Diaz, through his conduct of foreign relations, raised Mexico to a proud position among the nations. In 1877 only six and in 1910 no fewer than 42 foreign Governments had representatives in Mexico. Early relations between Diaz and the United States were strained, due to the temporary refusal of the United States to accord recognition and to border disturbances. These differences were satisfactorily adjusted and after 1888 disputes with the United States were transient. The second Pan American Congress met in Mexico City in 1901. In 1906 and 1907 Diaz co-operated with President Roosevelt in mediating successfully between Central American belligerents and took part in the establishment of the Central American Court of Justice.

Successful and beneficent as had been some of the policies of Diaz, others had been prejudicial to the best interests of the country. Particularly disastrous were the land policies. A presidential decree in 1890 expropriated and allotted in severalty the theretofore inalienable tillable lands of the villages, known as ejidos--or communal lands, which had long constituted the prin-

cipal means of independent support of the majority of the sedentary Mexican Indians. The reactionary land law of 1894 legalized the squandering within a few years of a vast national domain. Both measures were highly favourable to the landed aristocracy and unfortunate for the masses. By 1910 a total of 96.9% of the rural heads of families owned no real property. That in the possession of the other 3·1% was owned by fewer than 1,000 powerful landholders whose estates varied in size up to 6,000,000 acres. Approximately 10,000,000 Indians (probably three-fifths of the population), in addition to losing their communal lands, had become serfs. The condition of the masses in 1910 was even more deplorable than it had ever been. Under such conditions Mexico's third great socio-economic upheaval was inevitable and at hand. Other errors of Diaz may be briefly described. Rural education was almost completely ignored. Showy urban education had been promoted to some extent, but in 1910, 80% of the population was illiterate. The reform laws were not observed. The church made considerable economic and political recovery. Foreign concessionaires were so favoured that national resentment was deeply stirred. The Diaz Government had become a closed political corporation ruled by a narrow grafting clique, known as the *Científicos*.

8. Revolution of 1910.—Political discontent finally culminated in armed rebellion. Diaz' announcement in 1908—the famous Creelman declaration—that he would welcome opposition in the next campaign inspired Francisco I. Madero to initiate a political crusade in which he condemned presidential succession and demanded effective suffrage. Madero was nominated by the anti-reelectionists, but was arrested for sedition in June 1910. Escaping to Texas he issued a plan which, in addition to political reforms, included a demand for agrarian reforms. This plank caught the ear of the downtrodden masses who promptly gave Madero their support. Diaz attempted unsuccessfully to suppress the resultant revolution by force. Promises and belated reforms were likewise futile, and he resigned on May 25, 1911, and soon left Mexico forever.

After a short provisional presidency, Madero was inaugurated as constitutional president on Nov. 6, 1911. His administration was characterized by weakness and blunders, and was actively opposed by Ambassador Henry Lane Wilson. Making concessions to the old Diaz party, Madero lost the support of those who had rebelled to secure political reforms; when he did nothing to achieve agrarian reforms, he aroused the active antagonism of the masses; he aroused the hostility of American capital. Rebellions flared up, resulting in chaotic conditions and by 1912 President Taft placed an embargo on arms and advised Americans to leave Mexico. This sealed Madero's doom.

A Conservative counter-revolution, headed by the Indian general, Victoriano Huerta, met with success in Feb. 1913. The forced resignations of President Madero and Vice President Suárez on February 19, enabled Huerta to seize executive power through constitutional forms. Three days later Madero and Suárez were assassinated while in military custody. Huerta, however, faced insuperable obstacles, though supported by British oil interests and receiving a British loan. President Wilson refused to recognize him because of his usurpation of authority and because of holding him responsible for the political executions. From within, he was opposed by the disappointed masses, led by Carranza, Villa, and Zapata, who had joined the revolution to obtain social and agrarian reforms. They were aided indirectly by the troubles of Huerta with the United States. At Tampico an affront to an American naval officer, trespassing on a military reserve, prompted an official demand that the United States flag be saluted. Huerta's refusal was followed by the American seizure of Veracruz (April 21, 1914). Huerta had already been embarrassed by the mission of John Lind, who had been sent to Mexico by President Wilson to induce him to assent to his own elimination, and the seizure of Veracruz led to the severance of diplomatic relations with the United States. Argentina, Brazil, and Chile proffered their good offices, which were accepted, but the Niagara Falls Conference that followed failed to agree on a provisional president. Huerta was finally forced to resign on July 14, 1914.

9. Carranzapresident.— Betweenthe revolutionary leaderswho co-operated to overthrow Huerta, a sanguinary civil war developed which further delayed much-needed agrarian reforms. But a provisional decree issued by Carranza on Jan. 6, 1915 provided, where practicable, for the restitution to villages of *ejidos* illegally alienated in the past and for the expropriation of lands necessary to endow with ***ejidos*** other villages in need of them. The decree crystallized revolutionary sentiment in support of Carranza which, in turn, won for him the recognition of the United States and eight associated Latin-American republics as *de facto* president. This success piqued Villa, who, in a deliberate attempt to involve Carranza in international difficulties, perpetrated the massacre of 18 American miners at Santa Isabel (Jan. 10, 1916) and the raid on Columbus, New Mexico (March 9), in which 17 Americans were killed. The Pershing punitive expedition of 12,000 troops immediately but ineffectually pursued Villa far into northern Mexico, much to the embarrassment of Carranza. The expedition was attacked by Carranza's forces, several Americans being killed and a score captured (June 21, 1916). The expedition thereupon remained largely immobile on Mexican soil until nearly a year later, not being withdrawn until Feb. 5, 1917.

This was the date of the ratification of the new constitution of Querétaro, against the proposed oil provisions of which the U. S. State Department was already secretly protesting. Mexican historians claim that the Pershing expedition remained on Mexican soil not to pursue Villa but to exercise moral coercion against the delegates to the Querétaro convention.

However, the expedition cemented patriotic fervour behind Carranza and intensified the revolutionary demands in the convention. The new constitution incorporated the Carranza land decree of 1915, set forth an extensive labour code (at that time the most advanced in the world), provided for the return to national ownership of the subsoil deposits alienated by Diaz by the laws of 1892 and 1909, amplified the religious reform provisions of the 1857 constitution, limited the right of foreigners to acquire agricultural property, and established frontier and seacoast zones where foreigners were excluded from all ownership.

Carranza's administration as first president under the new Constitution was disappointing. Little was realized in the way of effective agrarian reforms. Decrees, charged with being confiscatory, by which Carranza sought to enforce the constitutional provisions relating to the national ownership of subsoil deposits, involved him in diplomatic controversies with foreign powers. In the United States intervention was loudly demanded, danger of which was augmented prior to the close of World War I by Carranza's anti-American and pro-German attitude. Finally, through threats of curtailing production, the petroleum companies forced Carranza (Jan. 1920) to suspend his objectionable decrees, but without prejudice to the final adjudication of the dispute. During 1919 Carranza's hold on the country weakened. Rebel activities were widespread. corruption prevailed in the army and banditry was general. This situation, together with the nonenforcement oi the constitution and Carranza's attempt to impose a nonentity civilian, I. Bonillas, as his successor in the presidency, inspired an armed rebellion headed by the so-called Sonora triumvirate, composed of De la Huerta, Obregón and Calles. The rebel movement got under way in Sonora early in April 1920, and on May 8 Obregon entered Mexico City on the heels of the fleeing Carranza, who was assassinated 13 days later. Following De la Huerta's provisional presidency, Obregon was installed Dec. 1, 1920.

10. Revolutionary Reorganization, **1920–34.—The** many aims of the revolution began to be realized during Obregon's administration. The prompt application of the agrarian laws enabled the government to re-establish peace throughout the country. Supreme court decisions upholding some of the contentions of the petroleum companies stimulated their activities, and in 1921 production reached the record-breaking total of 193,397,587 bbl. In June 1922 Mexico assumed full obligation ior the $500,000,000 principal of the foreign debt, the $200,000,000 of defaulted interest, and agreed to resume service payments Jan. 1, 1923. The agreement was suspended on July 1, 1924. Education was encouraged among the rural classes, largely Indians, for whom 960 schools were built. One of the outstanding events of 1923 was the expulsion of the papal delegate, Mgr. Filippi, causing Vatican and Catholic lay protests.

The agrarian and petroleum policies of the Obregón government strained relations with the United States. Secretary of State Charles Evans Hughes unsuccessfully endeavoured to negotiate with Obregón a treaty of amity and commerce that would adequately guarantee protection of U.S. property rights. Charles B. Warren and John B.

Payne were then sent to Mexico as members of a joint commission, with instructions to secure the restoration or proper reparation for the taking of lands owned by U.S. citizens, to obtain satisfactory assurances against confiscation of subsoil interests owned by U.S. citizens prior to the promulgation of the constitution on May 1, 1917, and to negotiate appropriate claims conventions. The joint commission (in session from May 14 to Aug. 15, 1923) reached satisfactory understandings on the most important questions at issue. U.S. owners of lands expropriated by the Mexican government for *ejidos* for villages were obligated to accept 20-year 5% bonds for a maximum of 1,755 ha. and a just value, paid in cash, for any excess taken. The Mexican government recognized the right to the subsoil of all surface owners who, before May 1, 1917, had performed some positive act indicating their intention to exploit the deposits beneath their surface lands. It refused, however, to do more than grant preferential rights to the oil in the subsoil to surface owners who before May 1, 1917, had not performed the afore-described positive act. On the basis of the above understandings, as mutually approved by Presidents Obregón and Coolidge, the Obregón government was recognized by that of the United States on Aug. 31, 1923. A special claims commission, whose report was signed on Sept. 10, provided for the adjudication of all claims against Mexico of citizens of the United States suffered "through revolutionary acts" between Nov. 20, 1910 and May 31, 1920. A general claims convention signed on Sept. 8, provided for the adjudication of all other claims of the citizens of either country that originated between July 4, 1868, and the date of the termination of the commission.

An exciting presidential campaign followed late in 1923 and when Obregón threw his support to Plutarcho Calles, Adolpho de la Huerta and his followers rebelled. Their initial successes menaced the government and Obregón took the field and conducted a campaign on three fronts, with the aid of the regular army and agrarian and labour volunteer battalions. Material and moral aid from the U.S. enabled Obregón to triumph, after which Calles was elected president and inaugurated on Dec. 1, 1924.

President Calles, a strong supporter of the program of 1917, came into power pledged to maintain order, to practice economy, and to promote the economic and social welfare of the Mexican people. He was supported by the Labour party. New labour legislation was promoted and land-distribution was speeded up. But the program of economic and social development was impeded by the deplorable financial condition of the government. However, a drastic policy of retrenchment effected a saving of more than 60,000,000 pesos in less than eight months. In Oct. 1925, the debt agreement of 1922 was modified to Mexico's advantage—chiefly by the separation of the debt of the national railways, which were returned to private management, from the national debt—and arrangements were made for the resumption of interest payments beginning Jan. 1, 1926. Service, however, was soon suspended. Upon the recommendation of President Calles the Mexican congress, in Dec. 1925, passed the alien land and petroleum laws. The first was an enabling act designed to put into operation the theretofore unfulfilled constitutional provisions relating to the limitation of the acquisition by foreigners of agricultural land in Mexico; the second law was designed to put into operation by legislative action, as opposed to presidential decrees, the constitutional provisions relating to the national ownership of subsoil deposits. Early in Jan. 1926, just as a spirited diplomatic controversy with the United States concerning these laws reached an apparent crisis, the Mexican Catholic episcopate took a positive stand against the theretofore almost wholly unenforced religious and educational provisions of the constitution and thus precipitated a conflict between church and state. An apostolic letter of Pope Pius XI (Feb. 2, 1926) which voiced sympathy for the Mexican clergy because of the "wicked . . . regulations and laws . . . against the Catholic citizens of Mexico," intensified the uncompromising attitude of both the government and the episcopate. The conflict reached a crisis on July 31, at which time the clergy, in preference to submitting to an executive decree designed to enforce the religious and educational provisions of the constitution, withdrew from the churches, and thus suspended religious exercises requiring the services of priests. Churches, as well as all other church property, which had been nationalized, were taken in charge by government agents. Opposition to the law resulted in several outbreaks, which were suppressed. Many members of the episcopate were deported on the ground that they had encouraged the Catholic uprisings. The so-called *Cristero* religious revolt occurred, centring in Jalisco and Guanajuato and keeping five states in turmoil till the end of Calles' administration. It was marked by bloody reprisals on both sides.

Despite international and internal troubles the Calles government made notable progress in developing irrigation projects, in building roads and in promoting education, particularly among the rural classes. In 1926 a total of 46,000,000 pesos was spent on education. This sum was equivalent to 8½% of the federal budget plus about 40% of the total budgets of all the states.

The alien land and petroleum laws were vigorously protested against by the U.S. government, chiefly because of their alleged retroactive and confiscatory character. The diplomatic exchanges yielded no agreements but the tension was relieved in March 1926, when Secretary of State Frank B. Kellogg apparently indicated a willingness to be content with the petroleum law provided U.S. owners who had performed an above-described positive act before May 1, 1917, were confirmed in their rights to the subsoil. The second phase of the diplomatic controversy was opened by Kellogg on July 31, 1926. Vigorous complaints against specific provisions of both land and petroleum laws were made and the United States in a virtual ultimatum (Oct. 30) warned Mexico not to deprive U.S. owners in Mexico of any of their property rights. The Mexican government countered by requesting that violations of recognized principles of international law be indicated. Articles 14 and 15 of the petroleum law, which were among those vigorously protested against by Kellogg, required owners of the surface who acquired their titles prior to May 1, 1917, to exchange them for "confirmatory concessions," good for 50 years, and, under certain conditions, renewable. Property of owners not complying with the law before Jan. 1, 1927, was to revert to the Mexican nation. On the latter date, however, the Mexican government made no move to take over such property, and, instead, merely cancelled drilling permits of nonconforming companies on the ground that they had not complied with articles 14 and 15. Tension continued, and Dwight W. Morrow, former partner in the house of Morgan, was rushed to Mexico to replace Ambassador Sheffield and arrived in Oct. 1927. After a famous ham-and-egg breakfast between Morrow and Calles at Chapultepec castle, a decision of the Mexican supreme court (Nov. 17, 1927) declared in favour of the U.S. oil companies on a number of points. Before adjournment in December the Mexican congress hurriedly re-enacted the petroleum law with the two controverted articles amended so as to conform with the supreme court decision. Authorized executive regulations governing the new law promptly met with the approval of the U.S. government when they were issued on March 27, 1928. Thus two, but only two, of the various provisions of the law that were objectionable to the U.S. interests upheld by Kellogg were eliminated by the supreme court decision.

The remainder of Calles' term, carried on in close collaboration with Ambassador Morrow, was featured by rapid abandonment of the revolutionary reforms. Labour was restrained with an iron hand; land-distribution was largely halted and subsequently denounced by Calles himself. Newspapers were suppressed. Preliminary efforts, under Morrow's guidance, were taken to bring about a truce with the Catholic Church.

In spite of the constitutional "no re-election" clause which could be interpreted as referring to any former president, Obregón became a candidate in the 1928 election on a radical agrarian platform with the active support of the agrarian groups. Late in 1927, the rival candidates, Arnulfo Gómez and Francisco Serrano, joined forces and revolted. Their movement was promptly suppressed with wholesale executions.

The anticlerical program of Obregón aroused the antagonism of the church. An attempt to assassinate him was made in Chapultepec park Nov. 13, 1927. Four men, including the priest Padre Pro and his brother, were accused of the crime and were shot without trial and without evidence being given to the public.

On July 17, 1928, President-elect Obregón was assassinated by the religious fanatic, José de León Toral. The congress elected Emilio Portes Gil, secretary of the interior, provisional president, and he took office on Dec. 1, 1928. He founded the National Revolutionary party as the official party of the regime, and thereafter ruthlessly suppressed labour and peasant organizations. A reign of terror in the rural districts largely put an end to the agrarian movement, and enemies of the regime were sent to Islas Marias penitentiary without trial. In June 1929, Ambassador Morrow succeeded in patching up a truce between the church and the government.

On March 3, 1929 a concerted revolt broke out in Veracruz and in the northern states. Calles, appointed secretary of war, took control of operations and broke the revolt in the battles of Jiménez and La Reforma. Pascual Ortiz Rubio was elected president in Nov. 1929, and visited the United States just before his inauguration in the following February. In 1931 the pope, claiming that the states were not permitting all priests to register, and protesting against interference with religious education, broke off the Morrow truce between church and state. The National Revolutionary party retaliated by voting to expel the foreign religious hierarchy and to suppress the four leading church papers. A political crisis within the party occasioned the resignation of the entire cabinet in Oct. 1931, but General Calles intervened, placing four generals in the cabinet. A year later President Rubio resigned, due to disagreement with Calles, and congress elected Gen. A. L. Rodríguez, business associate of Calles, for the uncompleted term.

In 1933, at the suggestion of Calles, whose hand had been forced by left-wing elements, the National Revolutionary party formulated a six-year plan designed to establish a "co-operative economic system tending toward socialism," which included programs of socialist education, land distribution, labour legislation and public works. In the same year the presidential term was extended to six years, and the "no re-election" principle was reaffirmed and made completely unambiguous.

(C. W. H.; Car. B.; X.)

11. Revived Revolution, 1934–40.—World depression undermined much that the conservative Sonora dynasty had built up. In 1933, to help still discontent, Calles had prepared for the P.R.N. a six-year plan of social, economic and political programs which would fulfill some of the deferred promises of the constitution of 1917. The party convention that nominated Lázaro Cárdenas added further radical features. In a precedent-breaking campaign tour which took him to tiny hamlets

in lone reaches of the republic, Cárdenas publicized the six-year plan and built a large personal following among agrarians and labour. Though expected to defer to Calles' wishes after his election in 1934, Cárdenas mobilized his army power, backed by popular support, and broke the hold of the Sonora clique. Calles was exiled, as was Morones. With the double power of party chieftain and president, Cárdenas proceeded to revive the social revolution, aided by extreme left wing elements. Education again received impetus and rekindled anticlerical zeal as article 3 was rewritten to make Marxian socialism its guiding doctrine. The weight of the administration was placed behind organizing labour to equalize its position in the class struggle it was believed the Mexican masses were waging; under Vicente Lombardo Toledano in 1936 was formed the Confederacibn de Trabajadores Mexicanos (C.T.M.). Organizational and political strikes mere numerous, the chief targets being foreign-owned enterprises. Under an expropriation law signed Nov. 23, 1936, the government seized many struck properties and turned them over to workers for co-operatives. Under this movement, most of the foreign-owned railways were nationalized in 1937, and after a bitter labour dispute, the petroleum industry met a similar fate on March 18. 1938. The same expropriation act was effectively used against Mexican landholders; hoping to make Mexico a land of communal co-operatives, Cárdenas nationalized not only land but equipment of commercial plantations, turning them over to peasants for formation of sugar, henequen, coffee, even rice *ejidos.* Compared with the 20,000,000 ac. distributed 1916–34, Cárdenas placed 43,000,000 ac. of nationalized land in peasant hands 1934–40. To consolidate these gains and to provide a mass base for government, the P.R.N. was reorganized in 1938 by changing its name to the Mexican Revolutionary party (P.R.M.) and dividing its components functionally rather than geographically into army, labour, agrarian and popular sectors which operated autonomously but jointly comprised the official party for purposes of national elections, each sector being pledged to support the common candidates which party primaries selected. Drastic reorganization of the economy led to a drop in agricultural and industrial output and near national bankruptcy, complicated by boycotts by British and U.S. suppliers and buyers as result of the oil nationalization. Mexico was driven to barter deals with axis powers. The "Mexico for the Mexicans" slogans of the revolution reached an apogee under Cárdenas, generally considered by his people to have achieved their economic independence of foreign capitalism.

12. World War II and After.—Cárdenas' main concerns were domestic matters, but a darkening international situation dominated the following administration of Gen. Manuel Avila Camacho, secretary of war in the Cárdenas regime and his choice. Avila Camacho, taking over the presidential reins in Dec. 1940, initiated a program of moderation which. while consolidating efforts of Cardenas, did not extend them. A *modus vivendi* was worked out with the church; landholders were guaranteed against further nationalizations; many communal *ejidos* became subdivided into individual parcels; and workers' administrations of railways and the national oil monopoly gave way to administration-directed management. An effort was made to displace known Communists and fellow travellers who had infested departments of welfare and education, as well as unions. The army sector of the official party (P.R.M.) was dropped as an effort to professionalize the armed forces and remove them from politics occurred. To raise production, irrigation projects and increased rural credit were pushed, and under liberalized laws manufacturing and industry were thrown open to foreign investment. The Avila Camacho regime took a strong stand against the axis, and after Mexican tankers were sunk, declared war in May 1942. A personal meeting of Pres. Franklin D. Roosevelt and President Avila Camacho in 1943 cemented Mexican-U.S. friendship, signalized earlier by a series of agreements that laid to rest most of the old problems: settlement of the oil expropriation claims, U.S. silver purchases. claims arising from the revolution and mutual defense plans. To the mar effort Mexico contributed strategic materials. farm labour in the United States *(braceros),* induction of Mexicans into the United States forces and finally squadron 201 of the Mexican air force which flew combat and bombing missions in the far east. The Mexican officials rallied Latin-American participation and played a leading role in conferences of ministers during World War II and in the formation of the United Nations aiter it, being a charter member of the Security council.

The impact of World War II on the local scene increased extremisms of left and right, and twisted Mexico's economy. Leftist agitation led to resumption oi relations with the U.S.S.R., while conservative elements sponsored a fascistlike peasant movement known as Sinarquism ("With Order") to overthrow the revolution. Cut off from imports of manufactures but with rising foreign sales of basic materials, local industry sprang up to fill the vacuum. Treasury surpluses were applied to wipe out old international obligations, though inflation and black markets, plus widespread corruption, darkened the scene. At the end of the war, Pres. Avila Camacho divested himself of the dictatorial emergency powers voted him in 1942 and inaugurated electoral reforms looking to honest polling and formation of national opposition parties on a permanent basis. His program of conciliation and unification had also brought from exile the former presidents of Mexico, who were given important defense posts and formed a body of elder statesmen dedicated to national rather than partisan ends. Mexico thus emerged from World War II materially stronger.

A record number of voters in 1946 peacefully elected Miguel Alemdn Valdes the first civilian president since Madero. To signalize the fact that the revolution was permanent, and past its experimental and probationary period, the official party again changed its name and structure in 1946 to Party of the Institutionalized Revolution (P.R.I.) and in 1950 stressed its function as the harmonizer of distinct class interests, promising fuller recognition of the long-forgotten middle classes. Many hopes of the Avila Camacho regime, postponed by World War II and by domestic turbulence, saw fulfilment under his former secretary of interior, Alemán. Both Sinarquism and Communism withered as all classes benefited from the agricultural and industrial revolutions, increased trade, extended communications, revamped and augmented education, hydraulic works, electrification and favourable international balances oi payments.

The broadened P.R.I. selected as its nominee for president in the 1952 elections Alemán's civilian secretary of interior, Adolfo Ruiz Cortines, pledged to extend the middle-of-the-road *plan Alemán.* He was elected in July 1952. Mexico continued in peace and steady growth under Ruiz Cortines. Graft and corruption among public officials were curbed by stern measures, and women's suffrage became the law of the land in 1953. Inflation continued at the rate of about 10% a year, and it became necessary to devaluate the peso on April 17, 1954, to the level of 12.5 to the U.S. dollar, but the Mexican economy was healthier in 1956 than in 1952. As a decade of drought came to an end renewed emphasis was put on improving agriculture. Cortines was succeeded as president by his labour minister, Adolfo López Mateos, in 1958.

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MEXICO, a small interior state on the central plateau of Mexico. Pop. (1950) 1,392 623; area, 8,268 sq.mi. Except on the south, the state surrounds the separately administered federal district and national capital, Mexico City. The general elevation is more than 10.000 ft. above sea level, standing some 2,500 ft. above the Mesa Central. of which it is a part. The extreme height ensures a coo!, healthful climate. which with fertile lava-based soils and plentiful rainfall made the area a heavily populated one from aboriginal days; México's density of 168 persons per square mile is second only to that of neighbouring Tlaxcala (183).

Much of the northern part of the state lies in the Valley of México or Anáhuac. a circular lacustrine plain and intermontane basin from nhich most of the lakes have disappeared, leaving only swamps, sodden meadows and lagoons. Chief of these are Zumpango, San Cristóbal, Xaltocan, Xochimilco and Texcoco, the latter three lying partly in the federal district. The stream flow into this depression and beyond was altered greatly by opening of the Tequixquiac tunnel, conducting water eventually to the Gulf of Mexico, and by the system of tunnels and tubes completed in 1951 providing the state and the federal district with pure water and hydroelectric power.

Agriculture, mining and manufacturing are principal mainstays of the economy. Cereals, especially maize, have been principal crops, in addition to nhich maguey grown for pulque has long been a mainstay; coffee is also important, and in valley bottoms sugar cane and fruits grow. Manufacturing is concentrated chiefly at the edge of the federal district, where assembly plants, aluminum processing, cement fabrication, iron and steel works and many other industrial activities have been established. Mining dwindled in importance while dairying grew. Many communication lines traverse the state. Its capital is Toluca (*q.v.*); altitude 8,659 ft.; pop. (1950) 52,983.

The state contains many preconquest ruins, among them Tenayuca at Tlalnepantla and the great centre of San Juan Teotihuacán, about 30 mi. N.E. of Mexico City, which covers 8 sq.mi. Its Pyramid of the Sun, constructed around A.D. 200, is 211 ft. high, and 693 ft. by 693 ft. at the base. (J. A. Cw.)

MEXICO, FEDERAL DISTRICT OF (MÉXICO DISTRITO FEDERAL), seat of the national government of Mexico in a territory comprising Mexico City and its suburbs under the direct supervision of the president. Area, 573 sq.mi. Pop. (1950) 3,050,442; (1956) 4,226,981. About 90% of the population reside in the central department (metropolitan Mexico City), with the remainder in 12 subordinate jurisdictions (delegations), all under a presidentially appointed governor with cabinet rank.

The district occupies the southeastern corner of the Valley of Mexico. bounded on three sides by the state of México but touching Morelos at the south. An irregular polygon, the district lies between 19° 36' W. long. (Cerro Sombrero) and 19° 05′ N. lat. (Cerro Chichinautzin). about 32 mi. N. to S., and between 98° 56' and 98° 18' W long., about 27 mi. broad, with an average altitude of well over 8,000 ft. Its northern limits are the Sierra de Guadalupe, round topped and barren, which include the peaks of Sombrero, Gachupines and Tepeyac. The Sierra Nevada, including numerous volcanoes and especially Popocatepetl and Ixtaccihuatl (*qq.v.*), together with the San Pablo range of cones, limits the district to the east; on the south are high ranges of Ajusco and Cuautzin, and to the west Las Cruces range, connected with Ajusco. Vestiges of an important lacustrine region, including Lakes Texcoco and Xochimilco remain in the southeastern portion of the district, while lava beds (pedregales) are extensive in its southern sections. Under the minister of hydraulic resources a commission of the valley is concerned nith providing the district with drainage, sufficient and pure drinking and industrial water and hydroelectric power from the many streams, notably the Lerma, that traverse the district. Apart from the city of Mexico, there are eight distinctive ecological and physiographic subzones within the territory, which is divided into 13 political units. Largest and most important of these is the central department or Mexico City proper, together with municipalities it had annexed by 1931: Tacubaya, Tacuba and General Anaya. all later subdivided into residential and business districts blurring their original identities. Apart from this nucleus are the delegations, each of which has a complicated local history from aboriginal days as well as a special role as urban, semirural or agricultural suburb within the metropolitan district. The delegations include Guadalupe Hidalgo (Gustavo A. Madero), Atzcapotzalco. Ixtacalco, Ixtapalapa, Coyoacin, Tlalpan, Xochimilco, Tláhuac. Milpa Alta, Magdalena Contreras. Villa Obregón (San Angel) and Cuajimalpa. Both the central urban area and the delegations or fringes have grown during the 20th century. but the modern city at the centre (see MEXICO CITY) vastly overshadows its cdgcs. Comparative populations, in thousands of people, indicate the growth and relationship:

	1900	1910	1921	1930	1940	1950	1956
Mexico City . . .	369	471	615	1,029	1,448	2,234	3,300
Federal District . .	542	721	906	1,229	1,756	3,050	4,227

Thus, more than 10% of the nation's population is in this restricted area.

The governor, appointed by the president, administers by a congressionally approved organic statute which provides for appointment of local officials and others concerned with justice, public works and fiscal matters. Most of these are highly centralized, with the result that duties of the functionaries in the delegations and their lesser satellites are quite nominal.

Directly north of Mexico City is the delegation of Guadalupe Hidalgo, relatively barren, but famous as a religious shrine. Delegations in the extreme south—Milpa Alta, Tlalpan, Contreras—tend also to be more lightly populated and rural than the agriculturally and industrially richer jurisdictions of Cuajimalpa, Ixtapalapa, Xochmilco and the other suburbs on the outer ring. Atzcapotzalco, Coyoacin and Villa Obregón are highly urbanized. Crisscrossed by networks of bus, streetcar and railway lines terminating in the city, and containing about a third of the republic's automobiles, the district is knit together by communications, though these proved increasingly inadequate to care for its swelling numbers.

Numerous clusters of ruins and aboriginal remains of all sorts are still visible, side by side with colonial Spanish, 19th-century Mexican and ultramodern buildings. (HD. C.; R. B. McCK.)

MEXICO, GULF OF, a partially landlocked body of water indenting the southeastern periphery of North America, connecting to the Atlantic ocean by the Straits of Florida between Florida and Cuba, and to the Caribbean sea by the Yucatán channel between the Yucatán peninsula and Cuba. Its northern boundary is the southern C.S. coast from Florida to Texas. In the southwestern part of the gulf a broad embayment is formed by the Gulf of Campeche west of the Yucatán peninsula.

Mexico and the United States share equally the shoreline of

about 3,000 mi., not counting many small indentations. Western Cuba lies midway between Yucatán and Florida. The greatest length — Tampico, Mex., to Cape Sable, Fla.—is almdst 1.100 mi.; the greatest width — Galveston, Tex., to Puerto Mirxico—is about 775 mi. The total area is about 615,000 sq mi.

The continental shelf forms an almost continuous terrace around the margin of the Gulf of Mexico, varying in width from about 8 mi. beyond the southern pass of the Mississippi river and off the Mexican coast near Veracruz to 117 mi. off the west coast of Florida and 135 mi. off northern and western Yucatán. The shelf is important economically for its oil reserves (see PETROLEUM: *Methods* of Production: Offshore Drilling).

Although the shelf slopes somewhat regularly from the shoreline to the 100-fathom line, it is not a featureless plain. It has numerous minor knobs, ridges, depressions, escarpments and at least two submarine canyons. The most striking topographic features are two great limestone banks — one west of Florida and the other north of Yucatin — and the Mexican basin, deepest part of the gulf. The Mexican basin is a large triangular area near the center of the gulf, hounded by abrupt fault scarps toward Florida and Yucatán and by more gentle slopes to the north and west. Its bottom is nearly flat. The deepest place, Sigsbee deep, is 12,425 ft. below sea level. The gulf shores are mostly low, sandy and marshy, with barrier islands and lagoons extensive in most sections.

Tidal range in the Gulf of Mexico is small. averaging less than two feet at most places. A remarkable feature of most gulf tides is the daily occurrence of only one high water and one low nater the greater part of the time. This diurnal tide contrasts with the semidaily type which is prevalent elsewhere. Current movement in the Gulf of Mexico, which feeds the Gulf stream (q v.) consists essentially of a clockwise movement in the main body of the gulf and counterclockwise rotation in some of the larger coastal indentations. A significant portion of the current entering from the Caribbean through Yucatin channel moves directly eastward to the Straits of Florida. Surface currents through Yucatan channel range from one to three miles per hour.

Average surface temperatures in the Gulf of Mexico are very nearly uniform at 84° F. in the summertime. During the winter the temperature is between 65° and 70° F. along the U.S. coast and about 7j° F. in the southern part of the gulf. The prevailing winds are the northeast trades, which are particularly strong during summer. The deflection of minds due to the rotational force of the earth causes considerable inflow of moist air from the gulf into southeastern United States. The relatively high temperature of the gulf in winter causes strong cyclonic inflows of air which are associated with the northers that affect the Mexican coast.

See U.S. Fish and Wildlife Service, *Gulf of Mexico* (1954).

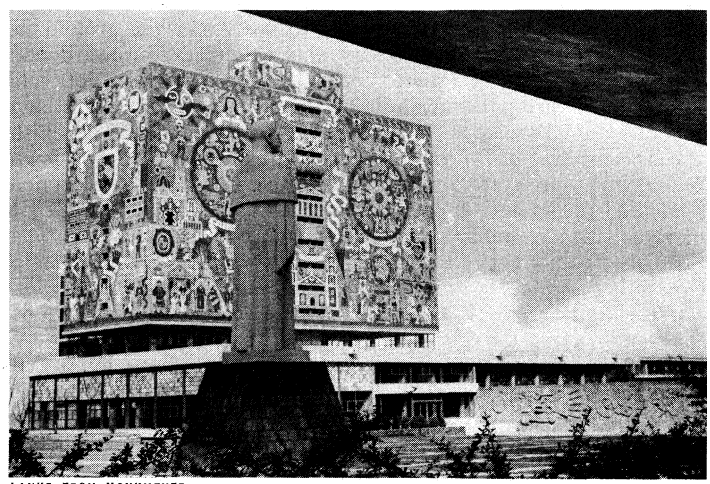
(D. R. D.)

MEXICO CITY (CIUDAD DE MÉXICO), capital and metropolis of the republic of Mexico. Pop. (1960) 2,697,994. Officially designated as the central department in 1945, Mexico City forms the core of the federal district mhich it dominates, the 12 other major political jurisdictions being metropolitan suburbs functionally connected to the central department and without major identity. The city proper, Ciudad de México. to which were annexed in 1930 the ancient municipalities of Tacubaya. San Pedro de los Pinos, Tacuba, Mixcoac, Portales. Popotla, Colonia del Valle and Pueblo de la Piedad, occupies about 53 sq.mi. of the total 573 sq.mi. in the federal district. giving the central department a density of about 51,000 persons per sq.mi. and the other twelve delegations a density of 1,200.

The capital is located at the southern margin of the Mesa Central. It is about 800 mi. S. of Laredo, Tex., on the international boundary, with which it is connected by rail and highways; about zoo mi. in direct line west by north of its major Gulf port, Veracruz, to which it is joined by two railways and highways; and about 288 mi. N.N.E. by road of its nearest port on the Pacific, Acapulco, to which railways reach only part way, but which is reached by a well-developed highway net. With but few exceptions, trunk rail and highway lines terminate in Mexico City, making it the communications and economic as well as political head of the nation, despite numerous physical drawbacks inherent in its location.

Physical Setting. — Mexico City stands on a small lacustrine plain in the southwestern part of the Valley of Mexico or Anáhuac, at an altitude of 7.347 ft., nearly 1½ mi. above sea level. About 3 mi. W. of the city lies Lake Texcoco, and 8 mi. S. are Lake Chalco and Lake Xochimilco, whose combined waters at one time covered most of the oval valley floor, which varies in altitude from about 7,400 ft. to 8,000 ft.. surrounded by spurs and chains of mountains and volcanoes which rise to 14,000 ft. above sea level.

Minor tremors are quite frequent, with occasionally violent earthquakes. Drainage works dating from early colonial times but completed in the 20th century nearly dried up these lakes, whose pulverized beds give rise to irritating dust storms (tolaveras) and whose spongy subsoils provide poor foundations. As a result until about 1940 Mexico City spread horizontally rather than rising vertically in the form of tall buildings. Completed in 1900, the Tequixquiac tunnel provided a discharge system for waste and sewage naters canalized and emptied into it. whence they pour into a tributary of the Pánuco river and then into the Gulf of Mexico. A series of aqueducts and tunnels from Toluca which cross the high Sierra de las Cruces divert waters of the Lerma river for use in the capital. As vestiges of the Aztec system of filling wicker baskets with earth to form *chinampas* ("floating gardens"), agri-



LANKS FROM MONKMEYER

LIBRARY OF THE NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO AT UNIVERSITY CITY, WITH STATUE IN FOREGROUND OF MIQUEL ALEMÁN VALDÉS, PRESIDENT OF MEXICO FROM 1946 TO 1952. THE EXTERIOR IS DECORATED WITH MOSAICS

culturalists and horticulturalists around Lake Chalco and Lake Xochimilco raise vegetables and floners for market.

Its altitude offsetting its tropical latitude, Mexico City has a temperate and healthful climate, divided into dry (October to March) and wet (April to September) seasons, with about 20–25 in. of annual rainfall, so that irrigation is necessary for any considerable cultivation. Temperatures average about 60° F., seldom rising above an average of 70° F. in the hottest months (June and July), or dropping below an average of 50° F. in the coolest month (December). Night frosts are frequent during winter months, and nights are always cool; there is a marked temperature contrast between sunny and shady places and between the heat of midday and the chill of mornings and evenings. Crops in the district cease growing when the sun sets. Of the mountains surrounding the city the twin volcanic peaks of the Sierra Nevada, Popocatepetl (17,887 ft.) and Ixtacihuatl (17,342 ft.) are perpetually snon-capped.

History. — Kith some justification Mexico City can claim to be one of the oldest metropolises in the new world. It was founded around A.D. 1300 and has been a principal theatre of Mexican history since. Its origins are wrapped in legend. the chief one being that an eagle landed on a cactus (nopal, called by the Indians *tenuch*), nhich itself was the child of a god. to show the Tenocha-Aztecs (also called Mexica) that a barren island in Lake Texcoco

was their promised site. Indeed, after wandering around the valley as slaves and allies of more powerful tribes, the Aztecs were exiled to the middle of the lake for bad behaviour. The traditional founding date of their main city, Tenochtitlán, is placed at 1325; beside it grew a second city, Tlaltelolco. The Aztecs reclaimed the swampy island, and by the middle of the 15th century had grown strong enough to launch a conquest of its riparian neighbours; by the time of the Spaniards' arrival it was the centre of a loosely held confederation of Indian towns and principalities that rendered it tribute from an area westward to Michoacán, east and north to the Gulf at about Tampico, southward to the isthmus of Tehuantepec. The national seal and flag of Mexico retain the original legend in a representation of an eagle eating a snake while perched on a cactus growing out of a split rock. The main Aztec public buildings of Tenochtitlán were grouped around what is the modern Zócalo or La Plaza Mayor de la Constitución in the heart of Mexico City, which in Aztec times was connected to the mainland by causeways. The aboriginal population of the city is variously given from 250,000 to 500,000 people.

Cortes' siege of the city required filling in many of the causeways, and subsequent rebuilding by Spaniards obliterated the many canals used by Indians in lieu of streets. After Nov. 1521, Tenochtitlán was rebuilt as Mexico City to gain for the conquerors its prestige as a capital, since geographic logic pointed to Puebla as the preferable location. Northern and eastern parts of the city, including Tlaltelolco, were assigned to natives, while around its new main plaza the Spanish city was extended southward and westward as a grid of square blocks, divided into house lots and interspersed with parks according to a master plan. Under a long line of colonial viceroys consistent etiorts were made to embellish this ancient seat of power, now capital of Spanish America down to Panamá. In 1522 the city was chartered and its town council (cabildo) recognized, and a year later it was provided with a coat of arms that symbolized Spanish triumph over the natives. The Spanish crown (1535) gave Mexico City priority and leadership over other cabildos within New Spain, placing it in seniority on a par with Burgos, capital of old Castile; the additional title of "very noble, great, and very loyal city" was added by Charles V in 1548. Local riots in 1692 destroyed some of the municipal buildings which were rearranged internally in their repair, especially the viceregal palace (originally built by Cortes for his residence and acquired by the crown in 1562). It is the modern national palace, covering nearly ten acres and containing the executive offices and national archives. There also is the liberty bell rung by Padre Miguel Hidalgo y Costilla on Sept. 16, 1810, Independence day. On this anniversary the president of the republic repeats Hidalgo's original "grito de Dolores."

The city was a much sought prize during the wars of independence (1810–21) and in the many subsequent political upheavals during the first half of the 19th century. Foreign invaders occupied the city twice in this period, U.S. troops in 1847–48, and French forces, 1863–67. The latter supported the Habsburg emperor of Mexico, Archduke Maximilian, who laid out the Paseo de la Reforma to reach his palace in Chapultepec, now a beautiful park. Growth of population led to formation of new residential sections or colonias, first of which was Santa Maria de la Ribera (1862), followed by Guerrero (1880).

Under the long rule of Porfirio Diaz (1876–1911), Mexico City was transformed from an overgrown village into a modern metropolis by vast construction of public buildings, including the post office and Palace of Fine Arts, large business edifices and railway stations, while introduction of streetcars, gas and electric lighting modified many old features. Architecture followed European styles. The completion of drainage works in 1907 notably improved public health.

With the outbreak of the Mexican revolution in 1910 the capital, as always, proved to be the main prize. Without it, possession of other parts of the nation was relatively meaningless. From Feb. 9 to Feb. 17, 1913, troops loyal to the successful revolutionary president, Francisco I. Madero, engaged in an artillery duel from the national palace with rebels in the nearby Ciudadela, during which numerous victims were killed and many buildings, including the U.S. consulate, damaged. A counter-revolution headed by Victoriano Huerta resulted in Madero's death and brought temporary peace and stability. Though ringed with enemies seeking to avenge Madero's murder and Huerta's usurpation, the latter by control of the capital was able to resist until 1914. In subsequent civil wars the metropolis frequently changed hands until 1920, when some coherence reappeared and the revolution passed into a more constructive phase. Troubled countrysides helped swell the tide of emigration to the capital that increased as new social and economic elements came into being. A new phase in Mexico City's evolution was marked in 1930 by suppression of many small municipalities within its limits and the planning activities detailed below. The city's population at various years has been: 112,463 (1772); 131,000 (1790); 200,000 (1880); 331,781 (1895); 368,777 (1900); 470,659 (1910); 615,367 (1921); 1,029,068 (1930); 1,448,422 (1940); 2,233,914 (1950).

Metropolitan Growth.— At the centre of the aboriginal city of Tenochtitlán, Spaniards created a preplanned town for themselves, placing the main public buildings around a square and utilizing materials and Indian sites, so that the great cathedral stands very nearly on the spot of the Aztec main temple, and the viceroy's palace (now national palace) was substituted for the palace of the Montezuma. The grid plan employed in laying out streets for the then small city of Mexico became standard for the whole Spanish empire. Until Mexico City reached a population of more than 1,000,000 in 1930, its growth and development was haphazard and unplanned, as it gradually broadened and enveloped various new nuclei (colonias) from 1862 onward. Suppression of numerous municipalities and annexation in 1930 set the stage for a series of planning commissions, first of which mas founded in 1933, to reorganize and reform the metropolis. Between 1930 and 1950, the city more than doubled its population without significantly expanding its physical limits. For planning purposes, the city is divided into 19 zones, each of which has been assigned a function. As part of the reforms inaugurated in 1940, street names and numbers were unified, central railway cargo and passenger terminals constructed at the northern edges of the city, and an enormous University City built to house the National Autonomous University of Mexico at the south.

The central zone around the Zócalo remains the heart of the metropolis, and at it terminate most streetcar and city and national bus lines. Within a one-mile radius is the chief commercial and shopping district, chiefly to the south and west. Arterial avenues branch out toward the industrial and often slum-ridden areas to the east and north, while a principal avenue, Avenida de Francisco I. Madero, branches oti to the west, broadens to become the Avenida Juárez as it passes the Alameda, the city's oldest park, and the Palace of Fine Arts, and near a colossal monument to the revolution merges with the city's chief boulevard, the Paseo de la Reforma, which continues nearly 3 mi. to Chapultepec park. After 1940 a number of skyscrapers (offices, hotels and government buildings) sprang up along the Paseo, built on floating caisson foundations. Residential areas are in general south and west of the central zone, though at the extreme southwestern part of the city there is an industrial zone. One of the perennially fascinating aspects of Mexico City is the conjunction of old and new, as solid colonial Spanish constructions are still in use, many residences clinging to the Moorish fashion of interior patios, while near by are late examples of modern functional architecture. Similarly, in the more native sections of the city, toward the east, the Aztec language is still spoken. The striking contrasts within the city have since early days provided an almost inexhaustible literary theme.

Especially noteworthy buildings are grouped around the Zócalo. These include the cathedral consecrated as the church of La Asuncion de Maria Santisima and the largest in Latin America, started in 1573 but not completed until about 1810; the national pawnshop (Monte de Piedad) founded in 1775 and is now a part of the public charities; the municipal palace or city hall; and the national palace, containing modern murals, ancient relics and most of the executive government apparatus, as well as libraries and archives. At Chapultepec castle and the surrounding park, reached

by the impressive Paseo de la Reforma, are clustered numerous other points and items of interest and beauty, while each of the suburbs contains special features, such as the floating gardens at Xochimilco, the shrine at Guadalupe Hidalgo, University City, the Desert of the Lions and the archaeological ruins in the southern and western outskirts. The extensive City of Sports on the Avenida Insurgentes includes a bullring, a football stadium, a boxing arena, a frontdn court and a theatre.

Education and Culture. — As a direct dependency of the federal government, Mexico City's educational and cultural institutions are highly developed models for the rest of the nation. Within the national ministry of education a special department deals with the problem of primary and adult education for the federal district, which has about 1,200 elementary schools. About a quarter of the enrollment in secondary schools through the nation is concentrated in the federal district, specifically in Mexico City, with more than 100 schools (national and private). The National university was founded in 1551 as the Royal and Pontifical University of Mexico, interrupted during the 19th century and reopened in 1910; its several staffs train a student body of 30,000–40,000 annually in excellent schools ranging from architecture through law. Completion of University City in 1952 provided it with an impressive up-to-date plant. An interesting experiment in blending Mexican with American ways is represented by the privately run Mexico City college, founded in June 1940. Specialists of all sorts are trained at the huge and modern National Polytechnic institute, made autonomous in 1944, with 20,000 or more students. Near Mexico City at Chapingo is the National Agricultural school for advanced training. There are smaller schools of tropical medicine, health and hygiene and physical education, and a number of teacher-training schools. Most of the major centres of learning and teaching support extensive research and publication efforts; Mexican scholars connected with them and the diverse activities supported by government ministries in Mexico City have made notable contributions in astronomy, archaeology, chemistry, history, tropical medicine and all branches of the humanities. Mexico City is considered one of the great intellectual metropolises of the western hemisphere, a reputation gained and maintained in early colonial days. As compared with a national illiteracy rate of around 40% that of the Federal District and Mexico City is close to 15%.

Popular museums supplement the great collections in the National Ethnological and Historical Museum, just as local libraries paralleled the National library. The Benjamin Franklin library was established by Americans for Mexicans as a good-will gesture in 1942. The Palace of Fine Arts at the east end of the Alameda houses the National Theatre, art galleries and auditoriums.

Industry. — Mexico City's role as political and cultural head of the republic has traditionally been associated with its hegemony in fiscal and commercial matters; to this has been added the development of industry and manufacturing. It is the seat of the main sources of credit from private banking, national banks under the Banco de Mexico (founded in 1925 and later evolved into a central bank), and government-sponsored investments. With markets at hand, raw materials accessible and a vast labour pool, it is not surprising that Mexico City represents the single largest industrial aggregate in the republic. Much industrial expansion took place after 1944, when "new and necessary" industrial establishments within the federal district were given substantial tax exemptions and other aid in securing industrial sites at low cost by presidential decree. Dating from 1907 are iron and steel works (La Consolidada), leader among more than 30 foundries and fabricators in the district; other older industries include textiles, cigars and cigarettes, paper, shoes, bricks, glass, pottery, industrial chemicals and a wide range of food processing and household manufactures. There are numerous assembly plants established by large foreign producers, chiefly U.S., to finish their products in Mexico City. They include plants for automobiles and trucks, refrigerators, radio and television sets, electrical motors and appliances, pumps and miscellaneous consumer items. The total number of manufacturing establishments in and around Mexico City in the mid-1950s was estimated at 16,500, responsible for from 50% to 60% of the national manufacturing output.

Communications and Transport. — Mexico City's connections with the rest of the republic and the world are superior to its local facilities for moving people and goods from one part of the federal district to another, though neither are optimum. Rail, highway and air lines converge on the capital, a major terminal and transshipment point. Foreign-built and owned railways were nationalized, so that by mid-20th century no road longer than 100 mi. remained in private hands. Under the National Railways of Mexico, a semiautonomous government agency, efforts were made to standardize gauges and rehabilitate trunk lines by replacing light with heavy rails and to improve terminal facilities in Mexico City. The several small, scattered and unsatisfactory passenger stations were sold, and the money applied to construction of a modern union station north of the Zócalo. The Nonoalco freight station in the congested business zone gave way to a modern housing unit for 38,000 people, with a modern cargo terminal substituted in the suburb of Gustavo A. Madero (Guadelupe Hidalgo) near the major industrial core of the city. Rail connections from the capital link it to Veracruz by two lines, the old Mexicano and the old Inter-Oceanic, with connections to the isthmus of Tehuantepec and to Guatemala; a direct Mexico City-Tuxpán route was begun, while a link to the important Gulf port of Tampico is maintained indirectly via San Luis Potosi, which also is a transfer point for the Pacific port of Manzanillo (via Guadalajara). Connections between Mexico City and Guadalajara. terminal of the Mexican South Pacific, tap the Pacific littoral and thence to the U.S. border at Nogales. A trunk line from Laredo, Tex., to Mexico City is a major economic artery. Mexico City is linked to the peninsula of Yucatán and its local network, while Mexicali, Lower California, was reached by national lines via Sonora. About 2 mi. N.E. of Mexico City is a large central airport capable of handling the largest civil aircraft on the numerous scheduled national and international routes which crisscross the country. Several broadcasting stations and television transmitters (one the first in Latin America), long-distance and telecommunication circuits to the United States and Europe make the capital a prime communications centre.

The rapid growth of Mexico City created a serious internal transportation problem. The 16th-century city was ill-adapted to the sudden traffic load created by extensive use of vehicles by its swollen population. At the turn of the 20th century, British capital provided streetcars that continued in service, without major maintenance or replacement. In the mid-1950s within the city limits there were more than 140,000 vehicles, including about 100,000 private automobiles.

See also Index references under "Mexico City" in the Index volume. (HD. C.; R. B. McCK.)

MEYER, ADOLF (1866–1950), U.S. psychiatrist, whose teaching, called psychobiology (see PSYCHIATRY: History: Psychobiological School), was based on a concept of man as a psychologically integrated biological unit, was born Sept. 13, 1866, in Niederweningen, canton of Ziirich. Switz., obtained his medical education in Ziirich and went to the United States in 1892. Starting as pathologist in hospitals for the mentally ill, he found that he could not limit himself to the dead body but had to devise methods for the clinical study of the living patient. The outstanding scientifid and practical quality of his work at Worcester, Mass. (1895–1902), led to his appointment as director of the pathological institute of the New York State hospitals (1902–10), where his leadership revolutionized methods of treatment. In 1910 he was called to Baltimore, Md., to the chair of psychiatry at the Johns Hopkins university, with the responsibility of creating and directing the Henry Phipps psychiatric clinic. He was among the first to stress psychological factors as medically pertinent, and his "reaction sets" pointed to the variety of causes responsible for mental illness. His emphasis was always on the concrete person. Prevention was a strong interest, and he served as adviser in the organization of the National Committee for Mental Hygiene. He retired in 1941 and died March 17, 1950. Meyer's Collected Papers were published in four volumes, 1950–52, and his Psychobiology posthumously in 1957. (E. E. W.)

MEYER, CONRAD FERDINAND (1825–1898), one of the greatest of Swiss poets and novelists, was born at Ziirich on Oct. 11, 1825, and died on Nov. 28, 1898, at Kilchberg (near Ziirich), where he had settled in 1875. He studied law and pursued historical researches in Italy, but he began his career as author comparatively late in life. As compared with Gottfried Keller (*q.v.*), for example, Meyer is more of the cosmopolitan and patrician and less of the democrat. His style is singularly pure and polished, and he appeals strongly to readers of culture. His poems include *Balladen* (1867), *Romanzen und Bilder* (1870), *Huttens letzte Tage* (1871) and *Engelberg* (1873) — the last two powerful narrative poems. His *Gedichte* have been published in at least 20 editions. Of his novels, in which he shows a preference for Renaissance subjects, the most popular are *Jürg Jenatsch* (1876; 312th ed., 1924) and *Der Heilige* (1880; 198th ed., 1924). The latter was translated into English by M. von Wendheim, as *Thomas a Becket, the Saint* (1885). *Die Versuchung des Pescara* (1887) was translated by Mrs. C. Bell (1890). His charming short stories were collected in 1885, and went through many editions thereafter. Lives of Meyer were written by A. Reitler (1885); A. Frey (1900); R. d'Harcourt (1913); M. Nussberger (1919); and H. Maync (1925).

MEYER, EDUARD (1855–1930), German historian who established ancient Egyptian chronology, recognized the value to a historian of folklore, numismatics and historical monuments and did pioneer work in ancient history. Oswald Spengler was among those he influenced. Born in Hamburg, Jan. 25, 1855, he was educated at the excellent Johanneum school. where he began his classical and historical studies and learned Hebrew and Arabic, and at Bonn and Leipzig universities. He became professor of ancient history at Breslau (1885), Halle (1889) and Berlin (1902). Meyer's lifework was the *Geschichte des Altertums,* 3 vol. (1884–1902; new edition by E. Stier. 1953 *et seq.*), which he spent his later years revising. His numerous other books. including *Agyptische Chronologie* (1904), *Casars Monarchie und das Prinzipat des Pompejus* (1918) and *Ursprung und Anfänge des Christentums* (1921–23), were more detailed explorations into the universal history which was his goal. He died in Berlin on Aug. 31, 1930.

See H. Marohl, *E. Meyer Bibliographie,* with memoir (1941).

MEYER, KUNO (1858–1919), German Celtic scholar and editor whose fine translations made him the chief interpreter of Irish literature to English readers. was born at Hamburg on Dec. 20, 1858. After studies at Edinburgh and Leipzig, he became in 1884 lecturer in German at the University college, later the University. of Liverpool. An ardent propagandist, he founded the School of Irish Learning. Dublin (1903), and its journal *Ériu* (1904), as well as later establishing Celtic reviews in Germany. Meyer's many publications include *The Voyage of Bran* (1895) and *Selections from Ancient Irish Poetry* (2nd ed., 1911). In 1911 he became professor of Celtic at the University of Berlin. He died at Leipzig on Oct. 11, 1919. (Ms. D.)

MEYER, (JULIUS) LOTHAR (1830–1895), German chemist, was born on Aug. 19. 1830, at Varel in Oldenburg. His earliest work was on the chemistry of the blood, but his name is best known for the share he had in the development of the periodic classification of the elements (*see* PERIODIC LAW). He studied medicine at Zurich and Wurzburg and then turned to physiological chemistry at Heidelberg and finally to mathematical physics at Konigsberg. After lecturing on chemistry at Eberswalde and Karlsruhe, he became, in 1876, professor of chemistry at Tübingen. where he died on April 11, 1895.

Meyer noted, as did J. A. R. Newlands independently in England, that if the elements are arranged in the order of their atomic weights they fall into groups in which similar chemical and physical properties are repeated at periodic intervals. In particular he showed that if the atomic weights are plotted as ordinates and the atomic volumes as abscissas, the curve obtained presents a series of maxima and minima, the most electropositive elements appearing at the peaks of the curve in the order of their atomic weights. Other physical properties gave the same type of curve. His book on *Die modernen Theorien der Chemie,* which was first published in Breslau in 1864 and later translated into English, contains a discussion of relations between the atomic weights and the properties of the elements. In 1882 he, along with Dmitri Mendeleyev (*q.v.*), received from the Royal society the Davy medal in recognition of his work on the periodic law.

See K. Seubert, *Ber. dtsch. Chem. Ges.,* vol. *28,* p. 1103, and B. Bedson, J. *Chem. Soc.,* p. 1403 (1896); also: P. Walden, essay in G. Bugge, *Buch der grossen Chemiker* (1929–30).

MEYER, (MARIE) PAUL (HYACINTHE) (1840–1917), French philologist, who ranks as a great modern authority on the French language. was born in Paris on Jan. 17, 1840. He was educated at the École des Chartes and in 1863 was attached to the manuscript department of the Bibliothèque Nationale. In 1876 he became professor of the languages and literatures of southern Europe at the Collège de France. In 1882 he was made director of the École des Chartes and in 1883 became a member of the Academy of Inscriptions. He was one of the founders of the *Revue Critique* and a founder and the chief contributor to *Romania* (1872). Meyer began with the study of old Provençal literature. He edited many old French texts for the *Société des anciens textes français,* and independently. He died on Sept. 7, 1917, at Paris.

MEYER, VIKTOR (1848–1897), German chemist who developed an important method for measuring the density of vapours. was born at Berlin on Sept. 8, 1848. He studied at Heidelberg under R. W. Bunsen (inorganic and analytical); E. Erlenmeyer (organic); H. Kopp (theoretical chemistry); G. R. Kirchhoff (physics) and he also worked under A. Baeyer in Berlin. In 1871 he was appointed extraordinary professor at Stuttgart polytechnic, and in 1872 succeeded J. Wislicenus at Zurich polytechnic. He was then only 24. In 1885 he obtained the chair of chemistry at Göttingen, and in 1889 he succeeded Bunsen at Heidelberg. He was awarded the Davy medal in 1891. Meyer proved to be not only a great investigator but also a stimulating teacher, with a wonderful command of language. He suffered from ill-health and committed suicide on Aug. 8, 1897. He is buried not far from Bunsen and Kopp in the Heidelberg cemetery.

Meyer's first papers dealt with the composition of a camphor, chloral hydrate and the structure of benzene. In 1872 he discovered the aliphatic nitro compounds (*q.v.*), and this led him on to the study of nitroso compounds and nitrols. In 1882 he discovered the oximes (*q.v.*) and showed that they can exist in stereoisomeric forms; he also investigated the chemistry of these compounds thoroughly. He invented the term "stereochemistry." In 1871 he devised a method for determining vapour densities, and this led him on to a series of pyrochemical studies, in which the vapour densities of inorganic substances were determined at fairly high temperatures. The results of this work, with his brother, Carl Meyer, were collected in *Pyrochemische Untersuchungen* (1885). In the course of a lecture demonstration he made an observation which led him to the discovery of thiophene (*q.v.*) in 1883; he studied the substance and determined its structure; the results are published in *Die Thiophengruppe* (1888). In 1892 he discovered the iodoso compounds. He also studied "steric hindrance," a name coined by him. He and Paul Jacobson compiled the famous large *Lehrbuch der organischen Chemi,* 2 vol. (1893–96; 2nd ed., 1922–29).

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MEYERBEER, GIACOMO (1791–1864), German composer, whose eclecticism won him simultaneously in his lifetime great success abroad and a verdict that he had betrayed German music. First called Jakob Beer, he changed his name to Meyerbeer after he received a legacy from a relation named Meyer; Giacomo resulted from his Italian success. Born at Berlin. Sept. 6. 1791. he studied the pianoforte, first under Franz Lauska. and later under Lauska's master, Muzio Clementi. When seven years old he played Mozart's Concerto in D Minor in public, and at nine he

was pronounced the best pianist in Berlin. For composition he was placed under Carl Friedrich Zelter and then under Bernard Weber, director of the Berlin opera, by whom he was introduced to the Abbé Vogler, the organ virtuoso and teacher. Vogler received him into his house at Darmstadt. where he formed an intimate friendship with Carl Maria von Weber. In 1812 the grand duke appointed Meyerbeer court composer. His first opera, *Jeptha's Gelübde*, failed at Munich in 1812 and his second, *Wirth und Gast (dlimelek)*, was an even greater failure at Vienna in 1814. Bitter disappointment over these failures drove him to Italy. At Venice he was captivated by Rossini and produced a succession of Italian operas — Romilda *e Costanza* (Padua, 1817), *Semiramide riconosciuta* (Turin, 1819), *Emma di Resburgo* (Venice, 1819), *Margherita d'Anjou* (Milan, 1820) — which all achieved a success as brilliant as it was unexpected. Against this act of treason to German art Weber led the protest, and an invitation to Paris in 1826 led Meyerbeer to review his position dispassionately. For several years he produced nothing in public; but, in concert with Scribe, he planned his first French opera, *Robert le Diable* (Grand Opéra, 1831). It was the first grand romantic opera, with situations more theatrically effective than any that had been attempted either by Cherubini or Rossini, and with ballet music such as had never yet been heard, even in Paris.

His next opera, *Les Huguenots*, was first performed in 1836. In gorgeous colouring, rhetorical force, consistency of dramatic treatment and careful accentuation of individual types, it is at least the equal of *Robert le Diable*. Meyerbeer then spent many years in the preparation of his next greatest works — *L'Africaine* (Paris. posthumously. 1865) and *Le Prophète* (Paris. 1849). The libretti of both these operas were furnished by Scribe; and both were subjected to countless changes.

Meanwhile Meyerbeer accepted the appointment of general music director to the king of Prussia and spent some years at Berlin, where he produced *Ein Feldlager in Schlesien*, a German opera, in which Jenny Lind made her first appearance in Prussia. There he also composed, in 1846, the overture and incidental music to his brother Michael's drama, *Struensee*. But his chief occupation after 1845 was conducting and his chief care at this period was bestowed upon the worthy presentation of the works of others: Weber's *Euryanthe*, and *Rienzi* and *Der fliegende Holländer*, the first two operas of Richard Wagner, who, then in poverty and exile, would! but for him, have found it impossible to obtain a hearing in Berlin. With Jenny Lind as prima donna and Meyerbeer as conductor, the opera flourished brilliantly in the Prussian capital. In 1854 he brought out *L'Étoile du nord* at the Opéra Comique and in 1859 *Le Pardon de Ploermel (Dinorah)*. His last great work; *L'Ajricaine*, was in active preparation at the Académie when, on April 23. 1864, he became ill, and died on May 2.

MEYERHOF, OTTO (1884–1951), German biochemist, was awarded the Nobel prize in physiology and medicine, jointly with A. V. Hill (*q.v.*), in 1922 "for his discovery of the fixed relationship between consumption of oxygen and the metabolism of lactic acid in muscle." Meyerhof was born at Hanover. Ger.. on April 12, 1884. He studied medicine at the universities of Freiburg, Berlin. Strasbourg and Heidelberg (M.D., 1909).

Meyerhof's early interests were in psychology and philosophy, but under the influence of Otto Warburg he turned to the study of physiology and physical chemistry. He held positions at Kiel and at other German universities, and became well known in England and the United States as a visiting lecturer and as the author of a book on *The Chemical Dynamics of Life Phenomena* (1924). In 1929 he became head of the department of physiology of the Institute for Medical Research in Heidelberg, but in 1938 he was forced to leave Germany. He continued his work in Paris. and, after the German invasion of France in 1940, escaped to the United States, where he was appointed research professor in the department of physiological chemistry at the University of Pennsylvania. Although Meyerhof's work was greatly revised and extended as a result of later research it remained a basic contribution to the knowledge oi the very complex processes involved in muscular action. He died in Philadelphia, Pa., Oct. 6, 1951. (W. J. Bp.)

MEYERHOLD, VSEVOLOD EMILIEVICH (1874–1942), Russian theatrical producer who was head of the Communist theatre throughout the U.S.S.R., received his early training (1898–1905) in Stanislavsky's Moscow Art theatre. His stylistic experiments conflicted, however, with Stanislavsky's emphasis on naturalism. Subsequently Meyerhold developed his highly individualistic theories in a theatre with no proscenium, no curtain and a bare stage with the action projected on a forestage against constructivist and scenic abstractions.

During the Russian Revolution he became head of the theatre section of the Commissariat of Education, responsible for all Bolshevik theatre activities including a new form of political propaganda theatre for the masses. His productions developed a more allegorical and symbolical style and in the 1930s was criticized as too individualistic; *Camille* in 1936 and Tschaikovsky's *Queen of Spades* were said to reflect a bourgeois, formalistic departure from the revolutionary pattern. *Pravda* denounced him for his persistent production of "anti-Soviet" plays and he came under the fire of Communist party officials. His theatre was liquidated. In June 1939, as a principal speaker before the first national convention of theatre directors in Moscow, he clarified his own views on the art of the theatre. The following day he was arrested and he was not heard of again in the west until 1958, when the *Great Soviet Encyclopaedia* reported his death in 1942. Meyerhold wrote *On the Theatre* (1913) and *Reconstruction of the Theatre* (1930). (D. M. O.; X.)

MEYER-LUBKE, WILHELM (1861–1936), Swiss philologist, a central figure of Romance linguistics, was born in Dübendorf, Switz., on Jan. 30, 1861, and taught at Zurich, Jena, Vienna (1890–1915) and Bonn. Meyer-Lubke established his reputation as a comparativist with his *Grammatik der romanischen Sprachen* (4 vol., 1890–1902; French trans., 1890–1906), which revolutionized the discipline and with his less influential *Romanisches etymologisches Wörterbuch* (1911–20; 3rd ed., 1930–35). He published manuals and monographs on Old Sardinian (1903), Old Portuguese (1904–17), Catalan (1925) and Rumanian; his *Italienische Grammatik* (1891), revised and translated into Italian, became widely accepted. The *Historische Grammatik der französischen Sprache* represents for phonology (1908), chronological sequences and for derivation (1921), a novel patterning around functional nuclei. Most successful in methodology, Meyer-Lübke reached his peak in the *Einführung in das Studium der romanischen Sprachwissenschaft* (1901; 3rd ed., 1920; Spanish trans. and rev, by R. Castro, 1926). He died Oct. 4, 1936, at Bonn, Ger. (*Y.* M.)

MEYNELL, ALICE (1849–1922), English poet, was the younger daughter of Thomas James Thompson, who after his marriage with Christiana Jane Weller, a beautiful and accomplished girl to whom her friend Charles Dickens introduced him, made his home much in Italy. Thompson devoted himself to the liberal learning of the two daughters: Elizabeth, afterward Lady Butler, noted as a war painter; and Alice, who early began to put her rhymed thoughts shyly upon paper.

Alice's volume of *Preludes* (1875) was issued by Tennyson's then publisher, Henry S. King, on the word of his "reader" — later his successor — C. Kegan Paul, who, not trusting his own judgment all the way. read some of them aloud to George Eliot. receiving her deciding approbation. The critics were mostly silent; and even those who praised hesitated. But the volume made its own quiet way. It brought her many a friend — and more. For the reviewer in *Tlze Pall Mall Gazette* — *a* paper to which she was later to be a conspicuous contributor — quoted the sonnet, "My Heart Shall Be Thy Garden," and found for it a reader whom it reached revealingly. A consequent introduction to the sonneteer by a common friend was followed by a marriage. On Mrs. Wilfred Meynell, as she then (18; 7) became, fell a long silence as a poet. Eight children were born. one of whom died in infancy. A sensitiveness to life's cruelties put her, for all her reticence, on political platforms. and marched her in many processions, in favour of granting votes to women and opening professional doors.

Her married life matured her vigilance as a mistress of prose. In W. E. Henley of *The Scots Observer* and *Tlze National Observer*, she encountered an editor who heartened her by his

boisterous welcomes: "That woman's taking her place at the steering wheel" was one of his recorded acclaims. Later, in *The Pall Mall Gazette* of Harry Cust's editorship, she was accorded a weekly column which left her a large range in the choice of subjects. George Meredith, reading here her "princely journalism," sought with her an acquaintance that soon became a "dearest friendship."

Coventry Patmore, too, her yet warmer admirer, published. when Tennyson died, his unavailing plea for her succession to the laureateship. Her close friendship for such seniors coincided with that for her contemporaries, and for her juniors. chief among whom was Francis Thompson, who addressed to her his exquisite sequence of poems *Love in Dian's Lap,* of which, Patmore said, Beatrice or Laura might have been proud.

Alice Meynell's *Preludes* (1875), long out of print, re-appeared in a volume of *Poems* (1893) including new ones; and these, together with yet later verses separately issued as *A Father of Women* (1917) and *Last Poems* (1923), were assembled in the complete volume of *Poems* (1923). Of her prose, several small volumes of essays in the 1890s—The *Rhythm of Life* (1893), *The Colour of Life* (1896) and *The Spirit of Place* (1899)—mere folloned by *Ceres' Runaway* (1909), by *Hearts of Controversy* (1917), by *The Second Person Singular* (1921) and finally by the standard volume of selected *Essays* (1914)—the selection being her own. Other books were *John Ruskin* (1900), *The Children of the Old Masters* (1903), *Mary, the Mother oj Jesus* (1912) and *London Impressions* (1898). Two anthologies give her choice among poems—The *Flower of the Mind* (1897) and *The School of Poetry* (1923), the first including Notes and the second Commentaries. She prefaced editions of *The Sonnets from the Portuguese* and Christina Rossetti's *Poems* (1910), as well as a decade of volumes "The Red Letter Library"; she introduced in 1903 a volume of reproductions of Sargent's Portraits; and she made for English readers a Selection from the Poems of J. B. Tabb (1906). She died in London on Nov. 27, 1922. (W. ME.; X.)

See Viola Meynell, *Alice Meynell* (1929).

MÉZIÈRES, PHILIPPE DE (*c.* 1327–1405), French soldier and author, was born at the chbteau of Mézières in Picardy. He served under Lucchino Visconti in Lombardy and under Andrew, king of Naples, who was assassinated in Sept. 1345. He then set out for the east in the French army. After the battle of Smyrna in 1346 he was made a knight, and went to Jerusalem.

He planned a new order of knighthood, the first sketch of which was drawn up by him in his *Nova religio passionis* (1367–1368; revised and enlarged in 1386 and 1396). In 1347 he went to Cyprus to the court of Hugh IV, but he soon left Cyprus and had resumed soldiering when the accession of Peter I to the thrones of Cyprus and Jerusalem (Nov. 1358) induced Mézières to return, probably in 1360, when he became chancellor. He came under the influence of the pious legate Peter Thomas (d. 1366), one of the chief promoters of the crusade of 1365.

In June 1366 Mézières was delegated to obtain help for Cyprus against Egypt. His efforts were in vain: even Pope Urban V advised peace with the sultan. Mézières remained for some time at Avignon, seeking recruits for his order, and writing his *Vita S. Petri Tlzomasii* (Antwerp, 1659), which is invaluable for the history of the Alexandrian expedition. The *Prefacio* and *Epistola,* which form the first draft of his work on the projected order of the Passion, were written at this time.

Mézières returned to Cyprus in 1368, but was again in Venice when Peter I mas assassinated at Nicosia at the beginning of 1369. He remained in Venice until 1372, when he went to the court of the new pope Gregory XI at Avignon. In 1373 he was in Paris, and he was thenceforward one of the trusted counselors of Charles V. He was tutor to the future Charles VI, but after the death of Charles V he was compelled to retire. He lived thenceforward in the convent of the Celestines in Paris, but continued to exert an influence on public affairs.

To this period of his life belong most of his writings. Two devotional treatises belong to 1386–1387. In 1389 he wrote his *Songe du vieil pélerin,* an elaborate allegorical voyage in which he described the customs of Europe and the near east and advocated peace with England and the pursuit of the crusade. His *Epistre lamentable* was written after the disaster of Nicopolis (1396). Mézières died in Paris on May 29, 1405.

MEZÖTÚR, a town in Hungary near the right bank of the Koros. It is a market and fair town for the cereal and cattle-rearing district in which it lies. It has also small flour mills and important potteries. Pop. (1957) 24,000 (mun.).

MEZZO-SOPRANO: *see* SINGING.

MEZZOTINT or **MEZZO TINTO,** as it was first called, is a process of engraving in which a plate that has been prepared to produce a black impression in paper is burnished in such a way that it will produce a picture in tonal values. A copper or steel plate is first pricked with innumerable small holes which mill hold ink. The pricking of the plate was originally done with a roulette or small wheel covered with sharp points, but later an instrument called a cradle or rocker was used. This resembles a small spade with a toothed edge and with it a copper or soft steel plate can quickly be roughened all over. Nevertheless. this is a tedious and laborious procedure. The rocking process not only punctures the plate to hold ink, but also produces a burr on the metal's surface. which, cutting into the paper while in the press. causes a deeper absorption of ink. and produces that velvety effect characteristic of the mezzotint in an early impression.

After the surface of the plate has been prepared, the high lights in the picture are obtained by scraping away and burnishing parts of the plate. thus reducing or obliterating the small holes, according to the effect desired. The surface of the roughened plate is left undisturbed where the deepest black is required. and by a graduated scraping of the plate. which removes both burr and punctures so that ink is held in lesser degrees, middle and light tones are obtained when an impression is taken from it. In mezzotint, as in all other forms of printmaking, the ink used is a thick ink which does not run.

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"THE STANDARD BEARER" BY PRINCE RUPERT (1619–1682): DUTCH. IN THE ART INSTITUTE OF CHICAGO

HISTORY

The 17th Century.—About the middle of the 17th century, Ludnig van Siegen (1609–76), a Dutch officer in Hessian service, who was also an amateur artist, applied the old device of dotted work to a metal plate by means of a small roulette, and succeeded in producing an excellent print entirely by its use. His portrait of Amelia Elizabeth of Hesse (1642) is the earliest dated mezzotint. In 1654. Van Siegen met Prince Rupert, count palatine of the Rhine and grandson of James I of England, at Brussels. Prince Rupert, a skilled amateur artist, became deeply interested in Van Siegen's invention, which he at once tried. In a short time he produced a very fine piece of rouletting in a print of "The Large Executioner," after José Rihera. William Sherwin. the English engraver and a friend of Prince Rupert, learned the new art from him and made mezzotint portraits of Charles II and his queen in 1669, dedicating them to Prince Rupert.

The early mezzotinters were Dutchmen who, curiously enough, did most of their work in England. Their productions are not particularly distinguished until the arrival in 1673 of Abraham Blooteling who did splendid work, especially after Van Dyck, Sir Godfrey Kneller and Sir Peter Lely. However, his greatest contributions to the method were his improvements in technique. Instead of using only a roulette to produce dark space. he began by roughening the plate all over, so that if printed from, it would show simply a black space, and then he cut away the roughness with a scraper to render the high lights as required. It was Blooteling who invented the tool called the rocker, which is described above, and substituted it for the roulette.

The 18th Century.— After Blooteling, and during the 18th century, a remarkable school of English mezzotinters became prominent, and did such distinguished work that abroad the process became known as *la manière anglaise*. This pre-eminence was due. not only to their remarkable skill and the beauty of their work, but also to the fact that there were in England at that time portrait painters of the very first rank for them to interpret. We owe the existence of the finest mezzotints ever made to the inspiration of men like Lely, Reynolds, Lanrence, Romney, Hoppner, Constable and several others of lesser reputations. It was in England that J. C. Le Blon (1667–1741) made the earliest attempts to produce multicolour mezzotints.

BY COURTESY OF THE ART INSTITUTE OF CHICAGO

"SIR JOSHUA REYNOLDS" BY VALENTINE GREEN (1739–1813); ENGLISH. 18TH CENTURY. IN THE ART INSTITUTE OF CHICAGO

Early in the 18th century an Irishman. Thomas Frve (1710–62), who had tried several other byways of art before specializing in mezzotint, ended by "scraping" a series of large portrait heads from his own drawings. Another Irishman James MacArdell (1729–65), became one of the greatest mezzotinters. Sir Joshua Reynolds had so high an estimation of MacArdell's work that he declared he would be immortalized by his engravings, a statement which may prove true because the paintings have in many cases deteriorated badly and the mezzotints of MacArdell are lasting records of their original qualities. Richard Earlom (1743–1822) used only the roulette where he wanted shadows. His most famous work is the "Liber Veritatis" after the drawings of Claude Lorrain uhich suggested to J. M. W. Turner, in the next century. his "Liber Studiorum."

The numerous mezzotints by Valentine Green (1739–1813) are of the highest quality. He frequently printed his plates in brown ink, a practice nhich became very popular. and he was especially successful in his renderings of the full length female portraits by Sir Joshua Reynolds. John Raphael Smith (1752–1812) began his artistic career as a miniature painter. but eventually became one of the foremost mezzotint engravers. He worked mainly after Reynolds but was very successful in his interpretations of Romney. S. W. Reynolds (1773–1835), uho made 357 plates of portraits after Sir Joshua Reynolds. was much more successful in his larger plates. He was an accomplished artist and produced many plates after his own work. Later he did mezzotinting on some of the plates in Turner's "Liber Studiorum."

The 19th Century.— The use of steel plates for mezzotint was introduced by William Say (1768–1834), who sought to substitute a more durable metal for copper which, because of its softness, produced only a small number of impressions of high quality. He used a hard steel and the results were not as satisfactory as those of T. G. Lupton (1791–1873), nho employed a softer quality of the same metal. Instead of being able to print only about 50 proofs of excellence from copper, it was found possible to print about 1.500 from steel, without the appearance of deterioration.

Samuel Cousins (1801–87), an apprentice to S. W. Reynolds, used etching and engraving freely nith mezzotint. so much indeed that his method is known as the "mixed" style. His plate of "Bolton Abbey in the Olden Time," after Sir Edwin Landseer, published in 1837, is said to have killed the art of line engraving in England by proving that paintings could be much more effectively reproduced by mezzotint.

The 20th Century.— Despite its inimitable charms and individual qualities, mezzotint had always been practised principally as a reproductive medium and the introduction of photogravure and a myriad of photomechanical processes has mode it almost obsolete. During the latter part of the 19th and the first half of the 20th centuries it had its practitioners, although it had lost much of its purpose and vitality. Sir Frank Short, C. W. Campbell, John D. Miller. Gerald P. Robinson, William Strang and S. Arlent Edwards produced work which had success with amateurs and collectors but was looked upon as old-fashioned by the following generation. The once highly popular medium has been rarely used since. Its most distinguished and almost solitary advocate afterward was Yozo Hamaguchi, a Japanese artist living in Paris.

See also ENGRAVING, LINE; ETCHING; STIPPLE AND CRAYON ENGRAVING.

BIBLIOGRAPHY.—John Evelyn, *Sculptura* (1662), with the first mezzotint ever published in a book, a head of "The Large Executioncr" by Prince Rupert; J. C. Le Blon, *L'Art d'imprimer les tableaux* (1756); *L*. de Laborde. *Histoire* de *la gravure en ntanidre noire* (1839); John Chaloner Smith, *British Mezzotinto Portraits,* 4 vol. (1884); Cyril Davenport, *Mezzotint* (1904); Charles E. Russell, *English Mezzotint Portraits and Thrir States, From the Invention of Mezzotinting Until the Early Part of the 19th Century,* 2 vol. (1926).

(C. DA.; H. Es.)

MIAMI, a tribe of North American Indians of Algonkin stock, closely related to the Illinois. They were first found around Green Bay. Wis., about 1668. Their civilization was advanced, and they lived in stockaded towns.

See W. V. Kinietz, *The Indian Tribes of the Western Great Lakes* (1940). (H. B. Cs.)

MIAMI, the metropolis of southeastern Florida. U.S., the transportation and business hub of Greater Miami and the administrative and political centre of Dade county. The city is located on Biscayne bay at the mouth of the Miami river. The climate and vegetation are subtropical. with generally wet summers and dry winters. Average monthly mean temperature ranges from 66.5° F. in January to 81.4° in August, with recorded extremes of 27° and 97°. The warmth of the north-flowing Gulf Stream and the prevailing southeasterly winds help to make an ideal winter climate for tourists: tropical fruits and vegetables.

Greater Miami. or the Miami standard metropolitan statistical area (as defined by the federal census), comprises all of Dade county and includes several smaller cities. each with its own personality. Only Miami Beach (*q.v.*), across Biscayne bay on the Atlantic ocean. is older than the real-estate boom of the 1920s. Until 1912 it was a mangrove swamp on which coconuts and avocados had been planted. It since became the tourist, hotel and convention centre of Greater Miami with housing for 120.000 visitors. West of Miami. Coral Gables (*q.v.*), born of the real-estate boom and chartered in 1925, is almost exclusively a middle and upper middle-class residential city with many winter homes and apartments rather than hotels. Hialeah (*q.v.*), to the northeast, grew from a ranch in 1911 to a real-estate development in 1917 to incorporation in 1925. Hialeah is characterized by its industries and the workers who live there and by Hialeah Park, the leader of Miami's three horse tracks. North Miami (*q.v.*) represents the northern reach of Miami.

Other smaller municipalities are: North Miami Beach, Miami Springs, Opa-Locka, Miami Shores and South Miami. Yet another group of 13 municipalities range in population up to 5,000; seven of them are under 1.000. The population of the city of Miami in 1960 was 291.688; of the metropolitan area, 935,047. (For comparative population figures *see* table in FLORIDA: *Population.*)

History.— Spaniards in the 16th century found a village of Tequesta Indians at the mouth of the river, estimated to have been there for perhaps 2,000 years, subsisting chiefly on the bounties of nature. The name "Mayaimi" seems to have belonged to a large inland lake, probably Okeechobee, and to a nearby Indian group who may have been in contact with Biscayne bay by way of the watery Everglades. In 1567 the Spaniards planted a mission among the Tequesta tribe in a futile effort to pacify the hostile Indians, protect the route of the treasure fleets from America and provide a refuge for victims of storms and wrecks on the Florida reef.

The British made the first recorded land grant in 1774 during their 20-year control of Florida, but nothing came of it. The Spaniards returned (1784–1821) and made five grants in the city area. Richard Fitzpatrick acquired the lands early in the Ameri-

can period and came with slaves to establish a plantation of cotton and tropical fruits. The Seminole War in 1835 made the slave property insecure and Fitzpatrick moved to Key West. U.S. armed forces occupied the plantation and named it Fort Dallas. Naval and military expeditions into the interior by way of the Miami river and the nearby Everglades sought out the Indians to punish them for raids and to remove them to Indian territory.

After passing through several hands the lands north of the river came to Mrs. Julia D. Tuttle, "mother of Miami." South of the river, William B. Brickell established a home, a post office and a trading post frequented by Seminole Indians who brought in skins, hides and feathers. A few settlers drifted in around the 1890s. Usually homesteaders, they lived by gardening, hunting, fishing, beachcombing and some fruit and vegetable farming for the Key West market, from which some of the produce reached New York by the Mallory Line steamers. Boat onners often engaged in "wrecking." the salvaging of ship and cargo from wrecks on the Florida reef, the most lucrative business until about 1900.

In 1896, induced in part by Mrs. Tuttle. Henry M. Flagler pushed his Florida East Coast railroad to Miami and started the Royal Palm hotel. Miami was incorporated in the same year. TRO years later the Spanish-American War made Miamians conscious for the first time of their all-important geographical relationship to Cuba and other Latin-American lands. The Royal Palm hotel was filled with people on war business, and the 7.500 troops uho came to protect the 1,500 Miamians completely overwhelmed them during their brief stay.

Miami slowly grew to almost 30.000 people by 1920. It then became the focus of the Florida land boom and by 1925 had almost 85,000 inhabitants. By the end of 1926 the boom had come and gone, reaching its highest point in 1925 when building permits in the area totaled over $100,000,000. The *Miami* Herald for a time led the nation in the amount of newspaper advertising linage sold and the *Miami Daily* News put out an edition of 504 pages in 32 sections. In Sept. 1926 a severe hurricane, the first in 20 years, destroyed any hope that the boom might be revived and made a shambles of flimsy boomtime construction. Many tangible benefits remained, however, such as streets and sidewalks cut into the wilderness that would be developed after World War II, highways. a second railroad, a 27-story courthouse and a downtown skyline that would not be altered until the new surge of building in the 1950s.

The expansive 1920s led to the growth of older communities and some new ones around Miami. The central city grew from 13 to 43 sq.mi. in 1925 by annexing Allapattah, Buena Vista, Coconut Grove, Lemon City. Little River and Silver Bluff. all of which remain clearly identifiable sections of the city. Coconut Grove. oldest and most unique, several miles down the bay, had once been better known than Miami, with the Peacock inn, the first tourist hotel in the region, the Biscayne Bay Yacht club, the Coconut Grove Subscription library and the Housekeepers' club. This area still allows for individuality in architecture and attracts many artists and writers as residents.

Pan American World airways based its overseas operations on the Miami waterfront until overwater flights became land-based. The old terminal became the Miami city hall; one large hangar was converted into a 12,000-seat meeting hall; and other buildings house various city administrative departments. The U.S. coast guard maintains a base there.

Though Miami annexed no other territory and population grouth in satellite communities was more rapid in the mid-20th century, the city tripled its 1930 population in the next 30 years. More significant was the appearance after World War II of new skyscraper hotels and business buildings and the expansion of the mercantile, financial and professional services in the donntown area. Miami responded to the competition of outlying areas with greater attention to traffic problems, advertising and specializations of its offerings.

Metropolitan Government. — Mid-20th century political and governmental developments are of revolutionary importance. Miami adopted a commission-manager plan of government in 1921 but since 1957 some municipal functions have been taken over by a county-wide government with broad powers over municipal affairs. This metropolitan government could absorb the municipalities. Otherwise, since Miami is completely surrounded by incorporated areas that show no interest in annexation, any integration with the central city is difficult. The county board of commissioners, which appoints the county manager and directs policy, is made up of 13 members, one elected by each of the five old county districts, five by the county as a whole, one by the city of Miami, one by Miami Beach and one by Hialeah. Any municipality with 60,000 people—a status reached by Miami Beach and Hialeah in 1960—may elect a commissioner. Abolition of any of the municipalities may be accomplished by a vote of its citizens without further action by the state legislature. The board of county commissioners also functions as a port authority, makes policy and appoints a director for the Miami International airport and the port of Miami. Public schools of the county, consolidated in 1945, are administered by an elected board of public instruction.

The Economy. — The great debate in the Miami area is tourism versus a diversified economy. In the 1960s tourism led, but industry was growing more rapidly (see also FLORIDA). Miami's industries are selective, being limited mostly to clothing, plastics, electronics, contract construction and allied industries, with cement plants west of the city utilizing the native limestone. Manufacturing ranks third after wholesale and retail trade and services. including hotel services. The effort is to increasingly attract visitors the year around, and conventions play a larger role in the economy. Miami and Miami Beach, with private and public facilities, are most active,

Greater Miami is served by railroads to the north and south; the Dixie highway, Tamiami trail, Sunshine State parkway and other highuays lead to the north, south and west. The port of Miami, an ocean harbour on Biscayne bay near the downtown business district is being replaced by a new port facility under construction on a nearby island. Miami International airport handles both passengers and freight cargo; most of the volume of international cargo goes to Latin-American destinations. A new airport costing $80,000,000 and a $26,000,000 terminal opened in 1959. In the 3.000-ac. airport area are numerous aircraft overhaul and outfitting plants.

Education and Cultural Activities. — The University of Miami in Coral Gables, Barry college, a Catholic school for women in North Miami and public. private, and parochial elementary and secondary schools attract people interested in educational opportunity. The Jackson Memorial hospital is the centre of a complex of medical services which, together with the University of Miami school of medicine, make this a growing health centre. The Miami public library, with branches and bookmobile services, together with the libraries of some of the older municipalities, provide books for every age and interest group. Other cultural activities include the University of Miami Symphony orchestra, the Miami Beach Summer Pops orchestra, the Miami Opera guild, two subscription concert series, the Coconut Grove playhouse, the drama, music and art activities of the university and college, experimental play groups, Vizcaya (the estate of James Deering, a palatial villa of Italian type, now a county museum), the Historical Association of Southern Florida, the Museum of Science and Natural History and the Fairchild Tropical gardens.

Recreation. — Recreational facilities abound with yacht clubs, docking facilities and boat services, boat liveries and charter boats for the water-minded, and several golf courses, part of them public. Horse tracks, greyhound tracks and a jai alai fronton operate in the winter and permit parimutuel wagering. The Orange Bowl stadium is in Miami. (C. W. TE.)

MIAMI BEACH, the hotel, tourist and convention city of southeastern Florida, U.S., in Dade county, lies on the ocean front with 9 mi. of natural sandy beach; it is separated from the mainland and the city of Miami by Biscayne bay. Until 1912 this 7.4-sq.mi. island was a mangrove swamp. Henry B. Lum and his son had planted 38,000 coconuts, and John S. Collins, another nursery-

man from Morristown, N.J., had planted a large acreage of avocados. In 1912 the reclamation and development of the island began. Collins and his son-in-law, Thomas J. Pancoast. started a wooden bridge across.the bay. The brothers J. N. and J. E. Lummus, Miami bankers. refinanced the bridge and began to take an active part in the development. In the same year Carl Graham Fisher became interested in the project, to which he brought youthful energy and ample means, and as a result of their combined efforts Miami Beach was incorporated in 1915, with J. N. Lummus the first mayor. In 1920 the first of four causeways across the bay was built in Dade county, this one carrying street railway tracks. In 1921 Pancoast headed the first chamber of commerce and started an extensive advertising campaign to attract visitors. Growth was slow. the population being only 6.494 in 1930. The 1926 collapse of the Florida land boom stopped all activity; the national depression followed and World War II halted a wave of recovery and hotel building. The war ended the tourist business but served to advertise the city widely when the U.S. government took over three-fourths of the hotels to house trainees in the armed services. Thousands of men spent six or more weeks on the beach and the families of many visited them. After the war the hotels along the beachfront grew northward, highlighted by the plush Fontainbleau, the Eden Roc and the Americana. Behind the hotels were apartments and homes. Many of the more exclusive homes are on 28 man-made islands in the bay, connected to each other and to roadways by bridge and causeway.

The size of the city's resident population (63,145 in 1960) is no measure of its relative importance. Its hotels, motels and apartments provide housing for 120,000 visitors. There are one-third more telephones than permanent residents. Miami Beach is becoming a year-round resort and convention city. Many of the larger hotels provide meeting facilities for 450 to 5,000 persons. The city auditorium seats 3.500 and the adjoining exhibition hall 15,000. Recreation and entertainment are big business. The beach (much of it private for beachfront hotels), private and public golf clubs, boating and fishing services! night clubs and restaurants, the Miami Beach Kennel club, and specialty shops on Lincoln road and in the largest hotels cater to the visitors. The city has no industries, no railroads and no airports. It receives its visitors by way of Miami and the multiple transportation services there, as well as by yacht and automobile. It has a council-manager form of government, in effect since 1923; some municipal functions were being turned over to the metropolitan Miami government (see also MIAMI).

For comparative population figures see table in FLORIDA: *Population.* (C. W. TE.)

MIAO-TSZE, a term: meaning "the Miao people," often indiscriminately applied to hill tribes of southwest China but properly restricted to groups calling themselves Hmong living mainly in Kweichow and Yunnan. Miao live interspersed with Chinese whose culture they have largely adopted: their own language has affinities with Mon. The subtypes Pei Miao. Ch'uan Miao, Hua Miao. etc. indicate mainly regional differences of costume. The whole group numbers some millions.

See D. C. Graham, articles on Ch'uan Miao, *Journal of the West China Border Research Society* (1937–38); M. P. Mickey, *The Cowrie Shell Miao of Kweichow* (Salem, Mass., 1947). (E. R. L.)

MIAOULIS, ANDREOS VOKOS or BOKOS (1769–1835), Greek admiral and politician, was born in Euboea. He settled in the island of Hydra east of the Morea. and with the islanders took an early and active part in the Greek War of Independence. As early as 1822 Miaoulis was appointed navarch, or admiral, of the swarm of small vessels which formed the insurgent fleet. For events of the struggle see GREEK INDEPENDENCE, WAR OF. He continued to be the naval chief of the Greeks till Thomas Cochrane entered their service in 1827, when he retired in order to leave the English officer free to act as commander. When independence had been obtained. Miaoulis in his old age was entangled in the civil conflicts of his country, as an opponent of Capodistrias an'd the Russian party. He used his skill in the employment of fireships against them at Poros in 1831. He died on June 24.1835 at Athens.

MICA, an important group of common rock-forming minerals characterized by their highly perfect cleavage yielding thin laminae (sheets or flakes). The name is the Latin *mica,* "a grain." The principal members of the group are muscovite, biotite and lepidolite. These are aluminosilicates with potassium, magnesium, iron or lithium. as well as hydroxyl or fluorine. The micas as a group are highly variable in chemical composition. physical and optical properties and occurrence; however. they are all based on a simple crystal-structure unit (see Crystal *Structure,* below).

The different kinds of mica vary greatly in colour and are frequently zoned. Muscovite is commonly colourless and may be gray, brown. light green. lavender or ruby red. The biotites are commonly black, brown, green. yellow and occasionally colourless. Pink. violet, yellow, gray, red. brown and green are the colours displayed by the lepidolites. The lustre varies from pearly. as in muscovite, to submetallic, as in lepidomelane.

Occurrence. — The micas as a group are of wide occurrence in all rock types — igneous, metamorphic and sedimentary. Members of the group are found under the entire range of geological conditions: in lavas, schists. granites. marbles, soils and deep-sea sediments; in veins, pegmatites, alteration zones: and as weathering products of other minerals. The largest crystals are found in veins and pegmatites: the largest book (block of laminae) of mica discovered was 14 ft. in diameter and 33 ft. long. A characteristic occurrence is in granite where both muscovite and biotite usuallv form. not uncommonly in parallel intergrowth. Phlogopite is common both in ultrabasic rocks such as dunites and periodotites and in dolomitic marbles. Fine-grained white micas. or sericite. particularly muscovite, form in the early stages of metamorphism of sediments and are joined closely by biotite. During retrograde metamorphism the aluminous silicates are altered to sericite: these silicates include andalusite. kyanite. sillimanite, cordierite. staurolite. as well as the feldspars. The illites. composed in part of a mica. are a common constituent of soils and deep-sea sediments. The glauconites are found characteristically in marine deposits. Celadonite is an alteration product of some basic igneous rocks. Lepidolite is mainly found in veins and pegmatites, often in parallel growths with muscovite.

Synthesis. — Micas very closely approaching the properties of those found in nature have been synthesized in the laboratory; these include phlogopite. muscovite. paragonite. margarite, clintonite, annite and eastonite. Some of the fluorine analogues of these micas, such as fluorophlogopite. fluoromuscovite and fluoroparagonite, as well as polylithionite, have been made. In addition. other compounds having the mica structure, but not found in nature, have been prepared for special commercial applications. Examples of successful synthesis include: $BaMg_3Al_2Si_2O_{10}F_2$, $KMg_3BSi_3O_{10}F_2$, $KNi_3AlSi_3O_{10}F_2$ and $KMg_2MnAlSi_3O_{10}F_2$. The hydrous micas are grown in steel pressure vessels capable of withstanding high water pressures and the fluoromicas are grown from melts in platinum, graphite or bonded silicon carbide crucibles at approximately atmospheric pressure. A few crystals in excess of four inches square and one-eighth inch thick have been produced from fluoride melts. Smaller synthetic fluoromica crystals have been bonded into large sheets and other forms.

Mining.—Mica mining is difficult because the mica books are readily damaged by rough handling. The methods of extraction are therefore primitive and necessarily wasteful. The veins and pegmatites are usually worked by quarrying; however. underground stoping (see MINING, METAL) may be economical. The books are split and trimmed by hand, sorted according to size, transparency. colour and freedom from spots or strains. and the scrap is ground. The production of sheets seldom exceeds 10% of the total mine output. Mining is carried on primarily in the United States (North Carolina, Idaho. South Dakota), India. Union of South Africa, U.S.S.R., Brazil, Argentina. Canada and Madagascar.

Uses. — Because some micas are poor electrical conductors, they are used in the construction of electrical equipment. Some micas are also poor heat conductors, transparent and relatively resistant to water corrosion, and have been useful as store windows and

boiler gauge packings. Ground mica is commonly employed as a filler, lubricant, absorbant, dusting powder and packing material. It is used in the manufacture of wall paper, roofing paper and paints. It is employed for special effects by decorators and toy manufacturers, for example as "frosting" or Christmas tree "snow." Sheets of mica are used to make quarter-wave plates, used in the analysis of polarized light. Lepidolite is an important source of lithium and rubidium (*qq.v.*) salts. Some of the synthetic micas are used as electrical insulators and in special delicate electronic instruments. The high infrared transmission of synthetic fluorophlogopite has important applications as a window material in spectral transmission equipment. (See also NATURAL RESOURCES: *Nonmetallic Minerals.*)

Crystal Structure. — The unit of structure of the micas has been deduced by X-ray analysis (see MINERALOGY) of single crystals. The fundamental unit consists of two sheets of oxygen tetrahedra containing silicon and usually some aluminum. Each sheet consists of tetrahedra linked at each of three corners to form a hexagonal or pseudohexagonal array with all the bases parallel and all the vertexes pointing the same way. The two sheets are parallel and have opposing vertexes. These sheets are held together by magnesium or other ions co-ordinated with two apical oxygens and one hydroxyl from one sheet and two apical oxygens and one hydroxyl from the opposing sheet, forming an octahedron. The hydroxyls occupy the centres of the hexagonal or pseudohexagonal arrays of apical oxygens. The structure is a succession of such double sheets with alkali atoms, potassium for example, between them, the alkali atoms sitting between the hexagonal or pseudohexagonal arrays formed by the basal oxygens of the adjoining double sheets. The alkali atoms are thereby in twelvefold co-ordination, occupying the centre of a hexagonal prism formed by six basal oxygens from each of the adjoining sheets. The general structure may be represented by the formula $XY_{2-3}Z_4O_{10}(OH,F)_2$ where X in twelvefold co-ordination may be K, Na, Ca, or Ba; Y in sixfold co-ordination may be Mg, Fe^{+2}, Fe^{+3}, Al, Li, Mn and rarely Cr, V and Ti; and Z in fourfold co-ordination may be Si and Al.

TABLE—*Principal End Members of the Mica Group*
(General Formula $XY_{2-3}Z_4O_{10}(OH,F)_2$)

Name	X	Y	Z	O_{10}	$(OH,F)_2$
Dioctahedral					
Muscovite	K	Al_2	$AlSi_3$	O_{10}	$(OH)_2$
Paragonite	Na	Al_2	$AlSi_3$	O_{10}	$(OH)_2$
Margarite	Ca	Al_2	Al_2Si_2	O_{10}	$(OH)_2$
Celadonite	K	$MgFe^{+3}$	Si_4	O_{10}	$(OH)_2$
Al-celadonite	K	MgAl	Si_4	O_{10}	$(OH)_2$
Trioctahedral					
Phlogopite	K	Mg_3	$AlSi_3$	O_{10}	$(OH)_2$
Annite	K	Fe^{+2}_3	$AlSi_3$	O_{10}	$(OH)_2$
Clintonite	Ca	Mg_3	Al_2Si_2	O_{10}	$(OH)_2$
Eastonite	K_2	Mg_5Al	Al_2Si_6	O_{20}	$(OH)_4$
Iron-eastonite	K_2	Fe^{+2}_5Al	Al_2Si_6	O_{20}	$(OH)_4$
Polylithionite	K	Li_2Al	Si_4	O_{10}	F_2
Intermediate					
Siderophyllite	K	$Fe^{+2}_{1.66}Al$	$Al_{1.33}Si_{2.67}$	O_{10}	$(OH)_2$
Lepidomelane	K	$Fe_{1.66}Fe^{+3}$	$Al_{1.33}Si_{2.67}$	O_{10}	$(OH)_2$

Polymorphism. — Minerals having the same chemical composition and different structures are called polymorphs. The simple structure unit described above has monoclinic symmetry. If successive units are stacked on top of each other with precisely the same orientation the repeating unit of the mica is described as having a one-layer monoclinic structure (1M). If successive units are stacked with different orientations in a regular way, different structures (polymorphs) result. The symmetry of the surface of the unit restricts the number of ways in which successive units may be stacked. The structures resulting from the various types of stacking may be described by the number of layers involved and the symmetry produced. The following structures have been observed in addition to the 1M: two-layer monoclinic, type one ($2M_1$); two-layer monoclinic, type two ($2M_2$); three-layer trigonal (3T); eight-layer triclinic (8Tr); twelve-layer monoclinic (12M); and eighteen-layer monoclinic (18M). Other more complex structures may exist. A structure in which the units are randomly stacked (1Md) has also been found. In addition, two more polymorphs, two-layer orthorhombic (20) and six-layer hexagonal (6H), have been predicted but not found in nature. A single hand specimen may contain several polymorphs; however, the biotites usually are 1M, the muscovites $2M_1$ and the lepidolites $2M_2$.

Chemical Composition. — The various species of the mica group may be described for the most part as consisting of variable proportions of ideal end members. Actual compositions are complex due to substitutions. The group may be divided into those micas which have two atoms in octahedral co-ordination (Y position), the dioctahedral micas; three atoms in octahedral co-ordination, the trioctahedral micas; and between two and three atoms in octahedral co-ordination, the intermediate micas. The ideal end members are listed in the table: The various atoms are arranged according to their structural position. Broadly speaking, the white micas, commonly referred to as sericite when fine grained. consist of muscovite, paragonite or both. These form a limited series of solid solutions. Common glauconite consists of about two-thirds celadonite and one-third muscovite. It is not known whether glauconite is a true compound or a random mixed-layer structure. a structure consisting of discrete structural units of both muscovite and celadonite. Illite, a field term for some sedimentary micas, is a mixed-layer mineral usually consisting of muscovite and montmorillonite. Common biotite is widely variable in composition and incorporates in solid solution various proportions of phlogopite, annite, eastonite, iron-eastonite, siderophyllite and lepidomelane. The biotites do not form solid solutions with muscovite. Lepidolite consists mainly of polylithionite and forms limited solid solutions with muscovite and paragonite. There is no known complete series of solid solutions between a dioctahedral and a trioctahedral mica. The rare micas include: a vanadium-rich mica, roscoelite, $K(V,Al)_2(AlSi_3)O_{10}(OH)_2$; a chromium-rich mica, fuchsite. $K(Cr,Al)_2(AlSi_3)O_{10}(OH)_2$; the manganese-bearing manganophyllite, $K(Mg_2Mn)(AlSi_3)O_{10}(OH)_2$; and taeniolite, $K(Mg_2Li)Si_4O_{10}F_2$, one of the aluminum-free micas, and zinnwaldite, $K(LiFe^{+2}Al)(AlSi_3)O_{10}(OH)_2$, the lithium-iron mica. Some mica samples yield more water on chemical analysis than that indicated by the formula. These are erroneously referred to as hydromica, and are mixtures or mixed-layered minerals of mica and a more hydrous mineral such as montmorillonite. A true hydromica in which the hydronium ion, H_3O^+, replaces potassium has not as yet been described.

Mineralogical Properties. — The crystals are usually tabular with hexagonal or pseudohexagonal outline; commonly six-sided prisms; often massive lamellar. The perfect basal cleavage yields thin laminae which are usually elastic. Some varieties, margarite for example, have brittle laminae. The perfect basal cleavage reveals the layered character of the crystal structure. The weakest bonds in the structure are those about the alkali atoms in twelvefold co-ordination, and it is these bonds which break first, yielding laminae parallel to the principal double sheets in the crystal structure. The cleavage laminae are not equal in thickness throughout, but may have a series of steps. Each step is exactly equal to, or a multiple of, a crystal structure unit. When a cleavage flake is struck a sharp blow with a blunt needle point, a six-rayed star of cracks, or percussion figure, develops. A similar set of cracks develops 30° from the percussion set when a blunt punch is pressed against the crystal; these cracks, the pressure figure, coincide with the secondary parting planes in the crystal. The marked hexagonal or pseudohexagonal character of many of the features of the micas attests to the symmetry of the crystal structure.

The hardness of the micas ranges from 2.5 to 4.5; the specific gravity, from 2.8 to 3.4; and the indexes of refraction from 1.535 to 1.705. The birefringence (double refraction) is strong in all the micas. The dark-coloured micas exhibit strong pleochroism, that is, exhibit different colours in different directions. Inclusions are common in the micas and sometimes produce pleochroic halos. The micas often enclose flattened crystals of garnet, tourmaline, quartz and magnetite in thin plates between the sheets. Minute acicular inclusions arranged parallel to the rays of the percussion figure, particularly in phlogopite, give rise to asterism similar to that observed in rubies and sapphires.

The muscovites are relatively insoluble in acids, and the bio-

tites and lepidolites are attacked by acids leaving a residue of silica. Most micas yield water on ignition. The structure of muscovite can be completely destroyed by prolonged grinding, Alteration of muscovite usually results in a loss of alkalies and hydration, producing a mixed-layer mineral with montmorillonite. Strong alteration may produce kaolinite or gibbsite with quartz. The biotites on alteration are converted into chlorite. Potash feldspar; rutile, hematite. magnetite or serpentine may also be produced. Weathering of biotite usually changes it to a soft, brown or yellow mineral with a bronze lustre; vermiculite (*q.v.*).

More detailed information on mineralogical and crystallographical concepts used in this article is given under CRYSTALLOGRAPHY and MINERALOGY. See also the separate articles on BIOTITE; MUSCOVITE; OTTRELITE; PARAGONITE; PHLOGOPITE. (H. S. Y.)

MICAH, the sixth in literary order of the "minor prophets" of the Old Testament, is not to be confused with the 9th century Micaiah (1 Kings xxii; the gloss in verse 28b. quoting Micah i, 2, and absent from the Greek version, shows that such confusion occurred at an early date). Micah was a younger contemporary of Isaiah. living in the closing decades of the 8th century, though, unlike Isaiah, he belonged to the country, not to the city. He is called "the Morashtite" as being a native of Moresheth-Gath (i, 14), *i.e.,* a daughter village of Gath, in the "Shephelah," a district in which his interest is manifest (i, 10–15).

The editorial title of the book of Micah declares that Micah prophesied "in the days of Jotham (739–734), Xhaz (733–721) and Hezekiah (720–693), kings of Judah." Nothing in the book itself can claim to belong to the reign of Jotham, but the prophecy against Samaria (i, j–8) may have been uttered originally before the fall of Samaria in 722, *i.e.,* in the reign of Ahaz. In its present form, however, it has been incorporated in a prophecy against Judah, belonging most probably; to the years shortly before 701, when a new Palestinian rising provoked Sennacherib's campaign. This prophetic activity of Micah under Hezekiah is confirmed by the direct statement of Jer. xxvi, 17 seq., where Mic. iii, 12 is quoted ("Zion shall be plowed as a field:" etc.). The verse quoted forms the climax of Mic. i–iii, from which chapters only any certain conclusions as to the prophetic message of the historic Micah can be drawn; the remaining sections of the present book (iv–v, vi–vii) consist mainly of writings of a later period.

The subject matter of i–iii consists of a declaration of divine judgment against Israel, a warning to other nations (i. 2). This takes the form of a theophany (i, 3.4) and issues in the destruction of the northern and southern capitals (i, 5), in which the evil to be punished is concentrated, and in the destruction of idols. The prophet wears the garb of a mourner, and loudly laments the fate that befalls Judah as well as Samaria, in a "dirge" that describes the destruction of the countryside, with many plays on names (i, 10–16). The moral evils denounced are the rapacity of "land grabbers" and the eviction of former owners (ii, 1–11), the injustice of rulers and the falsity of prophets (iii, 1–8), whose selfish interests dictate their conduct (iii, 9–12). Their false confidence in the protection of Yahweh can have but one issue—the destruction of Jerusalem and its temple.

Our only evidence as to the reception of Micah's message by his contemporaries is that afforded by Jer. xxvi. 17 seq., both directly. in the recorded effect on Hezekiah and the people; and indirectly, in the fact that the impression created was remembered a century afterward. Micah resembles Amos, both in his country origin. and in his general character, which expresses itself in strong emphasis on the ethical side of religion, As the last of the four great prophets of the 8th century he undoubtedly contributed to that religious and ethical reformation whose literary monument is the book of Deuteronomy.

The remainder of the book bearing the name of Micah falls into two main divisions, viz., iv, v and vi, vii. Each differs from the first division (i–iii) in a marked degree. The second consists mainly cf prophecies of restoration including eschatological (iv, 1 seq.) and Messianic (v, 2 seq.) hopes. The third is formed of three or four apparently unrelated passages, on the spirituality of true worship (vi, 1–8), social immorality and its doom (vi, 9–16; vii, 1–6), and Israel's future recovery from present adversity through Divine grace (vii, 7–20). It is improbable that much, if any, of these chapters can be ascribed to Micah himself, not only because their contents are so different from his undoubted work (i–iii), for which he was subsequently remembered (Jer. xxvi, 18), but because they presuppose the historic outlook of the Exile, or a later age (*e.g.,* iv, 6 *seq.;* vii, 7 seq.). It is neither psychologically nor historically impossible for a prophet of judgment to be also a prophet of comfort; but the internal evidence of composite and (in whole or part) later authorship must outweigh the traditional attachment of these passages to a manuscript containing the work of Micah. It is noteworthy that the triple division of the book of Micah (i–iii; iv. v; vi, vii) corresponds with that of the book of Isaiah (i–xxxix; xl–lv; lvi–lxvi) in the character of the three divisions (judgment; coming restoration; prayer for help in adversity) respectively, and in the fact that the first alone gives us pre-exilic writing in the actual words of the prophet to whom the whole book is ascribed. In both cases, it need hardly be said, the great literary and spiritual value of the later passages ought in no way to suffer prejudice from critical conditions as to their date and authorship. Amongst these passages there are two that call for special notice. The first is the prophecy that the little clan of Ephrathah, which includes Bethlehem, the birthplace of David, is destined to be the source from which comes the future Davidic prince who shall "shepherd" the Messianic kingdom (v, 2, 4; the intervening verse is a gloss. connecting this "Messiah" with a Messianic interpretation of Is. vii, 14). The second is the summary of the fundamental principles of prophetic religion—justice, mercy, and humility (vi, 6–8).

BIBLIOGRAPHY.—The German commentaries of Nowack (1897, 1904), Wellhausen (1898), Marti (1904), Sellin (1922); the French commentary of van Hoonacker (1908); the English commentaries of Cheyne, *Cambridge Bible* (1882); G. A. Smith (1896, 1927); J. M. P. Smith, International Critical Commentary (1912); H. Wheeler Robinson in *Peake's Commentary* (1919); G. W. Wade, *Westminster Commentary* (192;). (*H.* W. R.)

MICA SCHIST, a metamorphic rock composed essentially of mica and quartz (*qq.v.*), and possessing a foliated or schistose structure due to the parallel arrangement of the mica flakes. Mica schists differ from gneisses principally by the absence of conspicuous alternations of schistose and granular bands characteristic of the latter rocks, and by the paucity of feldspar minerals. Between phyllite (*q.v.*) and mica schist there are all gradations. Mica schists possess a greater variety of constituent minerals and are more coarsely crystallized. The mica may be muscovite or biotite; both are often present. Paragonite and fuchsite (chrome mica) are rare. In addition to quartz. minor quantities of albite or oligoclase feldspar are frequently found. A great number of accessory minerals are known in mica schists, and when these are conspicuous they may be regarded as constituting special varieties receiving distinctive names. These minerals include almandine garnet, staurolite, kyanite, andalusite and sillimanite. Many of them are indicators of a special grade of metamorphism. Accessories include rutile, hematite, ilmenite, tourmaline and zircon.

In nearly all cases mica schists are metamorphosed sedimentary rocks of the composition of clays, shales and slates, though examples are known which are clearly transmuted acid igneous rocks, such as rhyolites and porphyries. The origin of these latter types, if not decipherable by their field relations, is usually indicated by their bulk chemical composition.

The common associates of mica schist are quartzites, quartz schists and limestones, representing sediments of a siliceous and calcareous nature interstratified with clays and mudstones from which the mica schists are derived.

Like most metamorphic rocks mica schists are found in areas of Pre-Cambrian rocks. In the mountain chains of the Alps, the Himalayas, etc., mica schists of Paleozoic and Mesozoic eras are known as they are seen to pass into sediments containing recognizable fossils. At Bergen, in Norway, Paleozoic fossils have been found in mica schists, and some of the Mesozoic schists of the Alps retain identifiable organic remains. Mica schists are rarely of economic value, being too fissile for building stones and too brittle for roofing slates. *See* also SCHIST. (C. E. T.)

MICHAEL, an Old Testament name, synonymous with

Micaiah or Micah (Num. xiii. 13; 1 Chron. v. 13, et passim). In the book of Daniel the name (which means "Who is like God?") is given to one of the chief "princes" of the heavenly host, the guardian angel or "prince" of Israel (Dan. x. 13, 21; xii. 1; cf. Enoch xx. 5 and possibly Mal. iii. 1). He holds the secret of the mighty "word" by which God created heaven and earth (Enoch lxix. 14), and was "the angel who spoke to Moses in the Mount" (Acts vii. 38). It was through Babylonian and Persian influence that names were given to the angels, and Michael finds a parallel in Vohumano, "Ahura's first masterpiece," one of the Zoroastrian Amesha-spentas or arch-angels. It is as guardian angel of Israel, or of the Church, the true Israel, that Michael appears in Jude g and Rev. xii. 7.

MICHAEL, the name of nine East-Roman emperors.

MICHAEL I. RHANGABES (d. 845), an obscure nobleman who had married Procopia, the daughter of Kicephorus I. He was made emperor in a revolution against his brother-in-law, Stauracius (811).

Elected as the tool of the orthodox party, Michael diligently persecuted the iconoclasts on the northern and eastern frontiers of the empire, but allowed the Bulgarians to ravage a great part of Macedonia and Thrace; having at last taken the field in the spring of 813, he was defeated near Versinikia, and relegated to a monastery in the island of Prote where he died in 845.

MICHAEL II., called PSELLUS, "the stammerer," emperor 820–829, a native of Amorium in Phrygia, began life as a private soldier, but rose by his talents to the rank of general. He had been sentenced to death in December 820 for a conspiracy against Leo the Armenian; his partisans, however, succeeded in assassinating Leo and called Michael to the throne. The principal features of his reign were a struggle against his brother general, Thomas (822–824); the conquest of Crete by the Saracens in 823; and the beginning of their attacks upon Sicily (827).

MICHAEL III (839–867), "the drunkard," was grandson of Michael II. and succeeded his father Theophilus (q v.), when three years old (842). During his minority the empire uas governed by his mother Theodora who entirely neglected the education of her son. As a result Michael grew up a debauchee, and fell under the sway of his uncle Bardas, who induced him to banish Theodora to a convent, and practically assumed the chief control (8j7); in the wars of the period Michael himself took a more active part. During a conflict with the Saracens of the Euphrates (856–63), the emperor sustained a personal defeat (860), which was retrieved by a great victory on the part of his uncle Petronas in Asia Minor. In 861 Michael and Bardas invaded Bulgaria and secured the conversion of the king to Christianity. On sea the empire suffered under the ravages of the Cretan corsairs; and in 865 the first pillaging expedition of the Russians endangered the Bosporus. In 867 Michael was assassinated by Basil the Macedonian.

MICHAEL IV. (d. 1041), "the Paphlagonian," owed his elevation to Zoe, the wife of Romanus III., who poisoned her husband and married Michael, her chamberlain (1034). Michael, however, being weak and subject to epileptic fits, left the government in the hands of his brother, John the Eunuch. John's reforms of the army and financial system revived for a while the strength of the Empire. On the eastern frontier the important post of Edessa was relieved. The western Saracens were almost driven out of Sicily (1038–40); but an expedition against the Italian Normans suffered several defeats, and subsequently most of the Sicilian conquests were lost (1041). In the north the Serbs achieved a successful revolt (1040), but a dangerous rising by the Bulgarians and Slavs which threatened the cities of Thrace and Macedonia was repressed by a triumphant campaign which the decrepit emperor undertook in person shortly before his death (1041).

MICHAEL V. CALAPHATES, or "the caulker," nephew and successor of the preceding, surnamed after the early occupation of his father. He owed his elevation (Dec. 1041) to his uncle John, whom along with Zoe he almost immediately banished; this led to a popular tumult in consequence of which he was dethroned after a brief reign of four months, and relegated to a monastery.

MICHAEL VI., "the warlike," was already an old man when chosen by the empress Theodora as her successor shortly before her death in 1056. He was unable to check the disaffection of the feudal aristocracy, who combining with an officer named Isaac Comnenus, dethroned Michael (1057).

MICHAEL VII. DUCAS, or PARAPINACES, was the eldest son of Constantine X Ducas. His father left the empire jointly to him and his brothers Andronicus and Constantine, with their mother Eudocia as regent (1067); but her new husband Romanus IV Diogenes ruled as emperor till 1071, when John Ducas established Michael bn the throne. The feebleness of Michael and the avarice of his ministers were disastrous to the empire. As the result of anarchy in the army, the Byzantines were forced to cede a large strip of Asia Minor to the Seljuk Turks (1074). These misfortunes caused widespread dissatisfaction. In 1078 two generals, Nicephorus Bryennius and Nicephorus Botaniates, simultaneously revolted. Michael resigned the throne with hardly a struggle.

MICHAEL VIII. PALAEOLOGUS (1234–1282) was the son of Andronicus Palaeologus Comnenus and Irene Angela, the granddaughter of Alexius Angelus, emperor of Constantinople. At an early age he rose to distinction, and ultimately became commander of the French mercenaries in the employment of the emperors of Kicaea. A few days after the death of Theodore Lascaris II. in 1259, Michael, by the assassination of Muzalon, became guardian of the young emperor, John Lascaris. Afterwards invested with the title of "despot," he was finally proclaimed joint-emperor and crowned alone at Kicaea on Jan. 1, 1260. In July 1261 Michael conquered Constantinople through his general Strategopoulos. He thereupon had John Lascaris blinded and banished. For this last act he was excommunicated by Arsenius, and the ban was not removed until the accession of a new patriarch (1268). In 1263 and 1264 respectively, Michael, with the help of Urban IV.. concluded peace with Villehardouin, prince of Achaia, and Michael, despot of Epirus, who had been decisively beaten at Pelagonia in Thessaly (1259); Villehardouin was obliged to cede Mistra, Monemvasia and Maina in the Morea.

Subsequently Michael was involved in wars with the Genoese and Venetians, whose influence in Constantinople he sought to diminish by maintaining the balance of strength between them. In 1269 Charles of Sicily, aided by John of Thessaly, made war with the alleged purpose of restoring Baldwin to the throne of Constantinople, and pressed Michael so hard that he consented to the papal supremacy at the council of Lyons in 1274. The union thus brought about between the two Churches was, however, extremely distasteful to the Greeks, and the persecution of his "schismatic" subjects to which the emperor was compelled to resort weakened his power so much that Martin IV. was tempted to enter into alliance with Charles of Anjou and the Venetians for the purpose of reconquering Constantinople. The invasion, however, failed, and Michael so far had his revenge in the "Sicilian Vespers," which he helped to bring about. He died in Thrace in December 1282.

MICHAEL IX. PALAEOLOGUS, was the son of Andronicus II. and was associated with him on the throne from 1295, but predeceased him (1320). He took the field against the Turks (1301, 1310) and against the Grand Catalan Company (1305), but was repeatedly defeated.

See Gibbon's ***Decline and Fall (ed.*** Bury, 1911); G. Finlay, ***Hist. of Greece (ed.*** 1877); G. Schlumberger, *l'Epopée byzantine* (1896); J. Bury, in ***Eng. Hist. Rev,*** (1889); Meliarakes, *Ἱστορία τοῦ βασιλείου τῆς Νικαίας καὶ τοῦ δεσποτάτου τῆς Ἠπείρου,* pp. 539–627 (Athens, 1898).

MICHAEL (1596–1645), tsar of Russia, was the first tsar of the house of Romanov, being the son of Theodore Nekitich Romanov, afterwards the Patriarch Philaret (*q.v.*), and Xenia Chestovaya, afterwards the nun Martha. He was elected unanimously tsar of Russia by a national assembly on Feb. 21, 1613, but not till March 24 did the delegates of the council discover the young tsar and his mother at the Ipatievsky monastery near Kostroma. He was crowned on July 22. The first care of the new tsar was to clear the land of the robbers that infested it. Peace was made with Sweden and Poland by the peace of Stolbova (March 10, 1617) and the truce of Deulina (Feb. 13, 1619). The most important result of the truce of Deulina was the return from exile of the tsar's father, who henceforth took over the government till his death in October 1633. Michael died

on July 12, 1645.

See R. Nisbet Bain, The *First Romanovs* (Lond., 1905).

MICHAELIS, GEORG (1857–1936), German statesman, was born on Sept. 7, 1857 at Haynau. He studied law and for some years lectured at the university of Tokyo. He entered the Prussian administration in 1879, and by 1909 had risen to the grade of under-secretary of state in the Prussian ministry of finance. On the outbreak of the World War he was appointed director of the imperial department for the control of the grain trade, and in Feb. 1917 State commissioner for the national food supply. On the retirement of Bethmann Hollweg in July 1917, the military authorities, with the object of avoiding conflict with the civil administration, advised the appointment of a chancellor who would accommodate his policy to theirs. Michaelis, as a colourless Prussian official, was selected, but even in the first weeks of his chancellorship his weakness became manifest. He was confronted with the demand of the parliamentary majority that he should publicly identify himself with the spirit and letter of the so-called Peace Resolution in favour of a peace "without annexation or indemnities" passed by the Reichstag on July 19, 1917. Under the influence of the military authorities he attempted to evade this obligation by declaring himself, in a phrase that became celebrated, the supporter of the resolution "as he understood it." He had still further to compromise himself over the naval mutiny before it was recognised that his position was untenable. He was succeeded by Count Hertling on Nov. 1, 1917. He was then appointed chief president in the province of Pomerania, an office which he held till 1919. He died on July 24, 1936.

See his autobiographical *Fur Staat und Volk* (1922).

MICHAELIS, JOHANN DAVID (1717–1791), German biblical scholar and teacher, was born at Halle, on Feb. 27, 1717, a member of a family which included several good biblical scholars. He qualified as university lecturer at Halle in 1739–40, but he did not feel at home in the pietistic atmosphere of the university at that time, and was glad to accept a position as *privatdozent* at Gottingen. He became full professor in 1750, and remained there until his death on Aug. 22, 1791. His works include *Supplementa* (1784–92) to the Hebrew lexicons· *Sticilegium geographiae Hebraeorum exterae post Bochartum* (1769–80); an interesting autobiography, *Lebens beschreibung* (1793). He also edited the *Orientalische und exegetische Bibliothek* (24 vols. 1771–79; new series, 8 vols. 1786–91).

MICHAEL OBRENOVIĆ III. (1823–1868), prince of Serbia, was the youngest son of Prince Milo5 Obrenović I. (*q.v.*). After the abdication of his father (1839) and the death of his elder brother, Milan Obrenović II. (1840), he ascended the throne of Serbia. He began his reign with an ambitious programme of self-assertion abroad and reform within; but alienated Turkey and Austria, while the heavy taxation imposed multiplied the party which had forced his father to abdicate. In Aug. 1842 Vučić, the leader of the malcontents, forced him to leave the country, Alexander Karageorgević, son of Karageorge (*q.v.*), being elected in his place. He married, in 1856, Julia, Countess Hunyadi.

In 1858 Alexander was dethroned in his turn, and Miloš Obrenović I. recalled to the throne; on whose death (1860) Michael succeeded him. His policy was generally wise and moderate. He abolished the oligarchic Constitution of 1839, limiting the powers of the Senate and increasing that of the Skupština; established a regular national army, and reformed the judicature and administration. Meanwhile, he was planning an ambitious foreign policy, negotiating secretly with Bosnian, Bulgarian and Albanian leaders. Had his plans succeeded a great Yugoslavia would have been formed. including Bulgaria under Serbian leadership. He secured the sympathy of France to his plans, and a promise of neutrality from Austria; but his long diplomatic duel with the Turks only succeeded in obtaining the withdrawal of the last Turkish garrisons from Serbia (1867). Before he could take the next step, he was assassinated in the Topčider, near Belgrade, on the night of June 10, 1868.

MICHALAKOPOULOS, ANDREAS (1875–1938), Greek statesman, was born at Patras, in 1875, and first joined the military school, but subsequently became a practising lawyer. He entered politics in 1910 as an independent, joined the Liberals, and was minister of national economy under Venizelos in 1912 and 191j, and minister of agriculture in Venizelos' Salonika cabinet of 1916. He accompanied his leader to Paris for the peace negotiations; was out of office during the Royalist reaction of 1920–23, but re-elected in 1923, and negotiated the important Greek Refugees loan. In Nov. 1924 he became prime minister and minister of war, and in Jan. 1925, also minister of foreign affairs, holding office for the record period of eight months, despite the difficult situation (see GREECE). In June 1925 he was overthrown by General Pangalos and subsequently exiled to Naxos. In the "Oecumenical cabinet" formed on Dec 4, 1926, he again became minister of foreign affairs, a post for which his long experience, his moderate views and his knowledge of languages peculiarly fittedhim.

MICHAUD, JOSEPH FRANÇOIS (1767–1839), French historian and publicist, was born on June 19, 1767, at Albens, Savoy. He was a strong counter-revolutionary, and editor of *La Quotidienne*. He was proscribed more than once during the revolutionary period. He entered the Academy in 1814, and died at Passy, Paris on Sept. 30, 1839. His principal work is an *Histoire des croisades,* which was published in its final form in six volumes in 1840 under the editorship of his friend Poujoulat.

See Sainte-Beuve, *Causeries du lundi,* vol. vii.

MICHAUX, ANDRÉ (1746–1802), French botanist whose work on the flora of North America was a valuable contribution to American botany. was born at Versailles, March 7, 1746. In 1779 he spent some time botanizing in England, and in 1780 explored Auvergne, the Pyrenees and the north of Spain. In 1782 he was sent by the French government on a botanical mission to Persia. After two years he returned with a fine herbarium, and also introduced numerous eastern plants into France. In 1785 he was sent to North America, but on his return in 1797 he was shipwrecked and lost most of his collections. In 1800 he went to Madagascar where he died on Nov. 16, 1802.

MICHEL, CLAUDE: *see* CLODION.

MICHEL, CLÉMENCE LOUISE (1830–1905), French anarchist, called *la Vierge rouge de Montmartre,* was born at the château of Vroncourt (Haute-Marne) on May 29, 1830, the daughter of a serving-maid, Marianne Michel, and the son of the house, Étienne Charles Demahis. She was brought up by her father's parents, and received a liberal education. After her grandfather's death in 1850 she was trained to teach, but her refusal to acknowledge Napoleon III. prevented her from serving in a state school. She found her way in 1866 to a school in the Montmartre quarter of Paris, where she threw herself ardently into works of charity and revolutionary politics. During the siege of Paris she joined the ambulance service, and untiringly preached resistance to the Prussians. On the establishment of the Commune she joined the National Guard. She was with the Communards who made their last stand in the cemetery of Montmartre, and was closely allied with Théodore Ferré, who was executed in Nov. 1871. This ardent attachment was perhaps one of the sources of the exaltation which marked her career, and gave many handles to her enemies. When she was brought before the 6th council of war in Dec. 1871 she defied her judges and defended the Commune. She was sent as a convict to New Caledonia, among her companions being Henri Rochefort, who remained her friend till the day of her death.

The amnesty of 1880 found her revolutionary ardour unchanged. She travelled throughout France, preaching revolution. For being concerned in a Paris riot in 1883 she was condemned to six years' imprisonment but was again released in 1886. She was touring France and lecturing on behalf of anarchist propaganda when she died at Marseilles on Jan. 10, 1905.

Her *Mémoires* (1886) contain accounts of her trials. *See* also E. Girault, *La Bonne Louise* (1906).

MICHEL, FRANCISQUE XAVIER (1809–1887), French scholar, was born at Lyons on Jan. 18, 1809. He edited the works of many mediaeval French writers, and the French Government, recognizing their value, sent him to England (1833) and Scotland

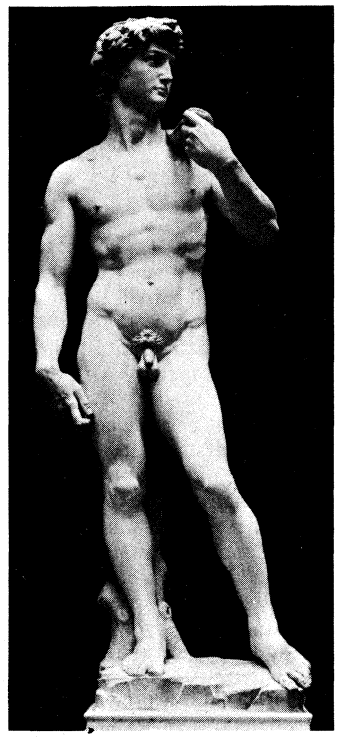
(1337) to continue his researches there. In 1839 he was appointed professor of foreign literature in the *Faculté des lettres* at Bordeaux. Between 1834 and 1842 he published editions of a large number of works written between the 11th and 14th centuries in French, English and Saxon, including the *Roman de* la *rose* and the *Chanson dc Roland*. He died in Paris on May 18, 1887.

MXCHELANGELO (MICHELAGNIOLO BUONARROTI) (1475–1564), the most famous of the great Florentine artists of the Renaissance, was the son of Ludovico Buonarroti, a poor gentleman of that city, and of his wife Francesca dei Neri. The Buonarroti Simoni were an old and pure Florentine stock of the Guelf faction. Ludovico was barely able to live on the income of his estate, but boasted that he had never stooped to add to it by mercantile or mechanical pursuits. He held the appointment of podestà or resident magistrate for six months, from the autumn of 1474, at Castello di Chiusi and Caprese in the Casentino. At Caprese, on March 6, 1475, his second son Michelagniolo or Michelangelo was born. The child was put to nurse with a marble-worker's wife of Settignano. His mother died a few years later, after bearing three more sons. While still a young boy Michelangelo determined, in spite of his father's opposition, to be an artist. He had sucked in the passion, as he used to say, with his foster-mother's milk. After a sharp struggle his stubborn will overcame his father's pride and at thirteen he was articled as a paid assistant in the workshop of the brothers Ghirlandaio. Domenico Ghirlandaio, bred a jeweller, had become by this time the foremost painter of Florence. Michelangelo studied also, like all the Florentine artists of that age, in the Brancacci chapel, where the frescoes of Masaccio, painted some sixty years before, still held their own; and here, in reply, to a taunt he had flung at a fellow-student, Torrigiano, he received the blow on the nose which disfigured him for life.

Sculpture. — Though Michelangelo's earliest studies were directed towards painting, he was by nature and predilection much more inclined to sculpture. In that art he presently received encouragement and training under the eye of Lorenzo dei Medici. On the recommendation, it is said, of Ghirlandaio, he was transferred, before the term of his apprenticeship as a painter had expired, to the school of sculpture established by Lorenzo in the Medici gardens. Here he could learn to match himself against his great predecessor, Donatello, one of whose pupils and assistants, the aged Bertoldo, was director of the school, and to compare the works of that master and his Tuscan contemporaries with the antiques collected for the instruction of the scholars. Here, too, he could listen to discourses on Platonism, and steep himself in the doctrines of an enthusiastic philosophy which sought to reconcile with Christian faith the lore and the doctrines of the Academy. Michelangelo remained a Christian Platonist to the end of his days; he was also a devoted student of Dante. His powers soon attracted attention. and secured him the favour of his patrons in spite of his rugged exterior and scornful unsociable temper. A notable work of this period is the marble Centauromachia (Casa Buonarroti, Florence), a fine work in full relief : Michelangelo followed the antique in his conception and treatment of the nude but the arrangement is his own.

FEDERICO ARBORIO MELLA

"HOLY FAMILY" BY MICHELANGELO. IN THE UFFIZI GALLERY, FLORENCE


ALINARI

"DAVID" BY MICHELANGELO. IN THE ACADEMY OF FINE ARTS, FLORENCE

Michelangelo had been attached to the school and household of the Medici for barely three years when, in 1492, Lorenzo died.

. Lorenzo's son Piero dei Medici inherited the position but not the qualities of his father; Florence soon chafed under his authority; and towards the autumn of 1494 it became apparent that disaster was impending.

Michelangelo was constitutionally subject to dark and sudden presentiments, and without awaiting the popular outbreak. which soon followed, he took horse with two companions and fled to Bologna. There he was received with kindness by a member of the Aldovrandi family, on whose commission he executed two figures of saints and one of an angel for the shrine of St. Dominic in the church of St. Petronius. After about a year, work at Bologna failed, and since his name had been included on the list of artists appointed to provide a new hall of assembly for the great council of Florence, Michelangelo returned home.

He found a friend in another Lorenzo, the son of Pierfrancesco dei Medici, for whom he executed a statue of the boy St. John. Having also carved a recumbent Cupid in imitation of the antique, it was suggested to him by the same patron that it should be so tinted and treated as to look like a real antique, and sold accordingly. Michelangelo for amusement lent himself to the counterfeit, and the piece was then actually sold for a large sum, as a genuine work of antiquity, to a Roman collector, Raffaelle Riario, cardinal di San Giorgio; the dealer appropriating the profits. When the cardinal discovered the fraud he caused the dealer to refund; it was represented to Michelangelo that if he went to Rome the amateur who had just involuntarily paid so high a tribute to his skill would certainly befriend him. He arrived at Rome for the first time at the end of June 1496. He received no countenance from the cardinal di San Giorgio; neither did the banished Piero dei Medici, who also was now living at Rome, do anything to help him. But Michelangelo won the favour of a Roman nobleman, Jacopo Galli, and through him of the French cardinal Jean de Villiers de la Grolaie, abbot of St. Denis. From the former he received a commission for a "Cupid" (sometimes identified with the cupid in the Victoria and Albert Museum but this, if by Michelangelo, must belong to a later date) and a "Bacchus," (Bargello, Florence), from the latter for a "Pietà" (St. Peter's, Rome). Equal originality of conception and magnificence of technical execution mark the two contrasted subjects.

Michelangelo's stay in Rome at this time lasted from the summer of 1496 till that of 1501. The interval had been one of extreme political distraction at Florence, which had created an atmosphere most unfavourable to art. Nevertheless Ludovico Buonarroti, who in the troubles of 1494 had lost his permanent appointment in the customs, and had come to regard his son Michelangelo as the mainstay of his house, had been repeatedly urging him to come home. A spirit of family duty and family pride was the ruling principle in all Michelangelo's conduct. During the best years of his life he submitted himself sternly and without a murmur to pinching hardships and almost superhuman labour for the sake of his father and brothers. Having now, after an illness, come home in 1501, Michelangelo was requested by the cardinal Francesco Piccolomini to adorn with a number of sculptured figures a shrine already begun in the cathedral of Siena in honour of Pope Pius II. Four only of these figures were ever executed, and those not apparently, or only in small part, by the master's hand.

A work of greater interest in Florence itself had diverted him from his engagement to his Sienese patrons. This was the execution of the famous colossal statue of David, popularly known as "the Giant." It was carved out of a huge block of marble on which another sculptor, Agostino d'Antonio, had begun unsuccessfully to work forty years before, and which had been lying idle ever since. Michelangelo had here a difficult problem before him. Without much regard to the traditional treatment of the subject or the historical character of his hero, he carved out of the vast but cramped mass of material an adolescent, frowning colossus, tensely watchful and self-balanced in preparation for his great action. The result amazed every beholder by its freedom and science of execution and its victorious energy of expression. The best artists of Florence debated on what site it should be set up, and the terrace of the palace of the Signory was chosen, in preference to the neighbouring Loggia dei Lanzi. Here accordingly the colossal "David" of Michelangelo took, in the month of May 1504, the place which it continued to hold until in 1882 it was removed for the sake of protection to a hall in the Academy of Fine Arts, where it inevitably looks crushed and cabined. Other works of sculpture belong to the same period: among them a second "David," in bronze and on a smaller scale, commissioned by the maréchal Pierre Rohan and left by the young master to be finished by Benedetto da Rovezzano, who despatched it to France in 1508 and which is no longer extant; a great rough-hewn "St. Matthew" (Bargello, Florence), begun but never completed for the cathedral of Florence; a "Madonna and Child" executed on the commission of a merchant of Bruges and still to be seen in the Church of Notre Dame at Bruges; and two unfinished bas-reliefs of the same subject, one at the Diploma Gallery, Royal Academy, London; the other in the Bargello, Florence.

Painting: Early Works. — Neither was Michelangelo idle at the same time as a painter. Leaving disputed works for the moment out of sight, he in these days at any rate painted for his and Raphael's common patron, Angelo Doni, the "Holy Family" now in the Uffizi at Florence. The unfinished painting of "the Virgin and Child with Four Angels" in the National Gallery, London has been confidently claimed for Michelangelo; but it lacks his strength and mastery. In the autumn of 1504, the year of the completion of the "David," he received from the Florentine state a commission for a work of monumental painting on a heroic scale. Leonardo da Vinci had been for some months engaged on his great cartoon of the "Battle of Anghiari," to be painted on the wall of the great hall of the municipal council. The gonfalonier Piero Soderini now procured for Michelangelo the commission to design a companion work. Michelangelo chose an incident at the battle of Cascina during the Pisan war of 1364, when the Florentine soldiery had been surprised by the enemy in the act of bathing. He dashed at the task with his accustomed fiery energy, and had carried a great part of the cartoon to completion when, in the early spring of 1505, he broke off the work in order to obey a call to Rome which reached him from Pope Julius II. In the unfinished cartoon of the "Bathers" the qualities afterwards proverbially associated with Michelangelo — his *furia,* his *terribilità,* the tempest and hurricane of the spirit which accompanied his unequalled technical mastery and knowledge — first found expression.

Second Visit to Rome. — Michelangelo had not been long in Rome before Pope Julius entrusted to him the task of executing a sepulchral monument to be completed during his lifetime. The design being approved, the artist spent the winter of 1505–1506 at the quarries of Carrara, superintending the excavation and shipment of the necessary marbles. In the spring he returned to Rome, and when the marbles arrived fell to with all his energy at the preparations for the work. For a while the pope followed their progress eagerly. But presently his disposition changed. In Michelangelo's absence an artist who was no friend of his, Bramante of Urbino, had been selected by Julius to carry out a new architectural scheme, viz., the rebuilding of St. Peter's church. To the influence and the malice of Bramante, Michelangelo attributed the unwelcome invitation he now received to interrupt the great work of sculpture in order to decorate the Sistine chapel with frescoes. Soon, however, schemes of war and conquest interposed to divert the thoughts of Julius from artistic enterprises. To add to the artist's discomfiture, when he went to apply for payments due, he was first put off from day to day, and at last actually with scant courtesy dismissed. At this he took horse and left Rome, and before the messengers of the pope could overtake him was safe on Florentine territory. Michelangelo's flight took place in April 1506. Once among his own people, he turned a deaf ear to all overtures made from Rome for his return, and stayed throughout the summer at Florence.

Statue of Pope Julius at Bologna. — During the same summer Julius planned and executed the victorious military campaign which ended with his unopposed entry at the head of his army into Bologna. Thither, under strict safe-conduct and promises of renewed favour, Michelangelo was at last persuaded to betake himself. Julius received the truant artist kindly, as indeed between these two volcanic natures there existed a natural affinity, and ordered of him his own colossal likeness in bronze, to be set up over the principal entrance of the church of St. Petronius. For the next fifteen months Michelangelo devoted his whole strength to this new task. In the technical art of metal casting he was inexperienced, and the work was cast by a Milanese whom Michelangelo had called, and on Feb. 21, 1508, the majestic bronze colossus of the seated pope, robed and mitred, with one hand grasping the keys and the other extended in a gesture of benediction and command, was raised to its station over the church porch. Three years later it was destroyed in a revolution. The people of Bologna rose against the authority of Julius; his delegates and partisans were cast out, and his effigy hurled from its place. The work of Michelangelo, after being trailed in derision through the streets, was broken up and its fragments cast into the furnace.

Sistine Chapel. — Meanwhile the artist had followed his reconciled master back to Rome. The task that here awaited him, however, was the execution of the series of paintings in the Sistine chapel. Painting, he always averred, was not his business; he was aware of his enemy's hopes that a great enterprise in fresco-painting would prove beyond his powers; and he entered with misgiving and reluctance upon his new undertaking. Destiny, however, so ruled that the work thus thrust upon him remains his chief title to glory. The only work which in all his life he was able to complete as he had conceived it was this of the decoration of the Sistine ceiling. The pope had at first desired a scheme including figures of the twelve apostles only. Michelangelo proposed instead a design of many hundred figures embodying the story of Genesis from the Creation to the Flood, with accessory personages of prophets and sibyls dreaming on the new dispensation to come, and, in addition, those of the forefathers of Christ. The whole was to be enclosed and divided by an elaborate framework of painted architecture, with a multitude of nameless human shapes supporting its several members or reposing among them — shapes mediating, as it were, between the features of the inanimate framework and those of the great dramatic and prophetic scenes themselves. The pope bade the artist do as he pleased. By May 1508

the preparations in the chapel had been completed and the work begun. Later in the same year Michelangelo summoned a number of assistant painters from Florence. He soon dismissed them, and carried out the remainder of his colossal task alone, except for purely mechanical and subordinate help. The physical conditions of prolonged work, face upwards, upon this vast expanse of ceiling were trying in the extreme.

After four and a half years of toil the task was accomplished. Michelangelo had been harassed alike by delays of payment and by hostile intrigue. Absolute need of funds for the furtherance of the undertaking constrained him at one moment to break off work and pursue his inconsiderate patron as far as Bologna. This was between September 1510, by which time the whole of the great series of subjects along the centre of the vault were completed, and January 1511, when the master set to work again and began filling the complicated lateral spaces of his decorative scheme.

The main field of the Sistine ceiling—in form a depressed barrel vault—is divided in Michelangelo's scheme into four larger, alternating with five smaller fields. The following is the order of the subjects depicted in them: (1) the dividing of the light from the darkness; (2) the creation of sun, moon and stars; (3) the creation of the waters; (4) the creation of man; (5) the creation of woman; (6) the temptation and expulsion; (7) the sacrifice of Noah; (8) the deluge; (9) the drunkenness of Noah. The figures in the last three of these scenes are on a smaller scale than those in the first six. In numbers 1, 3, 5, 7 and 9, the field of the picture is reduced by the encroachments of the architectural framework with its seated pairs of supporters, commonly known as "Slaves" or "Atlases." Flanking these smaller compositions, along the lateral spaces between the crown of the vault and the walls on either side, are seated figures of prophets and sibyls alternately; two other prophets are introduced at each extremity of the series—making seven prophets and five sibyls in all. In the triangles to right and left of the prophets at the two extremities are the death of Goliath, the death of Holofernes, the brazen serpent and the punishment of Haman. In the twelve lunettes above the windows are groups of the ancestors of Christ, their names designated by inscriptions, and in the twelve triangles above them (between the prophets and sibyls) other kindred groups crouched or sitting. These last are all shown in relatively simple human actions and household relations, heightened but not falsified by the artist's genius, and rising into majestic significance from roots deep in daily human nature. The work represents all the powers of Michelangelo at their best. Disdaining all the accessory allurements of the painter's art, he has concentrated himself upon the exclusive delineation of the human form and face at their highest power. His imagination has conceived attitudes and combinations of unmatched variety and grandeur, and countenances of unmatched expressiveness and power. As for the intellectual meanings of his vast design, they are inexhaustible, and can never be perfectly defined. Whatever the soul of this great Florentine, the spiritual heir of Dante, with the Christianity of the middle ages not shaken in his mind, but expanded and transcendentalized, by the knowledge and love of Plato;—whatever the soul of such a man, full of suppressed tenderness and righteous indignation, and of anxious questionings of coming fate could conceive—that Michelangelo has expressed or shadowed forth in this great scheme of paintings. The powers of the artist seeem to have expanded with the progress of his work. He seems to have begun (as the spectator entering the chapel has to begin) with what is chronologically the last subject of the series, and rising in ascending scale of majesty through the successive acts of creation from the last to the first.

Death of Pope Julius.—The Sistine chapel was no sooner completed than Michelangelo resumed work upon the marbles for the monument of Julius. But four months only had passed when Julius died. His heirs immediately entered (in the summer of 1513) into a new contract with Michelangelo for the execution of the monument on a reduced scale. What the precise nature and extent of the original design had been we do not know, only that the monument was to stand four-square and free—a thing hitherto unknown in Renaissance sepulchral architecture—in one of the chapels of St. Peter's. But the new design was to consist of a great three-sided structure, two courses high, projecting from the church wall, and decorated on its three unattached sides with statues. A much injured and not indisputable sketch by the master at Berlin, with a copy of the same by Sacchetti, are supposed to show the design at this stage of its reduction. The entire work was to be completed in nine years' time. During the next three years, it would seem, Michelangelo brought to completion three at least of the promised figures, for which the blocks had reached Rome from Carrara as early as July 1508; and they are among the most famous of all existing works of the sculptor's art—namely, the "Moses," now in the church of S. Pietro in Vincoli at Rome and the two "Slaves" at the Louvre.

The "Moses," originally intended for one of the angles of the upper course, is now placed at the level of the eye in the centre of the reduced monument. The prophet supposed to have just found the Israelites worshipping the golden calf, sits heavily bearded and draped, his head raised and turned to the left, his right arm grasping the tables of the law—an incarnation of majestic indignation and menace. The work, except in one or two places, is of the utmost finish, The "Slaves" at the Louvre are youthful male figures of equally perfect execution, nude but for the band which passes over the breast of one and the right leg of the other. One, with his left hand raised to his head, his eyes almost closed, seems succumbing to the agonies of death; the other, with his arms bound behind his back, looks upward still hopelessly struggling. All three of these figures were finished between 1513 and 1516.

By 1516 Michelangelo's evil star was again in the ascendant. Julius II. had been succeeded on the papal throne by Cardinal Giovanni dei hfedici under the title of Leo X. The Medici, too, had about the same time re-established their sway in Florence. The consequence to him of the rise to power of the Medici was a fresh interruption of his cherished work on the tomb of Julius. Leo X. and his kinsmen were full of a new scheme for the adornment of the façade of their own family church of San Lorenzo in Florence. Michelangelo offered his services for the new faqade. They were eagerly accepted, although for a moment the idea had been entertained of entrusting the work to Leonardo da Vinci. The heirs of Julius at the request of Leo allowed their three-years'-old contract to be cancelled in favour of another, whereby the scale and sculptured decorations of the Julian monument were again to be reduced. Michelangelo soon produced for the San Lorenzo faqade a design of combined sculpture and architecture as splendid and ambitious in its way as had been that for the original monument of Julius. The contract was signed in January 1518, and the artist went to Carrara to superintend the excavation of the marbles.

When all was well in progress there under his own eye, reasons of state induced the Medici and the Florentine magistracy to bid him resort instead to certain new quarries at Pietrasanta, near Serravalle in the territory of Florence. Hither Michelangelo accordingly had to transfer the scene of his labours. Presently he found himself so impeded and enraged by the mechanical difficulties of raising and transporting the marbles, and by the disloyalty and incompetence of those with whom he had to deal, that he was fain to throw up the commission altogether. The contracts for the faqade of San Lorenzo were rescinded in March 1518, and the whole magnificent scheme came to nothing. Michelangelo then returned to Florence, where proposals of work poured in on him from many quarters. The king of France desired something from his hand. The authorities of Bologna wanted him to design a faqade for their church of St. Petronius; those of Genoa to cast a statue in bronze of their great commander, Andrea Doria. Cardinal Grimani begged hard for any picture or statue he might have to spare. Lastly his friend and partisan Sebastian del Piombo at Rome besought him on Raphael's death to return at once to Rome, and take out of the hands of the dead master's pupils the work of painting still remaining to be done in the Vatican chambers. Michelangelo complied with none of these requests. All that we certainly know of his doing between 1518 and 1522 is the blocking out in the rough of four more of

the "Slaves" for the tomb of Julius, and carrying out a commission, which he had received from three citizens of Rome as early as 1514, for a statue of the risen Christ. The roughed-out, "Slaves" now stand in the Academy of Fine Arts, Florence; the Christ, practically finished by the master but with the last touches added by pupils, stands in the church, for which it was destined, of Sta. Maria sopra hfinerva at Rome.

Return to Florence and Patronage of the Medici.—The next twelve years of Michelangelo's life (1522–1534) were spent at Florence, and again employed principally in the service of the Medici. The plan of a great group of monuments to deceased members of this family, to be set up in a new sacristy or mortuary chapel in San Lorenzo, was first broached to Michelangelo in 1520 by Cardinal Giulio dei Medici. No practical impulse, however, was given to the work until Giulio had in his turn become pope in 1523 under the title of Clement VII. First Clement proposed to associate another artist. Sansovino, with Michelangelo in his task. This proposal being on Michelangelo's peremptory demand abandoned, Clement next distracted the artist with an order for a new architectural design—that, namely, for the proposed Medicean or "Laurentian" library. When at last the plans for the sepulchral chapel or "Sagrestia nuova" took shape, they did not include, as had been at first intended, memorials to the founders of the house's greatness, Cosimo (*pater* patriae) and Lorenzo the Magnificent, or even to Pope Leo X. himself, but only to two members of the house lately deceased, Giuliano, duke of Nemours, and Lorenzo, duke of Urbino. Michelangelo was still engaged on the execution of this work—his time being partly also taken up by the building-plans for the Medicean library—when political revolutions interposed to divert his industry. In 1527 came to pass the sack of Rome by the army of Charles V., led by the connétable de Bourbon, and the apparently irretrievable ruin of Pope Clement. The Florentines seized the occasion to expel the Medici, and set up a free republican government once more. Naturally no more funds for the works in San Lorenzo were forthcoming, and Michelangelo, on the invitation of the new signory, occupied himself for a while with designs for a group of Hercules and Cacus, and another of Samson and the Philistines—the latter to be wrought out of a block of marble which had been rough-hewn already for another purpose by Baccio Bandinelli. Soon, however, he was called to help in defending the city. Clement and his enemy Charles V. having become reconciled, both alike were now bent on bringing Florence again under the rule of the Medici. Michelangelo was appointed engineer-in-chief of the fortifications. He spent the early summer of 1529 in strengthening the defences of San Miniato; from July to September he was absent on a diplomatic mission to Ferrara and Venice. Returning in the middle of the latter month, he found the cause of Florence hopeless from internal treachery and from the overwhelming strength of her enemies. One of his dark seizures overcame him, and he departed again suddenly for Venice. There for a while he remained, negotiating for a future residence in France. Then, while the siege was still in progress, he returned once more to Florence; but in the final death-struggle of her liberties he bore no part. When in 1530 the city submitted to her conquerors, no mercy was shown to most of those who had taken part in her defence. Michelangelo believed himself in danger with the rest, but on the intervention of Baccio Valori he was presently taken back into favour and employment by Pope Clement. For four years more he continued to work at intervals on the completion of the Medici monuments, with the help from 1532 of Giovanni Montorsoli and other pupils, and on the building of the Laurentian library. In 1531 he suffered a severe illness; in 1532 he made a long stay at Rome, and entered upon yet another contract for the completion of the Julian monument, to be reduced now to a still more shrunken scale and to be placed not in St. Peter's but in the church of San Pietro in Vincoli. In the autumn of 1534 he left Florence for good. What remained to be done in the Medici chapel was done by pupils, and the chapel was not finally opened to view until 1545.

The Medici Monument.—The statues of the Medici monument take rank beside the "Moses" and the "Slaves" as the finest work of Michelangelo in sculpture. They consist of a Madonna and Child and of the two famous monumental groups, each composed of an armed and seated portrait-statue in a niche, with two emblematic figures reclining on each side of a sarcophagus below. The "Madonna and Child" (left unfinished because the marble was short in bulk) combines the divers qualities of realistic motive and natural animation with learned complexity of design and imposing majesty of effect. It was set up finally—not in accordance with the artist's first intention—against a blank wall of the chapel, and flanked by statues of SS. Cosmo and Damian, the work of pupils. The portraits are treated not realistically but typically. In that of Lorenzo seems to be typified the mood of crafty brooding and concentrated inward thought; in that of Giuliano, the type of alert and confident practical survey immediately preceding action. At the feet of the duke Giuliano recline the shapes of "Night" and "Day"—the former a female, the latter a male, personification; the former sunk in an attitude of deep but uneasy slumber, the latter (whose head and face are merely blocked out of the marble) lifting himself in one of wrathful and disturbed awakening. As grand, but far less violent, are those of the two companion figures that recline between sleep and waking on the sarcophagus of the pensive Lorenzo. Of these, the male figure is known as "Evening," the female as "Morning." In Michelangelo's original idea, partly founded on antique precedent in pedimental and sarcophagus groups, figures of "Earth" and "Heaven" were to be associated with those of "Night" and "Day" on the monument of Giuliano, and others—no doubt of a corresponding nature, with those of the Morning and Evening Twilight on that of Lorenzo. These figures afterwards fell out of the scheme and the recesses designed for them remain empty. Michelangelo's obvious and fundamental idea was to exhibit the elements and the powers of earth and heaven lamenting the death of the princes. River-gods were to recline on the broad bases at the foot of the monuments. These too are lacking. They were never finished, but a bronze cast from a small model of one of them, and the torso of a large model, have lately been identified, the former in the National Museum and the latter in the Academy at Florence.

Other Works, 1522–1534.—"Victory" marble (National Museum, Florence). A youthful conqueror standing over a bearded enemy, whose shoulders he crushes down with his left knee. Fine and finished work: whether intended for one of the emblematic Victories of the Julian monument, or having some connection with the "Hercules and Cacus" and "Samson and the Philistine," subjects undertaken for the Signory in 1528, must remain uncertain. For the former of these two subjects a wax model at the Victoria and Albert Museum, for the latter a plaster model at the Casa Buonarroti, are claimed, perhaps rightly, as original. "David" (formerly called "Apollo"), marble, unfinished (National Museum, Florence). Both the authenticity and the approximate date of this fine work are beyond doubt: of its origin and destination we are uninformed. "Crouching boy," marble, unfinished (the Hermitage, St. Petersburg). Another masterly sketch in marble; the seated lad stoops forward between his parted knees, having both hands occupied with his left foot; the figure blocked out of the marble, with the least possible sacrifice of the material; the subject and motive enigmatical. "Cupid," marble (Victoria and Albert Museum); probably, but not quite certainly, authentic; if so, then of 1530 or thereabouts; its identification with the early Cupid done for Jacopo Galli at Rome in 1496 is untenable.

Later Life in Rome.—Michelangelo had fully purposed, as soon as he could get free of his task on the Medici tombs, to devote all his powers to the completion of the Julian monument in accordance with the new contract of 1532. But his intention was again frustrated. Pope Clement insisted that he must complete his decorations of the Sistine Chapel by painting anew the great end wall above the altar, adorned until then by frescoes of Perugino. The subject chosen was the Last Judgment; and Michelangelo began to prepare sketches. In the autumn of 1534, in his sixtieth year, he settled for the remainder of his life, at Rome. Immediately afterwards Clement died, and was succeeded by a Farnese under the title of Paul III Even more than his predecessor, Paul insisted on claiming the main services of Michelangelo for himself.

For the first seven years after the artist's return to Rome, his time was principally taken up with the painting of the colossal and multitudinous "Last Judgment." This being completed in 1541, he was next compelled to undertake two more great frescoes—one of the Conversion of Paul and another of the Martyrdom of Peter—in a new chapel which the pope had caused to be built in the Vatican, and named after himself—Capella Paolina.

The fresco of the "Last Judgment" in the Sistine Chapel is probably the most famous single picture in the world. In it Michelangelo shows more than ever the omnipotence of his artistic science, and the fiery daring of his conceptions. But the work, so far as its deplorably deteriorated condition admits comparison, is hardly comparable in the qualities of colour and decorative effect to the earlier and far more nobly inspired frescoes of the ceiling. It is to these and not to the "Last Judgment" that the student must turn if he would realize what is best and greatest in the art of Michelangelo.

The frescoes of the Pauline Chapel are on their part so injured as to be hardly susceptible of useful study or criticism. In their ruined state they bear evidence of the same tendencies that made the art of Michelangelo in its latest phase so dangerous an example to weaker men—the tendency, that is, to seek for unqualified energy and violence of action, both in place and out, for "terribleness" quand *même,* and to design actions not by help of direct study from nature, but by scientific deduction from the abstract laws of structure and movement. At best these frescoes can never have been happy examples of Michelangelo's art.

Other Works of **1534–1549.** SCULPTURE.—During the fifteen years when Michelangelo was mainly engaged on these paintings, he had also at last been enabled to acquit himself, although in a manner that can have been satisfactory to none concerned, of his engagements to the heirs of Julius. Once more the influence of the pope had prevailed on them to accept a compromise altogether to their disadvantage. By a final contract dated 1542, it was agreed that the "Moses" executed thirty years before, seated on a low plinth in a central recess, should be the chief figure of the new scheme; in niches at either side of him were to be standing figures of "Leah" and "Rachel." These Michelangelo himself executed hastily with the help of assistants. To pupils entirely was left the carrying out of the upper cornice, with the recumbent effigy of the pope occupying the centre of a weak and incongruous architectural scheme, a Madonna and Child in a niche above, and a prophet and a sibyl in recesses at either side. Meantime all idea of incorporating any of the "Slaves" in the new design had been abandoned. The master gave the two that had been finished in 1513–1516 to Robert Strozzi, who gave them to Francis I. "Brutus," marble (National Museum. Florence). Probably executed soon after 1539, in memory of the tyrannicide Lorenzino de' Medici To the end of this period or to a year or two later belongs the infinitely pathetic unfinished sketch in marble of a life-size "Pietd" (Palazzo Rondini, Rome)—the mourning mother, standing on an elevation behind her son, holds his body upright in front of her by the shoulders. Still later, after 1550, is the more complicated and more finished group of the "Pietd," with the corpse of Christ collapsing in utter relaxation through the arms of those who try to uphold it: this Michelangelo destined for his own sepulchre; it stands now in the cathedral at Florence.

PAINTING.—"The Entombment of Christ" (National Gallery, London). This unfinished painting bears all the marks of Michelangelo's design, and must have been begun from a cartoon by him, probably of about 1535–1540.

For nearly all his great life-works mentioned above, preparatory sketches and studies by the master's hand exist. These, with a large number of other drawings, finished and unfinished, done for their own sakes and not for any ulterior use, are of infinite value and interest to the student. Michelangelo was the most learned and scientific as well as the most inspired and daring of draughtsmen, and from boyhood to extreme old age never ceased to practise with pen, chalk or pencil. There are some 250 genuine sheets scattered amongst various collections, chiefly public; those in England (at the British Museum, the University Galleries, Oxford, and the Royal Library, Windsor), are quite half the whole number; other important examples remain still at what was for centuries the home of his heirs, the Casa Buonarroti at Florence; others at the Uffizi, Florence; the Venice Academy; the Albertina, Vienna; the Louvre; the Condé Museum at Chantilly; the Berlin Museum; and, not least, the Teyler Museum at Haarlem. By means of these drawings and the many published facsimiles we are best able to trace the progress of the master's genius and its secrets. We see him diligently copying in youth from the frescoes of Giotto, Masaccio, and his own master Ghirlandaio. At this date his instrument was the pen only, used in a manner of hatching: sometimes extremely careful and close, at others fiercely bold and free, and in either case all his own. Sketches and studies thus drawn with the pen exist for the "David," the "Bathers Surprised," the accessory figures for the tomb of Julius as first conceived, and the great series of the Sistine Chapel decorations. By, or even before, the date of the Sistine Chapel, chalk, red or black, comes into use along with the pen. and many of the finest studies for the "Slaves" or "Atlases" and other decorative figures of the ceiling are in the latter material (many more studies are preserved for these subordinate figures than for the main compositions). After the Sistine Chapel period the pen gives way to red or black chalk almost entirely. Sketches are rare for the great abortive scheme of the Julius monument; almost non-existent for the equally abortive San Lorenzo façade; fairly abundant for the various stages of the Medici monument scheme in its architectural parts, but not for the great figures. About the time of Michelangelo's final change of domicile from Florence to Rome (1532–153j) he began the practice of making highly finished and fully shaded drawings of classic or symbolic subjects in red or black chalk for presentation to his friends, especially to young Tommaso Cavalieri, the object of his passionate Platonic affection, from about 1532. The "Fall of Phaeton," the "Tityos," the "Ganymede," the "Men shooting at a Mark," are well-known examples; in this class of work the Windsor collection is far the richest. At the same time, or soon afterwards, were produced drawings little less powerful and finished of Christian subjects, especially the "Crucifixion," "Entombment" and "Resurrection." Then comes the great fresco of the "Last Judgment," for which there exist both general sketches and particular studies. In the few extant drawings for the Capella Paolina a faltering both of the imagination and of the hand become discernible. To the same or to still later years belong many beautiful but somewhat tentative drawings done either directly for, or nearly in the spirit of, the famous "Crucifixion" which he is recorded to have painted with so much devotion for Vittoria Colonna.

Poetry.—During his later years the long-pent human elements of fervour and tenderness in Michelangelo's nature had found utterance such as they had never found before. He had occasionally practised poetry in youth, and there are signs of some transient love-passages during his life at Bologna. But it was not until towards his sixtieth year that the springs of feeling were fairly opened in the heart of this solitary, this masterful and stern, life-wearied and labour-hardened man. About 1533–1534 we find him beginning to address impassioned sonnets—of which the sentiment is curiously comparable to that expressed in some of Shakespeare's—to a beautiful and gifted youth, the young Roman noble Tommaso Cavalieri. Soon afterwards he made the acquaintance of the pious, accomplished and high-souled lady, Vittoria Colonna, widow of the Marquess Pescara. For ten years until her death, which happened in 1547, her friendship was the great solace of Michelangelo's life. On her, in all loyalty and reverence, he poured out all the treasures of his mind and all his imprisoned powers of tenderness and devotion. She was the chief inspirer of his poetry—of which, along with her praises, the main themes are the Christian religion, the joys of Platonic love, and the power and mysteries of art. Michelangelo's poetical style is strenuous and concentrated like the man. He wrote with labour and much self-correction; we seem to feel him flinging himself on the material of language with the same overwhelming energy and vehemence with which contemporaries describe him as flinging himself on the material of marble—the same impetuosity of temperament combined with the same fierce desire of per-

fection, but with far less either of innate instinct for the material or of trained mastery over its difficulties.

Last Years: Architecture.—And so the mighty sculptor, painter and poet reached old age. An infirmity which settled on him in 1544, and the death of Vittoria Colonna in 1547, left him broken in health and heart. But his strength held on for many a year longer yet. His father and brothers were dead, and his family sentiment concentrated itself on a nephew, Leonardo, to whom he showed unremitting practical kindness, coupled with his usual suspiciousness and fitfulness of temper. During the last years of his life he was much employed in the fourth art in which he excelled—that of architecture. A succession of popes demanded his services for the embellishment of Rome. Between 1536 and 1546 he was engaged on plans for the rearrangement and reconstruction of the great group of buildings on the Capitol—plans which were only partially and imperfectly carried out during his lifetime and after his death. For Paul III. he finished the palace called after the name of the pope's family the Farnese. On the death of Antonio da San Gallo he succeeded to the onerous and coveted office of chief architect of St. Peter's church, for which he remodelled all the designs, living to see some of the main features, including the supports and lower portion of the great central dome, carried out in spite of all obstacles, according to his plans. The dome as it stands is his most conspicuous and one of his noblest monuments: the body of the church was completed in a manner quite different from his devising. Other great architectural tasks on which he was engaged were the reconstruction of the Porta Pia, and the conversion of a portion of the baths of Diocletian into the church of sta. Maria degli Angeli; the great cloister with its hundred columns, now used as the Museo delle Terme, is the only part of this reconstruction which remsins as he designed it. At length, in the midst of these vast schemes and responsibilities, the heroic old man's last remains of strength gave way. He died on the threshold of his ninetieth year, on Feb. 18, 1564.

AUTHORITIES.—For the bibliography of Michelangelo, which is extensive, *see* E. Steinmann and R. Wittkover, *Michelangelo-Bibliographie* (Leipzig, 1927). The most important works, taken in chronological order, are the following: P. Giovio, supplement to the fragmentary *Dialogus de viris litteris illustribus,* written soon after 1527, first published by Tiraboschi, *Storia della letteratura italiana* (Modena, 1871); G. Vasari, in *Vite degli* pi3 *eccellcnti architettori pittori, e scultori,* etc. (Florence, 1550); A. Condivi, *Vita di Michelangelo Buonarroti* (1553); this account, for which the author, a pupil and friend of the master's, had long been collecting materials, was much fuller than that of Vasari, who made use of it in rewriting his own life of Michelangelo for his second edition, which appeared after the master's death (1568). The best edition of Vasari is that by Milanesi (Florence, 1878–83); of Condivi, that by Antonio Maraini (Florence, 1927); for English readers there is a useful translation by H. Home (Boston, 1904). *See* also C. Holroyd, *Michael Angelo Buonarroti* with translations of the life of the master by Ascanio Condivi and three Dialogues from the Portuguese by Francisco D'Ollanda (1903). The first additions of importance were published by Bottari, *Raccolta di lettere sulla pittura,* etc. (Rome, 1754; 2nd ed. by Ticozzi, Milan, 1822); the next by Gaye, *Carteggio inedito* (1840). Portions of the correspondence preserved in the Buonarroti archives were published by Guasti in his notes to the *Rime di Michelangelo Buonarroti* (1863), and by Daelii in *Carte Michelangelsche inedite* (Milan, 1865). Complete biographies of Michelangelo had been meanwhile attempted by J. Harford (London, 1857), and with more power by Hermann Grimm, *Leben Michelangelos* (Hanover, 5th ed., 1879). A great increment of biographical material was at length obtained by the publication, in the four-hundredth year after Michelangelo's birth, of the whole body of his letters preserved in the Buonarroti archives, *Lettere di Michelangelo Buonarroti,* ed. G. Milanesi (Florence, 1875). This material was first employed in a connected but too trivial narrative by A. Gotti, *Vita di Michelangelo* (Florence, 1875). Next followed C. Heath Wilson, *Life and Works of Michelangelo Buonarroti* (Florence, 1876), the technical remarks in which, especially as concerns the fresco paintings, are still valuable. Other lives of Michelangelo are by J. A. Symonds. *The Life of Michelangelo* (London. 1893), full of valuable matter on the history and spirit of Michelangelo's times, but not trustworthy in the criticism of his works. *Michelangelo,* by Fritz Knapp, in the *Klassiker der Kunst* series (Stuttgart, 1906) is a very useful compendium. For the early works of Michelangelo the standard authority is H. Wölfflin, *Die Jugendwerke Michelangelos* (Munich, 1891, and later editions). The most elaborate study of the Sixtine frescoes, magnificently illustrated, is by E. Steinmann, *Die Sixtinische Kapelle,* vol. ii. (Munich, 1905). Consult also C. Justi, *Michelangelo* (Leipzig, 1903), and with caution H. Thode, *Michelangelo u. das Ende der Renaissance* (1902–03). Of the poems of Michelangelo the first sound edition is that already referred to, G. Guasti, *Rime di Michelangelo Buonarroti* (1863); in earlier editions the text had been recklessly tampered with, and the rugged individuality of the master's style smoothed down. An edition with German translations was published by Hasenclever (Leipzig, 1875); and a thorough critical edition by Karl Frey (Berlin, 1897); for the English student the translations by J. A. Symonds, in *Sonnets of Michelangelo and Campanella* (1878) are invaluable. On the drawings of Michelangelo see especially B. Berenson, *Tlze Drawings of Florentine Painters* (1903). A comprehensive work on the same subject, in which the most important examples are reproduced and discussed, unfortunately not arranged chronologically, is Karl Frey, *Die Zeichnungen Michelangelos* (Berlin, 1908 *seq.*). An elaborate life by the same author (Karl Frey, *Michelagniolo Buonarroti, sein Leben und seine Werke)* is more to be prized for documentary fullness and accuracy than for critical insight. *See* also Romain Rolland, *Vie de Michelange* (1917); E. Steinmann, *Die Portraitdarstellungen des Michelangelo* (Leipzig, 1913).

(S. C.; X.)

MICHELET, JULES (1798–1874), French historian, was born at Paris on Aug. 21, 1798, of a family which had Huguenot traditions. His father was a master printer, and Jules was offered a place in the imperial printing office, but his father sent him to the Lycée Charlemagne, where he passed the university examination in 1821. Shortly after appointed he began to teach history in the Collège Rollin. Soon after this, in 1824, he married. Between 1825 and 1827 he produced divers sketches, chronological tables, etc., of modern history. In 1827 he was appointed maître de conférences at the École normale.

Four years later, in 1831, the *Introduction à l'histoire universelle* showed a very different style, displaying the peculiar visionary qualities which made Michelet the most stimulating, but the most untrustworthy (not in facts, which he never consciously falsifies, but in suggestion) of all historians. The events of 1830 had unmuzzled him, and had put him in a better position for study by obtaining for him a place in the Record Office, and a deputy-professorship under Guizot in the literary faculty of the university. Soon afterwards he began his chief and monumental work, the *Histoire de France.* But he accompanied this with numerous other books, chiefly of erudition, such as the *Oeuvres choisies de Vico,* the *Mémoires de Luther écrits par lui-même.* the *Origines du droit français,* and somewhat later the *Procès des templiers.* In 1838 he was appointed to the chair of history at the Collège de France. He published, in 1839, his *Histoire romaine.* The results of his lectures appeared in the volumes *Le Prêtre, la femme, et la famille* and *le peuple.*

The principles of the outbreak of 1848 were in the air, and Michelet was one of those who condensed and propagated them. When the actual revolution broke out Michelet devoted himself even more strenuously to his literary work.

He began and carried out, during the years between the downfall of Louis Philippe and the final establishment of Napoleon III., an enthusiastic *Histoire de la révolution française.* Despite or because of its enthusiasm, this was by no means Michelet's best book.

The *coup d'dtat* lost Michelet his place in the Record Office, as, though not in any way identified with the republic administratively, he refused to take the oaths to the empire. But the new régime only kindled afresh his republican zeal, and his second marriage (with Mlle. Adèle Malairet) seems to have further stimulated his powers. While the history steadily held its way, a crowd of extraordinary little books accompanied and diversified it. Sometimes they mere expanded versions of its episodes, sometimes what may be called commentaries or companion volumes. In some of the best of them natural science, a new subject with Michelet, to which his wife is believed to have introduced him, supplies the text. These are *Les Femmes de la révolution* (1854). *L'Oiseau* (1856). *L'Insecte. L'Amour* (1859), *La Femme* (1860), *La Mer* (1861), and *La Sorcière* (1862). Developed out of an episode of the history, *La Sorcière* has all its author's peculiarities in the strongest degree. It is a nightmare and nothing more, but a nightmare of the most extraordinary verisimilitude and poetical power. Later short works are: *La Bible de l'humanité* (1864), an historical sketch of religions; *La Montagne* (1868); *Nos fils* (1869), a tractate on education; and *Le*

Banquet, posthumously published, a vivid picture of the industrious and famishing populations of the Riviera. In 1867, the *Histoire de France* was finished. Michelet was perhaps the first historian to devote himself to anything like a picturesque history of the middle ages, and his account is still the most vivid that exists. His inquiry into manuscript and printed authorities was most laborious, but his lively imagination, and his strong religious and political prejudices, made him regard all things from a singularly personal point of view.

Uncompromisingly hostile as Michelet mas to the empire, its downfall and the accompanying disasters of the country once more stimulated him to activity. Not only did he write letters and pamphlets during the struggle, but when it was over he set himself to complete the vast task which his two great histories had almost covered by a *Histoire du XIX siècle* He did not, honever, live to carry it farther than Waterloo. The new republic was not altogether a restoration for Michelet, and his professorship at the Collège de France was not given back to him. He died at Hyères on Feb 9, 1874.

MICHELL, JOHN (1724–1793). English natural philosopher and geologist, has been called the founder of seismology. Born in 1724, he was educated at Queens' college, Cambridge. He was a fellow of his college, and was appointed Woodwardian professor of geology in 1762, and in 1767 rector of Thornhill in Yorkshire, where he died on April 29, 1793 He was elected a fellow of the Royal society in 1760. In 17jo he published at Cambridge a work on artificial magnets. Besides the description of the method of magnetization which bears his name, this work contains a lucid exposition of the nature of magnetic induction. Michell was the original inventor of the torsion balance, afternard made famous in the hands of its second inventor C. Coulomb. Michell described it in his proposal of a method for obtaining the mean density of the earth. He did not live to put his method into practice; but this was done by Henry Cavendish. His most important geological essay was *Conjectures Concerning the Cause and Observations Upon the Phaenomena of Earthquakes (Phil. Trans.,* li, 1760).

MICHEL-LÉVY, AUGUSTE (1884–1911), French geologist, born in Paris. Aug. 7, 1884, contributed much to the knowledge of igneous and metamorphic rocks. His first published papers (in 1874 and 18; j) deal with the texture and origin of volcanic rocks. In 1882 he published *Synthèse des minéraux et des roches,* which describes the artificial production of many of the minerals found in igneous rocks. Six years later Michel-Lévy was joint author mith A Lacroix of *Les minéraux des roches;* the first part describes optical and chemical methods of studying minerals in thin sections under the microscope and the second describes the microscopical properties of rock-forming minerals. His *Determination des feldspaths dans les plaques minces,* published in 1894, proved of lasting value in the microscopic study of feldspars in thin sections. He was inspector general of mines, and director of the *service de la carte geologique* (1903–11). He died in Paris on Sept. 25, 1911. (A. N. W.)

MICHEL OF NORTHGATE, DAN (fl. 1340), English monk who was the author of the *Ayenbite of Inwyt,* which is philologically valuable as an authenticated and dated example of the Kentish dialect. The *Ayenbite of Inwyt* ("Remorse of Conscience") is a literal translation of a French treatise, *Le Somme des vices et des vertues* (also known as *Le Miroir du monde* or *Le Livre des commandemens,* etc.), written in 1279 by Laurentius Gallus, a Dominican monk and confessor to Philip III of France. This was translated into Flemish, Catalonian, Spanish and Italian, and appears in six English translations. Dan Michel's autograph manuscript, preserved in Arundel manuscript 57 in the British museum, London, states that the work was completed in 1340 on the vigil of the feast of the apostles Simon and Jude by Dan Michel of Korthgate, a brother of St. Augustine's abbey, Canterbury. More than 25 books in the medieval library of this house are known to have been owned by him. The *Ayenbite of Inwyt* was edited by J. Stevenson for the Roxburghe club (1855) and, more completely, by R. Morris for the Early English Text society (1866).

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MICHELOZZO (MICHELOZZI) **DI BARTOLOMMEO** (1396–1472), Florentine architect and sculptor, an important figure in the development of Renaissance art, was born in Florence in 1396. Michelozzo collaborated with Ghiberti, Donatello and Luca della Robbia and after 1438 worked independently, chiefly as an architect, succeeding Brunelleschi as architect for the cathedral of Florence in 1446.

Michelozzo assisted Ghiberti on the north doors for the Florentine baptistery until the beginning of his partnership nith Donatello which lasted from 1423 to 1438 Michelozzo was mainly responsible for the architecture and for some of the decorative sculpture in their joint nork: the tabernacle of St. Louis. Or San Michele. Florence; sculpture for the baptismal font, Siena cathedral; tombs for the schismatic pope John XXIII (baptistery. Florence); Cardinal Brancacci (S. Angelo a Nilo, Naples) and Bartolommeo Aragazzi (cathedral. Montepulciano. and Victoria and Albert museum, London); and the pulpit outside the cathedral of Prato. In 1445 Michelozzo and Luca della Robbia contracted for the bronze doors of the sacristy of San Lorenzo.

Michelozzo's design for the tabernacle of Donatello's St. Louis was more classical in style than anything then built by Brunelleschi. A similar classicizing restraint is found in his sculpture. The Xragazzi monument reveals Michelozzo's independent style in marble: severe, formal arrangement of figures, uniform surface and firm contours clearly and sharply defined. A somewhat warmer and softer treatment is found in Michelozzo's work in other mediums, notably the silver statuette of St. John the Baptist (1452, Museo dell'opera del duomo. Florence).

Michelozzo's major works in architecture were executed for his friend and patron the elder Cosimo de' Medici His masterpiece, the Medici palace in Florence (1444–59, later enlarged as the Riccardi palace) was essentially a systematization of earlier palaces and consists of a large block around a central arcaded court. It is three stories high, with each story distinguished by graduated rustication and by bands of classical modillions, the whole crowned with an enormous, strongly projecting cornice. For Cosimo, Michelozzo also rebuilt the Convent of S. Marco, built villas at Careggi and Caffagiolo and remodeled the Medici palace and bank in Milan. In the fidelity with which Michelozzo followed an ancient prototype in the tribune of SS. Annunziata (145j) and the thoughtful and rational approach to architecture throughout his career, blichelozzo may be considered a distinguished precursor of Alberti. He died in 1472.

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MICHELSEN, PETER CHRISTIAN HERSLEB KJERSCHOW (1857–192j), Norwegian prime minister, was born at Bergen on March 1j, 1857. At the general election of 1903 he was returned to the *storting* as a member for the country district outside Bergen. Appointed prime minister in the spring of 1905 Michelsen played a leading part in the events which resulted in the dissolution of the union with Sweden and the establishment of the new kingdom of Norway. In 1907 he definitely retired from politics and died near Bergen on June 29, 1925.

MICHELSON, ALBERT ABRAHAM (1852–1931), **U.S.** physicist, who was awarded the 1907 Nobel prize in physics for his spectroscopic and metrological investigations, was born in Strelno. Ger., Dec. 19, 1852. His parents came to the U.S. in 1854 and settled at Virginia City: Nev., and San Francisco. He graduated from the U.S. Naval academy in 1873, and was instructor in physics and chemistry there (1875–79). From 1880 to 1882 he studied in Berlin, Heidelberg and at the Collège de France and École Polytechnique in Paris. He resigned from the navy in 1881. In 1883 he was appointed professor of physics at the Case School of Applied Science, Cleveland, O., and six years later accepted a similar position at Clark university, Worcester, Mass. In 1892 he was appointed professor and the first head of the department of physics at the newly organized University of Chicago.

Michelson early directed his researches to the velocity of light, and in 1881 invented his interferometer (*q.v.*) for the purpose of discovering the effect of the earth's motion on the observed velocity of light. This was employed by Michelson and Edward W. Morley in a celebrated experiment (1887), which demonstrated that light travels at a constant speed in all inertial systems of

reference. (See ETHER (IN PHYSICS); MICHELSON-MORLEY EXPERIMENT.) This instrument also enabled him to measure distances with great accuracy by means of the length of light waves (see SPECTROSCOPY).

Michelson measured a metre in terms of the wave length of cadmium light for the Paris Bureau International des Poids et Mesures. He received medals and prizes from many learned societies, and in 1907 mas awarded the Nobel prize for physics. During World War I he rejoined the naval service and devoted his entire time to new devices for naval use. His range finder was adopted as part of the U.S. navy equipment. In 1920 he was able to demonstrate by means of light interference that the diameter of Betelgeuse was 240,000,000 mi. This was the first approximately accurate determination of the size of a star. He published Velocity of Light (1902); Light Waves and Their Uses (Lowell lectures, Boston, 1899; 1903); *Studies* in Optics (192;) ; and numerous papers in scientific journals. He was the first to be appointed distinguished service professor at The University of Chicago (1926). (For the bearing of the Michelson-Morley experiment on the Einstein Special Theory of Relativity. see RELATIVITY.) Michelson died at Pasadena. Calif., on May 9, 1931.

MICHELSON-MORLEY EXPERIMENT. A celebrated experiment carried out by A. A. Michelson and E. W. Morley to attempt to measure a velocity of the earth through the ether by the effect which such a velocity might be anticipated to have on the velocity of light. Had such a velocity been established, axes fixed in the ether could have been taken as standards of fixed position, to which all velocities could be referred. and in this sense we should have been able to talk of the absolute velocity of a material body. as distinct from the relative velocity of two material bodies. The failure to detect any influence of the earth's motion on the velocity of light really formed the starting point of Einstein's theory of relativity (see RELATIVITY), and it is on account of its importance for this theory that the experiment is so fundamental. and has been so often repeated.

In the experiment light is sent along two paths at right angles to one another. If the luminiferous ether were a fixed medium, obeying the laws of such a wave-carrying medium as an elastic solid (or, to be more correct, if less suggestive, of a medium obeying the laws represented by Maxwell's original equations) then the time of the passage of the light should be greater for a to-and-fro path in the direction of the earth's motion through the ether than for a to-and-fro path, of equal length, at right angles to the direction of motion. More precisely, when light goes from a source to a mirror at distance l and back, and both source and mirror are moving with the same velocity v, the time taken is $\frac{l}{c-v}+\frac{l}{c+v}$ wnen the motion is in the direction of the rays, and is

$$\frac{2l}{c}\Big/\sqrt{\left(1-\frac{v^2}{c^2}\right)}$$

when it is crosswise, c being velocity of light. These expressions are approximately $\frac{2l}{c}\left(1+\frac{v^2}{c^2}\right)$ and $\frac{2l}{c}\left(1+\tfrac{1}{2}\frac{v^2}{c^2}\right)$ respectively, so that the difference depends on $\left(\frac{v}{c}\right)^2$ which, on account of the smallness of all terrestrial velocities compared to the velocity of light, is very small and requires the greatest refinement of experimental skill for its detection. (See RELATIVITY.)

If, therefore, the apparatus can be set so that one path lies in the direction of motion, and can then be turned through a right angle, the two beams of light will interchange their rôles, the one which in the first position travelled the faster travelling the slower in the second position. If, further, a system of interference fringes is formed by the two beams, as is done in the Michelson interferometer (*see* INTERFEROMETER), then it follows at once that this fringe system will shift when the apparatus is slowly rotated, so that it must pass through the two positions just specified t ice per revolution. Michelson and Morley looked for, but failed to find, any shift of fringes of the order of magnitude to be expected on the hypothesis of a fixed ether.

Preliminary experiments were carried out by Michelson alone in 1881; the experiment with Morley, of a supericr order of accuracy, was performed in 1887. In the experiment of 1887 the interferometer was mounted on a heavy block of stone which was carried by a disc of wood floating in a tank of mercury: this arrangement enabled the apparatus to be rotated smoothly without causing any strains to be set up. To increase the light path, and so the effect to be sought, each of the interfering beams was reflected several times backwards and forwards: four mirrors were used to replace each of the single mirrors in the simple form of interferometer, and their supplementary mirrors. The total length of the path of either beam was about 1,100 cm. With such a path length the difference of times to be expected on the fixed ether hypothesis, though only about 1 in 100,000,000, should give rise to a displacement of ·4 of a fringe. But the actual displacement measured was at most a fortieth of this value. In carrying out the experiment the orbital motion of the earth alone was considered, the sun being considered at rest. (The rotational motion of the earth produces a velocity which is, of course, negligibly small compared to the orbital motion.) Readings were made for sixteen different directions, the stone being kept slowly turning and the observations taken by the experimenter walking round with it. The experiment was carried out at midday, when the velocity relative to the sun is in the plane of the apparatus, and at 6 P.M., when the velocity is normal to the plane of the apparatus. To see if there was a velocity of the solar system as a whole through the ether, which might, by a remote chance, have cancelled out the orbital motion at the particular month of the experiment, it was proposed to repeat the experiment every three months. Recent experiments have put this possible explanation of the negative effect out of court.

The experiment is of such fundamental importance that it has been much repeated, with a view both to increasing the accuracy and to investigating suggested explanations of the negative effect, other than that offered by the theory of relativity. In 1904, that is, a year before Einstein first put forward his theory, Morley and Miller carried out new measurements. It had been suggested that the contraction in the direction of motion demanded by the Fitzgerald-Lorentz hypothesis (see RELATIVITY) might be a property of particular materials only, and that it would be desirable to try the effect of replacing the stone on which the interferometer parts were mounted by other substances. Morley and Miller used both a wooden and a steel framework to support the apparatus, which was floated on mercury, as in 1887. The path length was increased to 3,224 cm., which is 55 million wave lengths of yellow (sodium) light, so that the fringe displacement should, on the hypothesis of a stationary ether, be 1·1 fringes in place of the ·4 fringes of 1887. In the cellar at Cleveland where the apparatus was mounted the effect was less than one hundredth of this amount, which is alternatively expressed by saying that these results show that the velocity of the earth with reference to a hypothetical stationary ether is at most 3 kilometers (say 2 miles) a second. (The shift is, of course, proportional to the square of the velocity, and the earth's orbital velocity is about 30 kilometres per second.) Morley and Miller took into account the motion of the solar system towards a certain fixed point in the heavens, and compounded this with the velocity of the earth in the solar system when computing the magnitude and direction of the velocity of the apparatus.

In 1905 and 1906 Morley and Miller removed their apparatus from the cellar and installed it in a light shed at a height of 300 feet above Lake Erie. to see if possibly the nature of the immediate surroundings, whether massive or no, affected the "ether wind" which the experiment was designed to detect. A possible effect of about $\frac{1}{10}$ of the calculated value was detected, but it was not clear whether this was a spurious effect of temperature. It would be a result of the first importance, constituting a grave blow to the theory of relativity, if an actual effect, which varied with the height above sea level or with the surroundings, could be definitely established, and therefore in 1921 and again in 1925 D. C. Miller carried out experiments of the Michelson and Morley type at Mount Wilson, about 1,800 metres (6,000 feet) above sea

level. To avoid possible magnetic effects the steel frame used in the earlier experiments was later replaced by a concrete frame. Miller, as a result of several thousand readings, arrived at the conclusion that there was a small positive effect, about 9 kilometers per second, as against the full orbital velocity of 30 kilometers per second, and also considered that the experiments in the cellar at Cleveland showed a still smaller positive result. He attempted to explain. his results by a drift of the solar system in a direction nearly normal to the plane of the ecliptic. These experiments of Miller naturally attracted much attention, but it appears almost certain that the positive effect must be due to unrecognised sources of error, possibly to temperature effects. It has, for instance, been pointed out, notably by Thirring, that the measurements of Miller are not consistent among themselves, from the point of view of his explanation.

To check Miller's results R. J. Kennedy repeated the experiment, using an ingenious modification of the interferometer, produced by making a small step, only one-twentieth of a wave length in height, on one of the totally reflecting mirrors. This produces two fringe svstems bordering on one another, which enables a very slight displacement of the interference patterns, of the order of 4 thousandths of a fringe, to be detected. Kennedy's apparatus was comparatively small, the light path being only 4 metres, and sealed up in a case containing helium, the refractivity of which is only one-eighth that of air, at atmospheric pressure. The experiments were carried out at times of day when Miller's effect should be greatest, but no positive effect was ever found, although a shift one-quarter as great. as that measured by Miller would have been detected. K. K. Illingworth has repeated Kennedy's experiments, likewise finding no positive result (1927). Both Kennedy's and Illingworth's experiments were carried out in a constant temperature basement at Pasadena, California, which gives defenders of the reality of Miller's effect a possible line of criticism, namely that while no positive result can be found in a sheltered spot, where massive surroundings check the "ether wind," this does not prove that a small positive effect does not exist at a height, in a free situation. This last possibility is, however, removed by the experiments of Piccard and Stahel, carried out at intervals from 1926 to 1928. These workers placed the apparatus in a free balloon, the chief measurements being made at a height of 2,500 metres. The apparatus was a small interferometer of Michelson-Morley pattern, with multiple reflections. The fringes were registered photographically, on a moving film, and the balloon was kept in steady rotation by small air screws. No trace of an effect was ever found.

In January, 1929, Michelson published a preliminary account of a repetition of the Michelson-Morley experiment carried out by himself in collaboration with Drs. Pease and Pearson, with new refinements: the results, in contradiction to Miller's, were negative.

We may therefore say that the broad result of a series of experiments of Michelson-Morley type is that no motion of the earth through the ether can be detected by an influence on the velocity of light. For theoretical implications see RELATIVITY.

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(E. N. DA C. A.)

MICHIGAN, known as the "Wolverine state," is one of the north-central group of the Cnited States of America. It consists of two peninsulas, the upper, or northern, and the lower, or southern. The upper peninsula is bounded north by Lake Superior; east by Whitefish bay and St. Mary's river, which separates it from Ontario; south by Lake Huron and Lake Michigan, the Straits of Mackinac and Wisconsin; and west by Wisconsin. The lower peninsula is bounded north by Lake Huron and Lake Michigan and the Straits of Mackinac; east by Lakes Huron, St Clair and Erie and the Detroit and St. Clair rivers, through all of which runs the international boundary; south by Ohio and Indiana; and nest by Lake Michigan. The census bureau, omitting from its statistics that part of the Great Lakes over which Michigan has undisputed jurisdiction (38.504 sq.mi.), ranks the state 23rd in size, with an area of 58.216 sqmi., of nhich 1,197 sqmi. are inland water. The Michigan legislature, however, in 1915 passed an act declaring the area of the state to be 96,720 sq mi.. consisting of 57,022 sq.mi. of land and 39.698 sq mi. of inland water, and requiring official publications to use those figures. With similar adjustments for the seven other lake states. Michigan would rank eleventh nationally in area and be first instead of third among states east of the Mississippi river. Michigan was admitted to the union in 1837 as the 26th state. The official tree is the white pine, the official flower the apple blossom and the state bird the robin The name Michigan is derived from the Indian words *michi,* "great," and *gami,* "water." The capital is Lansing (*q.v.*).

PHYSICAL GEOGRAPHY

Physical Features.— The northern part of the state (which lies within lat. 41° 41' and 48° 18' N. and long. 82° 7 and 90° 25' W.) is rugged, mountainous old land, not completely worn down by erosion; and the southern part is a portion of the old coastal plain, whose layers contain salt, gypsum, oil and bituminous coal. Lake Huron on the east and Lake Michigan on the west of the lower peninsula are each 581 ft. above mean tide at New York city, and Lake Superior on the north of the upper peninsula is 602 ft. above. The surface of the state is in general gently undulating and at a slight elevation above the lakes. but low marshlands are common to many sections; the north part of the lower peninsula is occupied by a plateau of considerable dimensions, and the northwest part of the upper peninsula is rugged with hills and mountains. Crossing the lower peninsula from Saginaw bay west by south, through the valleys of the Saginaw, Maple and Grand rivers, is a depression—the former channel of an old glacial river—in which elevations for a considerable area are less than 100 ft. above the lakes. To the southeast of this depression a water parting, with summits varying from about 400 to 600 ft. above the lakes, extends from a point between Saginaw bay and Lake Huron, south by west, to the southern border of the state and beyond. The eastern slope descends quite rapidly to a low flat belt from 5 to 40 mi. wide along the eastern border of the state south of the outlet of Lake Huron. East and southeast of Saginaw bay is the portion known as the "Thumb" of the mitten-shaped peninsula; the southern part of its beaches is wide and sandy: followed northward by precipitous shores abounding in rocks and bluffs. Western Michigan, south of Grand Traverse bay, is drained by five major rivers, which empty into Lake Michigan among sand dunes; these dunes, formed by prevailing westerly winds and as much as 600 ft. high, line the lake shore from the Indiana border to Grand Traverse bay.

The surface of the upper peninsula is more irregular. Eastward from Green bay are two ranges of hills; one lines the southern shore and ranges from 100 to 300 ft. in height; the other is close to or touches the north shore and in places is 1,200 ft. above sea level. The famous Pictured rocks on the Lake Superior shore, east of Munising, display wide diversity of shapes and hues.

The most rugged portion of the state is farther west. South and southeast of Keweenaw bay, in the Marquette iron district, is an irregular area of mountains, hills, swamps and lakes; some of the peaks of the Huron mountains (Marquette county) and Porcupine mountains (Ontonagon county) rise to more than 1.400 ft. above Lake Superior, and there is the state's highest point, Mt. Porcupine (1,980 ft. above the sea). South of this is the Menominee iron district, marked somewhat regularly by east-west ridges. Extending in a general northeast-southnest direction through the Keweenaw peninsula to the Wisconsin border, and beyond, is the middle of three approximately parallel ridges. The northern portion of these contains Rlichigan's famous copper-bearing rocks. as does Isle Royale (209.1 sq.mi.), farther north in Lake Superior, a wilderness archipelago that mas designated a

national park in 1931 and dedicated as such in 1940. To the south, on the Wisconsin border, is the Gogebic iron district.

The numerous rivers are of clear water. In the interior of the upper peninsula, and in the Saginaw valley and the southeast, they are rather sluggish; but many of the larger rivers in the lower peninsula have sufficient fall to furnish a large amount of water power, while many of the small streams that flow into Lake Superior have in places high banks, rapids and falls. Tahquamenon falls, the largest, has an arc of 200 ft. and a drop of 40. Most of the larger rivers — the hfuskegon, Grand, St. Joseph. Manistee and Kalamazoo — are in the western portion of the lower peninsula.

Glacial action formed more than 11,000 lakes and ponds, about 6,500 of them large enough to be called lakes. The largest of these? in order, are Houghton, Torch, Burt, Mullett, Charlevoix, Gogebic and Manistique, the latter two in the upper peninsula. Also numerous are the islands dotting all Michigan shores.

Climate. — Although the temperature of the entire lower peninsula is considerably influenced by the lakes, it is in the western portion of that peninsula that the moderation is greatest, both the summer and winter isotherms being there deflected more than half the length of the peninsula, since the prevailing winds are westerly. In the upper peninsula, on the other hand! since the prevailing winds are northwesterly, the lakes have less effect on the temperature, and so, while in the southwest the extremes are not great, in the rest of the state they have ranged within two years from 108" F. to 48° F. below zero. The mean annual temperature is about 45° F. The mean annual precipitation is approximately 31 in., a little more than one-half of which falls during the five growing months from May to October; the rain is evenly distributed over all parts of the state; but the snow is exceptionally heavy along the north shore of the upper peninsula.

Soil. — The soil of southwestern and southeastern Michigan is for the most part a dark clay loam; in the north-central part of the lower peninsula it is a light sandy loam; along the Huron shore it is heavy with blue clay; in the mining districts of the northwest the rocks are usually either barren or very thinly covered; and elsewhere in the state the soil is generally rich in a variety of mineral elements.

Vegetation. — The area now included in Michigan was originally a forest, except in the southwest, where there were a few small open areas, possibly cleared by the Indians. The remainder of the southern part of this area, for about 60 mi. along the southern boundary, was a part of the great hardwood forest of the Ohio basin, with woods varying with soil and drainage: on the drier gravel lands were oak forests, consisting of red, black and white oak, hickory, ash, cherry, basswood and walnut; in depressions there were maple, elm, ash, beech, sycamore, poplar and willow; in the southeast there were also a few chestnuts and tulip trees. Korth of this southern hardwood forest there were pine forests on the sandier land, mixed hardwoods and conifers on the loam and clay, and tamaracks and cedar in the swamps. The sandy lands were in part burned over by Indians, and there was a growth of scrub oak, aspens and huckleberry bushes. The tamarack and cedar swamps now have a growth, especially on their edges, of spruce, birch, balsam, white pine, ash and aspens.

Animal Life. — Mammals include black bears, moose, deer, lynx, wolves, coyotes. wildcats, porcupines, foxes! squirrels, hares, rabbits, muskrats, opossums, minks, weasels! skunks, raccoons and woodchucks. The last native woodland caribou in conterminous United States disappeared from Isle Royale between 1927 and 1929. Among the game birds are quail, grouse, ducks, geese, coots, brant, woodcocks, snipe and plover, as well as imported Chinese ring-necked pheasants. Of songbirds the favourites are the robin, thrush, bobolink, oriole! chickadee, meadow lark, catbird, bluebird, wren and warbler. Among fish, whitefish, walleyes, lake trout, perch, herring, sunfish, bass, smelts, sturgeons, pike. chub, suckers, mullets, sheepshead and carp abound in the lakes. Speckled, brown and rainbow trout thrive in many of the streams.

Parks and Recreation. — Nearly 100 state parks and recreation areas with 7,500 camp sites make Michigan the leading state in providing accommodations for families. Swimming, boating and fishing are easily accessible. Mackinac Island State park is interesting for its natural setting and for the historic associations of the old fort, which contains an attractive museum. Isle Royale National park, in Lake Superior, is noted for its fishing, hiking trails and copper pits dug by prehistoric miners. It is estimated that more than 10,000,000 tourists visit Michigan annually. There is excellent hunting. especially for deer and game birds. Skiing is a popular winter sport, for which there are facilities at many areas in both peninsulas.

HISTORY

From 1622 to 1760 the territory now within the borders of Michigan formed a part of New France, and the first Europeans to found missions and settlements within those borders were Frenchmen. Two Jesuits, Charles Raymbault and Isaac Jogues, visited the site of Sault Ste. Marie (*q.v.*) as early as 1641 for the conversion of the Chippewas. In 1668 Père Jacques Marquette founded there the first permanent settlement within the state, and three years later he founded a mission among the Hurons at St. Ignace. Robert Cavelier de La Salle built a fort at the mouth of the St. Joseph in 1679, the sieur de Courtemanche constructed Ft. St. Joseph up the river (at Niles) in 1691, and in 1701 Antoine Cadillac founded Detroit (*q.v.*) as an important point for the French control of the fur trade. In 1715 the French built a fort called Michilimackinac, now Mackinaw City, to replace the one at St. Ignace, which had been abandoned. No other settlements were made, and there was little growth in those already established.

During the last war between the English and the French in America, the Michigan settlements passed into the possession of the English, Detroit in 1760 and the others in 1761. The white inhabitants, mostly French, mere subjected to an English rule that, until the Quebec act of 1774. was chiefly military. and as a consequence many of the more thrifty sought homes elsewhere. The Indians, most of whom had been allies of the French, were so ill-treated, both by the English officers and traders, that Pontiac, chief of the Ottawas, attacked Detroit. The fort was besieged for 155 days, and, aroused by Pontiac's example, local Indians took Michilimackinac and Ft. St. Joseph (Niles).

Michigan **Territory.**—At the conclusion of the American Revolution, title to what is now Michigan passed to the Cnited States, and in 1787 the region became part of the Northwest territory; it was not until 1796, however, that Detroit and Mackinac were surrendered by Great Britain. In 1803 the entire area of the present state became a part of the newly established Indiana territory. In 1805 Michigan territory was organized, consisting of the lower peninsula and a strip at the east end of the upper peninsula. During the War of 1812, Gen. William Hull, first territorial governor, although not greatly outnumbered, surrendered Detroit to the British without a struggle; in the same year Mackinac mas taken and Michigan again passed under British rule. However, soon after Commodore Oliver H. Perry's victory on Lake Erie (Sept. 10, 1813), Detroit and the rest of Michigan, except the Mackinac area; were finally taken into U.S. possession. Mackinac was reoccupied in 1815; but not until Nov. 14, 1828, did the British garrison quit Drummond island. They were the last British troops to leave the United States.

Up to about 1815 the territory had remained for the most part a wilderness in which the fur trade brought the largest profits. The few small settlements were confined to the borders, and the inaccurate reports of the surveyors sent out by the United States government described the interior as a vast swamp with only here and there a little land fit for cultivation. The large number of hostile Indians was also a factor in making the territory unattractive. But during the efficient administration of Lewis Cass (*q.v.*), governor of the territory from 1813 to 1831, the interference of the British was checked and many of the Indians were removed to the west of the Mississippi. Printing presses, established during the same period at Detroit, Ann Arbor, Monroe and Pontiac (*qq.v.*), became instrumental in making the country better known. The first steamboat on the upper Great Lakes, the "Walk-in-the-Water," appeared at Detroit in 1818, the Erie canal mas opened in 1825 and by 1830 a daily boat line ran between Detroit and Buffalo. The population of Michigan, which was only

4,762 in 1810 and 8,096 in 1820, increased to 31,639 in 1830 and to 212.267 in 1840.

Statehood. — In 1819 the territory was empowered to send a delegate to congress. In 1835 the people elected state officers and applied for admission to the union. but a dispute with Ohio over the boundary between the two delayed admission until Jan. 26, 1537. The bloodless "Toledo War" resulted in Ohio's being awarded the strip from Lake Erie westward, at the latitude of Toledo; as compensation Michigan received the entire upper peninsula.

During the first half century under the U.S. flag, farming supplanted the fur trade as the chief occupation, but opening of the canal at Sault Ste. Marie in 1855 provided for cheap transportation of the iron and copper ores, of which exploitation had begun a decade earlier, and Michigan became a mining state. In the 1870s and 1880s it was the nation's leading lumber producer.

The frontier disappeared with rapid extension of railroads and expansion of industry, and in the 50 years after 1880 the population changed from predominantly rural to principally urban. Automobile manufacturing began, and with it came the vast social and economic changes incident to a regional trend from agriculture to industry.

The Kepublican party was organized July 6, 1854, in an oak grove near Jackson, and the first Republican governor was elected in that year. Thereafter, the state usually gave majorities to that party. though after 1932 the industrial areas were commonly Democratic.

Closing of all the banks in the state precipitated the national banking crisis of 1933. Financial depression was severe in the state, but its industpies emerged to prosperity and record production, accelerated by World War II.

After World War II the political complexion of Michigan gradually changed. Democrats, with the aid of organized labour, elected G. Mennen Williams governor six times (1948–58) and in 1960 elected another Democrat, John B. Swainson, as his successor. Although the legislature had a majority of Republicans, Democrats in 1957 held all the elective administrative offices. The election of Philip A. Hart in Nov. 1958 gave Michigan two Democratic senators for the first time since 1856. In presidential elections since 1900 the state generally has voted Republican, although it supported Progressive candidate Theodore Roosevelt in 1912 and Democratic candidates Franklin D. Roosevelt in 1932, 1936 and 1934 and John F. Kennedy in 1960.

GOVERNMENT

The constitution under which Michigan is governed was adopted in 1850, when it was felt that the powers conferred upon the executive and the legislature by the constitution of 1835 were too wide. In 1908 it was revised.

An amendment to the constitution may originate in either house of the legislature and, by a two-thirds vote of both houses, be referred to the people; or it may be initiated by a petition signed by registered electors numbering at least 10% of the total vote cast for all candidates for governor at the last preceding general election at which a governor mas elected. However originated, an amendment becomes effective only if approved by a majority of the qualified electors voting thereon.

A clause in the constitution of 1850 provided that the question of general revision be submitted to popular vote in 1866 and every 16 years thereafter, and at such other times as may be provided by law. When this question was so submitted for the first time, in 1866. the vote was to revise; but the revision prepared by a convention called for the purpose was rejected at the polls. Revision by the convention of 1907–08 was adopted by popular vote and went into effect Jan. 1, 1909. Thrice thereafter, up to 1950, the question of revision was put to vote unsuccessfully. In 1948 it won a majority of votes cast but failed for lack of a majority of the number voting for governor. In 1960 the constitution was amended to provide that a majority voting affirmatively on the question of calling a constitutional convention would rule, and the proposal to call a convention mas placed on the April 1961 ballot.

The constitution confers suffrage upon every citizen of the United States who is 21 years of age or over and has resided in the state six months and in his township or city 30 days immediately preceding an election.

Executive. — At the head of the executive department is the governor. who is elected for two years, and who at the time of his election must be at least 30 years of age and must have been for five years a citizen of the United States, and for the two years immediately preceding a resident of the state. A lieutenant governor, for whom the same qualifications are prescribed, is elected at the same time for the same term. The secretary of state, treasurer, auditor-general, attorney general and superintendent of public instruction likewise are elected for terms of two years, the state highway commissioner for four. The lieutenant governor is president of the senate and succeeds the governor in case of a vacancy. Broad powers over departments. commissions, institutions and officers of the state mere lodged in an administrative board, created by the legislature in 1921 and consisting of the governor and the seven elective state officials named. Further concentration of authority was sought in 1949 by creation of a department of administration, its duties including budgeting. accounting and purchasing. An appointive controller is its executive head.

Legislature. — The legislature, consisting of a senate of 34 members and a house of representatives of 110 members (by an amendment adopted in 1952), meets annually. in regular session, on the second Wednesday in January, at Lansing. Both senators and representatives are elected for terms of two years. Beginning in 1913 and at each subsequent tenth year, the legislature, under the revised constitution of 1908, was required to rearrange the senatorial districts and reapportion the representatives among the counties and districts. using as a basis the returns of the next preceding decennial census; but this obligation was not followed. Until an amendment was adopted in 1952, the state had not been redistricted for senate seats since 1925, nor for the house since 1943. By this amendment, the senate came to represent the rural areas and the house the urban.

No bill can pass either house except by an affirmative vote of a majority of the members elected to that house, and on its third reading the ayes and noes must be taken and recorded; for appropriation bills a two-thirds majority of all members elected to each house is required. All legislation must be by bill. No bill, with the exception of joint and concurrent resolutions, may be passed at a regular session until it previously has been printed and in possession of each house for five days; no bill may be passed at a special session on any subject not expressly stated in the governor's proclamation or submitted by special message. The governor has ten days (Sundays not counted) in which to exercise his veto power (which may be applied to any item or items of any bill making appropriations of money and embracing distinct items), and an affirmative vote in each house of two-thirds of the members elected is required to pass a bill over his veto.

Judiciary. — Justice is administered in Michigan through both federal and state courts. The state is one of a few having two U.S. district courts. Its own system is one of modified common-law courts, at the head of which is a supreme court empowered to issue original and remedial writs, but having only appellate jurisdiction in other cases. The state is divided into judicial circuits by the legislature, which determines the number of judges needed in each; as also is the case for probate courts, of which there is one for each county. Every township has two to four justice courts, and many cities have municipal courts. Circuit courts not only have original jurisdiction but act as courts of appeal from probate. justice and certain municipal courts. Probate courts, though mainly concerned with estates. have original jurisdiction in all cases of juvenile delinquents and dependents. All state and county and most municipal judges are elected by nonpartisan ballot. though supreme court justices are nominated at partisan conventions.

Efficient and fair operation of the courts was advanced through (1) the creation of a presiding judge, empowered to distribute the fluctuating case load among judges of the various circuits;

(2) the pretrial process, whereby attorneys discover elements of agreement, evaluate opportunities for settlement and save the time of litigants and courts; and (3) the supreme court's exercise of its power of supervision over inferior courts and its disciplinary authority over attorneys after the organization of the integrated bar in 1935.

Local Government. — The state is divided into 83 counties, and the counties into a total of 1,262 townships. Basic governmental units in Michigan are nonoverlapping cities and townships; a village is part of a township, furnishing municipal services.

Officers of townships are a supervisor, clerk, treasurer and not more than four justices of the peace, constables and trustees. The supervisor (who functions also as assessor), trustees and clerk constitute the township board, with local legislative and administrative powers. An anomalous form of government, the charter toanship, of which there are but two, resulting from a legislative act of 1947, aims at municipal advantages for populous areas on the edges of large cities.

The business of the county, including the levying of taxes, is entrusted to a board consisting of township and municipal supervisors, the number from any city varying according to its population. A city attaining 100.000 population may be organized as a separate county, but this has never occurred. Creation of port and metropolitan districts is provided for in amendments to the constitution.

In the early 1960s Michigan had more than 500 municipalities (cities and villages) operating under varying forms of government; though whatever the form, each selected a mayor (in cities) or president (in villages), along with a council or commission. Of the cities, about 10% had the mayor-council form, in which the mayor is chief executive although his powers are limited by the council except in a few cities. notably Detroit; about one-fifth had the council-manager form, and a few the commission form. Most cities were incorporated under the home-rule legislation of 1909, but the vast majority of villages had failed to avail themselves of its advantages.

Finance. — In the late 1950s the state government experienced a severe financial crisis. Governmental expenditures in 1958–59 exceeded general revenues; on June 30, 1959, there was a deficit of $110,000,000. The recession of 1957–58 had reduced income and increased welfare costs. New tax money was needed. The legislature rejected the recommendations of a tax study committee that provided for a revision of the tax structure. Governor Williams proposed a personal income tax and a corporations profit tax. Instead, the legislature passed a one-cent use tax law, which the state supreme court held unconstitutional as actually an increase in the three-cent sales tax. To replace it, the legislature imposed a tax on motel rentals and increased the rate on gasoline, beer, liquor, cigarettes, intangibles and business activities.

POPULATION

The population of Michigan in 1810 was 4.762; in 1850 it was 397,654; in 1900. 2,420,982; in 1940. 5,256,106; in 1950, 6,371,766; and in 1960, 7,823,194. This last figure represented an increase of 22.87, over the population in 1950. The population per square mile in 1960 was 134.4, as compared with 92.3 in 1940, and nith 49.6 for the U S. in 1960.

Of the 1950 population, 4,099,007 or 64.3% lived in incorporated places of 2,500 or more. as compared with 65.77, in 1940 when these places constituted the urban area. The entire urban population amounted to 4,503,084 or 70.7% of the state total. The state has ten standard metropolitan statistical areas, which are Ann Arbor, Bay City, Detroit, Flint, Grand Rapids, Jackson, Kalamazoo, Lansing. Muskegon-Muskegon Heights and Saginaw. These areas had a total population of 5,720,419 or 73.17, of the total population of the state in 1960. The number of households in 1950 mas 1,791,639, as compared with 1,396,014 in 1940. The average population per household had declined from 3.8 in 1940 to 3.6 in 1950.

The population of the state was distributed by colour and nativity in 1950 as follows: 83.4% native white; 9.5% foreign-born white; and 7.1% nonwhite, practically all Negro. There were 101.7 males per 100 females in the 1950 population, as compared with 105.2 in 1940; 7.2% of the population was 65 years old or over, and 53.8% of the population 14 years old and over was in the labour force. Of the total number of employed males, 8.3% was engaged in agriculture; 6.4% in construction; 46.1% in manufacturing; 6.9% in transportation, communication and other public utilities; 15.1% in wholesale and retail trade; and 13.1% in service activities of all kinds, including public administration.

EDUCATION

Public Schools.——Though committed to an aggressive program of public education in territorial days, it was on admission to the union in 1837 that Michigan pioneered in the development of what nas to become the typical U.S. pattern of free, nonsectarian, tax-supported and state-controlled schools. Not, however, until the legislature acted to make teacher training adequate (1849–50) and attendance mandatory (1871) was the system fully effective. Local initiative and control through elective township school inspectors and school district boards were features borrowed from New England; but a state superintendent of public instruction as the appointed head of the system was a novel adaptation of European ministries of education (the office was made elective by the constitution of 1850). County school commissioners were added later, as was also a state board of education, which has control of state teachers' colleges and is responsible for issuance of teacher's licences and certificates, though it functions chiefly through the state superintendent, an ex officio member.

After 1900 the tendency was toward consolidated schools in the interests of efficiency and economy. School districts (of which there are seven types) declined in number from more than 6,500 in 1935 to slightly over 3,000 in the early 1960s, influenced by increasing financial dependence on the state and desire for equality of educational service, as well as by good roads and free transportation. In 1949 every county became by law a school district, and county boards of education, elected by representatives of district boards, took over the function of township officials relative to school districts. Their executives became employed county school superintendents, superseding elective commissioners, and receiving part or all of their compensation from the state. Two or more counties of less than 15,000 population may combine to form a single district. Special education. including training of handicapped children. is of long standing and highly developed.

Enrollment in the public schools in the early 1960s approximated 1,500,000, including about 1,000,000 in elementary grades (kindergarten through sixth grade) and 500,000 in secondary (grades 7–12). Michigan annually budgets nearly $800,000,000 for public-school expenditures. Nearly 20,000 students were enrolled in junior colleges. About 18% of the school population was enrolled in parochial schools.

Higher **Education.**—*University* of *Michigan.*—The University of Michigan was established in Detroit in 1817 by the territorial legislature. Because a local land company offered a 40-ac. tract, it was moved to Ann Arbor in 1837. This original campus was greatly extended, and a transfer began of research and graduate work to the north campus, an area of about 660 ac. outside the city. Facilities there include the Cooley Memorial laboratory (engineering research). the Phoenix Memorial laboratory (peacetime uses of atomic energy), the Ford nuclear reactor, the automotive laboratory and the aeronautics research laboratory.

Besides maintaining extension service centres in several cities of the state, the university opened Flint college in the Mott Memorial building in 1956. In the same year the Ford Motor company gave the university 210 ac. and $6,500,000 to establish a college in Dearborn.

The university is governed by a board of regents provided for in the state constitution. Two of the eight members are elected biennially for eight-year terms.

The university consists of the following schools and colleges: literature, science and the arts; medicine; law; dentistry; pharmacy; engineering; architecture and design; education; business administration; natural resources; music; public health; nursing;

*Michigan: Places of 5,000 or More Population (1960 census)**

Place	Population 1960	1950	1940	1920	1900
Total state	7,823,194	6,371,766	5,256,106	3,668,412	2,420,982
Adrian	20,347	18,393	14,230	11,878	9,654
Albion	12,749	10,406	8,345	8,354	4,519
Allen Park	37,052	12,329	3,487	—	—
Alma	8,978	8,341	7,202	7,542	2,047
Alpena	14,682	13,135	12,808	11,101	11,802
Ann Arbor	67,340	48,251	29,815	19,516	14,509
Battle Creek	44,169	48,666	43,453	36,164	18,563
Bay City	53,604	52,523	47,956	47,554	27,628
Benton Harbor	19,136	18,769	16,668	12,233	6,562
Benton Heights	6,112	6,160	—	—	—
Berkley	23,275	17,931	6,406	—	—
Beverly Hills	8,633	—	—	—	—
Big Rapids	8,686	6,736	4,987	4,558	4,686
Birmingham	25,525	15,467	11,196	3,694	1,170
Buchanan	5,341	5,224	4,056	3,187	1,708
Cadillac	10,112	10,425	9,855	9,750	5,997
Center Line	10,164	7,659	3,198	—	—
Charlotte	7,657	6,606	5,544	5,126	4,092
Cheboygan	5,859	5,687	5,673	5,642	6,489
Clawson	14,795	5,196	4,006	—	—
Coldwater	8,880	8,594	7,343	6,114	6,216
Dearborn	112,007	94,994	63,584	2,470	844
Detroit	1,670,144	1,849,568	1,623,452	993,678	285,704
Dowagiac	7,208	6,542	5,007	5,440	4,151
East Detroit	45,756	21,461	8,584	—	—
East Grand Rapids	10,924	6,403	4,899	1,310	466
East Lansing	30,198	20,325	5,839	1,889	—
Eastlawn	17,652	4,127	—	—	—
Ecorse	17,328	17,948	13,209	4,394	—
Escanaba	15,391	15,170	14,830	13,103	9,549
Fair Plain	7,998	4,134	—	—	—
Farmington	6,881	2,325	1,510	853	530
Fenton	6,142	4,226	3,377	2,507	2,408
Ferndale	31,347	29,675	22,523	2,640	—
Flint	196,940	163,143	151,543	91,599	13,103
Fraser	7,027	1,379	747	247	252
Garden City	38,017	9,012	4,096	—	—
Gladstone	5,267	4,831	4,972	4,953	3,380
Grand Haven	11,066	9,536	8,799	7,205	4,743
Grand Ledge	5,165	4,506	3,899	3,043	2,161
Grand Rapids	177,313	176,515	164,292	137,634	87,565
Grandville	7,975	2,022	1,566	799	457
Greenrille	7,440	6,668	5,321	4,304	3,381
Grosse Pointe	6,631	6,283	6,179	2,084	343
Grosse Pointe Farms	12,172	9,410	7,217	1,649	817
Grosse Pninte Park	15,457	13,075	12,646	1,355	—
Grosse Pointe Woods	18,580	10,381	2,805	—	—
Hamtramck	34,137	43,355	49,839	48,615	—
Hancock	5,022	5,223	5,554	7,527	4,050
Harper Woods	19,995	—	—	—	—
Hastings	6,375	6,096	5,175	5,132	3,172
Hazel Park	25,631	17,770	—	—	—
Highland Park	38,063	46,393	50,810	46,499	427
Hillsdale	7,629	7,297	6,381	5,476	4,151
Holland	24,777	15,858	14,616	12,183	7,790
Huntington Woods	8,746	4,949	1,705	—	—
Inkster	39,097	16,728	7,044	—	—
Ionia	6,754	6,412	6,392	6,935	5,209
Iron Mountain	9,299	9,679	11,080	8,251	9,242
Ironwood	10,265	11,466	13,369	15,739	9,705
Ishpeming	8,857	8,962	9,491	10,500	13,255
Jackson	50,720	51,088	49,656	48,374	25,180
Kalamazoo	82,089	57,704	54,097	48,487	24,404
Kingsford	5,084	5,038	5,771	—	—
Lakeview	10,384	975	824	886	935
Lansing	107,807	92,129	78,753	57,327	16,485
Lapeer	6,160	6,143	5,365	4,723	3,297
Lincoln Park	53,933	29,310	15,236	—	—
Livonia†	66,702	17,534	8,728	1,608	1,460
Ludington	9,421	9,506	8,701	8,810	7,166
Madison Heights	33,343	—	—	—	—
Manistee	8,324	8,642	8,694	9,694	14,260
Marquette	19,824	17,202	15,928	12,718	10,058
Marshall	6,736	5,777	5,253	4,270	4,370
Melvindale	13,089	9,483	4,764	—	—
Menominee	11,289	11,151	10,230	8,907	12,818
Midland	27,779	14,285	10,329	5,483	2,363
Monroe	22,968	21,467	18,478	11,573	5,043
Mount Clemens	21,016	17,027	14,389	9,488	6,576
Mount Pleasant	14,875	11,393	8,413	4,819	3,662
Muskegon	46,485	48,429	47,697	36,570	20,818
Muskegon Heights	19,552	18,828	16,047	9,514	1,012
Negaunee	6,126	6,472	6,813	7,419	6,935
Niles	13,842	13,145	11,328	7,311	4,287
Novi†	6,390	4,086	2,428	1,227	1,245
Oak Park	36,632	5,267	1,169	—	—
Owosso	17,006	15,948	14,424	12,575	8,696
Petoskey	6,138	6,468	6,019	5,064	5,285
Plymouth	8,766	6,637	5,360	2,857	1,474
Pontiac	82,233	73,681	66,626	34,273	9,769
Port Huron	36,084	35,725	32,759	25,944	19,158
Rirer Rouge	18,147	20,549	17,008	9,822	1,748
Riverview	7,237	1,432	804	—	—
Rochester	5,431	4,279	3,759	2,549	1,535
Roseville	50,195	15,816	9,023	—	—
Royal Oak	80,612	46,898	25,087	6,007	468
Saginaw	98,265	92,918	82,794	61,903	42,345
St. Clair Shores	76,657	19,823	10,405	—	—
St. Johns	5,629	4,954	4,422	3,925	3,388
St. Joseph	11,755	10,223	8,963	7,251	5,155
Sault Ste. Marie	18,722	17,912	15,847	12,096	10,538
Southfield	31,501	—	—	—	—
Southgate	29,404	—	—	—	—
South Haven	6,149	5,629	4,745	3,829	4,009
Springfield Place	5,136	13,161	—	—	—
Sturgis	8,915	7,786	4,745	5,995	2,465
Tecumseh	7,045	4,020	2,921	2,432	2,400
Three Rivers	7,092	6,785	6,710	5,209	3,550
Traverse City	18,432	16,974	14,455	10,925	9,407
Trenton	18,439	6,222	5,284	1,682	1,167
Troy	19,058	—	—	—	—
Warren	89,246	727	582	326	350
Wayne	16,034	9,409	4,223	1,899	1,361
Wyandotte	43,519	36,846	30,618	13,851	5,183
Wyoming	45,829	—	—	—	—
Ypsilanti	20,957	18,302	12,121	7,413	7,378

*Populations are reported as constituted at date of each census. †Formerly township; reported as city in 1960 census
Note: Dash indicates place did not exist during the reported census, or data not available.

social work.

Notable buildings include the Clements library, the law quadrangle, Hill auditorium, the Horace H. Rackham School of Graduate Studies, the Michigan league, the Michigan union. the Burton Memorial tower, the undergraduate library, the intramural sports building and the Michigan stadium. There are also a number of large residence halls for students.

The university library has more than 2,000,000 printed volumes. Manuscripts include Greek papyri and Arabic writings. Housed in the Clements library are many rare printed books relating to American history. The manuscript collection is especially rich for the period of the American Revolution. The 270.000 volumes in the law library comprise one of the largest collections of legal literature in the world. The archives of the university are in the Rackham building, administered by the Michigan Historical collections.

Natural science collections are in the Museums building, archaeological materials are in the Kelsey museum. art collections are in Alumni Memorial hall, and the Stearns collections of musical instruments is in Hill auditorium. There are three astronomical observatories. The one in Ann Arbor was built in 1854. The others are at Portage Lake and at Lake Angelus.

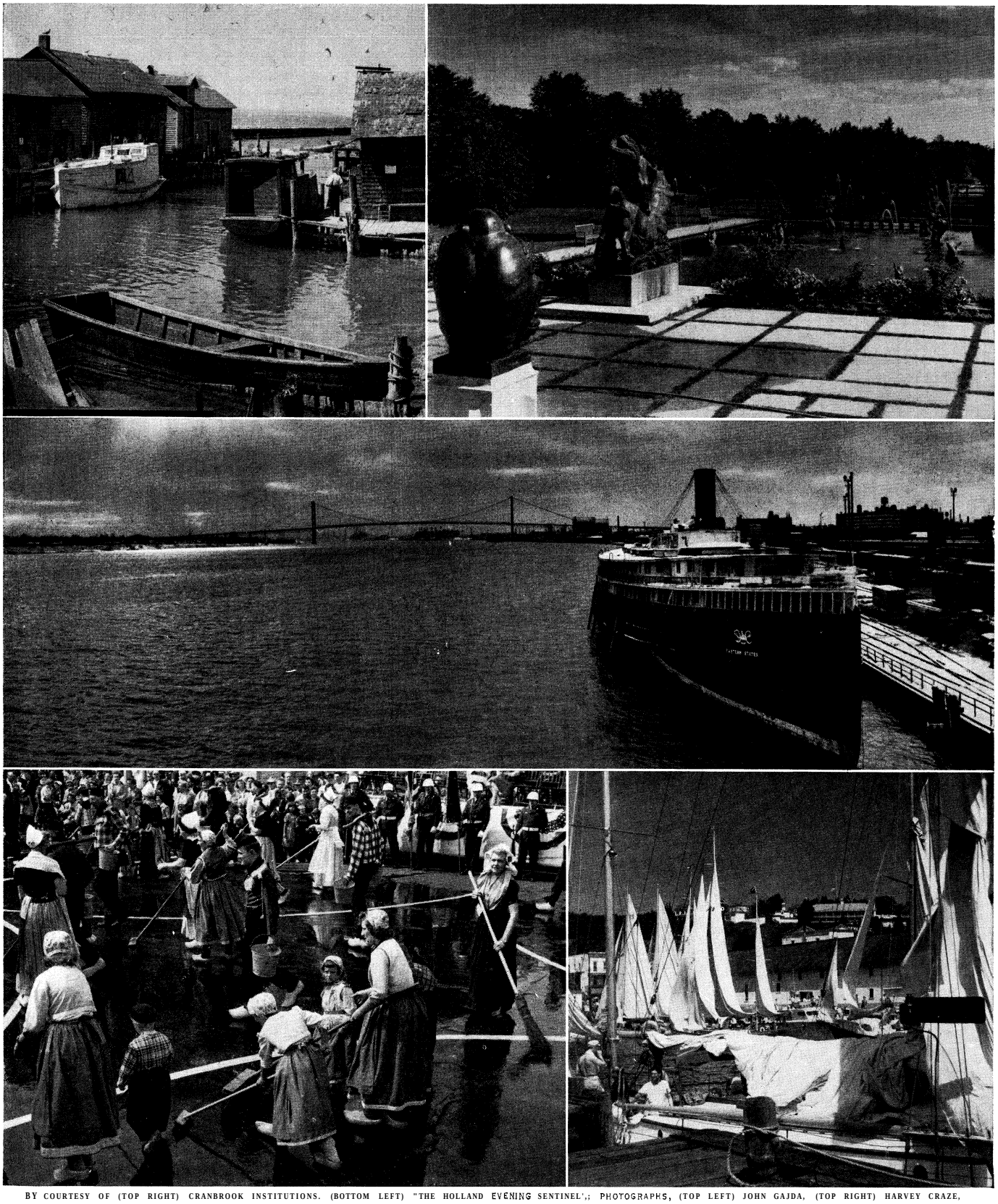
The university hospital has more than 1,000 beds. In addition to the main building there are: the neuropsychiatric institute, the veterans' adjustment centre, the women's hospital, the Alice Crocker Lloyd radiation therapy centre, the outpatient clinic, the children's psychiatric hospital, the Kresge medical research building and the Simpson Memorial institute. The hospital serves the medical school and the school of nursing in their training programs.

Enrollment in the late 1950s approached 25,000 full-time students annually. making the University of Michigan the fifth largest in the United States. The faculty numbered more than 2,000.

Other State Institutions.—Michigan State university (at East Lansing) had its beginning in 1855 as Michigan Agricultural college, the first state college of agriculture in the Gnited States. It is governed by the elected six-member board of trustees. After the addition of curricula in applied science and liberal arts, the name was changed in 1925 to Michigan State College of Agriculture and Applied Science; in 1955 the legislature substituted university for college in the title. Enrollment is approximately 20,000 each year. with faculty numbering about 1,200.

Wayne State university was established in 1868. By 1934 the Detroit school board had acquired several local colleges, organized new ones and combined them to form Wayne university as a unit of the Detroit school system Rapid gronth strained the financial resources of the city. and in 1956 the legislature made the university a part of the state system. It is under an elected six-member state board. Annual enrollment is over 20,000, including part-time students. and the faculty totals about 1.200.

The four teacher training schools are Eastern Michigan university. at Ypsilanti, the first west of the Appalachians when it was established in 1849 as hlichigan State Normal school: Central Michigan university, at Mt. Pleasant (1892); Northern Michigan college, at Rlarquette (1899); and Western Michigan university, at Kalamazoo (1903). They are governed by the elected state



BY COURTESY OF (TOP RIGHT) CRANBROOK INSTITUTIONS. (BOTTOM LEFT) "THE HOLLAND EVENING SENTINEL',; PHOTOGRAPHS, (TOP LEFT) JOHN GAJDA, (TOP RIGHT) HARVEY CRAZE, (CENTRE) C. E WESTVEER, (BOTTOM RIGHT) BENJAMIN OF MACKINAC ISLAND

URBAN AND RURAL VIEWS OF MICHIGAN

Top left: Port scene at the fishing town of Leland in the northwestern part of the state

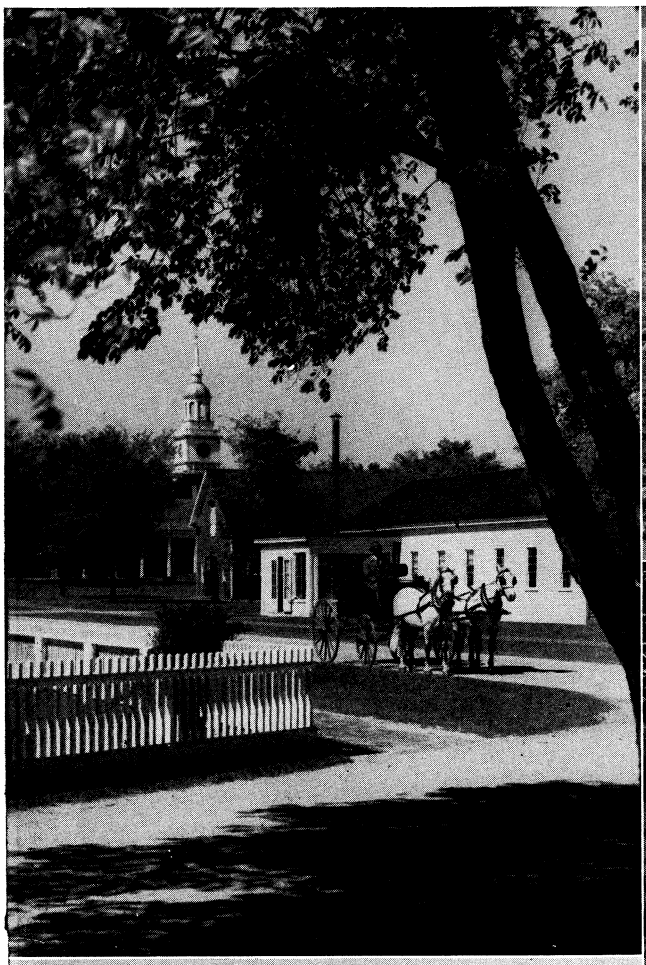
Top right: Fountain in the centre of the main quadrangle at the Cranbrook institutions, Bloomfield Hills. There are a variety of schools at Cranbrook, from kindergarten to the college of arts and sciences

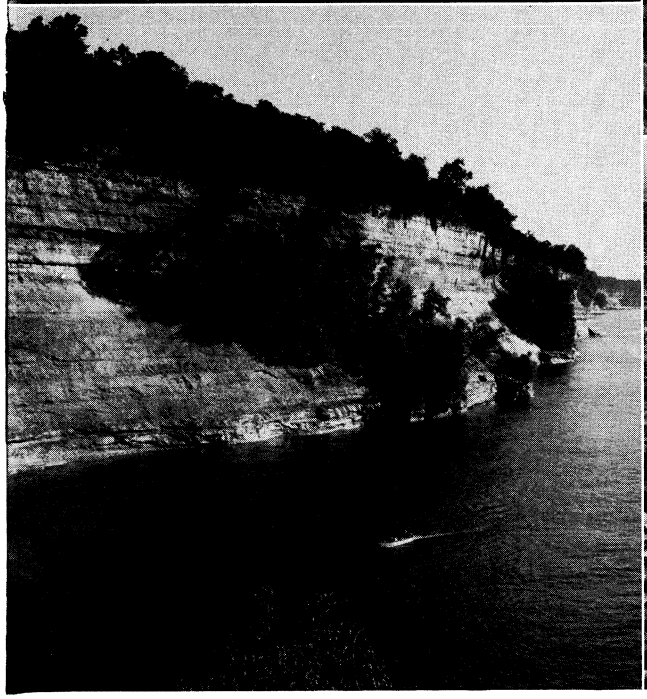
Centre: View of the Detroit river showing a iake freighter moored on the Detroit side of the river and the Ambassador bridge, which connects Canada with the U.S.

Bottom left: Descendants of the Dutch washing streets during the annual tulip festival at Holland, southwestern Michigan

Bottom right: Sailboats at Mackinac Island between races on Lake Michigan

MICHIGAN





BY COURTESY OF (TOP RIGHT) THE DETROIT NEWS, (CENTRE RIGHT) UNIVERSITY OF MICHIGAN, (BOTTOM LEFT) MICHIGAN TOURIST COUNCIL, (BOTTOM RIGHT) FORD MOTOR CO.: PHOTOGRAPH, (TOP LEFT) DAVID CORSON FROM A. DEVANEY, INC.

SCENES IN MICHIGAN

Top left: Carriage at Greenfield village, Dearborn museum built by Henry Ford. In the background can be seen the replica of Independence hail

Top right: Ore boats frozen in the ice at Whitefish bay, near Sault Ste. Marie, keep up their steam while waiting for icebreakers tc free them

Centre right: The University of Michigan's football stadium at Ann Arbor seats over 100,000 persons

Bottom left: The pictured rocks along the Lake Superior shore in Michigan's upper peninsula

Bottom right: Aerial view of the Ford Motor company's River Rouge plant near Detroit

board of education. Other state educational institutions are Michigan College of Mining and Technology, at Houghton (1885), and Ferris institute, at Big Rapids (1884), whose boards are appointed by the governor.

Private Institutions. — Long-established denominational institutions, of which the University of Detroit (Roman Catholic; 1877) is largest, include Adrian (Methodist; 1845), Albion (Methodist; 1835), Alma (Presbyterian; 1886), Calvin, at Grand Rapids (Christian Reformed; 1876), Hillsdale (Baptist; 1844), Hope, at Holland (Reformed; 1851) and Kalamazoo (Baptist; 1833) colleges, all coeducational. Major nonpublic technical and professional schools are Detroit and Lawrence institutes of technology, General Motors institute, Chrysler Institute of Engineering, Detroit College of Law and Cranbrook Academy of Art.

ECONOMY

Agriculture. — By the mid-1950s the acreage in farms had been reduced to less than 16,500,000 (44% of the state's land area), as compared with more than 19,000,000 (52%) in 1920. Farms numbered about 139,000, half of them ranging in size from 50 to 180 ac. Their value totaled nearly $2,200,000,000, and cash farm income was around $700,000,000 annually. About 262,000 persons were employed in agriculture.

Michigan is known as a fruit-producing state, and principal fruits are grown in vast quantities, especially in the fruit belt along the shore of Lake Michigan. Melon and berry crops also are large. Michigan generally leads all the states in the production of tart red cherries and dry edible beans, and it ranks high also in production of apples. peaches, celery, cantaloupes, plums, strawberries, tomatoes. cucumbers and onions.

Chief livestock industry is dairying, milk production being about 4,000,000,000 lb. annually. Michigan was the first state to require pasteurization of all milk sold to the public, and all cows are tested for tuberculosis. The number of pigs was about 800,000.

Industry. — The 1954 census of manufactures showed Michigan to be sixth in manufacturing employment and fifth in the value added by manufacture. Products of its nearly 13,000 establishments had a value added by manufacture of $8,700,000,000, compared with $5,000,000,000 in 1947. Employees numbered 1,000,000. of whom 800,000 were production workers.

The dominant automobile industry, concentrated in southeastern Michigan (Detroit, Lansing, Pontiac, Dearborn, Hamtramck [*qq.v.*] and Flint), produced 47% of the total value added by manufacture in the U.S. of motor vehicles and equipment. Output of passenger cars varied from 6,666,000 in 1950, to 4,321,000 in 1952, to 7,920,000 in 1955 and to 5,816,000 in 1956.

The diversity of Michigan manufacturing is revealed by the fact that of the 453 separate indust ial groups defined in the census of 1954, 369 are represented in the state. In 21 industrial groups it ranks first in value added by manufacture, in 11 second and in 13 third. It leads in motor vehicles and parts; boatbuilding and repair; internal-combustion engines; metalworking machinery; conveyors; industrial patterns and molds; machine shops; hardware; metal stampings; wirework and steel springs; gray iron and malleable-iron foundries; cereal preparations; salt; public-building fixtures; industrial leather belting; padding and upholstery filling; and sporting and athletic goods.

Minerals. — Michigan's mineral products are valued at about $407,000,000. Its diversified output includes iron ore, limestone, gypsum, salt, sand and gravel, cement and copper. Michigan leads all other states in quantity of gypsum and salt produced and is second in iron ore, bromine, and sand and gravel; it ranks high also in portland cement and copper.

In 1844 iron ore was discovered by a surveying party on the site of the present Negaunee. In 1846 mining began, and operations in the three upper peninsula ranges placed Michigan in the front rank of iron-producing states. It held first place from 1890 until 1900, when it was outstripped by Minnesota. During the 1950s, annual production averaged 11,000,000 tons of ore.

Prehistoric miners separated native copper from the rocks on Isle Royale and in the upper peninsula. Modern digging began in 1844, and two years later 27,000 lb. were shipped. Total production during the first 100 years was 9,700,000,000 lb. The record year was 1916, when the output was nearly 270,000,000 lb. Michigan stood first in copper production from 1847 to 1887, but because Michigan mines were deep, some a mile below the surface, Arizona and Montana, with open-pit mines, gradually took the lead.

A low-grade coal was mined from 1835 until 1952, when the last mine closed.

The presence of oil and gas in Michigan was known as early as 1834. Sporadic operations after 1886 produced some oil, but the petroleum industry had its real beginning in the 1920s. All the wells are in the lower peninsula. By 1948 Michigan ranked third among the states east of the Mississippi in oil production, but during the 1950s there was a gradual decline. About 4,200 wells were producing in 40 counties, and exploration continued. Natural-gas production averaged about 7,000,000,000 cu.ft. yearly, placing Michigan fourth among the gas-producing states. To meet the great demand of industries and homeowners, however, vast quantities of gas are received by pipeline from mid-continent fields.

Michigan has for many years been first in the nation in salt production, with nearly one-fourth of the total U.S. product. The Michigan chemical industry, sixth largest employer in the state, uses more than half the salt. Most of the remainder is utilized in soda ash plants and in the production of chlorine and other chemicals.

Forestry. — In the late 1950s the forested area totaled 19,300,000 ac. (53% of the state land area); of this, nearly 7,000,000 ac. were publicly owned, including 23 state forests, 5 national forests, Isle Royale National park and 54 state parks and 14 recreation areas. There were four state nurseries, and 50,000,000 trees were transplanted each year from state, federal and private nurseries. Michigan leads all other states in acreage planted, principal varieties being red, jack, Scotch and white pine, and white spruce. Forest fires are a continuing problem in spite of annual expenditures of about $1,500.000 for forest fire protection. Annual sawmill production fell steadily, while pulpwood production rose from 362,000,000 bd.ft. in 1953 to 490,000,000 in 1957. Standing timber in the mid-1950s was estimated at about 63,000,000,000 bd.ft. The forests and waters of Michigan provide the basis for the state's tourist and recreation business.

Transportation. — In 1836 the first trains in Michigan began running between Adrian and Toledo, O. The next year the state began building two railroads. The Central reached Kalamazoo from Detroit, and the Southern reached Hillsdale from Monroe, in 1846. In the same year they were sold to private companies, and both entered Chicago in 1852. Railway mileage increased until 1910, when it was 9,021 mi.; a gradual decline reduced it to about 6,500 in the late 1950s.

With a shore line of 3,100 mi. on four of the five Great Lakes, Michigan has always enjoyed excellent water transportation. Completion of the St. Mary's Falls canal (Soo canal) in 1855 permitted vast quantities of iron ore and copper to be shipped cheaply to cities near the coal supply. Later, wheat from the western plains moved from Lake Superior ports to elevators and mills on the lower lakes. The annual tonnage (more than 100,000,000) that passes through the canal is considerably larger than that of the Suez and the Panama canals combined. Foreign. as well as U.S., freighters call at ports around the lakes. their number having increased greatly after the opening of the St. Lawrence Seaway

Chief projects in a $1,250,000,000 road and bridge construction program undertaken in the 1950s were expressways from the Ohio line to Mackinaw City and Sault Ste. Marie, from Detroit to the Indiana line and from Toledo through Detroit to Port Huron. In Nov. 1957 a bridge, with a total span of 8,344 ft., was opened across the Straits of Mackinac, and during its first year nearly 500,000 vehicles crossed the bridge. In 1960 a lift bridge carrying automobile, rail and pedestrian traffic over the Keweenaw waterway between Houghton and Hancock was opened.

See also Index references under "Michigan" in the Index volume.

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(L. **A.** W.; F. CL. B.)

MICHIGAN, LAKE, named from the Algonkian Indian term for large body of water, "Michigami[n]" or "Misschiganin," is the third largest of the Great Lakes of North America and the only one located wholly within the boundaries of the United States. It is bordered on the east and north by the state of Michigan, on the west by Wisconsin and Illinois. and on the southeast by Indiana. It is 321 mi. long between its northern and southern shores and its greatest width is 118 mi. The surface area is 22,400 sq.mi. and the area of its drainage basin, exclusive of lake area, is 45,460 sq.mi. The mean height of the lake above sea level is j81 ft.. being the same as that of Lake Huron, to which it is joined at its northeastern extremity by the Straits of Mackinac (*q.v.*). The maximum depth of the lake is 923 ft. Lake level varies with the season. generally about 1.5 ft. from February to July. and also from year to year. In the 100 years from 1860 to 1959 the difference between the highest (j83.7) and the lowest (577.4) monthly mean stages of the whole period was 6.3 ft. The mean annual precipitation is 31 in. Currents in the lake are slight; there generally is a southward drift along the western side and a northward drift along the eastern side. and at times a counterclockwise swirl in the major southern basin and a similar swirl around the Beaver island group in the north. (For comparisons with the other Great Lakes. a discussion of their origins, connections. utilization. etc.. *see* GREAT LAKES. *THE.)*

Exploration. — Jean Nicolet. sent west by Samuel de Champlain in 1634. skirted the northern shore of Lake Michigan to Green bay, by canoe. Father Claude Xllouez began missionary work among Indians of Green bay and the Fox river, in 1668. Louis Jolliet and Father Jacques Marquette mapped the western shore of Lake hlichigan from Green bay to the site of Chicago in 1673, and Jolliet made further explorations of the lake in 1674–75. Robert Cavelier de la Salle brought the first sailing ship. the "Griffin," to Lake hlichigan in 1679. Sent eastward with a cargo of furs, the ship was lost in a storm La Salle later established posts near St Joseph, Michigan, and on the Illinois river.

Physiography. — Approximately 100 streams flow into the lake. only a fen of which are of appreciable size The principal rivers on the east side from north to south, are the Manistee, the Pere Marquette, the White, the Muskegon, the Grand, the Kalamazoo. and the St. Joseph; on the west side the two major rivers enter Green bay, the Fox at its south end and the Menominee on its west shore where it is the boundary between Wisconsin and the northern peninsula of hlichigan. (The Chicago river flows away from the lake, *see* below.) The north end of the lake contains all of the islands. the largest of which is Beaver. 13 mi. long. The discharge of the lake. through the Straits of Mackinac, has not been measured.

Lake Michigan lies within an area of Paleozoic sedimentary rock formations in a zone of relatively weak rocks which were eroded by preglacial rivers to form a lowland which was further deepened by the scouring action of glacial ice. More resistant Niagaran dolomite rock forms the western and northern rims of the lake basin. The eastern shore is underlain in part by other relatively resistant rock strata and in part by great thicknesses of unconsolidated glacial deposits. Sandy beaches are nearly continuous around the lake. The adjacent land generally is low and gently rolling. but wave-cut bluffs of rock or of unconsolidated material occur in many places. Sand dunes are common along the eastern shore, where the prevailing westerly winds blow sand from the beach and move it inland.

Abandoned shorelines indicate that the lake once stood 60 ft. higher and drained southwestward to the Illinois river while glacial ice occupied the northern part of the lake basin. and other evidence shows that the lake surface was 350 ft. below the present level after the ice melted and before upwarp of the land to the northeast raised the outlet area.

The principal mineral resources of the region are iron ore. in northern Michigan: petroleum and salt in the southern peninsula of Michigan; and limestone, sand and gravel.

The prevailing westerly winds produce a climate in western Michigan, in a belt extending 1j mi. inland from the lake. which is suitable for fruit growing. hlichigan is the leading producer of sour cherries and an important producer of peaches and apples. Several national and state forests in the surrounding districts provide for timber growth and recreation.

Harbours and Commerce. — Shipping on Lake Michigan includes long-distance hauls from the other Great Lakes and vessels from Europe. Accumulation of ice in the connecting waters and harbours in the winter season restricts navigation to a period from mid-April to mid-December. The open lake never freezes over, however, and railn-ay-car ferry service across the lake is maintained between several ports throughout the year. By the second half of the 20th century the service on Lake Michigan, by far the most extensive of its kind in the world. consisted of two ferries operated between Grand Haven and Milwaukee by the Grand Trunk railway; seven between Ludington and Milwaukee, Manitowoc and Kewaunee. by the Chesapeake and Ohio railway; four between Frankfort and Menominee and Manistique, and between Frankfort and Manitowoc and Kewaunee, by the Ann Arbor railroad. Many harbours are situated at the mouths of rivers. where piers and breakwaters have been built to afford protection from waves and to maintain adequate depth of water. The large outer harbours at Milwaukee. Wis.. Chicago and South Chicago (Calumet). Ill.. are artificial. The harbours of Port Washington, Wis.. Waukegan, Ill., and Indiana Harhor and Gary. Ind.. are entirely artificial. consisting of dredged channels and basins protected by piers and breakwaters.

The n-ater supplies of the Chicago district and of several other lake cities are drawn mainly from Lake hlichigan.

The Chicago district at the south end of the lake is a great industrial centre. consuming large quantities of water-borne raw materials, principally iron ore; coal and limestone, which are handled through the ports of Calumet, Indiana Harbor and Gary. Most of the iron ore is brought to Lake Michigan from Lake Superior, but some of it is loaded at Escanaba, Mich., on the north shore of Lake Michigan. Milwaukee and Green Bay, Wis., are centres of distribution of coal from Lake Erie ports. Calumet, Chicago and Milwaukee are grain-shipping ports.

Fisheries. — For many years the important commercial fish included lake trout, whitefish, perch. suckers and chub, taken by gill nets and pound nets. The annual catch of lake trout amounted

to more than 6,000,000 lb. for several years through 1945. A species of sea lamprey (eel), invading from the lower lakes, eliminated the trout as a commercial fish and seriously reduced the whitefish catch. (*See* also CYCLOSTOMATA.)

Connections with Illinois River.—The Illinois river watershed is separated from Lake hlichigan by a low divide. In 1848 the Illinois and hlichigan canal was constructed from the Chicago river across the divide to the Illinois river at a point just below La Salle, thus permitting through navigation. In 1900 the sanitary district of Chicago completed a drainage canal from the south branch of the Chicago river to the Des Plaines river at Joliet. This, combined with work in the Chicago river, reversed the flow of the latter and permitted water from Lake Michigan to flow through the canal into the Des Plaines and thence to the Illinois. 4 discharge of 8,500 cu.ft. per second from Lake Michigan was permitted in the years 1925–30, and of 1,500 cu.ft. per second thereafter. The drainage canal also provided a navigable channel 21 ft. deep, with a minimum bottom width of 200 ft., from the lake to a point between Lockport and Joliet, where a power plant was constructed. A Great Lakes-to-Mississippi river waterway was completed with federal aid and was officially opened in. 1933. The minimum depth, between Lockport and the mouth of the Illinois river. was 9 ft. and the minimum channel width was 200 ft. A branch of the canal system, extending from the Sag junction of the Calumet Sag channel with the Des Plaines river, about 10 mi. north of Lockport, eastward to Lake Calumet and connecting with Calumet harbour, was enlarged in 1958 as part of a program of expansion of port facilities in that area.

See Great Lakes Pilot, and charts, U.S. Lake Survey, Detroit (annual); M. M. Quaiie, ***Lake Michigan*** (1944). (J. L. HH.)

MICHIGAN, UNIVERSITY OF, at Ann Arbor, Mich., is one of the largest educational institutions of the U.S. and is one of the oldest state universities, having been founded in 1817. *See* MICHIGAN: *Education.*

MICHIGAN CITY, a city of La Porte county, northwestern Indiana, U.S., on Lake Michigan 50 mi. E. by S. of Chicago. It was planned and founded by Maj. Isaac C. Elston, who in 1831 purchased land from the government on which he plotted a townsite, incorporated as Michigan City in 1836. It was chartered as a city in 1867. Michigan City has many diversified businesses and industries. It is widely famed for its excellent beach, boating and recreational facilities, and beautiful residential areas in the famed Indiana sand dunes. It is a favourite vacation spot for thousands of visitors yearly. being readily accessible by water, rail, highway and air transportation. Development of the St. Lawrence seaway was a stimulus to the economy of the city. For comparative population figures *see* table in INDIANA: *Population.* (E. P. KI.)

MICHOACÁN, a central agricultural and mining state of Rlexico. Pop. (1950). 1,422,717, chiefly mestizos and Tarascan Indians. Area 23,202 sq.mi., bisected by the Sierra hladre Occidental running southeasterly from the high central Mexican plateau. of which the state forms a part. Michoacán lies in an area of fertile valleys. lakes and great volcanic activity: in 1759 Mt. Jorullo suddenly arose after an eruption in the midst of an agricultural area, and in 1943 Parícutin similarly appeared near Uruapan. Nearby stands the highest peak in Michoacán. Tancitaro (12,605 ft.). The rivers drain to the Pacific; the Lerma. on the northwestern frontier, and the Balsas-Tepalcatepec at the south, are the most important. Each is the scene of large-scale irrigation projects. The federal government began a long-term development of hydroelectric power, drainage, communication and of new industrial-agricultural communities on the underpopulated Pacific slopes.

The mountain valleys of Michoacán are cool and healthful. but the Pacific coastal plain is hot and insalubrious. The state has two large lakes: Chapala, bordering Jalisco, and Pátzcuaro. a popular resort where fishermen use butterfly nets. In the 1530s the Dominican \.-asco de Quiroga established the first successful missions among the Tarascan Indians around Lake Pátzcuaro on the site of Quiroga and the pre-Columbian town of Tzintzuntzán. Influenced by Thomas More's *Utopia,* Quiroga sought to organize a cooperative commonwealth among the natives. Crafts taught then survive today, and Quiroga's name is still venerated in this region.

In 1951 the United Nations Educational, Scientific and Cultural Organization and the Organization of American States jointly established on Lake Pátzcuaro a regional educational centre, Crefal. to train rura! teachers for Latin America. Former Pres. Lázaro Cárdenas of Mexico donated his home here as the school plant.

Michoacán produces a wide range of forest products, tropical crops. grains, gold. lead. silver, cinnabar. copper. coal, oil and sulfur. It is well supplied with highway, air and rail connections. Important cities of the state are Morelia (*q.v.*), the capital. Uruapan (q *v.*), Zamora and Patzcuaro. (J. A. Cn.)

MICKIEWICZ, ADAM (1798–1855), Polish poet, was born near Nowogrodek, in the Russian government of Minsk, where his father, who belonged to the lesser nobility, had a small property. The poet was educated at the Vilna university; but, becoming involved in political troubles as a member of a secret patriotic student society, he was imprisoned for a time by the Russian government and afterward ordered to live in Russia. He had already published two small volumes of miscellaneous poetry at Vilna, which had been favourably received by the Slavonic public, and on his arrival at St. Petersburg he found himself admitted to the leading literary circles, where he was a great favourite both for his agreeable manners and his extraordinary talent of improvisation. In 1825 he visited the Crimea, which inspired a collection of sonnets in which may be admired both the elegance of the rhythm and the rich oriental colouring. Among the most beautiful are ***The Storm, Bakchiserai,*** and ***Grave of the Countess Potocka.***

In 1828 appeared his ***Konrad Wallenrod,*** a narrative poem describing the battles of knights of the Teutonic order with the Lithuanians. There, under a thin veil, Mickiewicz represented the sanguinary passages of arms and burning hatred which had characterized the long feuds of the Russians and Poles. The object of the poem, although evident to many, escaped the Russian censors, and it was suffered to appear, although the very motto, taken from Machiavelli, was significant: "Dovete adunque sapere come sono duo generazioni da combattere . . . bisogna essere volpe e leone." This is a romance in the Byronic vein and contains two beautiful lyrics.

After a five-year exile in Russia the poet obtained leave to travel; he had secretly made up his mind never to return to that country or Poland so long as it remained under the government of the Muscovites, and he never saw his native country again. Wending his way to Weimar, he paid his homage to Goethe, who received him cordially, and, pursuing his journey through Germany, he entered Italy by the Spliigen, visited Milan, Venice and Florence, and finally took up his abode at Rome.

It was on these wanderings of his that Mickiewicz wrote the greatest scenes of his fantastic drama ***Dziady*** (Forefathers' Eve), the subject of which is the half-pagan religious commemoration of their ancestors practised among the peasantry of the Slavonic nations.

Interwoven with this subject from folklore, there is, in the earlier portion of the poem (the so-called "Fourth Part") a dramatic account of an unhappy early love affair of the poet's, and, in the later and more important portion, called the "Third Part," a picture of his own and his Vilna fellow-students' sufferings in the Russian prison, and a powerful poetic statement of the workings of his genius while a mystical religious philosophy was being produced in his mind by the influence of personal and national suffering.

Mickiewicz' acknowledged masterpiece is his epic poem ***Pan Tadeusz,*** published in 1834. Its scene is laid in Lithuania on the eve of Napoleon's expedition into Russia in 1812, and its subject is a family feud among the country gentry. happily terminated by a wedding. In this epic idyll, Mickiewicz gives us a picture of the homes of the olden-time Polish nobility and gentry, with their somewhat boisterous but very genuine hospitality, their meals and manners and pastimes, and their readiness for patriotic sacrifice in the service of their country. Turning to the land of his childhood with the loving eyes of an exile, he gives us delightful

descriptions of Lithuanian skies and forests: through the medium of his poetry, the modest landscape of the Lithuanian countryside has become dear and familiar to every Pole, and to many readers outside Poland.

In 1832 Mickiewicz left Rome for Paris, where most of his later life was spent in poverty and unhappiness. He had married a Polish lady, Celina Szymanowska, who became insane. In 1838–39, he occupied the chair of Latin literature in the University of Lausanne, Switzerland. In 1840 he was appointed to the newly founded chair of Slavonic languages and literature in the Collège de France, a post which he was especially qualified to fill, as he was then the chief representative of Slavonic literature, Pushkin having died in 1837. He was, however, only destined to hold it for a little more than three years, his last lecture having been given on May 28, 1844. He had fallen under the influence of a mystic named Towianski. His lectures became a medley of religion and politics, and thus brought him under the censure of the government.

A selection from his lectures was published in four volumes. They contain some good sound criticism but the philological part was necessarily defective for Mickiewicz was no scholar, and he was obviously only well acquainted with two of the literatures, *viz.*, Polish and Russian, the latter only to the year 1830. Nevertheless the poet showed much intuitive insight into the history and mentality of the Slavonic races, especially of Poland and Russia.

A very sad picture of his declining days is given in the memoirs of Herzen. At a comparatively early period the poet seemed to have exhibited all the signs of premature old age; poverty, despair and domestic affliction had wrought their work upon him. In his later years, Mickiewicz endeavoured to turn from poetry to active work for the cause of his country's deliverance. In 1848 he attempted to form a Polish volunteer legion in Italy, but the attempt came to nothing. In 1849 he founded a radical French newspaper, *La Tribune des peuples,* but it remained in existence only a year. His last composition was a Latin ode in honour of Napoleon III.

On the outbreak of the Crimean War he was sent to Constantinople to assist in raising a regiment of Poles to take service against the Russians. He died suddenly there in 1855, and his body was removed to France. In 1890 his remains were disinterred and buried in the cathedral of Cracow, the Westminster abbey of Poland.

Mickiewicz is one of the greatest among Slavonic poets. He is one of the best products of the so-called romantic school in Polish literature. While that literature was cribbed and confined by 18th-century classicism, the country was full of legends and picturesque stories which only awaited the coming poet to put them into shape. Hence the great popularity among his countrymen of his ballads, each of them being connected with some national tradition. In addition to *Konrad Wallenrod* and *Pan Tadeusz,* attention may be called to his early poem *Grazyna,* which describes the adventures of a Lithuanian chieftainess against the Teutonic knights. It is said by Ostrowski to have inspired the brave Emilia Plater, who was the heroine of the rebellion of 1830, and after having fought in the ranks of the insurgents, found a grave in the forests of Lithuania.

A fine vigorous oriental piece is *Farys.* Very good, too, are the odes to Youth and to the historian Lelewel; the former did much to stimulate the efforts of the Poles to shake off their Russian conquerors.

It is enough to say of Mickiewicz that he has obtained the proud position of the representative poet of his country; its customs, its superstitions, its history, its struggles are reflected in his works. He is the great voice of Poland appealing to the nations in its agony.

BIBLIOGRAPHY.—The poet's life has been written, and his correspondence edited, by his son, Ladislas Mickiewicz (4 vol., Poznan, 1890–1895; French *Life* in 1 vol., Paris, 1888). The standard modern Polish work on Mickiewicz is that of Prof. J. Kallenbach *(Adanz Mickiewicz,* 2 vol., 4th edition, Lwów, 1925). In English, see *Adam Mickiewicz, the National Poet of Poland,* by Miss Monica M. Gardner (London, 1912). Translations into English of *Konrad Wallenrod* and *Pan Tadeusz* were made by M. H. Dziemicki and Maude A. Biggs (1881–85), and more recently, by Prof G. R. Noyes in California and his students *(Pan Tadeusz,* 1917; *Konrad Wallenrod and other Writings,* 1925); *Forefathers' Eve,* prologue and scenes 1–5 of Part Third (London, 1926). (R. DY.; X.)

MICKLE, WILLIAM JULIUS (1735–1788), Scottish poet, son of the minister of Langholm, Dumfriesshire, was born on Sept. 28, 1735. He was educated at the Edinburgh high school, and in his 15th year entered business as a brewer. His father purchased the business, and on his death William Mickle became the owner; but he neglected his affairs, devoting his time to literature, and before long became bankrupt. In 1763 he went to London, where in 1765 lie published "a poem in the manner of Spenser" called the *Concubine* (afterward *Syr Martyn*); was appointed corrector to the Clarendon Press, and translated the *Lusiads* of Camoens into heroic couplets (specimen published 1771, complete work, 1775).

So great was the repute of this translation that when Mickle—appointed secretary to Commodore Johnstone—visited Lisbon in 1779, the king of Portugal gave him a public reception. On his return to London he was appointed one of the agents responsible for the distribution of prize money, and this employment, in addition to the sums brought him by his translation of the *Lusiads,* placed him in comfortable circumstances.

It has been suggested that the Scottish poem "There's nae luck aboot the hoose" was Mickle's. It is more likely, however, that Jean Adams was the author. Scott read and admired Mickle's poems in his youth, and founded *Kenilworth* on his ballad of *Cumnor Hall,* which appeared in Thomas Evans' *Old Ballads . . . with some of Modern Date* (1784).

MICMAC. An Algonkian-speaking Indian people of Nova Scotia. New Brunswick, Prince Edward Island and coastal Quebec, probably were the Indians discovered by John Cabot in 1497. They formed a confederacy of seven bands: their name means "allies." They were nonagricultural, used canoes for transportation and were dependent on fishing and hunting. They were consistently friendly to the French and hostile to the English settlers, whom they fought bitterly after the cession of Acadia to Great Britain in 1713; estimated at 3.000 to 3,500 during the 17th and 18th centuries. their descendants numbered about 4,000 in 1960, much intermixed with whites. Their dialect differs considerably from that of their neighbours, so that they may represent a fairly early offshoot of the Algonkian family.

See Smithsonian Institution, Bull. 30, *Handbook of the American Indians,* vol. i (1912). (A. L. K.; X.)

MICON (fl. 5th century B.C.), Greek painter, was closely associated with Polygnotus (*q.v.*) of Thasos. in conjunction with whom he adorned the Painted Stoa, at Athens. with paintings of the battle of Marathon and of the Greeks and Amazons. He collaborated with the same artist in paintings in the Theseum and the Anaceum. and was esteemed also as a sculptor of athletes.

MICROANALYSIS, CHEMICAL: *see* CHEMISTRY: *Analytical Chemistry, Microanalysis.*

MICROBE: *see* BACILLUS; BACTERIAL AND INFECTIOUS DISEASES; BACTERIOLOGY.

MICROCLINE, a potassium aluminum silicate, is an economically valuable mineral used in the production of ceramics. It is a triclinic potash feldspar having in the pure state the chemical composition $KAlSi_3O_8$. The deviation from monoclinic symmetry is small? the name microcline being derived from the Greek meaning "small" and "angle" because of the slight variation of the cleavage angle from 90°.

Detailed information on the crystallographic differences between microcline and monoclinic potash feldspar (sandine) is given under FELDSPAR: *Polymorphism.*

Intermediate microclines may have some sodium aluminum silicate, or albite. $NaAlSi_3O_8$, in solid solution, the amount tending to increase as monoclinic symmetry is approached. Most maximum microclines show perthitic unmixing; *i.e.*, they are intergrown with exsolved $NaAlSi_3O_8$. Single crystals of maximum microcline which are virtually pure $KAlSi_3O_8$ and therefore lack perthitic exsolution are very rare. Authigenic crystals or overgrowths on pegmatitic orthoclases are examples. As a rule microclines have

initially crystallized as monoclinic materials with some $NaAlSi_3O_8$ in solid solution. In the course of geological time they gradually became triclinic and developed the characteristic albite-pericline (microcline-type) twinning with simultaneous exsolution of $NaAlSi_3O_8$.

Usually microcline has no colour of its own. In places, however, it is found with a beautiful green colour *(see* AMAZON STONE). This is macroscopically monoclinic, microscopically twinned, and shows perthitic exsolution of albite. The nature of the colour, which is pleochroic *(see* MINERALOGY: *Optics),* is still unknown. Microcline is found predominantly in geologically old rocks, though occurrences in younger rocks (especially pegmatites) are sometimes met. (F. H. L.)

MICROCOSM (Gr. *mikros kosmos,* "little world"), a philosophical term designating man as being a "little world" in which the macrocosm or universe is reflected. The ancient idea of a world soul animating the universe had as a corollary the idea of the human body as a miniature universe animated by its own soul, and the notion of the microcosm dates. in western philosophy, from pre-Socratic times (Democritus specifically refers to it). Propagated especially by the Neoplatonists, the idea passed to the Gnostics, to the Christian scholastics, to the Jewish Cabalists and to Renaissance philosophers such as Paracelsus. The supposed analogy between the whole and its parts served not only to develop a cosmology in which the reality of the individual received due attention but was also fundamental to astrology and other sciences postulating belief in a metaphysical relationship between man and the rest of nature. In later philosophy the monadology of Leibniz presents a comparable view of man and the universe, and Lotze took *Mikrokosmus* as the title of his major work on the theory of knowledge and reality.

See G. P. Conger, *Theories of Macrocosmos and Microcosmos in the History of Philosophy (1948).*

MICROMANIPULATION (MICRURGY. MICROSURGERY) is a term applied to a specialized technique for operating on microscopic objects under the high magnifications of the compound microscope. The operations, which include microdissection, microvivisection, microisolation and microinjection, are made with especially fine needles and pipettes and are of such delicacy that a human blood cell less than 8 microns (0.008 mm.) across can be punctured and torn. This technique has many applications. especially in research on cells, cell constituents and embryos, and is also used in various technological examinations.

In 1901 S. L. Schouten, a Hollander, and in 1904 M. A. Barber, an American, independently of one another, described a technique for isolating a single bacterium in the field of the high powered oil-immersion lens. The isolation was accomplished by suspending a drop of liquid, containing the bacteria, on the underside of a cover slip and having the microneedle approach the drop from below. The cover slip was mounted so as to serve as the roof of a three-walled moist chamber. The needles with their tips bent upward were passed into the chamber through its open end.

In succeeding years many modifications of the original instruments used by Schouten and Barber have been developed. The tips of these microtools move in arcs of large circles that are unappreciable under the microscope, since the field appears so large. Remote, fine operating controls attached by flexible shafts eliminate the transmission of trembling of the hand. A well-controlled mechanical stage is essential because a great deal of the microoperative work is done by moving the moist chamber with the mechanical stage. For examples of the use of micromanipulation techniques. *see* ANATOMY, MICROSCOPIC; EMBRYOLOGY, EXPERIMENTAL; PROTOPLASM.

See M. J. Kopac, "Micromanipulation," in *The Encyclopedia of Biological Sciences,* ed. *by* Peter Gray (1961).

MICROMETER, a name generally given to any device for measuring small angles or dimensions (from Gr. μικρός, small, μέτρον, a measure). In particular a great variety of appliances used for astronomical measurement are called micrometers.

One of the immediate difficulties of accurate measurement of linear dimensions is to secure coincidence between the measuring appliance and the object measured. For inaccessible (celestial) objects, coincidence is, of course, impossible; for accessible objects, *e.g.,* a photographic plate, the plate and the measuring appliance are likely to get in each other's way. The remedy is that either the measuring scale or the thing measured should be *insubstantial.* Certain devices, such as interferometers, can be regarded as representing the first alternative; but, in general, the simplest solution is to arrange that the thing measured shall be insubstantial, viz., an optical image, accessible and offering no interference with our measuring tools, but forming a faithful reproduction to scale of the object whose dimensions we really wish to know. Both in the telescope and the microscope a real image is formed in the focal plane; here we place the "pointer" of our micrometer—a movable wire, a scale ruled on glass, or some other fiducial mark—and move it about in the midst of the ghost that we are measuring. We view the coincident pointer and image through an eyepiece, which acts as a magnifying glass. Most micrometers make use of the principle of the screw; the pointer is displaced uniformly by turning a screw. If, for example, the step of the screw is 0.5 mm., and the screwhead is read to $\frac{1}{100}$ of a revolution, we measure to 0.0005 mm. (about equal to the wave length of light). Needless to say, many precautions are necessary if we would actually attain such high accuracy.

Filar Micrometer.—The first micrometer used with a telescope was made by William Gascoigne, about 1638. It consisted of two pointers with parallel straight edges, which could be brought together or separated by turning a screw. He made measurements of the diameters of the sun, moon and planets, which are still extant, and prove that his invention made a very great advance on earlier measurements. The modern successor of this instrument is the *filar micrometer,* in which the two pointers are replaced by parallel wires or spider webs, carried on metal frames. Two screws are provided, one of which moves the pair of wires as a whole, and the other alters the separation of the two wires. In most observations, only the reading of the second screw is required, the first screw being merely an aid in setting. Much work formerly done by visual measurement is now done photographically, and the use of the filar micrometer is now mainly fbr measurement of the separations and position angles of double stars. *(See* also HELIOMETER.)

Travelling-wire Micrometer.—This is an appliance used in conjunction with the transit circle *(q.v.)* which has proved very successful in avoiding magnitude-equation and other systematic errors, and is now generally adopted in fundamental observation. The older method was to tap off on a chronograph the observed times of passage of a star across a series of fixed wires set in the focal plane of the telescope. In the travelling-wire or "impersonal" micrometer, the observer continually turns a screw so as to keep a fine wire or web continually bisecting the moving star image. (The turning of the screw moves the eyepiece as well as the wire, so that the bisected star remains apparently stationary at the centre of the field of view.) Electrical contacts are made when the moving frame reaches definite positions, and the time when the wire, and therefore the star, reaches a series of positions is thus automatically recorded on the chronograph.

Photographic Measuring Machines.—These are examples of the application of the micrometer to the *microscope.* There is a wide variety of patterns, and nearly every observatory has its own form, designed to embody some special improvement, valuable either for securing accuracy or for saving time in the particular work there pursued. Many lines of work involve a prodigious amount of measurement of photographs, and the time-saving factor is therefore of great importance. We can only summarize here some of the typical requirements. The photographic plate must be carried on slides allowing it to move in two perpendicular directions, so that any point of it can be brought directly under the microscope. The frame should have great rigidity, in order that perfect focus may be preserved. The cross-wires, glass scale or other fiducial marks, are in the focal plane of the microscope objective. The actual measurement is usually accomplished by moving the photographic plate relatively to the measuring microscope, or by the motion of the microscope itself relatively to the stationary plate. The eyepiece is mainly re-

sponsible for the magnification. Magnification by the objective is seldom greater than 3:1; there are, in fact, many advantages in using unit magnification, *i.e.*, the image in the focal plane of the objective is the same size as the photograph itself. It may be recalled that in visual observing we magnify with the eye lens an image formed in the focal plane of the telescope; by inserting a photographic plate in the focal plane this image is materialized and rendered permanent; the objective of the measuring microscope converts this back into an insubstantial image, preferably of the original size, and we then make our deferred examination of it with an eye lens.

A recent development has been the introduction of measuring machines which utilize the principle of projection. In this type of instrument an image of the micrometer wire, together with the lens-formed image of a small region of the photographic plate to be measured, are projected onto a white screen. The bisections of the star images are made while the observer sits in comfort watching this screen, which is located at a convenient reading distance from the eyes. This method reduces physical fatigue and the danger of eyestrain; in addition, the measures may be slightly more accurate. Instruments of this type are in use for measuring photographs of star fields for the determination of parallax and proper motion. In proper motion work the photograph at one epoch is sometimes taken through the glass of the plate; *i.e.*, with the plate "the wrong way round"; the two plates to be compared are then placed film to film so that corresponding images are very near together. In this case the comparison resolves itself into measuring exceedingly small distances between pairs of images, and there are comparatively few sources of error.

Similar principles apply to machines for measuring spectra (celestial or laboratory). Here the motion and measurement are in one dimension only, and a line is a somewhat easier object to set on, either with single or parallel wires, than a star image. Whenever possible the measurements are made relatively to a comparison spectrum, so that only small differences of position are to be measured. (A. S. E.; X.)

MICRONESIA (from Gr. *mikros*, "small," and *nēsos*, "island"), one of the three main divisions of Oceania (*q.v.*), lies west of Polynesia and north of Melanesia. It consists of the Mariana, Caroline, Marshall and Gilbert island groups and isolated Nauru Island. The Gilberts are part of the British Gilbert and Ellice Islands colony. The phosphate island of Sauru, a United Nations trust territory. is administered as a joint responsibility of Great Britain, Australia and New Zealand. Guam since 1898 has been a U.S. possession. The remainder of Micronesia comprises the Trust Territory of the Pacific Islands. since 1947 a United Nations strategic area trusteeship administered by the United States.

Geography. — Micronesian islands range between 2° 45' S. and 20° 32′ N. lat. and 131° 10′ and 177" E. long., an area as vast as the continental United States. Except for the high islands of volcanic origin, such as Guam, Saipan and Tinian in the Marianas, and Yap, Palau, Truk, Ponape and Kusaie in the Carolines. Micronesia consists entirely of scattered low coral islets. The latter, more than 2.000 in number. account for only 20% of Micronesia's 1,055 sq.mi. of land. Guam with its 205 sq.mi. is the largest island in Micronesia, while Agrihan, another of the Marianas, has the highest altitude, 3,166 ft. The United States maintains both sea and air transport between Guam and the more important islands of the trust territory. British-controlled shipping orients the Gilberts and Nauru toward Australia and New Zealand.

Temperatures average about 80° F. and show little seasonal change. Characteristics of altitude and latitude are responsible for marked local differences in rainfall, and populations located near the equator sometimes experience extremely long droughts. Destructive typhoons periodically visit the western islands, but malaria and certain other diseases often associated with tropical climates are lacking.

History. — Ferdinand Magellan's discovery of the Marianas in 1521 marked the onset of Micronesia's absorption by the western world. In the following decades Guam became a vital watering stop for Spanish crews sailing the galleon route from Mexico to Manila in the Philippines. Jesuit priests in 1668 began the wholesale conversion of natives throughout the Marianas. When the Chamorros resisted they were forcibly brought under Spanish rule and suffered great losses in population and cultural autonomy.

In the mid-1880s eastern Micronesians, especially on Kusaie, were exploited by New England whalers whose actions were vigorously opposed by Protestant workers of the Boston mission. German planter-traders in the Marshalls, building a commercial empire on the conversion of coconuts into copra, received the support of their government when Germany in 1885 proclaimed a protectorate over the area. In that year Spain successfully resisted German moves to expand into the Carolines when, recalling 16th-century discoveries by Spanish navigators, it convinced Pope Leo XIII of its prior claim to the islands. Britain entered the political arena in 1892 by declaring a protectorate in the Gilberts and outlawing slave-labour recruitment for Central American plantations. Phosphate was discovered on German Nauru and British Ocean Island in 1900. An Anglo-German agreement allowed it to be mined by a British company. The Spanish-American War led to the U.S. annexation of Guam and to Germany's purchase of the rest of Spain's interests in Micronesia. German administrative centres were established at Saipan, Yap, Ponape and Jaluit in the Marshalls.

Japanese naval forces in 1514 seized all German holdings north of the equator, and Australians occupied Nauru. Both territories aere later assigned as mandates by the League of Nations. Japanese administration, centred at Koror in Palau, stressed agricultural and fisheries development for export to the homeland and encouraged immigration from Japan's overcrowded provinces. By 1940 about 85,000 Japanese colonists accounted for nearly two-thirds of Micronesia's population. Native customs and living conditions changed most in the Marianas and Palau, where larger numbers of Japanese had settled. By comparison with the Germans, Japanese officials tended to limit or belittle local practices of the island peoples. From 1915 the British phosphate commissioners, representing Great Britain, Australia and New Zealand, managed phosphate operations on Nauru and Ocean Island. The same nations held the League mandate for Nauru, although administration became Australia's direct responsibility.

About 1935 Japan began to militarize the mandated islands, and after the attack on Pearl Harbor in 1941 moved quickly to occupy Guam, Sauru and the Gilberts. For Micronesians World War II meant population dislocation, battle-damaged properties and deprivation of trade and medical supplies. The Allied invasion, after restoring the Gilberts in 1543, moved on to take key islands in the Marshalls. Marianas and Palau. Following Japan's surrender in 1545 all Japanese civilians as well as the military were repatriated. Micronesia's resident population during the postwar years was almost all indigenous, the native population being estimated at 135.000.

Administration. — The oldest of the four administrations now maintained in Micronesia is the Gilbert and Ellice Islands colony, dating from 1916 and including as two of its five districts the Gilbert Islands and Ocean Island. Its resident commissioner has headquarters at Tarawa Island in the Gilberts. He is responsible for all functions of government, reporting to the colonial officein London through the high commissioner of the Western Pacific at Honiara, British Solomon Islands. Local government is carried on by native organizations under supervision of British officials.

The trust territory of Nauru, formed under the United Nations in 1547, is governed by an administrator appointed by the commonwealth government of Australia and responsible to the minister for territories at Canberra. He holds all powers of government. Since 1951 a local government council of eight elected indigenous members has aided him in the maintenance of peace and order among Nauruans. As with all UN trust territories the trusteeship council in New York city receives annual reports from the administering authority and sends a visiting mission to the area every three years.

The U.S. Trust Territory of the Pacific Islands is headed by a high commissioner, appointed by the president and responsible to the secretary of the department of the interior. The high com-

missioner's office is located at Agaña on Guam. District administrators serve at Koror. Yap. Truk, Ponape. Majuro (Marshalls) and Rota. Islands in the Mariana district other than Rota were in 1953 transferred to jurisdiction of the navy department for strategic military reasons as permitted by the trusteeship agreement. A naval administrator governs these islands from Saipan. In most districts an advisory congress composed of elected Micronesian representatives is empowered to enact legislation subject to the high commissioner's approval. An independent judicial system operates under a chief justice who is appointed by and reports to the interior secretary.

The unincorporated territory of Guam has progressed farther in the practice of self-government than any other Micronesian area. Since 1950 Guamanians have been full citizens of the United States. By popular vote they elect delegates to a unicameral legislature which meets twice annually in Agaña to pass laws subject to only limited gubernatorial veto. The judiciary is separated from exec-, utive and legislative offices. The governor is appointed by the president and reports to the secretary of the interior. In 1960 for the first time a Guamanian was named to this top island post.

Economy. — For most Micronesians daily subsistence is ensured by cultivation of taro, breadfruit, coconut and sweet potatoes, supplemented by lagoon or deep-sea fishing. Administrators urge continuation of these traditional practices for they realize the limitations of local resources for other economic development. Copra —the dried meat of coconuts and the source of oil for soap and margarine — is the leading export. Handicraft products and raw shell for button manufacture trail far behind. Imports greatly exceed exports and consist mainly of foodstuffs. clothing, hardware and building materials.. In some islands wage labour and small business are an important means of earning money. Several thousand natives, only a few of them skilled, work regularly for administrative agencies, trading companies and small service enterprises. Guam constitutes a special case, where wage employment for Guamanians has come to dominate the local economy because of the presence of an extensive military establishment and its attendant "stateside American" community.

Only Nauru and Ocean islands are involved in the quarrying of Micronesia's most valuable export, phosphate. The ram material shipped from these two islands for refinement as fertilizer helps to maintain the high standard of living enjoyed by the inhabitants. As landowners they receive compensation in royalties and land rents. On Ocean Island, however, mining had so seriously eroded native living areas that in 1946 the entire population was resettled on Rabi Island in Fiji. Since that date imported labour has worked the mines on a contract basis.

Ethnology. — Micronesia has not long — relatively speaking — been inhabited hy man. Without transportation like the outrigger sailing canoe long stretches of water could not be crossed, and without food plants such as taro, coconut and breadfruit voyagers could not survive on the small islands. These conditions had been met when migrants from eastern Asia and Indonesia entered western Micronesia, possibly as early as 3000 B.C. The wanderers were racially Indonesian-Mongoloid with some pygmy Negroid admixture from New Guinea and spoke languages of the Malayo-Polynesian family now widespread in Oceania. Eastern Micronesia may have been entered from the Solomons and New Hebrides and later from Fiji and western Polynesia. The movements of Micronesians in prehistoric times are slowly being clarified by painstaking archaeological excavation and comparative ethnology, but by mid-20th century all except the broad outline was still tentative.

The material culture of old Micronesia demonstrates the close bond between daily living and physical setting. Changes have been great in this respect, though some of the old technology still survives. Families lived in thatched, one-room houses with detached cooking huts. A larger building often dominated the residential area, serving as a clubhouse for males or as a council house in which heads of families deliberated. hlen and women shared the routine of work, the former assuming the heavier and more dangerous tasks while women undertook chores associated with homemaking. Food was cooked in earthen ovens and eaten by the household group that had produced it. Specialized fishing techniques maximized utilization of marine resources. Surplus yields of breadfruit and pandanus, preserved in pits or dried in rolls, supplemented taro and coconut in leaner seasons, and men drew sap from coconut flowers to make toddy, a substitute for drinking water. Tools and utensils were expertly fashioned from local supplies of shell. fibre and wood.

Since they lived in a tropical climate. Micronesians needed little clothing. Adults more sarongs and loincloths made from plaited mats of pandanus leaf or from loom-woven fabrics of banana fibre. Both sexes tattooed all or part of the body with intricate designs, and personal adornment received considerable attention. Flowers in great profusion, worn in the hair, in pierced ear lobes. and as wreaths and necklaces. vied with more durable decoration in shell.

Communities were small. comprised of hamlets of 20 to 50 residents or of villages of a few hundred at most, located near stream, lagoon or sea because the water provided both food and a means of transportation. Dugout hulls with balanced outrigger and lateen sail reflected superlative achievements in canoe design. Navigational skills, of atoll peoples particularly, demonstrated a remarkable understanding of star movements and patterns of wind and wave. Since the self-sufficiency of communities discouraged an economic exchange of goods, most travel served social and political ends.

The social relations of Micronesians have always depended first upon family and other kinship bonds and secondly upon face-to-face contacts with nonkinsmen in the locai community. Islanders have commonly channeled their social, economic and political activities along lines of mutual aid and obligation among local groups related by blood or marriage. This practice has hindered official attempts, as in the U.S. trust territory, to develop loyalties to larger territorial entities.

Premarital sexual freedom prevailed within the restrictions of incest. Though marriage was marked by little ceremony. the union reflected social and economic ambitions of the families involved. Adoption, a widespread custom, gave children an alternate set of parents rather than permanent replacements. Established households included various relatives who did not belong to the immediate family. A much larger kin group, composed of persons related to a common ancestor through their mothers and not living in common residence, played a dominant role in most island societies.

Male heads of lineages, clans and other kin groups acted as leaders within the community. In some islands they formed democratic councils; elsewhere they were ranked as a hierarchy of titles with privilege associated with those at the top. Kindreds, singly and in confederation, engaged in war and in competitive exchange of gifts and feasts. Shell and ceramic beads and large stone disks (often exceeding three feet in diameterj were used as money in formal exchanges between families in the western Carolines. Individuals as members of corporate kin groupings shared inherited rights to ownership and use of land, and hereditary status generally outweighed personal merit in determining succession to political office. On most high islands and the Marshall atolls, class stratification accompanied the emergence of powerful chieftains whose people gave them goods and services in tribute. The worldly authority of such chiefs gained support from the popular belief in their divine ancestry.

Micronesian religion allowed no separation of the spiritual from the physical. While Christianity has been successful and forms of worship have changed; Micronesians retain a fundamental conviction of the total unity of things.

Ceremonial burial prepared the soul of the deceased for its dangerous journey to the afterworld. Ghosts coritinued to be a vital force among the living and, according to belief. could aid or destroy humans depending on the vigilance shown by surviving relatives in memorial observance. Certain ancestral spirits were accorded the higher status of deity. These ghosts, gods and multitudinous nature spirits, both feared and respected, were supplicated in war, drought, sickness and other adversity. Sacred places and unpretentious shrines served individualistic shamans in their mediation through prayer, incantation and offerings, Black magic and white were practiced in social relations.

See also PACIFIC ISLANDS.

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MICRONESIAN LANGUAGE: see MALAYO-POLYNESIAN LANGUAGES.

MICROPALEONTOLOGY, the study of small fossils, differs from paleontology (*q.v.*), of which it is a division, mainly in the smaller size of specimens and the methods and techniques used in their preparation and study. It differs also in its more extensive use in stratigraphy (*q.v.*), the study of layered rocks, and in petroleum geology (*see* PETROLEUM).

Some microfossils belong to biological groups whose members are characteristically small. Fossil Foraminifera belong to the Protozoa, or one-celled animals. as also do the Radiolaria. Ostracodes are very small crustaceans with a clamshell-like covering. Diatoms are minute plants with boxlike outer skeletons. The small size of other microfossils may stem from the fact that they are fragments of larger plants or animals. Fossil spores and pollen belong in this category as do also the embryonic shells of mollusks: skeletal plates of sea cucumbers; scales. teeth and earbones of small fish; worm jaws; and the minute calcite prisms of which clamshells are composed. There are, in addition, a number of minute fossils whose relationships are unknown, but which are classified as microfossils.

Microfossils are almost never collected singly. but by the hundreds or even by the thousands in rock samples in which they occur. The collector rarely knows whether or not his samples contain microfossils until they have been processed in the laboratory. This may be done by reducing the sample to fine dustlike particles and manually picking the microfossils out of. the pulverized rock debris, or floating them out with a liquid the specific gravity of which is such that it will lift the microfossils and not the matrix. After removal, the fossils are placed in cardboard well slides for study and storage. A wide-field stereoscopic microscope with reflected light and capable of magnification ranging from 10 × to 100 × is used to study most microfossils.

Samples that are suspected of containing spores and pollen are digested in a series of acids—hydrofluoric (HF), hydrochloric (HCl) and nitric (HNO_3) are commonly used—and the residue centrifuged out of the containing liquid. The residue is then stained and preserved in glycerine jelly. A drop of this jelly placed on a transparent slide and covered with a transparent cover slip, is then ready for study under a binocular biological microscope, using transmitted light and magnifications ranging from 100 × to 1000 ×. A mechanical stage is used for scanning the slide and also for recording the location of spore and pollen grains.

Pollen grains range from 10 microns to 130 microns in size (0.0004 to 0.005 in.). Spores average about roo microns (.004 in.j in diameter. Animal microfossils probably average 500 microns in size. with extremely small forms ranging downward to 2j or 30 microns. The upward range is very great. Some discoidal foraminifera are as much as five inches in diameter, but are almost paper-thin. Others are one inch or so in diameter and as much as one-fourth inch thick. One giant is one inch thick and more than three inches long. These are considered microfossils only because they belong to a biological group whose members normally fall in the proper size range.

The large forms present a special problem in preparations and study. Because their internal structure is significant, they must be sectioned. They are ground on a hand or mechanical lap until the plane of grinding passes through the desired internal structures. The ground surface is then cemented to a transparent microscope slide and the remaining side ground down until the slice is so thin that it is translucent. The slide is then studied under the microscope. using transmitted light.

The animal and plant groups to which microfossils belong have evolved or changed through geologic time. In many instances this change has been sufficiently great to cause the microfossils of one geologic age to differ from those of other ages. Once the sequence of changes had been established for the whole of known geologic time through which the various groups have evolved, a micropaleontologist was able to establish the age of an unknown sample containing microfossils by comparing it to the known sequence.

Because microfossils are such good time markers. and because they come out of a drill hole intact, while larger fossils are broken beyond recognition. they have been used extensively in petroleum exploration and development drilling.

Although there were a few workers before his time, Alcide d' Orbigny (1802–57) of Paris is generally considered the father of micropaleontology as a science. From his time to about World War I, interest in the science was mainly academic and the workers were few. About the time of World War I, microfossils were first used in petroleum work. They were quickly found to be of great value in this field and work on them progressed very rapidly. In the early 1960s more than a thousand persons, most of them employed in the petroleum industry, were working with these minute fossils.

The American Museum of Natural History established a department of micropaleontology in 1940 as a centre for research on microfossils and for the dissemination of knowledge relating to them. A 58-volume reference work, containing descriptions and illustrations of more than 1,500 genera and about 25,000 species and subspecies of Foraminifera, has been published by this department. An international quarterly known as *Micropaleontology* is also published by the department. It has more than 1,000 subscribers located in every country in the world where work in this field is in progress.

See also GEOPHYSICAL PROSPECTING; GEOLOGY. (B. F. E.)

MICROPEGMATITE, in petrology, a fine-grained intergrowth of quartz and alkali feldspar. the latter usually poor in soda. The intergrowth is so fine that it can be resolved only under the microscope hut is otherwise indistinguishable from the coarser intergrowths known as graphic granite, for one of which the name pegmatite (*q.v.*) was originally suggested by the French mineralogist R. J. Haüy (1743–1822).

The quartz-feldspar interfaces are planar and in section the quartz areas tend to be triangular. Over large areas these patches of quartz are in parallel optical orientation and it was long supposed that they were actually continuous. either above or below the plane of observation. A detailed study of the coarser intergrowths common in many pegmatites indicated that the various quartz patches are usually separate individuals. Both the angular (runic) character of the quartz areas and their optical parallelism are evidently responses to growth conditions. The commonest angular relation between feldspar and quartz—a rule discovered by and later named after the Russian geochemist A. E. Fersman (1833–1915)—results in an angle of 42° 16' between the c-axes of the two minerals. Other angular relations occur. but there seems no doubt that the basic control is crystallographic. Where the intergrowth is coarse enough and sufficiently abundant to permit chemical analysis. the bulk composition averages about 25% quartz and 75% feldspar. This is a composition often found in granites and rhyolites, and one which experimental work indicates would have a relatively low melting temperature. There is thus good reason to suppose that micropegmatite represents an end stage or residual liquid, a view long held by many petrologists. To the extent that this view lends support—both implicit and explicit—to magmatic theories concerning the origin of both granite and granite magma, it is hotly contested by contemporary antimagmatists.

Micropegmatite is found particularly in granite. quartz-porphyry and diabase. Granophyre is composed largely or wholly of micropegmatite. In diabase it may be interstitial. or form pods. seams or veins, and the notion that the resulting "red rock" is a final product of fractional crystallization of diabase magma is one of the major supports of N. L. Bowen's hypothesis that granite magma is generated in this way (see GEOCHEMISTRY: *The Reaction*

Series). It is easy to show, however, that only a relatively small amount of granite magma would result from the process, and the amount of micropegmatite is often embarrassingly large, particularly in the numerous gabbro-granophyre associations of the British Tertiary province. The idea that micropegmatite represents in some way a residual or endstage liquid is also difficult to reconcile with its occurrence in the phenocrysts but not in the matrix of certain felsitic or glassy rhyolites.

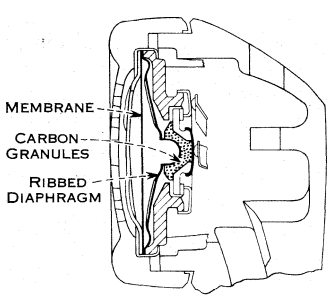
Something very similar to micropegmatite evidently may also form by devitrification of rhyolitic glass; in some spherulitic rhyolites the spherules consist of an exceedingly fine but clearly graphic or micropegmatitic intergrowth of quartz and alkali feldspar. For further discussion of the magmatic and other theories referred to in this article *see* GEOCHEMISTRY: *Geochemistry of the Lithosphere;* MINERALOGY; PETROLOGY: *Plutonic Complexes.*

(F. Cs.)

MICROPHONE, a device for converting acoustic power into electric power which has essentially similar wave characteristics. The first successful instrument for this purpose was the electromagnetic telephone transmitter used by Alexander Graham Bell in 1876. The term microphone was first used by David E. Hughes in 1878, when he elucidated the basic principle of the loose contact. By virtue of this principle, the variable resistance of a carbon telephone transmitter, under the influence of the varying sound pressure, controls the energy delivered by a battery so that the sound waves are converted into corresponding but amplified electric waves. It was the sensitivity of such a device in amplifying feeble sounds that gave rise to the name microphone (Gr. *micros,* "small" + *phone,* "sound").

While telephone transmitters comprise the largest class of microphones. the name microphone in modern usage is applied mostly to types which do not form part of a conventional telephone set. Microphones for receiving underwater acoustic waves are generally known as hydrophones. Such instruments also can be used to pick up sound waves in solids.

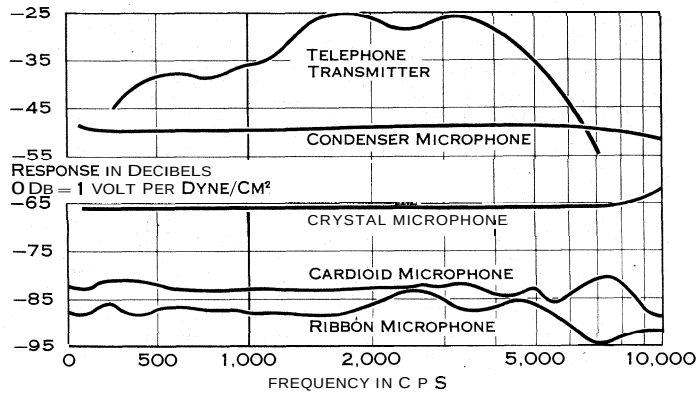
Apart from telephone transmitters, the largest fields of application of microphones occur in hearing aids, sound-recording systems (principally magnetic tape recorders) and dictating machines. Most of these microphones are of the crystal type, but considerable numbers of magnetic and other types are found also. Another widespread application of microphones is in public-address systems employed in assembly halls: lecture rooms, announcing and paging systems, etc. The microphones used for this purpose divide about equally between the crystal and the dynamic types. Microphones find extensive use also in communication systems, either radio or wire, for providing either better quality of response than can be obtained with the conventional telephone transmitter, or hands-free operation.



BY COURTESY OF BELL TELEPHONE LABORATORIES

FIG 1 — CROSS SECTION OF A WESTERN ELECTRIC COMPANY T1 TELEPHONE TRANSMITTER

The most exacting applications of microphones are in radio and television broadcast pickups, sound recording and sound measurement. Choice of microphone type for such purposes depends upon the nature of the application. The requirements to be satisfied may include: (1) substantially uniform and transient-free response over a wide range of frequencies. perhaps from 25 to 15,000 cycles per second or higher; (2) linear (*i.e.,* directly proportional) response over a wide range of input pressures; (3) high or moderately high sensitivity; (4) a high degree of freedom from inherent noise: (5) stability of characteristics under rugged handling conditions and over a substantial temperature range; (6) directional characteristic (i e., direction from which sound is most readily detected) adapted to the purpose at hand; and (7) size small enough to cause no serious disturbance to the sound field. Usually some compromise must be reached hetneen the desired characteristics.



BY COURTESY OF BELL TELEPHONE LABORATORIES

FIG 2 — GRAPH SHOWING THE FREQUENCY CHARACTERISTICS OF DIFFERENT TYPES OF MICROPHONES

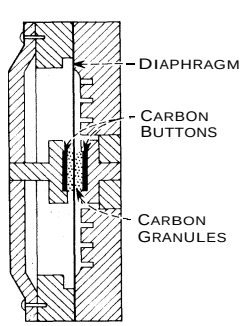
Classifications. — Microphones represent one class of the broad category of devices known as transducers, that is, devices capable of being actuated by waves from one or more transmission systems or media. and of supplying related waves to one or more other transmission systems or media. Thus a microphone is an acousto-electric transducer.

Microphones may be classified in various ways. One basis of distinction is whether the microphone is "active" or "passive"; *i.e.,* whether it controls a local source of direct-current energy, such as a battery or power pack, so that in converting the sound input into electric output it introduces amplification, or whether the process of conversion takes place without amplification, the electric output being derived solely from the sound input.

Amplifying or active microphones. developed chiefly for telephone systems, are used for other purposes also. Usually efficiency is a primary object, together with reasonably uniform response over the range of speech frequencies. The amplification from incident power to output power may be as much as two thousandfold.

Nonamplifying or passive microphones have been developed mainly for applications where higher quality is desired, as, for instance. in sound recording systems, broadcasting systems and sound measurement nork. Such a microphone is commonly followed in the electrical circuit by one or more stages of amplification.

The conversion. within a microphone. of sound pressure variations in the air into corresponding electrical waves usually occurs in two operations which take place simultaneously. In the first operation. the sound wave impinges on a surface. generally referred to as a diaphragm, which is capable of slight movement. Variation of air pressure on this diaphragm causes it to move to and fro in a manner corresponding to the movement of the air particles. In the second operation, the diaphragm by its movement causes a corresponding change in some property of an electric circuit. Thus, for example, the displacement of the diaphragm may cause variations in the resistance of a carbon contact, in electrostatic capacitance, or in the motion of a coil or conductor in a magnetic field. In each case motion of the diaphragm produces a variation in the electric output.



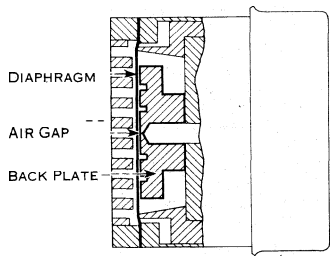
BY COURTESY OF BELL TELEPHONE LABORATORIES

FIG. 3.—CROSS SECTION OF A DOUBLE-BUTTON CARBON MICROPHONE

Thus. the sound vibrations are first converted into mechanical motion: then the mechanical motion is converted into electric waves. Hence. in studying the operation of a microphone two things must be considered: (1) the mechanical movement of the diaphragm; and (2) the method whereby this movement sets up the desired electric waves. Either part of the process may be taken as a basis for classifying microphones.

From the standpoint of diaphragm operation, microphones may be classified as pressure type, velocity type or a combination of

the two. Any microphone that has its diaphragm exposed to the sound wave on only one side is a pressure-operated type, that is, the displacement of the diaphragm is approximately proportional to the instantaneous pressure of the impressed sound wave. In a velocity microphone. the diaphragm is exposed on both sides to the sound wave, so that its motion can be made to correspond closely to the difference in pressure, and hence to the instantaneous particle velocity of the sound wave. According to the means or method employed to convert diaphragm movement into electric waves, microphones may be classified as carbon. condenser, crystal, ceramic, variable reluctance, moving-conductor, moving-coil, ribbon, magnetostriction and hot-wire.



BY COURTESY OF BELL TELEPHONE LABORATORIES

FIG. 4.— CROSS SECTION OF A CONDENSER MICROPHONE

Depending on response to different directions of sound incidence. microphones may be classified as omnidirectional, bidirectional or unidirectional. In accordance with the impedance level of the output. which is important in the design of connecting circuits, microphones may be classified as low-impedance or high-impedance. Microphones also may be described in accordance with manner of use. as for example, throat microphones which are designed for use in direct contact with the throat, lip microphones which operate in close proximity to the lips and lapel microphones adapted for positioning on the clothing of the user.

Carbon Microphone.— Outstanding among pressure types is the carbon microphone, which possesses not only historical interest but great modern importance. Both Emile Berliner and Thomas A. Edison in 1877 invented telephone transmitters whose operation depended on variable contact resistance, while Henry Hunnings in 1878 invented a transmitter employing a large number of finely divided carbon granules so as to obtain many points of microphonic contact whose resistance changed with sound pressure, thus introducing large amplification. Anthony C. White in 1890 invented the solid-back transmitter, using a "button" of granular carbon placed between a fixed electrode and a diaphragm-actuated movable one.

Modern telephone transmitters employ the same basic principles. Usually they are designed to be mounted in a telephone handset in conjunction with a receiver. Older types of transmitters, with clamped diaphragm, back cavity and carbon-filled cup, are characterized by a single sharp resonance. In a recent type (fig. 1): not only is the sensitivity considerably increased but the response over the speech frequency range is much improved through the employment of a doubly resonant system (fig. 2). The substantially uniform response over the range from about 400 to 3.200 cycles per second (c.p.s.) contributes a great deal both to articulation and to naturalness of conversation.

A microphone employing a single carbon button provides a linear relation between input pressure and output current for only a small range of sound pressures. For applications requiring low distortion over a wide range of outputs, together with a broader range of uniform frequency response, a double-button carbon microphone may be used (fig. 3). By mounting the diaphragm under great tension, the resonant frequency can, at the expense of some loss in sensitivity, be moved up to a fairly high frequency, 5,000 to 8,000 c.p.s., giving fairly uniform, or "flat," response over a wide range. Such microphones give high output, are rugged and are little affected by temperature or humidity. For high quality work, however, there is still a limitation fundamental to any carbon transmitter, namely, a characteristic background hiss due to arcing at minute carbon-granule contacts.

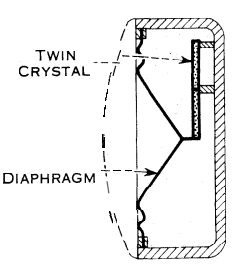


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FIG. 5.—CROSS SECTION OF A CRYSTAL MICROPHONE

Condenser Microphone.— The condenser (also called capacitor) microphone, originally described by A. E. Dolbear in 1580 and developed in practical form by E. C. Wente in 1916, is likewise of the pressure type. It consists typically of a thin stretched diaphragm separated by about one-thousandth of an inch from a parallel fixed plate (fig. 4). The diaphragm acts as one plate of a variable capacitor which is connected in series with a resistor and a direct-current source. The motion of the diaphragm in the condenser in response to sound waves varies the capacitance, producing a variable electric current.

Condenser microphones have excellent frequency response and reproduction quality. They have a small output, which usually is brought to a higher level by a built-in "preamplifier." In modern practice their use is largely confined to sound measurement and high-quality recording.

Crystal and Ceramic Microphones.— Still another pressure type is the crystal microphone, which depends for its operation on the piezoelectric effect; *i.e.*, the generation of a voltage by the deformation of a crystal through applied pressure (see PIEZOELECTRICITY). Since Rochelle salt crystals exhibit greater piezoelectric activity than any other known crystals, they are commonly used in crystal microphones. The first such use was by A. M. Nicolson in 1919, but it was not until 1931 that C. B. Sawyer developed a practical form of microphone employing two thin oppositely polarized Rochelle salt plates assembled to form a so-called "bimorph" element. This element may be driven in any one of several ways. In the direct-actuated type the sound pressure acts upon the crystal itself. while in the diaphragm-actuated type the sound pressure acts upon the diaphragm which is coupled to the crystal. Greater sensitivity can be obtained from the latter (fig. 5).

A crystal microphone gives good frequency response, hence good fidelity, but relatively low output as compared with carbon microphones. An advantage is that no external voltage or current is required. Loss of sensitivity at higher temperatures is a limitation, as is susceptibility to humidity damage. Crystal microphones are useful mainly for low-cost applications.

Polarized barium titanate has been used in place of Rochelle salts in what are called ceramic microphones. These are less sensitive than the crystal type but have the advantage of being able to withstand higher temperature and humidity.

Dynamic Microphone.— The dynamic (also called moving-coil) microphone falls within the general class of moving-conductor microphones; *i.e.*, microphones in which an electric voltage is generated in an electric circuit through motion of a conductor in a fixed magnetic field. In the dynamic microphone a coil is attached to a diaphragm which the sound waves cause to move back and forth in a magnetic field. thereby inducing a voltage in the coil. This principle was invented almost simultaneously by Charles Cuttris and Jerome Redding in the United States and E. W. Siemens in Germany in 1877. In its modern form, this type of microphone was perfected by Wente and A. L. Thuras in 1931. Dynamic microphones are advantageous because of their low-impedance output. and have considerable usage in recording, broadcasting and public address systems, especially where ruggedness is essential.

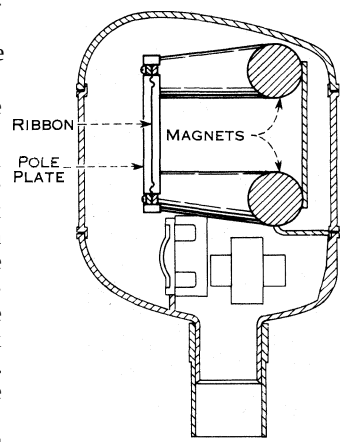

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FIG. 6.—CROSS SECTION OF A RIBBON MICROPHONE

Magnetic Microphone.— The magnetic microphone (also called variable-reluctance inicrophone) depends for its operation on variations in the reluctance of a magnetic circuit. The first transmitter of Bell, patented in 1876, consisted of a diaphragm-driven armature which, by its motion in the field of an electromagnet, modified the reluctance of the magnetic circuit and induced

a voltage in a coil. Thus a magnetic microphone was the earliest form of microphone. However, the earlier magnetic microphones were considerably inferior in quality and stability to the carbon. dynamic, condenser or ribbon instruments and were not extensively used. A modified small magnetic microphone is now widely used in application? where ruggedness, low weight and high sensitivity are important. as. for example. in military applications and hearing aids.

Ribbon **Microphone.**—A ribbon microphone is a form of moving-conductor microphone in which the moving conductor is a thin metallic ribbon. acted upon by the sound waves, which is suspended in a tnagnetic field, normally between the poles of a permanent magnet (fig. 6). The ribbon may be exposed to the sound waves on only one side, thus making a pressure microphone. which has an omnidirectional response. or it may be free (*i.e.*, exposed on both sides), constituting a velocity microphone. which has maximum response to sounds coming from front or rear, and thus gives a bidirectional characteristic. The ribbon microphone was invented by W. H. Schottky and Erwin Gerlach in Germany in 1923, and perfected in its modern form by H. F. Olson in 1931. Ribbon units of the pressure type and the velocity or free-ribbon type may be combined to obtain a unidirectional characteristic. as discussed below. Ribbon microphones, either omnidirectional or unidirectional, are used extensively in broadcasting and sound measurement.

Unidirectional and **Polydirectional Microphones.**—A unidirectional characteristic of microphone response is frequently advantageous for minimizing the effect of undesired noises or adverse room acoustics, for reducing the sound feedback from a loudspeaker into the microphone. etc. Such a pattern may be obtained either by combining a bidirectional microphone element and a nondirectional one (*i.e.*, adding the response characteristics at [A] and [B] of fig. 7 to obtain the characteristic shown at [C]), or by combining one or more microphone elements with an acoustical phase-shifting network. In the former approach. the commonest combinations are a ribbon velocity element with either a ribbon-pressure element or a dynamic-pressure element. Frequently the two response patterns are so combined as to yield an over-all characteristic of cardioid shape. The combined ribbon microphone was developed by J. Weinberger, H. F. Olson and F. Massa. The ribbon-dynamic combination was developed by R. N. Marshall and W. R. Harry: using special equalization techniques to match the characteristics of the two elements. Rlicrophones employing acoustical phase shift to obtain unidirectional operation have considerable use in recording, broadcasting and public address systems.

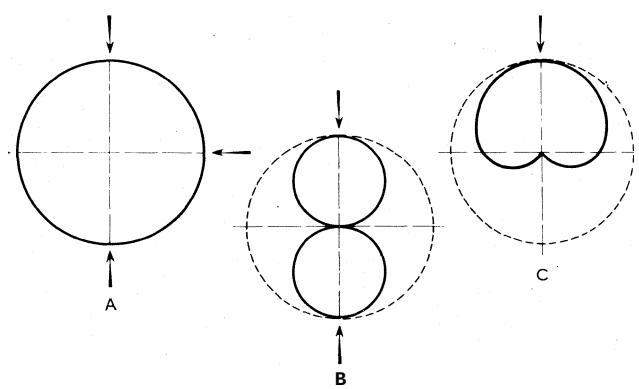

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FIG 7.— DIAGRAMSILLUSTRATING THE DIRECTIONAL CHARACTERISTICS OF MICROPHONES (A) OMNI- OR NONDIRECTIONAL; (B) BIDIRECTIONAL. AND (C) UNIDIRECTIONAL (CARDIOID)

In 1935 H. J. von Braunmühl and W. R'eber developed a condenser microphone using two plastic membranes installed at the opposite sides of a shallow perforated casing. which was capable of operating either as an omnidirectional or a unidirectional microphone by suitable electrical connection of the membranes. Some of the highest quality microphones built have been based upon this type of structure.

By appropriate design combinations, other desired response characteristics, as, for example. a polydirectional characteristic, can be obtained.

Microphone **Amplifiers.**—With modern techniques, amplifiers for use with microphones can be constructed with frequency and linearity characteristics that are practically perfect for almost any range of interest. Negative feedback is employed to minimize amplitude distortion, and resistance-capacitance interstage coupling to minimize frequency distortion. Although microphone amplifiers were formerly of the electron-tube type for the most part, transistors came to be increasingly used for this purpose because of their small size. low power consumption and adaptability to a low impedance microphone output.

Performance Testing.— The performance of a microphone may be determined either by listening tests or by acoustic measurements. Properly conducted listening tests by qualified personnel can give fairly good information regarding performance under actual conditions of use. The usual method is to compare the microphone for which information is desired with a known and used type. There is, of course, no assurance that the comparison is valid except for the conditions of test.

Acoustic measurement of microphone performance assumes two different aspects: comparison with another microphone used as a reference standard, and absolute measurement response. In either case the problem is to determine the microphone response, which is defined as the ratio of the open-circuit voltage generated at the terminals of the device to the acoustic pressure actuating the diaphragm. Since the presence of the microphone distorts the sound field. the undisturbed sound pressure existing prior to placing the microphone in the sound field is usually taken as the input pressure, the corresponding ratio being known as the free-field response.

In the comparison method. a reference microphone whose characteristic has been determined is introduced into a sound field and its output measured, for example, on a recording instrument. The output of the unknown microphone is then measured in the same sound field. and the ratio of the two outputs, when applied to the known response characteristic of the standard, yields the overall response of the unknown. A miniature condenser microphone is generally used as the reference standard.

Through a technique referred to as the reciprocity method. the absolute response of a microphone can be determined without an acoustic standard simply by measuring primary quantities. using an auxiliary reversible microphone first as a microphone and then as a sound source. The method depends on the validity, for the calibrating device. of the reciprocity principle, in accordance with which transmission in one direction through a linear passive device bears a reciprocal mathematical relationship to transmission in the opposite direction. *See* also ACOUSTICS OF BUILDINGS; RADIO; HIGH-FIDELITY SOUND SYSTEMS.

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MICROSCOPE, an instrument for producing enlarged images of objects that are too small to be seen with the unaided eye at the normal viewing distance of ten inches. Images formed by a microscope may be viewed directly with the eye or indirectly with a viewing screen or photographic apparatus. Counts of certain materials in the object may be made with special scanning devices. (Distant objects are often viewed to advantage with a telescope [*q.v.*].)

The microscope can be used to examine many different types of materials in many fields, such as medicine, mineralogy, petrography. chemistry. bacteriology, pathology and metallurgy. Specimens may be either transparent or opaque. The compound light microscope can be used ior viewing objects as small as the smallest bacteria : the electron microscope extends the visual range to small viruses and large molecules. Living material can be studied with the light microscope but not in the electron microscope because in the latter instrument the material is killed by the methods of speci-

men preparation and examination.

This article discusses the various types of microscopes and their uses. Related discussions of microscope principles will be found in the articles OPTICS; LENS; VISION; ELECTRON: *Quantum Theory of Electrons: Electron Wave Length.* Related articles on the use of microscopes include ANATOMY, MICROSCOPIC; HISTOLOGY; CYTOLOGY.

The material in this article is arranged under the following main headings:

I. Common Features and Principles
  1. Use of Waves
  2. Ability to Resolve
  3. Ability to Magnify
  4. Classification
II. The Light Microscope
  A. History
  B. Simple Light Microscope
    1. Optical Characteristics
    2. Common Forms
  C. Compound Light Microscope
    1. Monocular Microscopes
    2. Binocular Microscopes
    3. Aberrations of the Objective
    4. Eyepiece
    5. Condensers
  D. Image Formation
    1. Geometrical Aspects
    2. Diffraction and Resolution
    3. Equivalence Theory
    4. Magnification
    5. Phase Contrast
  E. Illumination
    1. Transmitted Light
    2. Incident Light
    3. Photomicrography
  F. Use of the Light Microscope
    1. Resolution
    2. Transillumination
    3. Micrometry
    4. Binocular Microscopes
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    6. Ultramicroscopy
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    8. Ultraviolet Microscopy
    9. Opaque Microscopy
  G. Chemical Microscopy
III. The Electron Microscope
  A. History
  B. Types of Electron Microscopes
    1. Emission
    2. Transmission
  C. Component Parts
    1. Lens System
    2. Vacuum System
    3. Electrical System
  D. Use of the Electron Microscope
    1. Methods for Preparing Specimens
    2. Ultramicrotomy
    3. Electron Metallography
  E. Theory of Electron Lenses

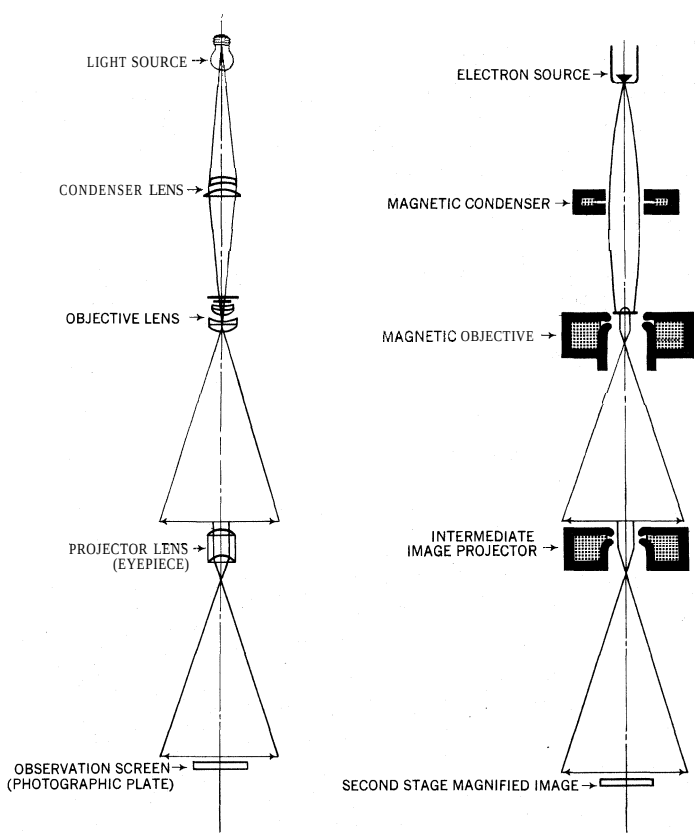
I. COMMON FEATURES AND PRINCIPLES

1. Use of Waves. — Microscopes make use of the wave character of moving particles such as electrons or light; these waves are bent as they pass through the microscope so that the image produced on the viewer's retina is magnified; *i.e.*, it is made larger than the image produced by the unaided eye. The nature of waves places inherent limitations on the microscope; *e.g.*, it is impossible to produce a perfect image because of diffraction and it is impossible to resolve. or separate, waves coming from two points that are less than approximately half a wave length apart.

2. Ability to Resolve. — The ability to resolve waves coming from two or more adjacent points on the object being viewed is an important characteristic of microscopes. Only when the images of the points are separated can the detail be discerned clearly. An indistinct image remains indistinct no matter how many times it is magnified. Effective magnification therefore is limited by resolution. The ability to resolve, which also is called the resolving power or power of resolution. is inversely proportional to the length of the wave; the shortest waves thus produce the greatest resolution. For example, electron waves, which are 1,000 times shorter than light waves, produce 1,000 times greater resolution than do light waves. The respective resolving powers are 5 angstrom units (A) for the electron microscope and 2000 A for the light microscope; in other words, the electron microscope can resolve details separated by 5 A and the light microscope can resolve details 2000 A apart (1 Å = 10^{-8}, or 0.00000001, cm). Proton waves. which are five times shorter than electron waves, should have a resolving power of about 1 Å, but technical difficulties have made it impossible to develop the proton microscope to its theoretical capabilities.

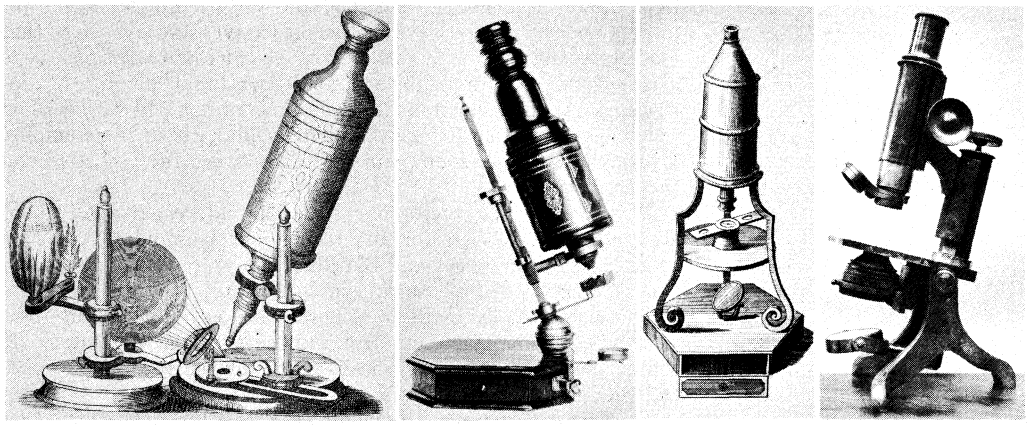
3. Ability to Magnify. — The ability of a microscope to magnify depends on, in addition to its power of resolution, the physical characteristics and design of its parts For example. a pocket magnifier or some other type of simple microscope will not produce satisfactory magnifications greater than three diameters, or three times (3×). since greater magnifications are accompanied by spherical and chromatic aberrations that are caused by the structure of the lens, particularly near its edges These aberrations can be mainly but not completely corrected by joining two such lenses into a single compound lens. Physical factors limit the useful magnification of compound light microscopes to about 2,000×. The electron microscope can produce a useful magnification of about 20,000× when the image is viewed visually through a fluorescent screen and about 1,000,000× when the image is photographed and then enlarged. Most electron microscopes have a resolving power of 20 Å and a magnification of 100,000×

4. Classification. — Microscopes can be classified broadly according to the kind of waves they use and can then be subdivided according to the number or type of lens systems used and their source of radiation. A lens system may consist of a single lens or of several lenses grouped in one unit. Microscopes that employ one lens system are called simple microscopes: the best-known examples are the pocket magnifier, hand reading glass and jeweler's eyeglass. In electron microscopes, an important subsidiary



REPRINTED BY PERMISSION FROM V. K. ZWORYKIN AND OTHERS, "ELECTRON OPTICS AND THE ELECTRON MICROSCOPE." JOHN WILEY AND SONS, INC.

FIG. 1. — COMPARISON OF WAVE PATHS IN THE LIGHT MICROSCOPE AND IN THE MAGNETIC TYPE OF ELECTRON MICROSCOPE



(LEFT, CENTRE LEFT AND RIGHT) BETTMANN ARCHIVE, (CENTRE RIGHT) CULVER PICTURES, INC.

FIG. 2.— HISTORICALMICROSCOPES: (LEFT) COMPOUND MICROSCOPE USED BY ROBERT HOOKE. 1665: (CENTRE LEFT) LEEUWENHOEK.~SIMPLE MICROSCOPE, 1673; (CENTRE RIGHT) FRENCH MICROSCOPE. 18TH CENTURY; (RIGHT) MICROSCOPE OF SIR RONALD ROSS. 1857–1932

method of classification is based on whether electrostatic or magnetic lenses are employed. Microscopes that use two or more lens systems are called compound microscopes: examples are the ordinary laboratory light microscope and the electron microscope. In a compound microscope, the lens system nearer the object being viewed is called the objective; it has a short focal length and forms a real. enlarged image that becomes the object of the second lens system. which is called the eyepiece, or ocular. in the light microscope and the projector lens in the electron microscope. The source of radiation is an important basis for classification in the electron microscope, where the object may be made to emit electrons or to transmit electrons emanating from another source.

II. THE LIGHT MICROSCOPE

A. History

Anton van Leeuwenhoek (*q.v.*) in 1673 invented the simple microscope that consists of a single lens with a relatively high magnification. With it he made many remarkable discoveries of microorganisms.

Zacharias Janssen devised the first compound microscope in 1590; it was composed of a convex objective and a concave eyepiece. In 1611 Johannes Kepler suggested the construction of a compound microscope that used convex lenses for both the objective and the eyepiece, but apparently he did not construct such an instrument. Christoph Scheiner constructed Kepler's microscope about 1628 and used it for visual observation and microprojection. The Kepler microscope gave a larger field of view than Janssen's and became the prototype of the modern microscope.

Christiaan Huygens, in about 1684, invented the simple but effective two-lens eyepiece that is named after him and is widely used in modern times. Charles A. Spencer (1813–81) advanced the design of microscope objectives by introducing higher numerical apertures; he also improved colour correction by using glass-fluorite combinations. The dark-field microscope condenser was invented in about 1853 by Francis H. Wenham.

Among the most famous names in the history of microscope development is that of Ernst Abbe (1840–1905), who designed the apochrosnatic objective and the compensating eyepieces for use with these objectives. The homogeneous immersion objective was first described and made by R. B. Tolles in 1874. In 1902 F. E. Ives set forth the basic system for modern binocular eyepieces. Frits Zernike. in 1935, successfully applied phase contrast to the microscope; for this he was awarded the Nobel prize in physics for 1953.

B. Simple Light Microscope

1. Optical Characteristics. — The magnifying power of a simple microscope is the ratio of the size of the image produced on the observer's retina by the instrument to the size of the retinal image when the object is viewed without optical aid. The standard distance for determining microscope magnification is 10 in., or 25 cm., which is the shortest distance at which the normal eye can accommodate; *i.e.*, focus on an object. Fig. 3(A) shows a naked-eye view of the object y at a distance d; fig. 3(B) shows a view of the same object moved closer to the eye and seen through a lens. In fig. 3(A) the size of the image on the retina is proportional to the tangent of the angle a subtended at the eye by the object (*i.e.*, it is proportional to the object height divided by the distance, or y/d), and in fig. 3(B) it is proportional to the tangent of the angle a' subtended at the eye by the virtual image y'. Thus the magnification $M = \tan \alpha'/\tan a$. For the standard viewing distance, d = 25 cm. and tan $a = y/25$. The value of tan $a' = y'/(s' + c)$ varies with the distance (s) between the object and the lens. the distance (c) between the eye and the lens and the focal length (f) of the lens. The focal length is the distance between the lens and the point at which rays passing through the lens converge, or focus. If the object is at the first principal focus of the lens. $s = f$ and s' approaches infinity. The eye distance c then becomes negligible in comparison with s' and tan $a' = y'/s' = y/f$. Thus $M = \tan \alpha'/\tan a = 25/f$ where f is the focal length of the lens in centimetres. This is the usual formula for specifying the magnification of a simple microscope. It presupposes that the object is at the first principal focus of the lens and that the eye is accommodated for the infinitely distant image.

The lateral extent of the object area that can be seen through the magnifier increases with the diameter of the lens and decreases as the distance between the eye and the lens increases.

The principal aberrations in a simple lens affect the outer parts of the field of view of an extended image. They are astigmatism, curvature of the field, distortion and chromatic difference of magnification: and it is principally with respect to the degree of freedom from these defects that magnifiers of the same power but of different types may differ one from another.

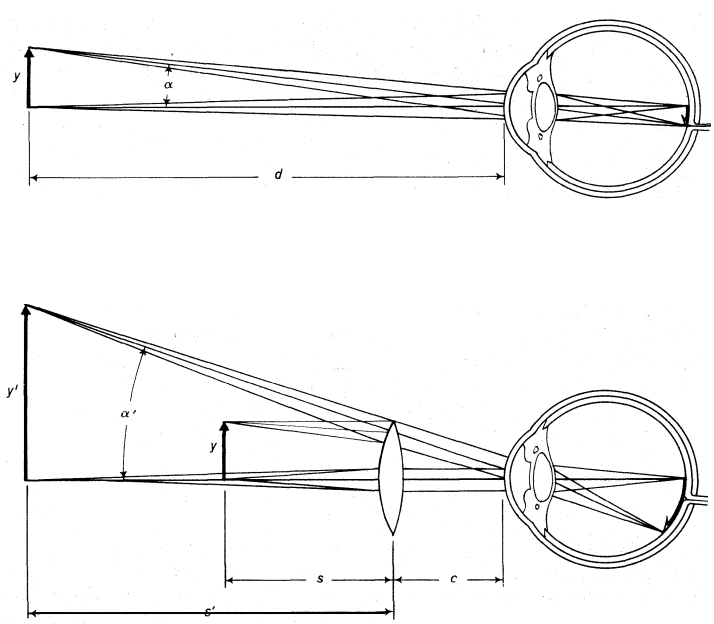


FIG 3 —COMPARISON OF VIEWS OF OBJECT y SEEN (A) WITH UNAIDED EYE AT NORMAL VIEWING DISTANCE OF TEN INCHES AND (B) THROUGH LENS AFTER OBJECT HAS BEEN MOVED CLOSER TO EYE WITH LENS FORMING A VIRTUAL IMAGE

2. Common Forms.— The least expensive magnifier is a double convex lens. Its performance is acceptable for magnifications up to 3×, and it finds common application in folding pocket magnifiers, watchmakers' loupes and reading glasses. For larger magnifications such simple lenses provide images that fall far short of satisfactory quality in several respects: they are lacking in contrast, colour fringes border objects in the outer parts of the field of view and there is marked cushion-shaped distortion.

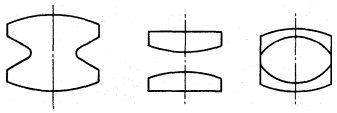


FIG. 4.— THREE FORMS OF MAGNIFIERS: (A) CODDINGTON; (B) DOUBLET; (C) HASTINGS TRIPLET

Various lens constructions have been used to improve the image quality of the simple microscope. There is first an interesting form, apparently devised by Sir David Brewster but generally credited to Henry Coddington, that is essentially a very thick double convex lens with a restricting diaphragm at its midsection, as shown in fig. 4(A).

Another type that is considerably superior to the double convex lens is the doublet magnifier shown in fig. 4(B). It consists of two plano-convex lenses mounted with curved surfaces facing each other. The separation between the lenses may vary from very little to a distance nearly equal to the focal length of the lens closer to the eye. The longer forms are better corrected, especially for colour. but their very short working distance (distance from lens to object) makes them inconvenient to use. Manufacturers differ in respect to the compromise they adopt between colour correction and working distance.

Fig. 4(C) shows a still better magnifier that consists of three elements; *i.e.,* two external flint lenses enclosing and cemented to a single double convex crown lens. Such magnifiers are known as Steinheil triplets, Hastings triplets or triple aplanats. They are the least sensitive of all magnifiers to lateral excursions of the eye when they are used. They are almost completely free from colour fringes; the field is satisfactorily free from astigmatism and curvature of field, and there is a fair correction for distortion. When the eye is held close to the magnifier, the field of view is about 70% of the focal length.

C. Compound Light Microscope

The compound microscope consists fundamentally of an objective and an eyepiece. The total magnification of the microscope is the product of the magnifications of the objective and the eyepiece. The magnification of the objective is approximately equal to the quotient of the length of the optical tube (also called the body tube) divided by the focal length of the objective; this magnification number is usually engraved on the objective mount. The magnification of the eyepiece is equal to 25 divided by the focal length of the eyepiece in centimetres. The image seen by the viewer is inverted and reversed.

The numerical aperture (N.A.), which also is usually engraved on the objective mount, is a number that expresses the resolving power of the lens and the brightness of the image it forms. The numerical aperture is expressed mathematically as $n \sin u$, where n is the refractive index of the medium separating the object and the objective and u is the half-angle of the largest light cone that the objective, can utilize in this medium. In general, the higher the N.A., the higher is the quality of the lens.

A compound light microscope may be equipped with one, two or three eyepieces for monocular, binocular or trinocular (binocular plus camera) vision and with one to four objective lenses. The basic instrument can be elaborated with a variety of accessory equipment that adapts the microscope for special uses.

1. Monocular Microscopes.––Fig. 5 shows a standard monocular microscope that is adequate for most microscope work done by the biologist. bacteriologist or physician. (One of the three objectives mounted in the objective turret has been cut away in the diagram). Customary optical equipment for such a microscope consists of a battery of three objectives with magnifications of approximately 10×, 43X and 97× and two interchangeable eyepieces of magnifications of 5× and 10×. The total magnifications therefore range between 50X and 970×. Higher and lower powers may be obtained with other objectives and eyepieces that are interchangeable with the above. A microscope of this type also is equipped with a substage condenser and a mirror Microscopes with a magnification that can be continuously varied while the image remains in focus were introduced in 1960; these employ a variable-power, or zoom, lens system between the objective and the eyepiece.

The Stend.—The microscope stand should be accurately constructed and arranged for the convenient manipulation of the optical parts, the object and the illuminating system. The stand generally consists of a base, an arm and a body tube.

The base. usually made in a horseshoe pattern. supports and is attached to the stage, the arm and the substage apparatus. It should be sturdy. relatively heavy and sufficiently broad to give the microscope good stability.

The arm is frequently fastened to the base through a joint that allows the body tube to be tilted to any angle between the horizontal and the vertical.

The body tube is connected to the arm through a rack and pinion focusing slide and usually a fine adjustment slide. Into the lower end of the body tube. called the objective end, is usually screwed a nosepiece in which one or more objectives are screwed. The upper end of the body tube, called the eye end, contains the eyepiece. The distance between the objective and eyepiece end is called the mechanical tube length and usually measures 160 mm. Some microscopes are equipped with a so-called drawtube by which the tube length can be varied.

The structures of the microscope stand take various forms, depending upon the work to be done, but it is convenient to think of them as classifiable into three main classes according to the complexity of design and equipment. The simplest class. which is suitable only for the most elementary work, is not provided with a substage condenser and may have only a coarse adjustment for focus. The intermediate class: which is adequate for general laboratory use, requires a substage condenser, fine adjustment for

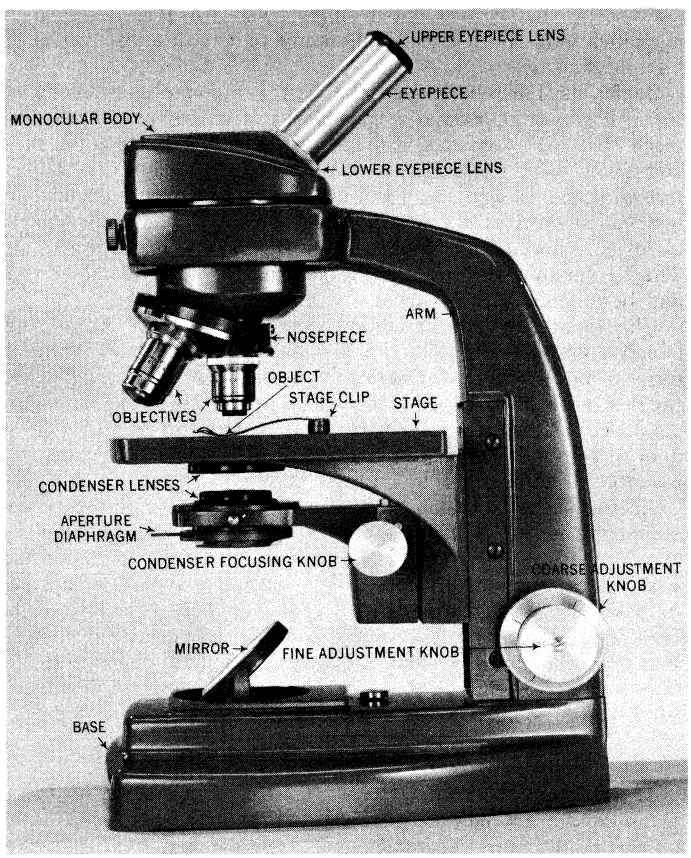


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FIG. 5.—THE PARTS OF A STANDARD MONOCULAR MICROSCOPE

focus, a mechanical stage and a battery of objectives and eyepieces; the objectives usually are mounted on a revolving nosepiece. Fig. 5 represents a typical microscope of this class. The advanced research worker requires more elaborate refinements such as a complete centring substage, a rotatable stage, a binocular eyepiece and a massive stand that can be used for photography as well as for visual observation. A binocular microscope equipped with a third eyepiece to which a camera can be attached is known as a trinocular microscope.

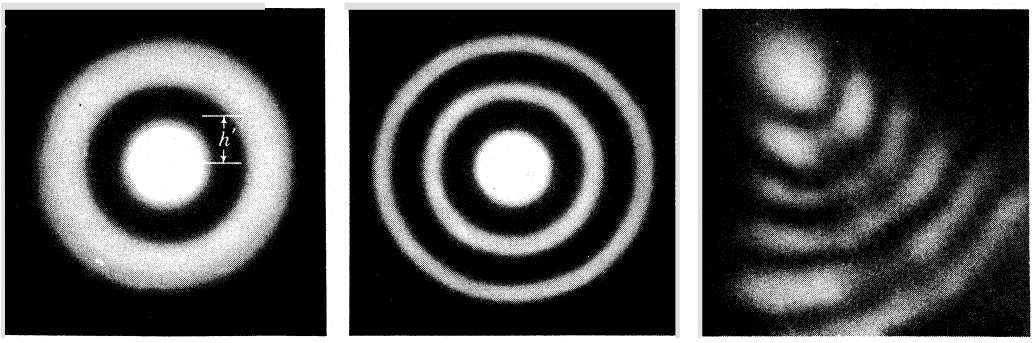

FIG. 6.—IMAGES OF A POINT OBJECT IN (A) SENSIBLY "PERFECT" OPTICAL SYSTEM, (B AND C) ABERRANT SYSTEMS. (A AND B: DRAWINGS FROM PHOTOMICROGRAPHS. C: PHOTOMICROGRAPH)

Focusing Adjustments.—The body tube is mounted on a dovetail slide to which a rack is screwed. The arm of the microscope carries a pinion that engages with the rack to permit its movement along the axis of the body tube in machined guides. This type of coarse focusing adjustment is the one almost universally employed.

The fine adjustment slide also works in machined guides but is operated by a mechanism capable of adjusting the position of the body tube by small amounts. The reduction of motion is accomplished in two stages. The first stage is a fine-pitch screw that translates the turning motion of the control knob into a slow lateral movement. This lateral movement is further reduced into an extremely fine vertical motion of the body tube by means of an L-shaped lever. All bearing surfaces ride on balls or rollers, and the driving force acts against a preloaded spring so that the motion is free and yet finely controlled.

Nosepiece.—The nosepiece may contain one, two, three or up to six objectives. Multiple nosepieces are convenient to use since they are made so that when the various objectives are swung into position, after the object has once been centred and brought in focus, the object remains in focus and in the centre of the field. When the nosepiece and the objectives are made in this way they are said to be parfocal. Single nosepieces are made for individual centring when more precise centring is required; *e.g.*, in petrography.

Sfage.—The stage. which supports the object, is frequently provided with either an integral or a detachable mechanical stage. This is a mechanism for systematically moving the object laterally or transversely by means of racks and pinions. The mechanical stage usually has graduations that are used for cataloguing the position of an object. Some microscopes are equipped with rotating and centring stages.

Substage.—The substage is the part that holds the illuminating condenser and the mirror. The illuminating condenser may be focused by either a screw motion or a rack and pinion motion, depending upon the particular instrument. The more elaborate microscopes have mounted beneath their condenser support an iris diaphragm that can be rotated and centred. Equipment of this type permits complete control over the illumination system of the microscope; such control is desirable in research work.

2. Binocular Microscopes.—Some microscopes employ a prism system with two oculars for convenience of viewing with both eyes. When one objective is used with such a system, the image seen is not stereoscopic unless the design provides for bisecting the aperture of the condenser and objective in such a way that the eyes perceive slightly different views of the object. To obtain truly stereoscopic vision! a complete microscope equipped with image-erecting prisms as in prism binoculars must be used with each eye. (See BINOCULAR INSTRUMENT: *Binocular Microscopes.*)

3. Aberrations of the Objective.— The quality of the image seen with the compound microscope depends primarily on the quality of the real image formed by the objective. Any imperfections in this image are magnified when the image is viewed through the eyepiece. The aberrations of the objective should therefore be reduced to the smallest practicable values. The primary aberrations for which microscope objectives must be corrected are spherical and chromatic aberration. Spherical aberration produces a hazy image; chromatic aberration produces colour fringes at the boundaries of objects in the centre of the microscope field and reduces the contrast in the image.

Abbe pointed out that even when aberrations are controlled the "sine condition" must be fulfilled if images of objects of finite size are to be well defined. The sine condition can be expressed mathematically as $n \sin u / \sin u' = \text{constant}$, where $n \sin u$ is the numerical aperture and u is the angle that a marginal ray makes with the axis in the image space. The constant is the magnification of the objective. If the spherical aberration has been corrected but the sine condition has not been fulfilled, the pencils of rays that come from an object point a little off the axis are brought to focus at different distances from the axis on the image side, giving different magnifications according to the zone of the lens through which the pencils pass.

The effects of these aberrations on the image may be demonstrated with a test object known as a star slide, which consists of tiny pinholes in an opaque metal film on glass. These holes, when viewed through the microscope, appear as tiny bright stars on a black background. The image of one such point object is shown greatly magnified in fig. 6(A). This image is sensibly (optically) "perfect"; *i.e.*, the rings that surround the central image spot are due to diffraction not to aberration. With the introduction of spherical aberration, the appearance of the star image degenerates to that shown in fig. 6(B), where much of the light has been lost from the central spot and spread out into the surrounding rings. The image contrast under such a condition is greatly lowered. Similarly. if the sine condition is not fulfilled, the off-axis image degenerates to a comet-shaped figure as in fig. 6(C). In the latter case the contrast is lowered and in addition the image has spread in an unsymmetrical manner, resulting in a very blurred image. This aberration is known as coma.

Achromatic Objectives.—Most microscope objectives are achromatic; *i.e.*, they are corrected for colour aberration so that the image is free of unwanted colours. With an achromatic objective rays of light of two different wave lengths originating from a point on the axis in the object space come together, after passing through the objective. at the same point on the axis in the image space. The wave lengths considered by the designer are usually those of the C (red) and F (blue) lines of the Fraunhofer spectrum.. If the C and F rays were brought together for a paraxial zone (*i.e.*, in a zone of the lens near its optical axis), the marginal zone of the lens would be chromatically overcorrected: that is, the blue rays would cross the axis at a greater distance from the lens than the red rays cross it.

Achromatic objectives must also be corrected for spherical aberration. Spherical aberration occurs when the lens fails to bring to a common focus all the rays of even one colour that fall on it coming from an axial object point. In a lens uncorrected for spherical aberration, black areas in the object are imaged as gray and outlines are indistinct. Spherical aberration can be corrected to a limited degree by constructing the achromatic lens

of a positive element of low index of refraction and a negative element of high index. In general, in such a lens, it is possible to make the rays for some one zone (the margin, for example) unite in a common focus with rays near the axis Rays passing through intermediate zones generally fail by a small amount to pass through that same point, but if the numerical aperture of the lens is not too large the image may appear sensibly perfect. As the numerical aperture is increased, the zonal spherical aberration increases rapidly, and it is in large part to keep this aberration within usable limits that the construction of high-power objectives is so elaborate. Even with the best design. however, not more than three zones in a high-power lens can he brought to a common focus; the other zones exhibit considerable spherical aberration, which in some zones may be overcorrected (*i.e.*, focusing farther from the lens than the axial zone) or undercorrected.

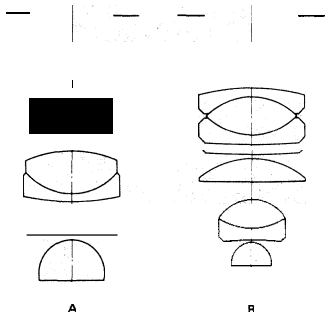

FIG. 7.—LENS SYSTEMS USED IN MICROSCOPE OBJECTIVES (A) ACHROMATIC; (B) APOCHROMATIC

Apochromatic Objectives.—In 1886 Abbe introduced apochromatic objectives; *i.e.*, those in which three colours, instead of two as in achromatic objectives. are brought to a common focus. Such objectives have a superior colour correction throughout the visible spectrum. This superiority is achieved by using fluorspar (fluorite) in some of the lens components. In addition. the correction for spherical aberration is further refined by the use of more components. The superior design permits a higher numerical aperture with apochromatic objectives than is practical with achromatic objectives of the same power.

Fig. 7 shows the optical construction of two objectives, one achromatic and the other apochromatic.

Aberration Associated With a *Cover Glass.*—Microscope objectives of numerical aperture 0.40 and above are more sensitive to cover glass thickness than those of lower numerical aperture. Most objects are mounted on glass slides about 1×3 in. in size and are covered with a piece of glass 0.15 to 0.25 mm. thick. The cover glass introduces spherical aberration, and if the cover-glass thickness differs by a few hundredths of a millimetre from that for which the objective is calculated. it can seriously affect the quality of the image. A small change in cover-glass thickness can be compensated by a change in the tube length of the microscope: *i.e.*, if the cover-glass thickness is somewhat greater than that for which the objective is designed, overcorrection of spherical aberration is introduced and can be compensated by shortening the tube length of the microscope. Conversely, if the cover glass is too thin, compensation can be achieved by increasing the tube length of the microscope. Modern apochromatic objectives are constructed with so-called correction collars with which the separation between lens components can be adjusted so as to introduce spherical aberration that will compensate for the variation in cover-glass thickness. The performance of oil immersion objectives is not affected by change of thickness of the cover glass: since the oil with which such objectives are used has the same index of refraction and dispersion as the cover glass, any variation in cover-glass thickness is automatically compensated by an equal and opposite change in the thickness of the oil.

4. Eyepiece.—The eyepiece serves primarily as a magnifying glass that is used to examine the real image formed by the objective. The simpler type of eyepiece is made with a large collective, or field. lens (the lens nearer the object! that bends the ray pencils from the objective toward the axis without greatly altering the convergence or divergence of the rays in the individual pencils. Above the field lens, and at some distance from it, is a second and much smaller lens, called the eye lens. which converts each ray pencil into a parallel or only slightly diverging ray system that can be focused by the eye. Alter emerging from the eye lens, all these pencils pass through a small circular area called the eyepoint, or the Ramsden circle. This area is the image that the eyepiece forms of the objective aperture. The eye of the observer should be placed at the Ramsden circle in order to obtain the largest field of view and the maximum brightness over that field.

The magnification of the microscope may be computed from the diameter of the Ramsden circle d in millimetres and the numerical aperture (N.A.) of the objective by the formula $M = \text{N.A.}\ 500/d$. When d is less than the diameter of the pupil of the observer's eye. the illuminance (illumination) of the retina. on which subjective brightness of the image depends, is proportional to the square of d and is therefore inversely proportional to the square of the magnification. On the other hand. when d is larger than the diameter of the eye pupil. its value has no effect on the subjective brightness of the image. The magnification at which the value of d is just equal to the diameter of the eye pupil is called the normal magnification. It provides maximum resolving power without loss of brightness.

Huygens.—The Huygens eyepiece (fig. 8[A]) is the commonest type of eyepiece used with the microscope. It consists of a plano-convex- collective lens and a piano-convex eye lens. The curved side of these lenses faces the objective. The focal length of the collective is about three times that of the eye lens. and the separation between the two lenses is roughly twice the focal length of the eye lens.

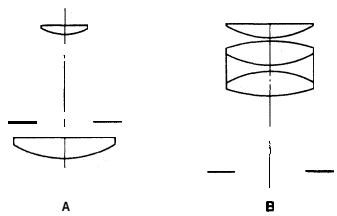

FIG. 8.—SIMPLE EYEPIECES: (A) HUYGENS: (B) COMPENSATING

Compensating.—The compensating eyepiece is used to correct. or compensate, the colour difference of magnification that exists in all high-power achromatic and apochromatic objectives. The achromatic quality of these objectives applies only to the position of the images formed with light of different colours. No matter how well designers have been able to correct objectives for chromatic aberration. they have been unable to eliminate a difference in magnification that is due to the wave length of light; consequently. when such objectives are used with the Huygens or any other achromatic eyepiece objects near the edge of the field are fringed with colour. By making the eye lens of the eyepiece a compound lens consisting of a crown and a flint element, this colour fringe can be eliminated. The distance from the eye lens to the eyepoint of this eyepiece is relati ely small. It becomes extremely small when made in high powers; *i.e.*, above $10\times$.

Another form of compensating eyepiece, called the orthoscopic, consists of a single lens and a cemented triplet (fig. 8[B]). For comparable focal lengths, the orthoscopic eyepiece provides a considerably longer eye distance than does the Huygens eyepiece. Since it also compensates any chromatic difference of magnification, most cornpensating eyepieces of powers higher than $10\times$ are of this form.

Ramsden and Kellner.—The Ramsden eyepiece (fig. 9[A]) consists of two plano-convex lenses mounted with their curved surfaces facing each other. In order to make the working distance (distance from collective lens to focal plane) assume a practically useful value. the lenses are mounted closer together than they should be for complete achromatization (correction of chromatic aberration). and even then their eye distances are uncomfortably short. By using a collective lens of longer focal length and achromatizing the eye lens. Kellner succeeded in producing an eyepiece that has longer eye distance and better achromatization. (See fig. 9[B].)

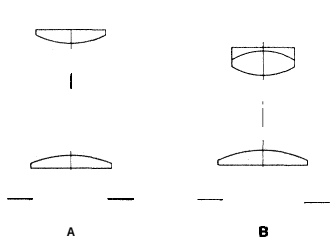

FIG. 9.—POSITIVE MICROSCOPE EYEPIECES: (A) RAMSDEN; (B) KELLNER

Location of *Lower* Focal Plane.—Eyepieces are classed as positive or negative according to the location of their lower focal plane. Eyepieces are called posi-

tive if this focal plane is external to the lens system and negative if it lies within the lens system. Huygens eyepieces are of the negative type while Ramsden, Kellner and orthoscopic eyepieces are of the positive type. Huygens eyepieces are frequently used for making measurements of the linear dimensions of objects by mounting a micrometer scale in the focal plane of the eye lens. This plane, while not identical with the lower focal plane of the eyepiece. is not far from it and also lies between the two lenses of the eyepiece. As a consequence the image is subjected to some geometric distortion due to the collective lens of the eyepiece but the micrometer scale lying above it is not distorted. Measurements made under such conditions are more or less in error depending on how large a part of this field of view they cover. Positive eyepieces having their lower focal plane external to both lenses are not subject to this error, for both image and scale are subiected equally to whatever distortion the eyepiece mav cause, and they are therefore preferred for use with micrometer scales.

5. Condensers.— The objects studied with the microscope are extremely small and the quantity of light falling on them from windows or lamps is totally inadequate. To overcome this lack of illumination, lens systems quite similar to objectives are placed beneath the object stage. These are called substage condensers. and their purpose is to concentrate light on the object so that it can be seen against a bright background. or field. The condenser should furnish a cone of light of the maximum angular extent that the objective is capable of receiving.

The Abbe condenser (fig. 10[A]) is a 1.25 N.A. condenser that utilizes only two lenses. Because of its simplicity and good light-gathering ability it is extensively used for general microscopy. It is not well corrected for aberrations but it serves very well for general visual observations. To obtain greater illuminated field coverage, a modified Abbe condenser called a variable focus condenser is sometimes used. The lower element. when focused downward. as indicated in fig. 10(B), brings light to a focus between the elements and illuminates a large field on the object slide. When the lower element is focused upward, it becomes a conventional Abbe condenser.

For research microscopy and colour photomicrography a more highly corrected condenser, such as the achromatic condenser (fig. 10[C]), is generally required. This is normally a 1.40 N.A. condenser and is corrected for chromatic and spherical aberration.

D. Image Formation

1. Geometrical Aspects.— The geometry of image formation in a light microscope is quite simple. It is easy to trace a group of rays from a single object point and find that they come more or less together in a region in the image space. It makes no difference how close two neighbouring object points are to each other; *i.e.*, as long as this distance is finite their images will be separated by a finite distance and two discrete images can be expected. This is found to be true until the distance between the object points becomes equal to half the wave length of light. They are then not distinguishable as two objects.

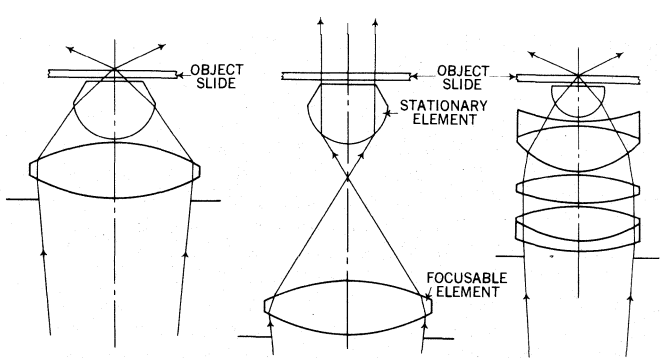

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FIG. 10.— SUBSTAGE CONDENSERS. (A) ABBE; (B) VARIABLE FOCUS: (C) ACHROMATIC

2. Diffraction and Resolution.—Since light has wavelike properties, the explanation of Image formation by rays is only a convenient approximation that overlooks diffraction phenomena that are inevitable in the propagation of waves It is diffraction that limits the resolving power of any well-designed optical system Because of diffraction the image of a point object can never be a point but at best is a small circular spot of light surrounded by faint circular bands (fig 6[A]) The cential spot that contains most of the light flux is called the Airy disk after Sir George B. Airy, who computed its size and the distribution of intensity nithin and around it. The radius h' of the Airy disk determines the smallest resolvable separation of the images of two object points. The corresponding least resolvable separation h in the object is $h = 0.61\ \lambda/n \sin u$, where λ is the wave length of the light and $n \sin u$ is the numerical aperture.

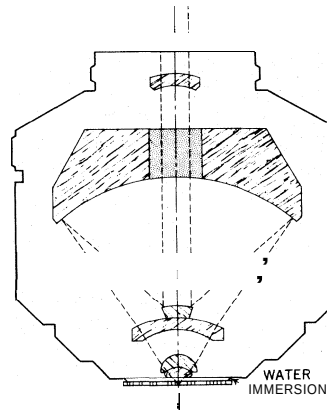

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FIG 11.—COMBINED REFLECTING-REFRACTING MICROSCOPE OBJECTIVE

The above formula indicates that three variables may be adjusted to reduce the least resolvable separation h. The wave length λ may be reduced. the refractive index n may be increased and the angle u that the objective can accept may be increased.

The wave length λ may be reduced by using selective filters to isolate the short wave length end of the spectrum; *i.e.*, the blue and violet region. This effect may be extended still further into the ultraviolet region, but here special optics and special techniques are required since it is not possible to see the image directly (*i.e.*, with the eye) and furthermore optical glass does not transmit very far into the ultraviolet region. Since optical materials that do transmit into the ultraviolet are quite expensive. the ultraviolet objectives most commonly used are reflecting systems or combined reflecting-refracting systems of the general construction shown in fig. 11. For the image to be made visible. wave length conversion techniques such as photography, fluorescence or flying-spot electronic scanning are required.

Within the limits of the visible spectrum, resolution can be improved by increasing the angle u toward the theoretical maximum of 90°. Apochromatic objectives of 0.95 N.A. represent about the practical limit to which the angle u can be pushed. Beyond this. further gain in resolution is achieved by the use of immersion objectives in which a fluid is used between the object slide and the front lens of the objective. The immersion fluid is normally oil ($n = 1.52$), although water ($n = 1.33$) and monobromonaphthalene ($in = 1.66$) have been used to some extent. Objectives as high as 1.60 N.A. have been produced for use with monobromonaphthalene but the practicable limit with oil as the immersion fluid is about 1.40 N.A.

3. Equivalence Theory.— The original diffraction theory of image formation. as applied to microscopes. assumes that the object is self-luminous. In 1873 Abbe developed a theory for microscopes in which the object was not considered self-luminous but served to diffract the light passing through it. He studied the diffraction patterns in the second focal plane of the objective experimentally and verified many conclusions of his theory. For many years there was considerable disagreement as to whether the older theory for self-luminous objects is applicable to nonself-luminous objects. It was finally established that. while the two theories are not generally equivalent, nevertheless. with the wide-angle illumination normally employed in microscopy, Abbe's theory for images of non-self-luminous objects is equivalent to the older theory for self-luminous objects.

4. Magnification.— To make fine detail visible, something more than resolving power is necessary; the image must be magni-Red enough so that the detail is visible to the eye. The basis for calculating how much magnification will be necessary to see de-

tail of a given degree of fineness lies in the resolving power of the eye, which in angular measure is about one minute of arc; this corresponds to about *350* lines per inch at a viewing distance of ten inches.

If, in the resolution equation $h = 0.61\ \lambda/n \sin u$, *0.5* is used instead of *0.61*, λ is assumed to be 0.0005 mm. (the wave length of blue-green light) and $n \sin u$ (N.A.) is assumed to equal *1.00*, then $h = 0.00025$ mm., corresponding to *100,000* lines per inch. This is really somewhat too high for ordinary conditions of light microscopy. but it is a convenient figure to remember. The resolution of any light microscope objective may be said to equal *100,000* lines per inch multiplied by the N.A.

The best the eye can do, however, is to resolve *350* lines per inch, so for the 1.00 N.A. objective the microscope must provide a magnification of 100,000/350 or 286×. The eye, however. cannot work at the limit of its powers for long without serious fatigue, hence it is desirable to supply more magnification than the minimum required.

A reasonable rule is to make the magnification *750* times the *N.A.* Even this can be exceeded in some types of material with profit. but it should always be the rule to employ the lowest magnification that permits comfortable seeing, for excessive magnification produces images of lower brilliance and poorer definition, with the result that the amount of object detail that can be seen is frequently reduced.

5. Phase Contrast.— Details within a normal microscopic object are seen because they have regions of varying density. In normal bright-field illumination (*i.e.*, with a strongly lighted background) a completely transparent specimen is very difficult to see in any detail. Dark-field illumination (*i.e.*, with a dark background) on such a specimen shows up border effects because of edge scattering and diffraction but shows little detail otherwise. Another method of observation, known as phase contrast microscopy, is of considerable value in viewing transparent media since it makes visible details that cannot be seen within such media by normal methods.

The refractive index of a transparent object. such as a live cell in a fluid medium, varies only slightly from point to point. These index variations give rise to diffraction spectra in the rear focal plane of the objective. The waves diffracted by irregularities in the object are a quarter wave out of phase with the undiffracted waves that pass through the surrounding areas. In the phase contrast method developed by Zernike, a shift of a quarter wave is introduced artificially in the undiffracted waves to cause a field contrast that is due to interference with the diffracted light. Either dark-field or bright-field contrast can be obtained (see fig. 12), depending on the direction of the quarter wave phase shift.

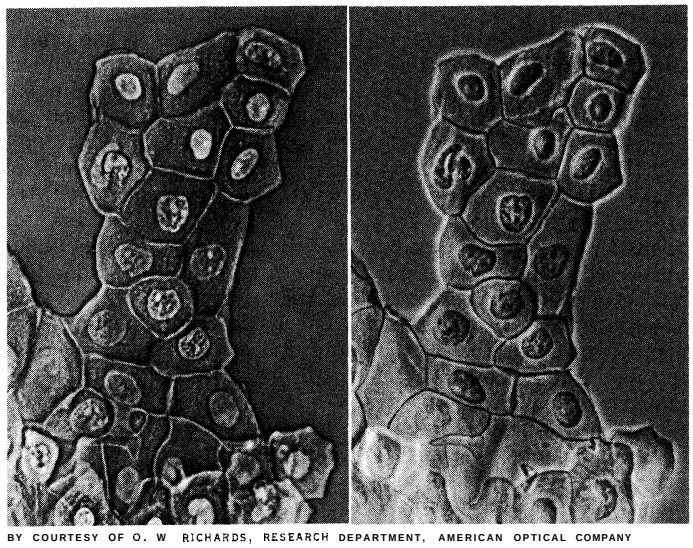

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FIG. 12.— UNSTAINED MICROSCOPE PHASE CONTRAST IMAGES OF EPITHELIAL CELLS FROM FROG NICTITATING MEMBRANE. AT FULL APERTURE, MAGNIFICATION ABOUT 240 ×; (LEFT) BRIGHT CONTRAST; (RIGHT) DARK CONTRAST

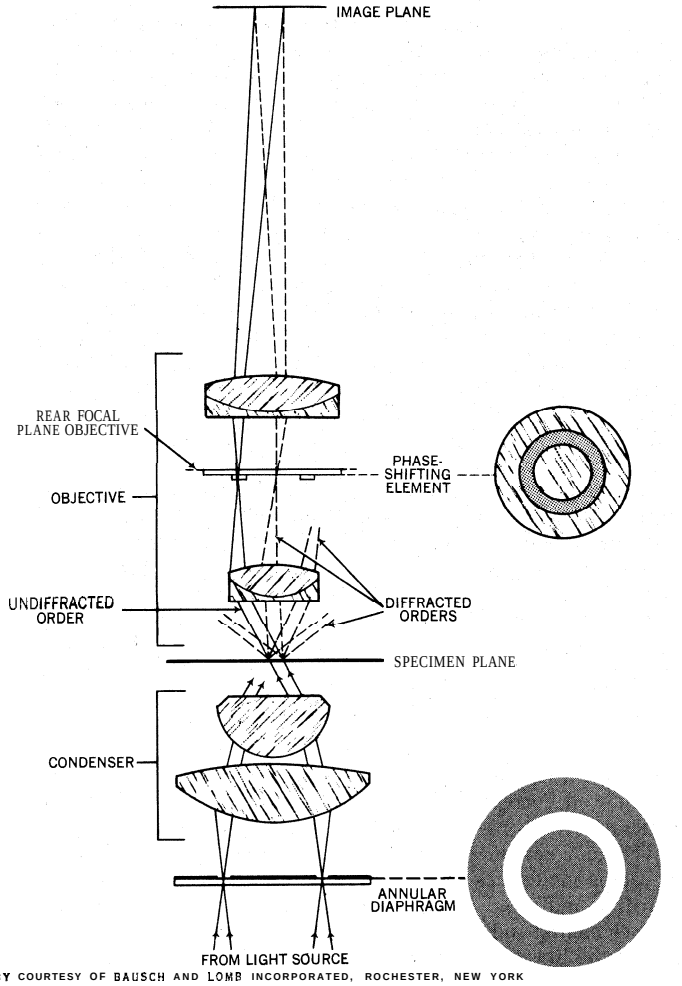

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FIG. 13.— OPTICAL SYSTEM FOR PRODUCING PHASE CONTRAST IN MICROSCOPE

A typical arrangement for producing phase contrast imagery is shown in fig. *13*. An annular diaphragm in the focal plane of the condenser is imaged at infinity by the condenser and then reimaged by the objective in its rear focal plane. An annular phase-shifting element is placed in this rear focal plane, where it is superimposed on the image of the annular substage diaphragm. All the light energy that is not diffracted by index gradients in the transparent specimen passes through the phase-shifting element, as indicated by the solid line rays in fig. 13, acquiring a quarter wave shift with reference to the diffracted energy (broken lines), some of which misses the phase-shifting annulus. Also, to render the diffracted and undiffracted portions more nearly equal in order to provide maximum contrast, an absorbing layer is added to the phase-shifting annulus. The end effect of these two changes in the undiffracted portion of the beam is to simulate intensity distribution that could have been produced by density gradations rather than index gradations.

E. Illumination

Objects may be illuminated by transmitted or by incident light, and in either case it is possible to cause the object to appear dark against a bright background or bright against a dark background. Several kinds of illuminators and illuminants are required to produce the different types of illumination.

1. Transmitted Light.— Most microscopy is done with transmitted light obtained from either natural or artificial sources. Many kinds of electric lamps, ranging from a 15-watt light bulb to a small carbon arc, may be used. If an artificial source is employed, it is nearly always mounted in a housing of some sort with optical aids such as collective lenses and ground glass disks to provide an illuminating beam of the character best suited to the

purpose.

If the objective in use is low in power (*i.e.*, less than 10×) and low in N.A. (*i.e.*, less than 0.10), a concave mirror can be used with an extended light source such as the sky to give adequate illumination. Most microscopes, however, are equipped with higher-power objectives, and the concave mirror is incapable of delivering an illuminating cone of light of sufficient angular aperture to fill such objectives with light. In such cases the substage condenser is used with a plane mirror. The condenser must be brought into alignment with the optical axis of the microscope; for this purpose the better microscopes are provided with centring screws. If the condenser is equipped with an iris diaphragm, it is possible to employ narrow-cone oblique illumination by rotating the diaphragm and shifting it laterally.

The condenser should be of sufficient N.A. to attain the highest limits of the most powerful objective on the microscope. Since the focal length of the condenser determines the size of the image of the light source that it projects into the plane of the object. the focal length should be small in order to avoid the necessity of making the condenser inconveniently large. The field of view of the microscope is so small when used with high-power objectives that it is quite possible for a short-focus condenser to fill the field with light; but when low-power objectives are used, the field of view is so large that it can no longer be covered with the short-focus condenser, and to meet this situation the condenser may be made divisible so that part of it may be removed, leaving the rest of it to function as a condenser of longer focal length and lower N.A., as described above. The variable focus condenser (fig. 10[B]) is a more convenient means of achieving the same end.

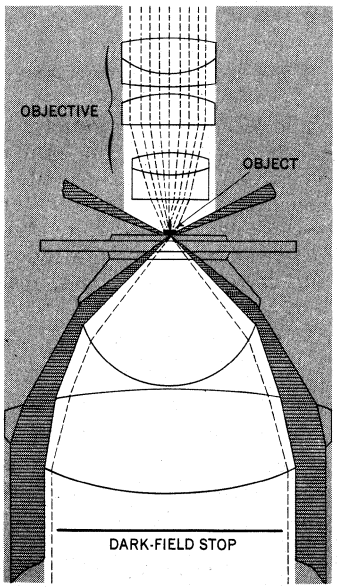

FIG. 14.— ABBE CONDENSER

When objectives of the immersion variety are used. the substage condenser should be immersed and precisely focused if full advantage of the high N.A. objective is to be secured.

Dark-Field Illumination.---The principle of dark-field illumination is to illuminate the object with a hollow cone of light, no part of which will pass directly into the objective. The object must lie at the apex of this cone, where it will receive light and deflect and reflect some of the light into the objective. This results in objects appearing bright against a black background. The Abbe condenser may be used with a central stop to obtain dark-field illumination (fig. 14), but it is not corrected well enough to produce a cleanly limited hollow cone of light with a sufficiently high concentration of light on the object.

The best dark-field illuminator is one that is corrected for spherical and chromatic aberration and also fulfills the sine condition. A reflector whose surface is a paraboloid of revolution has no spherical aberration for an infinitely distant object or image and is therefore used in dark-field illumination. Only a small annular section is used to reflect a strong conical beam of light to the object as shown in fig. 15.

The spot of light is very intense, but because of lack of fulfillment of the sine condition the paraboloid is less satisfactory than the cardioid condenser. The cardioid is not a true cardioid but is a pair of spherical surfaces arranged as shown in fig. 16 to reduce spherical aberration to a minimum and to obey the sine condition reasonably well. This condenser is used for critical dark-field work, such as the study of colloids, because the more concentrated light makes visible ultramicroscopic particles that are not made visible by the paraboloid condenser.

Polarized Light.—When a Nicol's prism or other polarizing apparatus is placed between the mirror and the condenser, the object can be illuminated by a cone of light in which all the waves vibrate parallel to one direction. If the object has any properties that cause it to modify the state of polarization of the light coming through the polarizer and condenser, these modifications can be observed, provided a second polarizing prism (analyzer) is used in conjunction with the eyepiece.

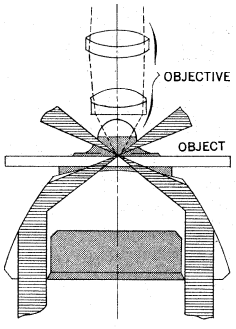

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FIG. 15.— PARABOLOID CONDENSER

If the analyzer is set with its polarizing axis at right angles to that of the polarizer, no light should be seen in the eyepiece, unless portions of the object have the power of modifying the state of polarization of the illuminating beam. For the complete examination of an object with polarized light, it is necessary to be able to rotate the polarizer and analyzer together while keeping the object at rest, or else to rotate the object between the stationary polarizing prisms. It is also necessary to be able to rotate one of the prisms relative to the other. Accessories of various types are used to examine the many kinds of objects that show polarization effects, such as fibres and crystals.

2. Incident Light.— Opaque objects are illuminated from the objective side by one of three general methods: (1) bright-field illumination, (2) oblique illumination and (3) conical, or dark-field. illumination. For the most part specularly reflecting objects are illuminated with vertical illumination. Rough objects are often illuminated obliquely.

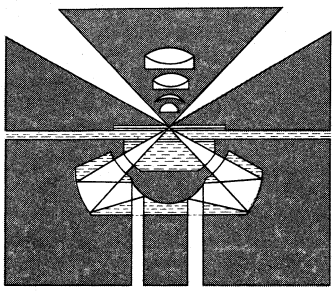

FIG. 16.—CARDIOID CONDENSER SHOWING PATHS OF LIGHT RAYS

Vertical *Illumination.*—This is accomplished with a vertical illuminator (fig. 17), which is a device located between the objective and the eyepiece; the illuminator contains a plane glass reflector that reflects light from a source at the side of the microscope through the objective onto the object and also transmits light from the object to the eyepiece. The objective of the microscope acts as a condenser for the light going to the object. converging light onto the specimen under an angle equivalent to the numerical aperture of the objective. Such illuminators are provided with both an aperture diaphragm and a field diaphragm so that both the quantity of light reaching the specimen and the size of the illuminated area can be controlled. The plane glass reflector of the modern vertical illuminator is given a coating of zinc sulfide, which, because of its higher index of refraction, provides a higher reflectance than uncoated glass.

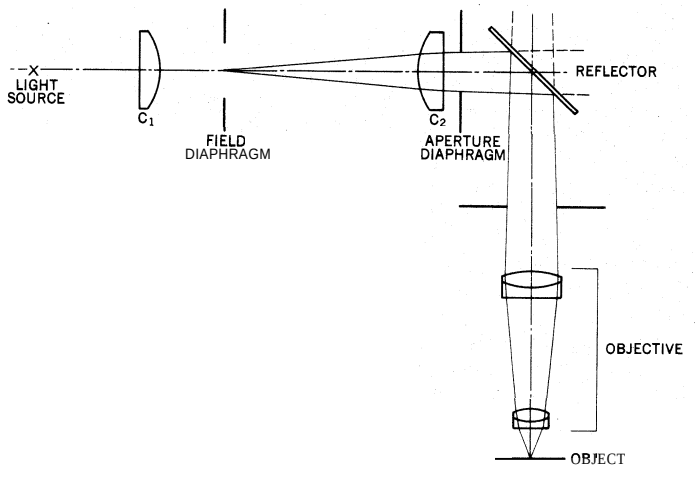

FIG. 17.— VERTICAL ILLUMINATOR (see TEXT)

In 1938 L. V. Foster showed that a vertical illuminator that employs polarized light increases the light incident on the object up to 50% (fig. 18). Such a device is especially useful for examining metal specimens.

Oblique *Illumination.*—The vertical illuminator usually has provision for introducing a small right-angle prism over half the aperture of the objective as a substitute for the plane glass reflector. This permits oblique illumination of an opaque object and also allows a great increase in the quantity of light incident on the object. For low-power (long-focus) objectives. oblique illumination is generally obtained by letting the light fall on the object from a lamp so stationed that the light reaches the object directly.

Dark-Field *Illumination.*—Many forms of annular incident illumination have been devised. These send a beam of light around the objective and focus it on the specimen by means of strong aspheric mirrors or strong condenser lenses surrounding the objective (fig. 19). The result is a negative of that secured with bright-field illumination; *i.e.*, the specular reflecting surfaces perpendicular to the axis of the objective will reflect no light to the objective and will appear black. Inclined surfaces or rough surfaces reflect light into the objective and appear bright; this effect is opposite to that obtained when strictly vertical illumination is used.

The Inverted Microscope.—The microscope for opaque materials is frequently inverted. Such an arrangement provides automatic leveling of the specimen surface regardless of whether or not it has parallel faces, since the surface to be examined is simply placed face down on the microscope stage. Such microscopes are widely used in the metal industry and are known as metallurgical microscopes. If provided with means for photomicrography they are called metallographic microscopes. The latter are frequently large and complex with (1) built-in spring shock absorbers that stabilize the image during photography, (2) viewing projection screens for comfortable prolonged viewing of the image and (3) means for changing rapidly from bright-field to dark-field, polarized light or phase contrast observation. An intense light source, such as an automatic carbon arc, is normally built into the equipment. (See also **METALLOGRAPHY:** Optical *Metallography.*)

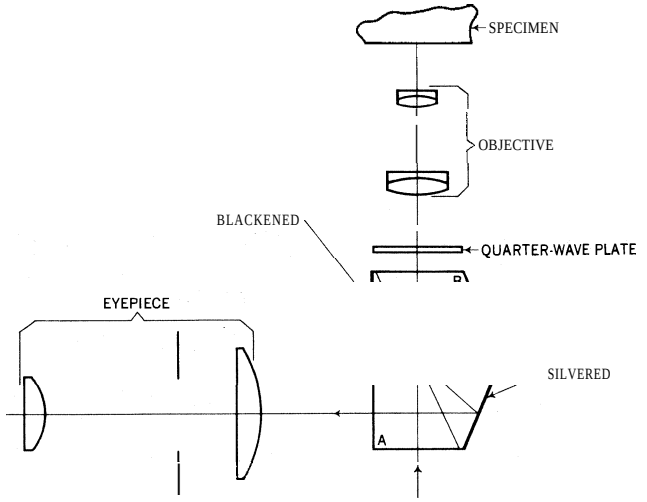

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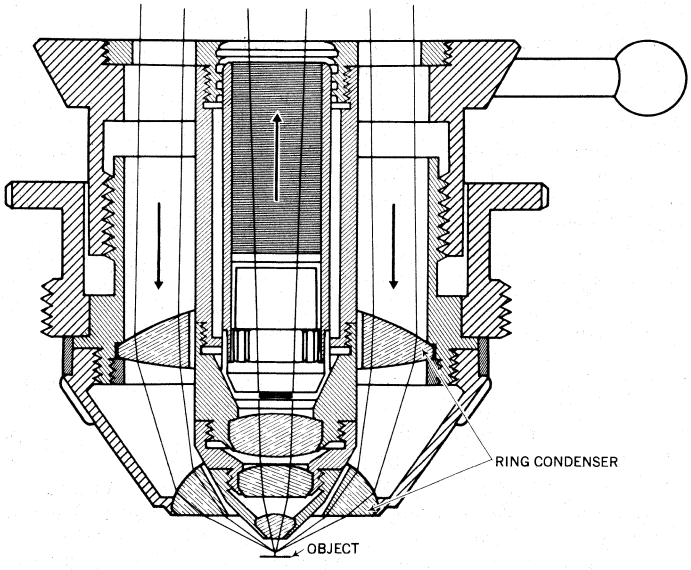
FIG. 18.— POLARIZING VERTICAL ILLUMINATOR WITH QUARTER-WAVE PLATE (see TEXT)



E. LEITZ, WETZLAR

FIG. 19.—LEITZ ULTROPAK

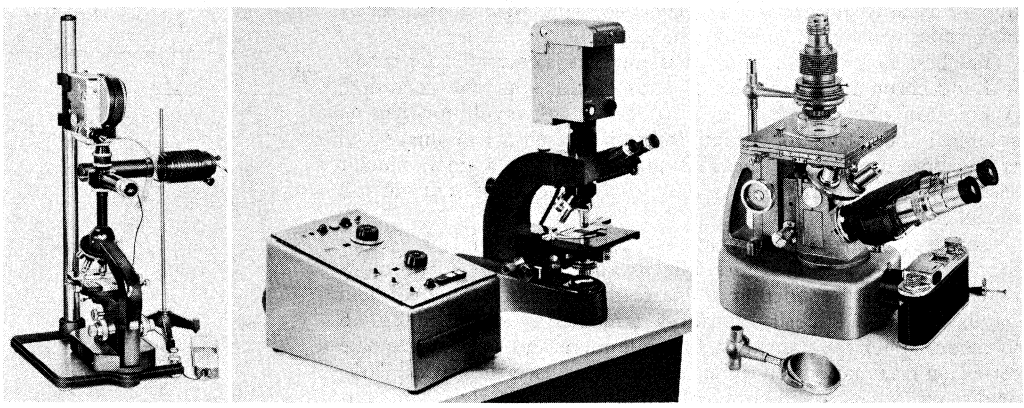
3. Photomicrography.— If the microscope is focused upward slightly from the position employed for visual use it will form a real image that can be recorded on photographic film. No additional lenses are required, but a camera body with provision for checking the focus and a shutter for controlling the exposure time is desirable. Improved images are obtained by using a projection eyepiece that is designed specifically for projecting a flat, real image on the film.

(*See* also **PHOTOGRAPHY:** Scientific and Applied Photography: *Photomicrography*). (J. VK.)

F. USE OF THE LIGHT MICROSCOPE

The science of using the microscope is known as microscopy. In order to become proficient in the use of the microscope it is necessary to work with the instrument frequently. Knowledge as to the nature of the object to be viewed is especially important nhen using transmitted light, or transillumination. For example, a fibre such as a single nylon thread or a human hair, when examined with light passing through the fibre, may look either like two opaque fibres separated by a bright line or like a single bright line. The reason for examining such an object also must be considered. for it might be more desirable to look for surface effects than for internal structure.

1. Resolution.— The significance of N.A. (see Diffraction and *Resolution,* above) is its use as a measure of the resolving power



BY COURTESY OF (LEFT) WILD HEERBRUGG INSTRUMENTS, INC , (CENTRE) E. LEITZ, INC., (RIGHT) UNITRON INSTRUMENT CO

FIG. 20.— OPTICAL MICROSCOPES USED IN PHOTOMICROGRAPHY: (LEFT) MONOCULAR INSTRUMENT USED WITH MOTION PICTURE FILM; (CENTRE) MONOCULAR INSTRUMENT WITH AUTOMATIC EXPOSURE CONTROL: (RIGHT) INVERTED BINOCULAR INSTRUMENT WITH LIGHT SOURCE AT TOP

of a microscope. A 10× objective of N.A. 0.25 is capable of separating into recognizable detail two objects separated by a distance of 0.001 mm. This resolution is possible only under very ideal conditions and with skilled use of the microscope. It is impossible to see detail finer than 0.001 mm. with an objective of N.A. 0.25. If object detail of this size is resolved, it must be magnified large enough for the eye to see it. A total magnification of 100× can be secured with the 10× objective and 10× eyepiece so that this detail will appear to the eye to be 0.1 mm. The unaided eye can easily distinguish detail of this size, for the eye has a resolution of about 1 to 1½ minutes of arc.

An angle of 1 minute of arc at the eye is equal to 0.07 mm. at a distance of ten inches from the eye. A simple way for the microscopist to test his acuity or resolution is to look at a printed page. a halftone or some other object whose size can be measured. The object is then placed far enough away so that the detail cannot be seen. The microscopist moves closer to the object and, when the detail is just perceptible, he measures the distance from the eye to the object and calculates the angle. By continual use of the microscope and attempts to see fine detail, it is possible to improve acuity. If acuity is low, higher eyepiece magnifications can be used until the total magnificatjon becomes about 1,000 times the N.A. of the objective in use.

2. Transillumination. — Thin layers of objects such as organic material are translucent. When they absorb some parts of the spectrum more than others, they appear coloured. If an object is to be examined for the purpose of learning its structure it must be illuminated by sending light through it. Transillumination is made possible by the substage condenser and a source of illumination. An electric light bulb frosted on the inside is suitable for most work in bright-field microscopy. Special microscope lamps, which consist of a concentrated light source, lamp condenser. iris diaphragm and filters, are desirable for many special problems confronting the advanced microscopist.

Transillumination is used in such procedures as the examination of tissue sections and in making blood counts. Since the objects are extremely thin and for the most part transparent, they are usually stained to make them more visible. They are always mounted on slides and protected by a cover glass. The standard slide is 1.5 mm. thick and the standard cover glass is 0.18 mm. thick. (*See* also ANATOMY, MICROSCOPIC; HISTOLOGY.) The light source, whether a simple lamp bulb or a professional type of lamp, should be placed about ten inches in front of the base of the microscope and the substage mirror aimed to send light through the condenser and objective. The alignment can be tested by looking through the microscope tube without the eyepiece. The microscope should be raised or lowered by the focusing adjustments until the back lens of the objective is seen filled with light. This observation and adjustment is best made with the 10× objective. If the lens cannot be made to appear bright by focusing, the substage mirror should be tipped. If light appears but the size of the spot is very small, the substage condenser should be raised by its focusing adjustment. When the lens of the objective is bright, an eyepiece should be placed in the microscope tube and slowly focused on the object. The beginner should make certain that the object is under the objective and that it has a number of opaque areas within it. The object cannot be seen unless it contains opaque areas. Prepared slides for practice and study can be purchased. A favorite subject for examination by beginners is the flea, whose legs, head and many other body parts can be seen comparatively easily because of their size and contrast.

After the 10× objective has been used with success, the objective of next higher power should be s ung into place and focused on the same object. The object will be found nearly in focus and only a small amount of adjustment of the fine-focus knob will be necessary.

Objects such as blood smears and weakly stained tissue sections display very weak contrast and require other attention to illumination. The brightness of the field can be made so great that the detail in the object is flooded; this often occurs when high-power objectives are used. The contrast can be governed somewhat by using the substage iris diaphragm. The size of the diaphragm should be reduced until about one-third of the aperture of the objective is illuminated when viewed without the eyepiece. If the object is discernible and is not fringed with diffraction lines. the microscope should be left at this setting.

A great deal can be learned about illumination and its effects by examining regular periodic structures. such as the skeletons of diatoms. The skilled microscopist uses diatoms to improve his acuity, to test his microscope optics and to learn how to use his instrument most effectively. A diatom is a unicellular plant whose protoplasm is contained within a delicate silica network. Mounted diatoms, which can be purchased, have been treated so that only the silica skeleton remains. *Pleurosigma angulatum* is a diatom well suited for microscopy practice and for testing illumination with a medium-power objective (*e.g.*, 43×). If the objective is well corrected and has an N.A. of 0.65 or 0.85 it will be possible to see an array of tiny hexagons. After the microscope is focused on the edge of some tear in the diatom. the substage iris diaphragm is closed to its smallest opening and the microscopist looks down at the rear lens of the objective with the eyepiece removed. There should be visible an image of the small iris at the centre of the lens and six moonlike images of the iris at the edge of the lens. These six images are diffraction images of the iris caused by the periodic structure of the diatom. Unless these six images are present the hexagonal structure cannot be seen. The microscopist gradually opens the diaphragm until the six diffraction images and the central image merge. He replaces the eyepiece, and the hexagonal structure is clearly evident.

A diatom that tests the optics of the best microscope and the technique of the most skilled microscopist is *Amphipleura pellucid~*;it can be used to test an apochromatic oil-immersion objective used with an achromatic aplanatic substage condenser In order to see the dots, which are about 0.00025 mm. in diameter. it is necessary to use illumination that makes an angle of about 45° with the structure. This illumination can be checked by viewing without the eyepiece in the manner described above. The angle of illumination should be adjusted so that two diffraction images of the iris diaphragm are apparent on the side of the lens opposite the bright image of the iris diaphragm. If a small iris diaphragm is used, either on axis or off, a source of bright light is essential. Under such conditions, filters can be used to control the wave length of light used.

3. Micrometry. — Microscopic objects can be measured linearly by using a filar micrometer in place of the regular eyepiece. Before such a measurement is made, the scale of the filar micrometer must be calibrated with a stage micrometer or some other known object. Stage micrometers accurate to 0.1μ are available and should be used if the measurements are to be relied upon. The stage micrometer is ruled on a 1 × 3-in. slide over a length of 2 mm. in intervals of 0.01 mm. It is advisable to calibrate all objectives at one time. The filar micrometer is then placed in the microscope and clamped in position. The stage micrometer is focused with the lowest power objective available, and the ruled area is brought to the centre of the field. The movable line of the filar micrometer is moved to the left side of the field and made parallel with the lines on the stage micrometer. The drum of the filar micrometer is turned until the movable line coincides with a chosen line of the stage micrometer. After settings and readings become consistent, a record is made of them. In making settings, the drum should be rotated in the sam'e direction for all readings in order to avoid error-causing backlash that may exist in the screw. A setting on a line in the stage micrometer about 1 mm. to the right of the first should then be made. A reading for 1 mm. of the stage micrometer might be 10.53 and would give a factor of $\frac{1}{10.53}$, or 0.09496. This is the factor that would always be used with this objective and filar micrometer when converting to the actual size of an object. That is, if an object measured 4.25 filar micrometer units, its actual size would be 4.25 × 0.09496 or 0.4036 mm.

Some measurements do not require the precision of a filar micrometer. A regular eyepiece can be equipped with a micrometer disk and, after being calibrated, can be used for estimating

object sizes.

4. Binocular Microscopes. — A monobjective microscope equipped with a binocular eyepiece has the advantage that both eyes are used to see the same object and thus there is no need to suppress the vision of one eye. Even when both eyes are used there is no depth, or stereoscopy. Stereoscopic effect can be secured only when different images are seen by the two eyes. These two images can be provided in a monobjective microscope by splitting the illuminating beam of light into two parts so that oblique beams pass through the object. These oblique beams are made to pass, one to the right eye and the other to the left eye. by the use of half-moon diaphragms over each eyepiece. These diaphragms should allow light coming through the inside halves of the exit pupils of the two eyepieces to pass to the eyes. If the outside halves of the pupils are used, the depth effect will be pseudoscopic. This method of providing depth perception in a microscope is fundamentally sound but is rarely used.

Low-power binocular microscopes made up of two separate microscopes are very practical and popular. Their magnifications range from 5× to more than 100×. The image is always erect in this type of microscope instead of being inverted, as in the monobjective microscope. Binocular microscopes of low power are used largely with gross objects where third-dimensional effect is as important as linear magnification. They do not require any substage accessories other than a mirror to reflect light around or through the object. Top illumination is usually adequate.

5. Specimen Preparation. — Dry material such as leaves, powders, sand and crystals can be laid on a 1 × 3 glass slide and retained in place with a cover glass. If the slide is to be a permanent preparation, the cover glass can be fastened to the slide with masking tape or by ringing the slide with paraffin or asphalt and attaching the cover glass to the ring; if the object is thick, the cover glass can be attached to a cardboard ring glued to the slide. The same material may be mounted by embedding, if the object is not soluble in the embedding material. Also, if the material is transparent, the index of refraction of the embedding material must be quite different from that of the object or the object will be hard to see without staining. For instance, a fly's wing can be mounted either dry or in balsam. If glass particles or pieces of sand are to be mounted, it is best to make a dry mount. To keep the particles from rolling around, a drop of albumen (egg white) can be placed on the slide. When small particles are dusted on a surface coated with albumen they will stick quite well.

Liquid mounts can be made easily but they tend to dry out in a few hours. A drop of pond water, for example, can be placed on a glass slide and covered with a cover glass. Examination will reveal paramecia, rotifers, vorticellae, stentors and possibly forms of algae.

6. Ultramicroscopy.—The ultramicroscope is a light microscope that is used to examine objects too small to be seen with a conventional light microscope. Particles are said to be ultramicroscopic when they are smaller than the wave length of light; *e.g.,* the small particles in a colloid such as colloidal gold. The ultramicroscope has three forms: (1) the cardioid ultramicroscope; (2) the slit ultramicroscope; and (3) the dark-field illuminator.

Any microscope on which a cardioid condenser can be mounted can be used to see the ultramicroscopic particles in a colloid. The cardioid condenser is a substage accessory capable of concentrating a beam of light into a very small spot and under a high obliquity. This condenser provides a hollow cone of illumination whose N.A. varies from about 1.10 to more than 1.40. The objective used with this condenser must have an N.A. of less than 1.10 (it often is about 0.90) so that the amount of direct light that passes through the objective from extraneous field rays is held to a minimum. When the cardioid condenser and objective are adjusted and a sol is mounted in a chamber for examination, the colloidal particles receive a strong beam of illumination that cannot pass through the objective unless it is deflected by the particles. The particles thus appear as self-luminous objects against a dark background. Care must be taken in preparing the slide so that fat globules do not become attached to the slide or cover glass; such globules can cause scattered light to appear in the background. Slides and cover glasses may be kept clean by storing them in a solution made by dissolving 5 g. of cleansing powder in 100 ml. of water. When required, a slide and cover glass are removed from the solution and allowed to dry. They are then shined by wiping them with a clean piece of gauze or a clean, lintless towel. Special slides made in the form of chambers should be used for best results in ultramicroscopy. These slides are made from fused quartz, and their central part is lower than the ring support for the fused-quartz cover glass by about 0 001 to 0.002 mm. The fused-quartz slides and cover glasses can be cleaned in sulfuric acid and alcohol.

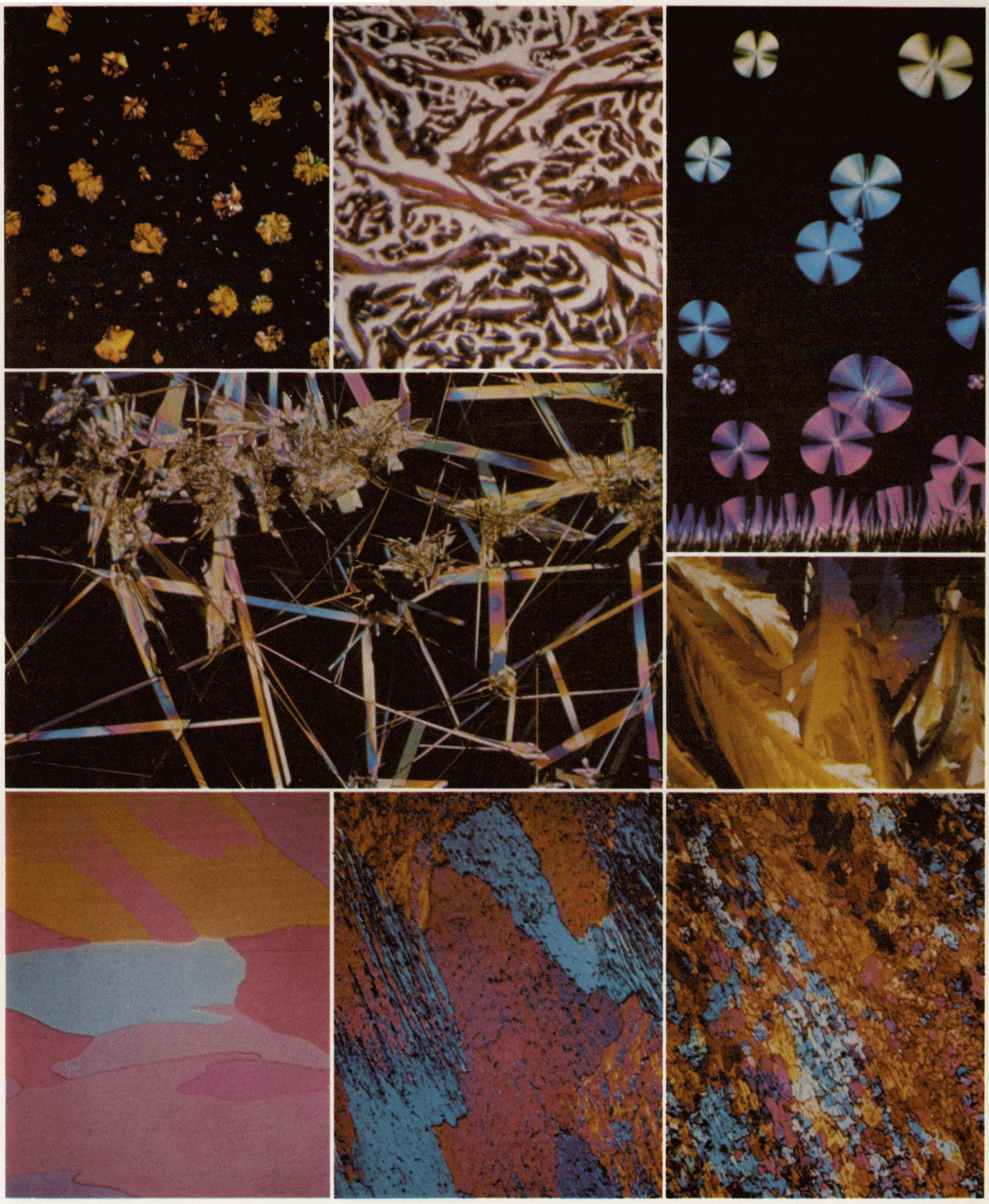
The slit ultramicroscope developed by H. Siedentopf and R. Zsigmondy makes use of an illumination system mounted at right angles to the optical axis of the microscope. The colloidal solution (or other fluid) is made to flow through a special chamber equipped with fused-quartz windows. The illumination beam can be rotated by an adjustable slit around the axis of an objective that is used to focus the slit at a reduction through one quartz window in the chamber. An arc lamp is focused on this slit, and the special objective is focused through the other quartz window into the sol. The slit can be made vertical when the microscope is focused on the beam of light as it passes through the solution and the thickness of the illuminated beam can be measured if a calibrated micrometer eyepiece is used. The examination of colloids with this instrument reveals various coloured star-like points and scintillating points of light. The reddish "stars" result from particles larger than the bluish stars. The scintillating "stars" are unsymmetrical.

The dark-field illuminator is a less exact form of the ultramicroscope and is used to make small microorganisms visible. Since it gives less concentrated light in a thin and small spot, its adjustment is less critical than the cardioid condenser and it does not require quartz slides and covers. Material, such as a drop of saliva, can be placed on a clean slide and covered with a clean cover glass; if examined with an oil-immersion objective, it will reveal mouth bacteria and several forms of spirochetes. The objective must be equipped with either a funnel stop or an iris diaphragm to reduce its N.A. below that of the dark-field condenser in order to make these objects appear bright against a dark background.

7. Phase Contrast. — Until phase-contrast methods were discovered, the microscopist had to fix and stain the cells and pathological sections he wished to examine. The nucleus of cells became dark when stained. It has been found that the index of refraction of a cell nucleus differs from that of the surrounding protoplasm. The phase microscope makes it possible to increase this difference and examine living cells and unstained tissue sections. Increasing the path difference causes invisible differences to appear as amplitude differences (*i.e.*, absorption, or contrast, differences). The phase-contrast accessories consist of special objectives with phase plates in their apertures and a special substage condenser that regulates the illuminating cone of light so that it corresponds with the phase-shifting zone in the objective.

The object material is mounted unfixed and unstained on a slide and is covered with a cover glass. The phase-contrast microscope is used in the regular manner with the added requirement that the illuminating annulus must fit tightly into the phase annulus in the back aperture of the objective. A focusing-tube microscope is supplied as an accessory and replaces the eyepiece temporarily while the condition of superposition is checked or adjusted. The substage condenser should be provided with a similar means for adjustment. The eyepiece can be replaced when the very slight phase difference in the object becomes outstandingly evident as an amplitude difference if the phase plate is correct and a phase difference exists in the object.

8. Ultraviolet Microscopy. — There are two chief advantages arising from the use of ultraviolet microscopy. First, resolution can be increased over light microscopy because of the shorter wave length, with the result that finer details can be seen than with the visible light microscope. Second, biological materials display increased differential absorption to various portions of the



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PHOTOMICROGRAPHS

Top left: Vitamin K crystals (illumination: transmitted polarized light)
Top centre: A thin section of cowhide leather
Top right: DDT insecticide crystals (transmitted polarized light)
Centre left: Anthranilic acid, used in the manufaoture of dyes, drugs, perfumes and pharmaceuticals (transmitted polarized light)
Centre right: Adipic acid, used in the manufacture of nylon (transmitted polarized light)
Bottom left: Aluminum *as* cast (incident polarized light)
Bottom centre: Alloy of aluminum and 2% uranium as cast, followed by 75% reduction by roiling (incident polarized light)
Bottom right: Alloy of aluminum and 2% uranium as cast, reduced 75% by rolling and recrystallized at 900° C. (Incident polarized light)

ultraviolet, a characteristic of importance to the biochemist and bacteriologist. Methods involving the use of ultraviolet radiations and quartz monochromatic objectives corrected for only one wave length in the ultraviolet are employed. Reflecting objectives with a low N.A. and catadioptric objectives with a high N.A. have been made that are achromatic over the visual and ultraviolet spectrum. A catadioptric objective is one that uses both mirrors and refracting lenses. The refracting lenses correct both the residual spherical aberration of the spherical mirrors and the chromatic errors of the quartz cover glass that is required to transmit the ultraviolet. The reflecting objectives are used with reflecting condensers of the same design.

The proper use of these optics requires an illumination system in which the wave length of the illuminating beam is known and can be controlled. Thus it is necessary to use a monochromator with wave length calibration and a source rich in ultraviolet radiation. Since the eye cannot detect ultraviolet light but can be damaged by it, photography is used to record the image. Eyepieces used with ultraviolet optics are made of fused quartz or other material that transmits ultraviolet. Since the reflecting and catadioptric objectives are not affected by chromatic errors, they can be focused with visible light and photographs made without further adjustment.

The technique developed by J. E. Barnard brought ultraviolet microscopy into an important position in bacteriological research. Bacteria are almost uniformly transparent to visible light but are not transparent to certain regions of the ultraviolet spectrum. Bacteria either must be stained in order to be examined in visible light or they must be examined in phase-contrast or dark-field illumination. With ultraviolet illumination staining is unnecessary and the organisms can be photographed alive at various wave lengths.

9. Opaque Microscopy. — The science of metallurgy is concerned with the crystal structure of iron, steel and alloys. Special microscopes called metallurgical microscopes are used for examining the surface of metals. They differ from the biological microscope in their method of illuminating the object. Since metal specimens prepared for microscopic examination are opaque, the illumination must come from above by the vertical-illumination method. Most metallurgical microscopes are made inverted so that the metal specimen can be laid with its polished side down on a stage. The objective is beneath the stage and points upward through a hole in the stage; the image is brought into focus by moving the stage and object up and down aith a rack and pinion.

The biological microscope can be used for examining opaque specimens by equipping it with a vertical illuminator and laying the metal specimen with its polished side up when the objective points down. The objectives used either on a metallurgical microscope or on a biological microscope with a vertical illuminator must be specially made for the purpose because the objects are not protected by a cover glass and the tube length is always quite different from that of the ordinary biological microscope. The vertical illuminator consists of (1) a thin flat plate of glass set at 45° to the axis of the objective and close to it on the image side; (2) a semicircular mirror; or (3) a Foster prism.

If the flat reflector is used it should be coated with antireflection film on one side and high-reflection film on the other. The high-reflection film should reflect 50% of the light while transmitting 50% in order to give best results. The semicircular mirror is sometimes replaced with a 45° reflecting prism that covers half of the aperture of the objective. (See also METALLOGRAPHY: Optical Metallography.)

The Foster prism is a calcite polarizing vertical illuminator that transmits and reflects plane-polarized light (see fig. 19). The plane of polarization of the transmitted beam is at right angles to the plane of polarization of the reflected beam. Thus if the polished metal specimen is specularly reflecting. no light will reach the eyepiece and the sample will appear black. A quarter-wave plate is placed between the prism and the objective with its axis 45° to the plane of polarization of the Foster prism. Since the light will pass through the quarter-wave plate tnice. the plane polarized light transmitted to the specimen will be circularly polarized. The light passes through the quarter-wave plate a second time on its return and becomes a plane-polarized beam but is rotated 90" to its original direction. Since the Foster prism reflects light polarized in this plane, the field of view will be bright. This type of illuminator provides bright-field illumination when the quarter-wave plate is used and polarized light illumination without the plate. Illumination by polarized light is used in testing for glassy inclusions, oxides and grain orientation.

A great deal of attention must be given to preparing the metal sample or mineral for examination. The specimen is easiest to handle if it is about 1 in. in diameter and $\frac{1}{4}$ to $\frac{1}{2}$ in. thick. If a biological type of microscope is to be used, the specimen should be sawed or filed so that two opposite surfaces are flat and parallel. The side to be examined must be lapped flat and polished before it is etched. The etching brings out the grain boundaries and the peculiar structures in the grains that disclose the effects of heat treatment. (L. V. F.)

G. CHEMICAL MICROSCOPY

Chemical microscopy includes the microscopical techniques and problems with which chemists have to deal. It does not include the specialized subjects of biological microscopy, metallography and petrography, although chemists are often involved in work related to these fields and may borrow and adapt apparatus and preparative techniques from them. It overlaps the field of microchemistry, since it includes qualitative analytical reactions performed on a small scale (a drop or less of solution). In such analyses, the reagents may be those employed in ordinary qualitative analysis. with the advantage that group separation may be unnecessary because of the characteristic crystalline appearances of the precipitates obtained. Specific reagents that function in the presence of ordinarily interfering ions are also employed.

Crystalline substances may be identified by their microscopical properties, such as angle, refractive index and double refraction, which can be compared with tabulated data when available or with known samples. Solid derivatives of liquid or solid organic compounds can be utilized in the same way to supplement or confirm ordinary tests. Mixtures of solids can be separated into their components mechanically for further analysis or small particles of contaminants can be collected. Often the constituents of mixtures can be identified in situ under the microscope by optical means.

Quantitative microscopical analysis of mixtures is feasible when recognizably different components are present; analysis can be made by comparison with standard samples, by counting the particles of different kinds (*e.g.*, foods, drugs, papers. fabrics, ore concentrates) or by measuring the areas of the components on a sectioned mass (rocks, ceramics, alloys) to find the composition by volume. Such analyses are particularly valuable when the components are chemically similar or complex and when determination of elements would not directly reveal the amounts of the structural constituents present.

Microscopical studies of crystals are particularly useful in physical chemistry of the solid state (*e.g.*, in the study or determination of (1) melting and transition temperatures and ranges; (2) condensation of sublimates; (3) contact angles and wetting of surfaces; (4) mechanisms of transformations; (5) phases in polymorphism and systems of double salts, hydrates or reciprocal salt pairs; (6) factors governing formation and "digestion" of precipitates; (7) modifications of crystal shape by different solvents or other substances).

Microscopical examination is important in the study of particulate materials. especially those finer than the range of sieve tests (less than about 50μ). The particles are usually far from uniform in size. Statistical analysis of the frequency of different sizes, rather than ordinary averaging, is essential for correlation with the performance of the material and is often greatly dependent on the total surface presented for the light scattering and colour (pigments), reactivity (ores, cement. sprays and dusts) or interfacial forces (flotation, emulsification).

The effects of physical condition on the appearance of coloured materials and the various kinds of structural colours shown by

colourless substances are best investigated microscopically. Photometric measurements over the entire spectral range can be made with the microscope on small fields. Hardness can be determined quantitatively by measuring minute indentations produced under controlled conditions. The effects of temperature can he observed by means of heating or cooling chambers. Technical processes may be miniaturized or products may be examined at various stages of manufacture or service; such procedures are useful in studies of dyes, paints, rubber, plastics, adhesives, paper, ceramics, corrosion. abrasion and weathering.

Chemical microscopy often supplies unsought information. particularly in analysis or technology, and reveals physical conditions that may be more significant than chemical composition. It emphasizes rather than obscures the heterogeneity of materials and the resulting fact that in them different things happen at different places and at different times under a given treatment. Its direct visual approach often furnishes an independent attack on problems ranging from research to trouble shooting and may suggest more extensive investigations or may clarify previous inquiries.

Although most work in chemical microscopy is done with light microscopes. the electron microscope is a valuable adjunct although its use is limited as regards sampling, preparation techniques and applicability to volatile or heated specimens. The electron microscope has greatly extended the knowledge of colloids derived from classic experiments with the ordinary microscope and ultramicroscope.

Microscopes equipped for use with polarized light (often called chemical microscopes) are valuable not only for determining the identifying optical properties of crystals but also for studying molecular orientation in complex polymers, tissues and other aggregates of submicroscopical crystallites. The observable changes in arrangement caused by growth or mechanical treatment (*e.g.*, the stretching of rubber or of nylon fibres after extrusion), chemical alterations (as in the nitration of cellulose fibres or tanning of leather) and the spontaneous alignment of large molecules to form liquid crystals (as in soaps) are potential evidence in the investigation of cryptocrystalline matter and the nature of some processes in biological growth. Many of the findings of X-ray diffraction studies in these fields are closely related to observations with the polarization microscope. (C. W. MA.)

III. THE ELECTRON MICROSCOPE

A. HISTORY

The development of the electron microscope was spectacular and rapid. In 15 years this instrument reached a degree of perfection comparable in many respects to that attained by the light microscope after nearly 300 years of development.

In 1924 Louis de Broglie (see BROGLIE) advanced his hypothesis that there was something of a wave nature associated with material particles, in particular with electrons. He derived a formula that showed that the wave length of an electron accelerated by a potential of 60.000 volts is 0.05 A, or $\frac{1}{100.000}$ as long as the wave length of ordinary light. (*See* also ELECTRON DIFFRACTION.) In 1926 Erwin Schrijdinger initiated the development of wave mechanics by recalling the analogy between mechanics and optics demonstrated by W. R. Hamilton in 1830 and by combining Hamilton's analogy with De Broglie's ideas. (See also QUANTUM MECHANICS: *Advent* of True *Quantum Mechanics*.)

While Schrijdinger had much of the information necessary for the development of an electron microscope, it was not until after the work of Hans Busch in Germany that the practical significance of this information became apparent. In 1926. after 15 years of intermittent work on the trajectories of electrons in magnetic fields: Busch published a theory stating that magnetic or electric fields possessing axial symmetry act as lenses for electrons or other charged particles. Busch's work thus called attention to an important practical aspect of the De Broglie and Schrödinger theories and initiated a new science of instrumentation that later became known as electron optics. In 1927 Busch experimentally verified his theory with a magnetic lens. It was not until 1931, however, that C. J. Davisson and C. J. Calbick in the U.S. reported corresponding verification on the lens properties of an axially symmetrical electric field.

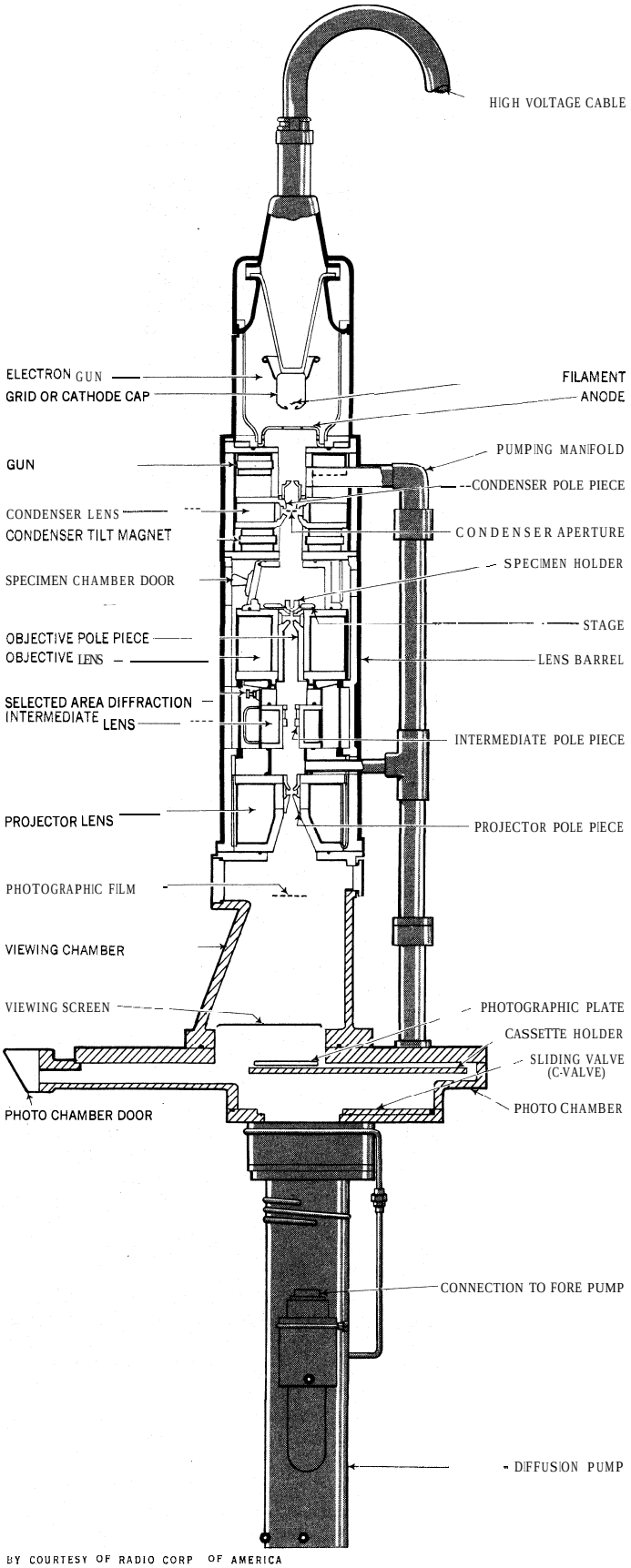

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FIG. 21.—CROSSSECTION OF EMU 3 ELECTRON MICROSCOPE

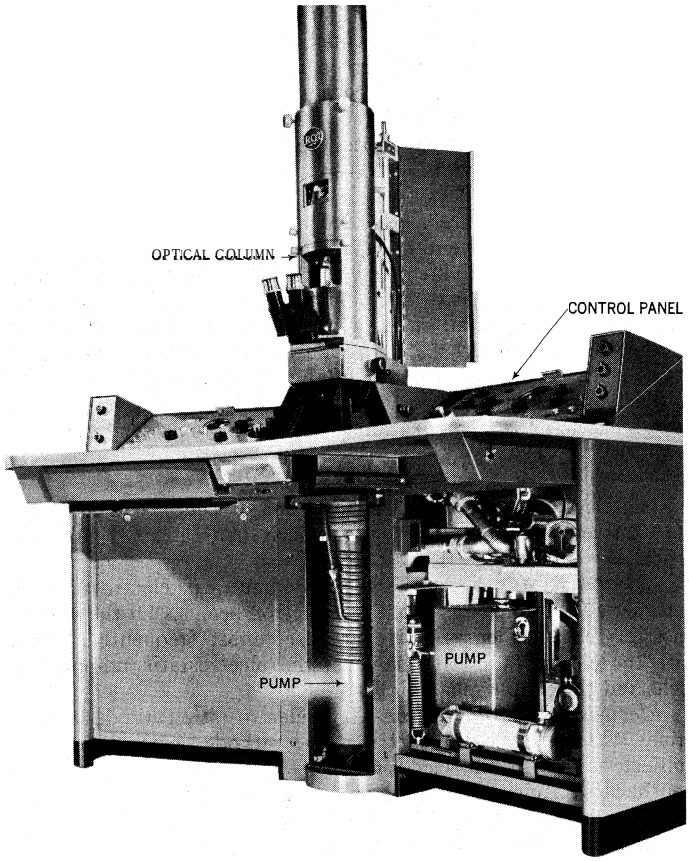

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FIG. 22.—ELECTRON MICROSCOPE, TYPE EMU 3.

In 1932 Ernst Brüche and H. Johannson in Germany produced images of a heated oxide cathode with an electron microscope system using electrostatic lenses and a 300-volt electron beam. In the same year M. Knoll and Ernst Ruska, also in Germany, constructed an electron microscope using short magnetic lenses and 60-kilovolt electrons and with it produced images of the electron source in a discharge tube. In 1932 Knoll and Ruska also stated that an electron microscope using high-velocity electrons should be capable of surpassing the resolving power of the light microscope by a large factor. By 1936 the emission-type electron microscope for the observation of various types of cathodes had reached a high degree of development.

The actual work on the development of the more generally useful transmission type of electron microscope for the observation of nonemitting substances, which was suggested by K. Rudenberg in 1931 in a German patent application, was started by Knoll and Ruska in 1932. In 1934 Ruska described the construction of a new electron microscope using magnetic lenses; this instrument was built specifically for attaining high resolution in the study of specimens by transmitted electrons. Shortly afterward, L. Marton in Belgium became the first to attempt to use the electron microscope with biological materials. Other work was being done at this time by L. C. Martin. R. V. Whelpton and D. H. Parnum in England. None of these early instruments, however, provided resolutions surpassing that of the light microscope. But in 1935 E. Driest and H. O. Müller, working with Ruska's microscope, in which they had incorporated a number of changes suggested by Ruska, exceeded the resolution of the light microscope. The work on Ruska's microscope was continued by F. Krause. who obtained a number of electron micrographs of various materials. Krause also showed that if specimens were made sufficiently thin they were not destroyed by the electron beam. thus disproving an earlier belief that specimens must be stained in such a way that a "skeleton" outlining their form would be left after they were destroyed by the electron beam.

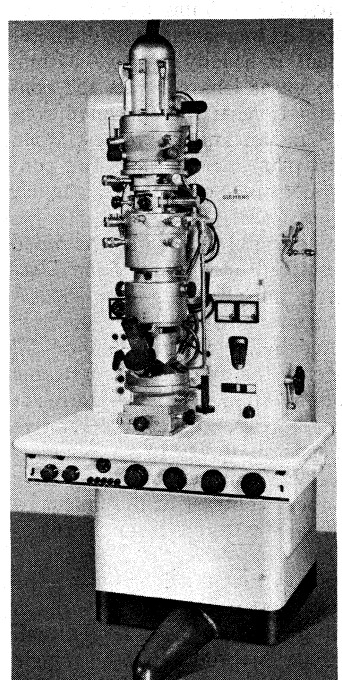
In the meantime, B. von Borries and Ruska were designing an improved magnetic electron microscope for the German firm of Siemens and Halske, and in 1938 they described a practical instrument for general laboratory use. In its early form, this instrument was capable of resolving details down to 100 **A.** At the same time and independently of the work by Borries and Ruska, another practical magnetic electron microscope was designed in Toronto by A. Prebus and J. Hillier and described in 1939.

After these beginnings new electron microscopes were described in rapid succession. In 1939 Hans Mahl, working in the laboratories of the Allgemeine Elektrizitäts Gesellschaft in Berlin, produced an electron microscope of high resolving power by using electrostatic lenses. In the same year Marton designed a magnetic instrument for the Radio Corporation of America in which electronically regulated power supplies designed by A. W. Vance were used for the first time. Late in 1939 H. Boersch described his shadow-type electron microscope. In 1940 R.C.A. announced the development of a commercial electron microscope (*i.e.*, a type made in quantity for sale) designed by Hillier and Vance that was capable of a resolving power of around 24 A. M. von Ardenne described an elaborate magnetic electron microscope that was capable of resolving 20 A. Ruska and Borries had, in the meantime, improved the resolving power of the Siemens instrument to 22 Å. In 1945 Hillier described a means for making a magnetic objective accurately symmetrical and achieved a resolving power of 10 Å. Refinements brought the resolving power of the leading commercial instruments to the range 5 to 10 Å, which is about the expected limit.

Fig. 21 shows a cross-sectional diagram of the optical column of a type EMU 3 electron microscope manufactured by the Radio Corporation of America; fig. 22 is a photograph of the same instrument showing the column, control panels and pumps. Fig. 23 is a photograph of an electron microscope manufactured by Siemens and Halske in Germany. Other electron microscopes are made in England, France, the Netherlands and Japan.

B. Types of Electron Microscopes

1. Emission.—The first electron microscopes were of the emission type. In all emission electron microscopes, the object is the source of the electrons, although the instruments may use different kinds of sources and may be differentiated on this basis; *e.g.*, as thermionic emission, photoelectric emission, secondary emission and field emission subtypes. Only those using thermionic emission are of much practical significance.



BY COURTESY OF SIEMENS AND HALSKE, WEST BERLIN

FIG. 23.—ELECTRON MICROSCOPE. TYPE "ELMISKOP" I

In its original and simplest form, as described by Briiche and Johannson in 1932. the thermionic emission electron microscope consisted of a single cathode lens. The final electrode potential was 750 v. and the instrument projected a magnified image of the emitting surface on a fluorescent screen, where it could be observed visually or photographed. Later instruments provided greater magnification and employed higher field strengths at the cathode to improve resolution. The main value of these instruments is in showing the emission patterns on the cathode as they vary with crystal structure, heat treatment and surface films. The best resolution is about 400 Å. (See also FIELD EMISSION: Field *Emission Microscopy.)*

In the field emission microscope invented by E. W. Müller, electrons are drawn out of a pointed metal cathode by a very

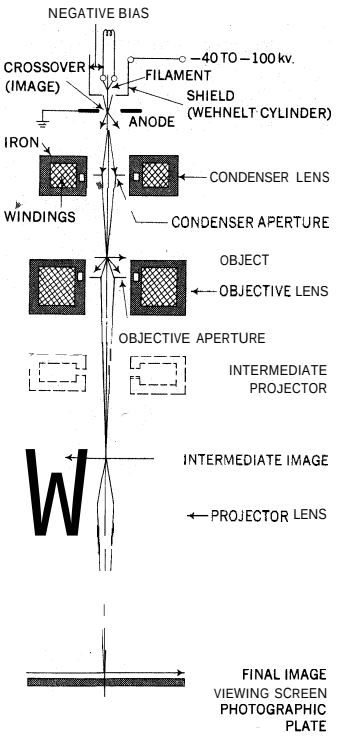


FIG. 24.— SCHEMATIC DIAGRAM OF ILLUMINATING AND IMAGE-FORMING SYSTEMS OF A MAGNETIC TRANSMISSION ELECTRON MICROSCOPE

high potential gradient. This type of electron microscope has a resolution of about 10 A. Miiller also used this instrument as an ion microscope by reversing the accelerating potential and admitting a trace of hydrogen or helium into the envelope. The gaseous atoms adsorb to the surface, where they lose their electrons, and the tively charged nuclei are pulled out by the applied field. The heavier mass of the nuclei increase the resolving power to about 2.7 A. With this type of microscope, operated with helium, it is possible to see clearly the individual atoms in the metallic point.

2. Transmission. — The illuminating and image-forming systems of the transmission electron microscope, shown in fig 24, are analogous to the components of a light microscope. Electrons emitted from the tip of a hot tungsten filament are accelerated toward the anode through the circular opening in a shield. or Wehnelt cylinder. that is negatively charged with respect to the cathode. The filament. Wehnelt cylinder and anode constitute a cathode lens and form an image of the filament tip; the image also is called the crossover. The cathode lens assembly, sometimes referred to as the electron gun, is analogous to the lamp of a light microscope. Beyond the crossover the electrons pass through a magnetic lens that condenses, or focuses. an image of the crossover at some distance beyond, depending upon the strength of the current through the windings. In fig. 24 the crossover is focused at the object plane to produce the highest intensity and the smallest illuminated area. When higher or lower currents pass through the condenser coil, the intensity of illumination at the object decreases and the area illuminated increases. The diameter of the aperture in the condenser lens is usually 0.1 to 0.3 mm. The size of the aperture of the condenser lens controls the convergence angle, or aperture of illumination, at the specimen (object). This angle is 10^{-4} to 10^{-2} radian and is greatest when the crossover is focused at the object plane. Sometimes two condenser lenses are used to achieve a wider range of spot size, angular aperture and intensity of illumination.

Details of the special ways for preparing objects to be examined with the electron microscope are described under Use of the Electron *Microscope*. In general, objects must be less than 1000 Å thick, must be able to withstand a vacuum and should not undergo morphological change when irradiated by an electron beam. All atoms scatter electrons to some extent; the amount of scattering increases with the atomic weight of the atom. This scattering is the main source of contrast in the electron image; the relative darkness of the specimen parts depends on ability to scatter electrons out of the imaging pencil. A small circular objective aperture 10 to 50μ in diameter enhances contrast in the image by removing from the beam all electrons scattered through angles greater than a certain value.

In fig. 24 the objective lens forms a magnified image of the object while utilizing only those electrons that have passed through the object without being scattered through angles greater than 10^{-3} to 10^{-2} radian. The magnification produced by a single lens (usually 50× to 200×) is approximately equal to the distance from the lens to the image divided by the focal length of the lens. In order to achieve direct magnifications of about 200,000×, two additional magnifying lenses, called projector lenses, are usually employed beyond the objective. By adjusting the amount of current in the objective coil, the final image can be brought to a sharp focus on a fluorescent screen as judged by visual observation with the naked eye or with a light magnifier that gives an additional magnification of 5× to 10×. The image also can be recorded on conventional photographic plates or film inserted above or below the viewing screen. Exposure time usually is 1 to 5 sec.

Micrographs are rarely recorded at the highest magnifications of which the instrument is capable since it is much more convenient to use relatively small plates or film with fine grain and arrive at the final magnification by enlarging the negative with a photographic enlarger. If the plate grain is sufficiently fine no loss of detail occurs through recording at low magnifications since the resolving power of the instrument is fixed by the objective lens and its characteristics are maintained approximately constant while the magnification is varied by the projector system.

C. Component Parts

The electron microscope has three major component systems: (1) the lens system; (2) the vacuum system; and (3) the electrical system.

1. Lens System. — Any axially symmetrical electrostatic or magnetic field can act as a lens for electron beams. Of the various possible electron lenses, three are used most frequently. They are the electrostatic cathode lens, the electrostatic unipotential lens and the simple magnetic lens.

Electrostatic Cathode Lens. — The electrostatic cathode lens derives its name from the fact that the cathode, which is also the object, is one of the electrodes of the lens. An example is shown diagrammatically in fig. 25. The cathode A emits slow electrons that are accelerated and focused by the symmetrical field produced by two electrodes with coaxial circular apertures at potentials V_1 and V_2 with respect to the cathode. An image of the cathode is produced at B. The focal length of the lens, and hence the position and magnification of the image, depends upon (1) the potentials applied to the electrodes; (2) the diameter of the apertures; and (3) the spacing between them.

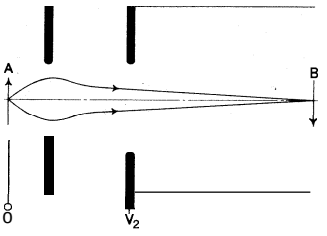


FIG. 25.— ELECTROSTATIC CATHODE LENS

A more versatile cathode lens designed by Johannson consists of three circular apertures in front of the cathode. In this system the potential on the first electrode is adjusted to focus an image of the cathode on a fluorescent screen. By varying the ratio of the potentials applied to the second and third electrodes, the positions of the principal planes and hence the magnification of the system can be varied.

Electrostatic Unipotential Lens. — The electrostatic unipotential lens, so named because there is only one difference of potential between the electrodes, is the essential component of all high-resolution electrostatic electron microscopes and is the most thoroughly investigated of the electrostatic electron microscope lenses. Since its object and image regions are at the same constant potential, the regions have the same refractive index and the object-side and image-side focal lengths are identical:

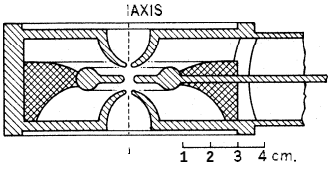


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FIG. 26.— SCHEMATIC CROSS SECTION OF MAHL'S UNIPOTENTIAL ELECTRON MICROSCOPE PROJECTION LENS

In its fundamental form, the unipotential lens consists of three parallel and coaxially aligned apertured disks (fig. 26). The two outer electrodes are electrically connected so that they are at the same potential, which is positive relative to the source of electrons in the system and equal to the full accelerating potential applied to those electrons. (In the interest of safety and simplicity

of construction, a high negative potential is applied to the source of electrons so that the remainder of the instrument, including the outer electrodes of the lenses. can be kept at ground potential.) The central electrode of the lens is electrically insulated from the other two and is operated at a high potential (usually negative) to them.

The design of a unipotential lens to be used in a high-power electron microscope must allow for a number of critical factors. such as the attainment of high lens strengths by the production of high gradients in the electrostatic field on the axis of the lens and the attainment of good optical properties by the proper shaping and polishing of the electrodes. By 1939 Mahl had developed a unipotential lens that had a focal length of 5 mm. at 50 kv. and was capable of resolving 70 A. Mahl's lens is the one shown in fig. 26.

Magnetic Lens.—All magnetic lenses are fundamentally alike in that the field strength on the axis varies from zero to a maximum and then back to zero. They are unique in that they cause the image to rotate about the axis.

Magnetic lenses were used to concentrate electron beams as early as 1899. These early "concentrating coils" consisted of a simple coil of wire wound coaxially with the beam and carrying an electric current (fig. 27[A]). By 1925 the magnetic coil was firmly established as the best means of concentrating an electron beam in high-voltage cathode ray oscillographs. At that time D. Gabor showed that the concentrating action could be improved considerably by encasing the ends and outside of the coil with a sheet of soft iron. Fig. 27(B) shows a weak magnetic lens encased in soft iron. Fig. 27(C) is a diagrammatic representation of the pole pieces of an objective lens of short focal length with electrodes to compensate for asymmetries in the field. The bore in the latter case probably would be about 3 mm. The maximum power of this type of lens is limited only by the magnetic properties of the iron of the pole pieces and, to a lesser degree, by the magnetic properties of the soft-iron casing on the coil. Thus the high-power magnetic lens is simply a powerful electromagnet consisting of an exciting coil, a soft-iron yoke and soft-iron pole pieces that concentrate the magnetic field to a small volume. A circular opening is bored through the pole pieces along the axis of symmetry to provide an unobstructed passage through the magnetic field for the electron beam.

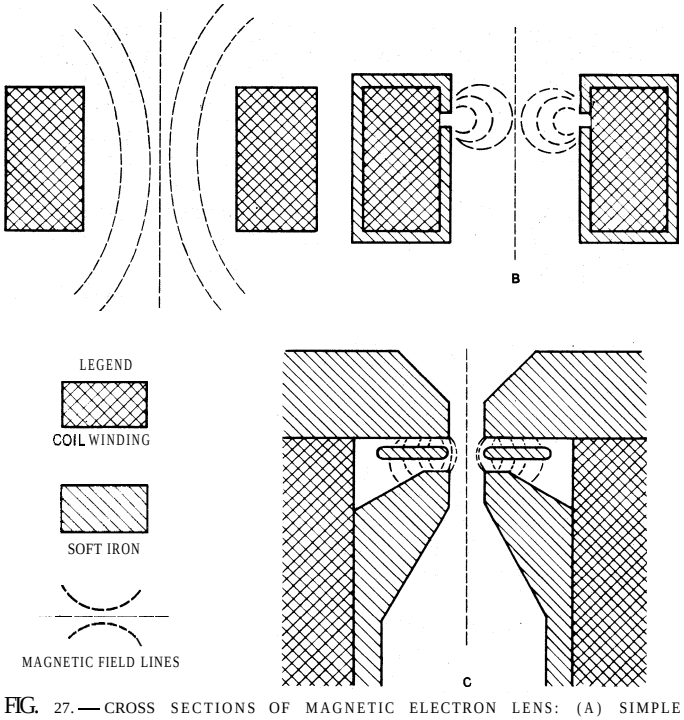


FIG. 27.—CROSS SECTIONS OF MAGNETIC ELECTRON LENS: (A) SIMPLE SOLENOIDS; (B) IRON-ENCASED COIL WITH GAP TO CONCENTRATE MAGNETIC FIELD: (C) ENLARGED VIEW OF POLE PIECES OF HIGH-POWER MAGNETIC LENS SHOWING PLACEMENT OF COMPENSATING IRON RODS

Magnetic lenses can be built with focal lengths of about 1 mm. and a resolving power of 5 Å. They have the disadvantage, compared with the electrostatic unipotential lens. that both the exciting current of the lens and the accelerating potential of the electron beam must be stabilized. This requirement introduces considerable complexity into the electrical circuits. On the other hand, the focal length of the magnetic lens can be varied over wide ranges by adjusting the exciting current; this feature reduces considerably the mechanical complexity of an instrument that uses magnetic lenses.

Magnetic lenses have other advantages over electrostatic lenses. For instance, the inherent aberrations of the magnetic lens are of smaller magnitude. with the result that a given resolving power can be attained more easily than with electrostatic lenses. When the magnetic lens is used, only half as many surfaces must be accurately shaped and aligned; moreover, the surfaces are simple planes, cones or cylinders instead of elaborately curved surfaces. Also. the necessity for attaining high mechanical precision in the presence of high-voltage insulation is not encountered in the magnetic lens. Finally, magnetic lenses of short focal lengths can be used with electron accelerating potentials that are several times greater than those that can be used with electrostatic lenses.

2. Vacuum **System.**—When the electron microscope is used, it must be exhausted to remove residual vapours and gas and to maintain a pressure of .0001 to ,00001 mm of mercury (atmospheric pressure under standard conditions is 760 mm of mercury). The instrument is exhausted by pumping on the column with one or more gaseous diffusion pumps, which are highly efficient at low gas pressures, in series with a mechanical pump that is capable of pumping against the back pressure of the atmosphere. Specimens and photographic materials are inserted into and removed from the vacuum through a system of vacuum gates, valves and air locks. On the more advanced instruments this system is controlled through automatic or semiautomatic machinery that requires little attention from the operator. Components of the optical system, such as the gun and lenses. are joined together with vacuum-tight gaskets. Parts are moved, *e.g.,* during alignment or the scanning of a specimen, by vacuum-tight shafts or sliding joints.

3. Electrical System.—This system consists of a high-voltage supply from which can be selected two to four values of beam potential in the range of 40 to 100 kv. with an output of 10 to 400 microamperes. Since the focal length of the lenses varies directly with the beam potential. the output of the supply must be stabilized so that it does not vary by more than 1 v. for even short periods of time. Similarly, the currents for the lenses, once they have been set for focus and magnification, should not vary by more than 1 part in 200,000 during the focusing and recording operations.

Successful electron microscopes have been built with electrostatic lenses of the type shown in fig. 26 in place of the magnetic objective and projector lenses shown in fig. 24. In such instruments, a condenser lens usually is not employed and the beam is focused by the electrostatic lens that comprises the gun system. This type of microscope is electrically simpler than the magnetic type since no separate electrical supply is needed to energize the lenses But other electrical factors, such as arc-over betneen lens electrodes and insulation problems. have prevented the electrostatic system from becoming practical.

D. Use of the Electron Microscope

1. Methods for Preparing Specimens.—The interaction between electron beams and a specimen examined by electron microscopy is quite different from the analogous process in a light microscope. Specimens therefore have to be prepared in ways that conform to the peculiarities of the instrument. Following the introduction of commercial electron microscopes around 1940. the major advances in the science were due mainly to the discovery of sppropriate methods for the preparation and handling of materials.

The conditions that apply for electron microscopic examination

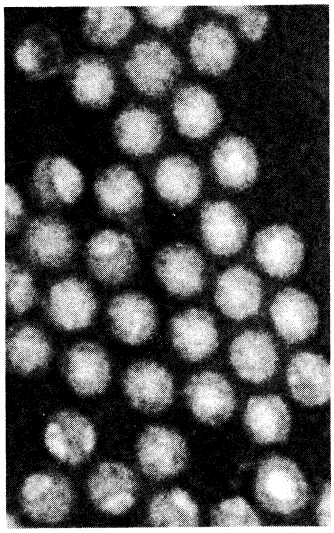
are as follows: (1) The specimen must be placed in a vacuum and hence loses volatile constituents, *e.g.,* water, at ordinary temperatures. (2) Specimens must be very thin, usually less than $\frac{1}{10,000}$ mm. (1000 A), since greater thicknesses scatter electrons excessively. (3) Electrons cannot be back-reflected efficiently for the observation of opaque surfaces. This once seemed to preclude the use of electron microscopy for the observation of important classes of materials such as metallic surfaces. (4) Contrast in the electron image results almost entirely from the scattering of electrons by atomic nuclei in the specimen (rather than by absorption). Atoms of low atomic number (or weight), which constitute the bulk of most biological materials, have very low scattering power. Small particles aith such composition cannot generally be seen unless their contrast can be enhanced. (5) The electron beam can produce heat and chemical changes that may alter the apparent structure of the specimen.

Film Supports.—Supports for objects to be examined with the electron microscope should be as thin as possible and composed of atoms of low atomic number so that scattering by the support does not obscure the scattering pattern of the material to be studied. A common technique for producing thin film supports consists of applying a drop of a 2% to 3% solution of collodion (chiefly cellulose nitrate) in amyl acetate to the surface of a dish of water. The drop spreads spontaneously over the surface and, when the solvent evaporates. a thin film of collodion 50 to 200 Å thick remains floating on the surface. These films are picked up over metal disks about 3 mm. in diameter with holes or slots sufficiently small (*e.g.,* 0.003 in.) so that the films remain intact over the openings. One of the commonest supports is a disk of electroplated mesh about $\frac{1}{8}$ in. in diameter and with 200 square holes per linear inch; these holes measure 0.002 to 0.003 in. on a side.

A number of other plastics and resins can be prepared in similar fashion. If they do not spread on water, they can be spread on a smooth glass surface and stripped after drying. Specimens such as dusts, smoke and aerosols can be caught on metal grids without films and examined where they adhere to the edges of grid wires and project into the openings.

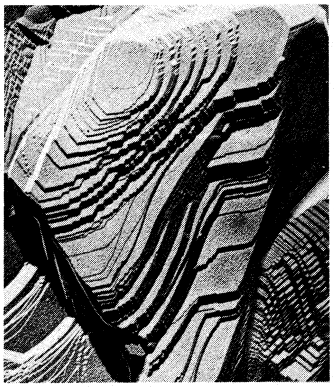
Inorganic films that are stronger and able to withstand high temperature also can be used for supporting specimens. Such films are most commonly made of carbon and silicon monoxide, which are evaporated in a vacuum onto collodion-filmed grids. The collodion may be removed later by immersing the grids in a solvent. Carbon is evaporated from two electrodes tapered, or necked down, at their point of contact and heated to a high temperature by the passage of an electric current. Silicon monoxide is vaporized from a conical helix of tungsten wire (0.020 in. in diameter) that also is heated electrically.

Electron Stains.—A major problem in the examination of small organic particles such as viruses and protein molecules with the electron microscope is that they consist mainly of lightweight atoms that scatter electrons weakly and so cannot be distinguished from the atoms that cause scattering in the supporting film or material in which the organic particles may be embedded. This problem can be solved by treating organic materials with chemicals that contain heavy atoms; the heavy atoms combine with the organic material (positive staining) and enhance their visibility. Of these chemicals, which are called electron stains, the one most widely used on tissues is osmium tetroxide; stains that contain tungsten, molybdenum and uranium also are commonly used. Some of these reagents combine with a wide variety of chemical groups while others are more selective so that the possibility exists for the identification of portions of a specimen according to its affinity for particular stains.



BY COURTESY OF ELIZABETH C. MACLEAN

FIG. 28.— ELECTRON MICROGRAPH OF POLIOMYELITIS VIRUS. NEGATIVE STAIN. MAGNIFICATION 340.000 ×



BY COURTESY OF A E VATTER AND R F BILS

FIG. 29.—ELECTRON MICROGRAPH OF REPLICA OF SURFACE OF MIXTURE OF BARIUM TITANATE AND STRONTIUM OXIDE, SHADOW-CAST. MAGNIFICATION ABOUT 10,700 ×

Another way of enhancing the visibility of small isolated specimens of low scattering power is to dry them on a thin film in a solution of a dense chemical with which they do not react. This leaves the specimen surrounded by or embedded in a dense matrix. The stain accentuates the outline of specimens of low scattering power by entering into pores or openings. This method, called negative staining, is frequently more effective than positive staining since it avoids the use of strong chemicals that may distort the morphology.

Shadow Casting.—Still another method of enhancing contrast in the electron microscope image is the so-called shadow-casting process introduced by R. Williams and R. Wyckoff in 1945. In this technique a specimen is first placed in a vacuum chamber where metal atoms are vaporized from an electrically heated tungsten filament and caused to strike the specimen at an oblique angle. The metal atoms travel in a straight line until they strike a cool surface, where they stick. Any projections will collect a metal coating on the side toward the evaporating source; the side away from the source will be free of metal. The effect of accentuating surface detail in this way is similar to the effect in aerial photographs taken when the sun is low in the sky. Areas where the metal deposits have high contrast correspond to highlights, and the areas shielded from the metal correspond to shadows. The height of objects in a specimen can be calculated from the length of the shadows and the angle at which the metal arrives at the specimen (*i.e.,* the angle formed by a line drawn from the evaporation source to the specimen and the plane of the specimen).

When a shadowed specimen is photographed in the electron microscope the shadows on the negative are dark and therefore appear white when the negative is printed. Such a print may cause confusion since viewers are accustomed to interpreting dark areas, not white areas, as shadows. These micrographs, therefore. are usually put through an intermediate positive transparency and printed as negative prints. The result is a three-dimensional effect of light and shadow that is meaningful to the eye.

Replication of Surface Structure.—The structure of the surface of bulk materials (such as the etched surface of metals) usually is studied indirectly in the electron microscope from a thin film impression of the surface that can be examined by transmission. The simplest method of preparing a replica begins with the application of a solution of collodion to the surface to be examined. After the film is thoroughly dry it is stripped from the surface and supported over a metal grid. This is a negative replica since projections on the original appear as depressions on the replica. A positive replica is obtained by making a second replica from the first so that the topography of the final replica is the same as that on the specimen. With this method the negative replica, since it does not go in the microscope, can be made with a film thick enough to be handled conveniently. Inorganic films (such as carbon) also are used. When it is difficult to separate the replica film from the sample, the original sample (or the intermediate replica if it is a two-step process) is dissolved chemically. Replicas placed in the electron microscope are nearly always shadowed with metal to enhance the contrast of the surface and to impart a three-dimensional effect to the final micrograph.

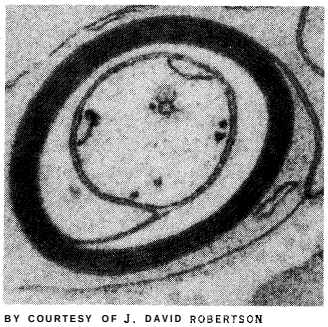
Replicas may also be made by shadowing the original surface with metal, backing the metal with a thin film and stripping the

metallic structure from the surface for examination by transmission with the electron microscope. This yields an exceptionally faithful representation of the original since the backing film contributes much less to the final image than does the metallic deposit. What is seen is exactly what would be seen if the original surface could be shadowed and observed by transmission. This transfer technique makes possible the utilization of very smooth substrates that otherwise could not be used because of their thickness. The surface employed in one such method is that of freshly cleaved mica, which is a crystal plane and smooth down to atomic dimensions. Molecules are placed on this surface and are shadowed; their contrast is enhanced free from the confusion of substrate structure that is present when ordinary film supports are used. The metallized molecules are then backed with a thin support film and stripped for observation by transmission in the usual way.

2. Ultramicrotomy.— Sections of biological materials examined in electron microscopy should be not more than *0.1* μ and preferably about *0.02* μ thick, compared with a thickness range of 1 to *10* μ in light microscopy. D. Pease and R. Baker first produced reliable sections at *0.1* to *0.2* μ in *1948.* In the years immediately following, refinements were introduced in microtome mechanics, cutting edges, methods of preparing the block of tissue to be cut and the handling of the fragile cut sections. By the mid-*1950s* the art had been advanced to the point where consistent sectioning could be performed down to about *0.05* μ and less. In the preparation of such sections, biological tissues are stabilized (fixed) by chemicals, treated with electron stains, dehydrated and infiltrated with a monomeric resin that, after polymerization. supports fragile structures and imparts good cutting qualities to the matrix. The face of the block to be cut is trimmed down to about *0.1* to *0.2* mm. on a side. The commonest cutting edge, introduced by H. Latta and J. Hartmann in *1950,* is a glass knife produced by fracturing plate glass in such a way that two fractured faces perpendicular to the original glass surface meet at an angle of 45° to form the cutting edge. As the sections are cut they float on a water trough attached to the knife edge, from which they are picked up over openings in metal holders. Successive sections adhere to each other at their edges as they are cut, producing a ribbon of successive layers of the material that can be examined serially to reconstruct a three-dimensional picture of the bulk material.

3. Electron **Metallography.**—The study of metals is an important application of electron microscopy. The most common approach is through replica techniques; but in such methods only the surface is displayed and there is no way of using the beam to explore the metal in any depth. It is possible to reflect electrons impinging on a metal surface efficiently only if the angle between incident and reflected beams and the surface is about 8° to 15°. The image therefore appears very foreshortened in one direction and interpretation is difficult. This scheme is useful in some instances but is not widely used.

A novel reflection electron microscope (or mirror microscope) for the observation of metallic surfaces was built by L. Mayer. In this instrument the electron beam is directed toward the specimen at nearly perpendicular incidence. A high negative charge placed on the specimen allows the electrons to approach very close to the surface but turns them around and reflects them much in the same way light is reflected by a mirror. The reflected beam is focused to form an image of the reflecting surface. In this image, detail is a function of the deflections that the reflected electrons receive as they approach the specimen surface; ie., a function of the structure of the surface. Resolution is about 2000 A.



BY COURTESY OF J. DAVID ROBERTSON

FIG. 30.— ELECTRON MICROGRAPH OF CROSS SECTION THROUGH A NERVE FIBRE. MAGNIFICATION ABOUT 44,000 X

For the study of metallic films by transmission electron microscopy the thickness of metallic specimens should not exceed 5000 Å and preferably should be much less. Thin metallic films can be made by vacuum deposition from the vapour state, electrode-position or deposition from the liquid state. Thick specimens can be thinned suitably by chemical etching, by bombardment in a vacuum or by electrolytic polishing. The production of thin specimens by cutting or machining is not generally satisfactory, since the structure is altered by the forces applied.

BY COURTESY OF G. A. BASSETT ET AL.

FIG. 31.— MOIRE PATTERN PRODUCED BY PARALLEL SUPERPOSITION OF GOLD AND COPPER CRYSTALS. MAGNIFICATION ABOUT 2,000,000 ×

Metals examined by transmission electron microscopy shoa remarkable patterns because most metals consist of a conglomerate of crystals whose regular structures produce Bragg reflections and interference effects in the transmitted beam (see ELECTRON DIFFRACTION). These patterns can be related to atomic dislocations, to faults and stresses and to orientation in the crystal lattices. If two dissimilar metallic crystals with slightly different periodicities are superimposed on one another (usually by vacuum vaporization and deposition), moire patterns appear with periodicities greater than occur in either of the crystals alone. The effect is similar to the production of beats between two sound frequencies that are close together. An imperfection in one crystal lattice will show up as a magnified imperfection in the moire pattern. In this way certain properties of crystal lattices can be detected at a level that is beyond direct resolution with the electron microscope.

Thermionic emission microscopes, though not as widely used as the transmission type, have been applied successfully to the study of surface structure of metals and the alterations that occur in them as a result of heat treatment.

E. THEORY OF ELECTRON LENSES

If a magnetic lens has a gap length L in centimetres that is large compared with the axial bore through which the electrons pass, the focal length f is given by the equation

$$\frac{1}{f}=\frac{1}{L}\times\frac{0.187\,NI}{\sqrt{V}}\times\sin\frac{0.187\,NI}{\sqrt{V}}\ \text{cm.}^{-1}$$

where f is in centimetres. V is the accelerating potential in volts and *NI* is the ampere turns. The image is rotated by an angle $\theta_i=\pm\frac{0.187\,NI}{\sqrt{V}}$ radians in addition to the usual 180° resulting from the formation of a real image. Many lens fields may be represented by the symmetrical bell-shaped function $H_z=\frac{H_o}{1+\left(\frac{z}{a}\right)^2}$ where H_z is the component of the field in gauss along the lens axis (z-axis), H_o is the maximum value of H_z and $2a$ is the breadth of the bell-shaped function at $H_z=\frac{H_o}{2}$. The focal length is then given by the formula

$$\frac{1}{f}=0.77\times\frac{0.15}{\sqrt{V}}H_o\sin 2a\frac{0.15}{\sqrt{V}}H,\ \text{cm.}^{-1}$$

and the angle of rotation $\theta_i=\frac{\pm\,0.15\pi aH_o}{\sqrt{V}}$. Both these formulas assume that the object is at a point where the field is of negligible magnitude.

An approximate formula for the focal length of the electrostatic unipotential lens is given by the equation

$$\frac{1}{f} = \frac{3}{16}\int_{-\infty}^{+\infty}\left(\frac{dV/dz}{V}\right)^2 dz \text{ cm.}^{-1}$$

where the z-axis is the lens axis. No rotation occurs as in the magnetic lens.

The minimum focal length for an electron microscope lens is between 1 and 5 mm. Electron lenses, except for certain kinds of cathode lens, are always convergent.

Electron lenses are subject to the same geometrical lens aberrations that occur with uncorrected glass lenses. For example, chromatic aberration occurs but can be minimized by using monochromatic beams. Pincushion distortion may occur under certain conditions to produce a variation in magnification from one part of the field to another. The most important aberration is spherical aberration, which causes each point of the object to be imaged as a blurred disk whose radius, called the spherical aberration error, is $d_{sph} = C_s\alpha^3$, where a is the half-angle of the cone of illumination (aperture angle) leaving a point at the object and C, is the spherical aberration constant of the lens. For magnetic electron microscope objectives, C_s has values between 0.1 and 2 cm. and is one of the chief factors limiting the resolving power of electron microscopes. A second factor that limits sharpness is the wave nature of electron beams. Because the beam is a wave, the best image of a luminous point that can be produced by a lens is a circular diffraction pattern consisting of a central bright disk whose radius, the diffraction error, d_{diff}, is given by the Airy formula $d_{diff} = \frac{0.16\lambda}{\alpha}$, where λ is the wave length and α is the aperture angle.

A comparison of the formulas for the spherical aberration error and the diffraction error shows that they depend on α in inverse proportion so that the combined effect of the two is a minimum when they are approximately equal, as they are when $\alpha = \left(\frac{\lambda}{C_s}\right)^{\frac{1}{4}}$. Typical numerical values for λ and C_s require that α be in the range 10^{-3} to 10^{-2} radian, which is extremely small compared with the apertures of optical microscopes and results in a great depth of field. For the optimum α, the smallest distance between resolvable points, or resolving power, becomes $d_o = C_s^{\frac{1}{4}}\lambda^{\frac{3}{4}}$. It would appear from this that d_o could readily be reduced by reducing λ; *i.e.,* by raising the accelerating potential. This cannot be done. however, since C, also depends on λ and the resolving power is affected very little when the beam voltage is raised above about 50 kv.

See also references under "Microscope" in the Index volume.
(C. E. H.)

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MICROTOMY is the technique of cutting animals or plants or their parts into minute slices. For many years both botanists and zoologists depended on freehand sections made by the razor, and this method is still used occasionally by botanists except for the finest work. The histologist, the embryologist or the morphologist, who studies the minute structure of organisms, and the cytologist, who investigates the structure of individual cells, use special niicrological techniques for the preparation of the thin slices of parts of animals or plants with which they are dealing.

Modern microtomy owes its efficiency to two things: (1) the development of methods of infiltrating tissues with supporting media like gelatine, paraffin wax and celloidin; and (2) the development of cutting instruments of precision. The infiltration of tissues with special hardening media is called imbedding; the special instruments for cutting the tissues into thin slices are called microtomes. *See* HISTOLOGY. (W. BM.)

MIDAS, a very old royal. possibly also divine, name among the Phrygians and the Briges (a people living north of Greece). In Greek mythology, the following *märchen,* all of a fairly well-known type, are told of "King Midas." (1) By mixing wine with the water of a spring he made Silenus (*q.v.*) drunk, caught him, and induced him to teach him some of his wisdom. (2) He restored Silenus to Dionysus, who, by way of reward, gave him a wish. Midas wished that all he touched might turn to gold; as this included food and drink he was nearly starved to death. and asked that the gift might be taken away again. The god bade him bathe in the river Pactolus, which has had gold in its sands ever since. (3) He preferred the music of Pan (*q.v.*) or Marsyas (*q.v.*) to that of Apollo; Apollo in wrath gave him ass's ears. He concealed this deformity from all but his barber, who, bursting to tell the secret, dug a hole in the ground and whispered it into that, afterward filling in the hole. Reeds grew from it, which, whenever the wind blew through them, whispered "King Midas has ass's ears."

MPDDELBURG, the ancient capital of the province of Zeeland, Neth., in the middle of the island of Walcheren, 4 mi. by rail north by east of Flushing, with which it is also connected by steam tramway and by ship canal (1873). Pop. (1957 est.) 21,968 (mun.). It is the seat of a court and of a butter market. The town hall. built about 1512, with a square tower 180 ft. high and a façade adorned with statues, contains the city archives and antiquarian and historical collections. The old abbey of St. Nicholas. founded in 1150 and now occupied by the provincial council, has old tapestry of the end of the 16th century. During World War II the town hall was destroyed to a large extent.

MIDDLE AGES, THE. The term is of course a modern term, coined consciously to define the contrast which its authors felt between the centuries which succeeded the downfall of the ancient world and their own time. To them the world of old Greece and Rome was in some ways nearer to them. more intelligible than the Europe held together by a common religious system. It would seem unnecessary to observe that the men and women who lived during the thousand years or so preceding the Reformation were not conscious of living in the middle ages A few—Petrarch was the most conspicuous among them—felt that their lot was cast in a dark time, which, as it had begun with the decline of the Roman empire, might end if Rome would "begin to know herself;" but they were only a few; and yet, so strong are the associations and implications of the phrase we often unthinkingly speak of the medieval world as though it was a world consciously medieval, inhabited by beings who thought of themselves as medieval This absurdity has been accentuated by obeisance to specialism. Conveniently enough, scholars are described as medievalists and modernists, or they are said to profess modern or medieval history.

Conventional Sense of Term.—A more far-reaching reason for using the term "the middle ages" in a more conventional sense is that, as time goes on, it will necessarily become more and more meaningless. The persons who first used it were making a gesture of their sense of freedom, and yet at the same time they were implicitly accepting the medieval conception of history as a series of well-defined ages within a limited framework of time. They did not speak of the six ages or believe in the chronology of Joachimite prophecy (see JOACHIM [of Fiore]), but nevertheless they inherited a scheme of history which began nith the Garden of Eden and would end with the Second Coming of Christ. In such a scheme the thousand years from the 5th to the 15th centuries after Christ might well be regarded as a distinct. respectable period of history, which would stand out clearly in the providential pattern. In modern times, me have discarded the Eusebian chronology (*see* EUSEBIUS [of Caesarea]); we look back to an

almost infinite past and forward to an almost infinite future. In the eyes of a scientist a period of a thousand years is neither here nor there. Moreover, the content of history, both before the middle ages and contemporary with them, has been immensely enlarged. The significance of many aspects of medieval life has been changed by our knowledge of previous civilizations — of the civilizations with which medieval Europe was in contact.

Limits of the Period. — If we set our preconceptions on one side, the middle ages are the period in the history of European people, and especially of the western peoples, since the downfall of the Roman empire. Historical studies have differed and will continue to differ about the dates when this period should begin and end. The breach between ancient and later history was not so clearly defined as we are wont to say — some distinguished scholars. for example, led by Henri Pirenne, would deny that there was any real breach until the Mohammedans occupied the Mediterranean — but the settlement on a large scale of the Germanic peoples within the borders of the Roman empire and the failure of the central imperial government to maintain itself, were developments so striking as to justify the use of the terms "ancient" and "medieval" to describe the state of society before and after them. It is impossible to fix any date, for tastes differ, and the date 250 or 410 or 476 has only a dogmatic significance in the minds of various historians. It is a convenience like the limits of legal memory or the legal doctrine that the house of lords and its personnel dates from the year 1295.

It is still more impossible to fix any date as marking the end of the middle ages. The view that the fate of Constantinople in 1453 was a catastrophic event, unexpected and devastating, which had violent effects upon the whole temper of western society, is quite discredited. The view that the breach between the papacy and various European countries — an event which we describe as the Reformation — diverted the stream of history or introduced new life into history, has more truth in it, but is grossly exaggerated. If we give a sufficiently wide interpretation to the movement known as the Renaissance, and remember that, although it was most consciously intense during the 15th and 16th centuries, it had no obvious beginning and has had no end, we may define the end of the middle ages as the point. reached in different ways and at different times, at which the spirit of the Renaissance mas victorious in political, social and artistic life. There has never been anywhere a complete breach with medieval institutions or modes of thoughts.

Political Developments. — The settlement of peoples and the gradual development of national states under the joint influence of native habit and the living traditions of the ancient world were not matters of a day. They required more than 1,000 years. Everywhere natural forces and conscious contrivance can be traced together, although the element of contrivance varied considerably in extent. Two great kingdoms, Germany and Italy, began to lose their political unity almost as soon as they had acquired it; they had to wait until the 19th century before they found it again. Switzerland and the Low Countries (the modern Netherlands and Belgium) were strongly welded into political units in a process in which it is difficult to disentangle the elements of nature, accident and artifice; but the unity, once acquired, has on the whole been permanent. Only a long and complicated process of events could decide that Portugal was to be separated from Castile. and Castile united to Aragon, that Catalonia was to be part of the kingdom of Xragon and not linked up with the Mediterranean littoral north of the Pyrenees, that Hungary was to be attached to the German marchland of Austria and that the Tweed river was to separate in part the kingdom of Scotland from England.

In these political developments the effect of Roman imperialism, working through geography and tradition, was not very marked. It might be an obstacle to be overcome, as in Italy and the Rhine valley, or an incentive to unity, as in France. But within the structure of society the element of contrivance was largely proportionate to the strength of classical influence. whether this were continuous or consciously revived. The extent and force of this influence have been the theme of endless discussion. How far the land settlement of the Franks was a continuation of the Roman system in Gaul, whether city life in north Italy and on the Rhine was completely interrupted, or, to take examples of a different kind. the extent to which the folklore and legendary literature of medieval peoples was drawn from native sources or derived from the treasure house of the east and the fancies of sophisticated brains, and whether medieval art is mainly popular or "learned" in origin — these are some of the problems which still arouse controversy. On the whole the tendency is to emphasize the extent of the artificial and learned element in later centuries and to minimize the importance of continuous classical survivals in the early middle ages. The continuous and ever present influence of the ecclesiastical system is, it is hardly necessary to say, undisputed and is regarded as exceptional even by those who deprecate the view that it was the really formative factor in medieval life.

Intellectual and Cultural Characteristics. — Whatever the final issue of these discussions may be, it is no longer possible to draw a sharp distinction between culture or intelligence in medieval and modern times. Compulsory education and the impact upon our everyday life of scientific inventions are recent developments which separate us in external and possibly in more far-reaching ways. from the middle ages, though their civilizing effects are still uncertain. The isolation in which so many people lived in earlier days, and the immense differences in wealth, social importance and external trappings between class and class have largely disappeared; the sum of human happiness and comfort is probably greater than in medieval times; but the contrast, once so fashionable, between the ages of darkness and the ages of light has no more truth in it than have the idealistic fancies which underlie attempts at medieval revivalism. The fascinating perplexity felt by students of medieval life is due precisely to the fact that our forefathers were not barbarians struggling forward, unaided, to a state of civilization; but were vigorous, intelligent, semicivilized people who fell at every turn under highly sophisticated influences. Even before they settled donn in the 5th century they had, more or less consciously, entered upon what is termed the "heroic age," in which an exotic element, derived perhaps from the east by way of the Black sea and the great trade routes of central Europe, gave direction to their barbaric qualities. Some of them, like the Visigoths, fell at once under the influence of Roman jurisprudence.

All in due course were affected by the church and were introduced to forms of organization, thought, art and conduct which they appropriated as best they could. Three or four centuries later their men of learning came under the steadily increasing influence of Greek thought, as transmitted by the Greek-speaking scholars of the eastern empire, by Arabs and Jews; an influence which reached its height in the 13th century. By this time social contact with the east, never entirely lost, had been deepened by the establishment of western states in the Levant, the result of the crusades. Hence the process of sophistication, if the term may be used. was intensified by new periodic injections. However indigenous the expressions of political, social, literary and artistic life were, they flourished in an atmosphere of self-consciousness. They were not all spontaneous, and were rarely "artless." The results were naturally varied. some bizarre and grotesque, with the seeds of decadence in them, some simple and effortless, some extraordinarily beautiful; some foolish, others profound; some pagan, others Christian.

These facts help to explain the strange inconsistencies of the medieval world. To return to our starting point they also make the usual distinction between the values, moral and intellectual, of medieval and later times very misleading. If me search in history for examples of sheer goodness, or of forms of delicate perception, or of intellectual greatness, of legal acumen or of constructive ability, we can find them as readily in the middle ages as elsewhere, just as we find, as nowhere else, depths of religious experience. All that was fresh and vigorous in the European peoples could be drawn out and directed in the service of religion and art, learning, and even of statesmanship. Similarly, it could be perverted into an intensity of persecution or cruelty, into decadent orgies of sophisticated superstition, just as it could respond to eccentric and heretical influences, or find its own vent

in ways which seem to us to be startlingly modern. A sedentary society. throwing off a continuous stream of wanderers; a conventional society, ruled by custom, yet indulging all sorts of adventures of the spirit; a pagan society responsive at every turn to the teaching of the Christian religion — such mas medieval society.

Mankind has not yet found the way to health without belief in its past. It steps back with relief into the old tried paths from the highest, the best thought-out experiments in constructive revolution. Societies, during the 1,000 years after the 5th century, found health in the vigorous persistence of custom, and the veneration for custom. The essential thing to remember is that medieval belief in custom was not a dead weight, but a conscious discipline in a changing world. Lawyers and church have idealized it in the light of their belief in a universe bound together by law. Moreover men instinctively clung to their trust in custom, for the conception of the universe with which they were presented did not permit of that constant discovery of the inner relations of things which we call science. However speculative or transitory modern science is, it has secured popular allegiance by using the mysteries of nature — heat, electricity and so on — in the everyday service of man, so that conservatism nowadays shares its old power with a belief in science. Yet, as has been well said. modern science was both made possible by the earlier, medieval, belief in the reasonableness of the world, and was also an adventurous reaction against the rationalism of medieval thought. It was a revolt against the rigidity of law. but the belief in law was at the root of the new investigation into facts. The conception of sovereignty illustrates the same tendency in the political world; it was a recognition of the fact that certain social entities were directing their energies in their own self-regarding way, and a repudiation of the belief (due to a mingling of Christian and Roman ideas) in the unity of mankind under a universal law of nature; yet a long discipline had been required, under the regime of custom, in order to make the conception of sovereignty safe or tolerable. Its value is on the wane, and the trust in law in the medieval sense seems to be returning.

Influence of the Church. — The Christian church shaped the European peoples in two ways. It gave direction to the energy of the robust European peoples, and it offered a higher interpretation of the meaning of life. Suicidal strife, with the succeeding stagnation, was checked. The Romans had impressed on the barbarians a system of law and order uhich they had neither the ability nor the desire to maintain. The church maintained this system in its own way and, while accepting the traditional social arrangements of the barbarians, enabled them to develop. The response was very extraordinary. Indeed the danger of absorption was so great that the church in self-defense strengthened its organization and emphasized its unity in the papacy. Hence we have the interplay of political and ecclesiastical forces which runs through the history of feudal and afterward of national or urban societies: and profoundly modified the structure of the church itself. Throughout the middle ages the church maintained the conception of unity and its claim to interpret the moral law. But its other great function, though sometimes lost in the development of organization, was never forgotten. There again the peoples responded, Their craving for certainties or for adventure was met by the development of dogma, the various monastic experiments, the Crusades. They produced an endless series of saints. They tried to comprehend in their schools and universities the learning of the ancient world and to harmonize it with the teaching of the theologian. They built thousands of buildings, bringing all their energy to expression in the name, if not in the service, of a church and the saints. Our political systems, our scientific thought, and our art are developed from those of the middle ages, and the conscious reactions against the fundamental ideas of the medieval church are a tribute to its strength.

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MIDDLE AMERICA, the portion of Latin America which to geographers is considered a part of North America embraces Mexico, Central America (Guatemala. British Honduras, El Salvador, Honduras, Nicaragua, Costa Rica and Panamá) and the West Indies. On the map the boundaries are sharp: the Mexico-United States, Panamb-Colombia frontiers, and the waterways separating the Lesser Antilles from South America. However, many of Middle America's historical. anthropological and structural characteristics are linked to North or South America.

Unique to Middle America is the structural region which lies between Mexico's volcanic axis (approximate latitude 19° N.) and the Lake Nicaragua-Rio San Juan depression, and extends eastward to the Virgin Islands. This folded and faulted east-to-west trending region is composed of a mainland segment (mantled by volcanic materials in the west), ridges and troughs of the Caribbean floor and the Greater Antilles. The Lesser Antilles, an arc of volcanic and coral islands and the northwest-to-southeast trending folded and volcanic structure of Costa Rica and Panamá connect Middle America with South America. These bridges facilitated the movement of Indians into Middle America from the south. The cultures were less sophisticated than the Aztec, Maya or Toltec cultures of central and south Mexico and northwestern Central America. (See also AZTEC; TOLTEC.) (J. T.)

Central and southern Mexico, Guatemala. British Honduras, El Salvador and part of Honduras are recognized by archaeologists to have constituted a cultural unity in pre-Columbian times. The name Mesoamerica is now generally used to refer to this culture area which is the main subject of this article.

For the geography, natural resources and population of Middle America see CENTRAL AMERICA, NORTH AMERICA, WEST INDIES, WEST INDIES (FEDERATION), and articles on the various countries; for history see LATIN AMERICA; for anthropology *see* INDIAN, LATIN-AMERICAN.

PREHISTORY AND ARCHAEOLOGY

Middle America as a Culture Area. — The archaeological-ethnological culture area of Middle America, or Mesoamerica, includes what is now Guatemala, British Honduras. Salvador, the western half of Honduras and the southern two-thirds of Mexico. The southern boundary of the area runs through central Honduras to the Gulf of Fonseca on the Pacific. The northern boundary extends from the Rio Soto la Marina, on the Gulf of Mexico, to the Rio del Fuerte, on the Gulf of Lower California. Like all culture area limits, these were not immutable borders but tended to shift by period with the expansion and contraction of cultural influences and the movements of peoples. In general, however, the area as defined mas the home of native Indian cultures of an essentially Middle American type over a long period of time.

This Middle American culture type is expressed in the common sharing of traits and patterns of behaviour which can be traced far back in the archaeological record. Fundamental among these are domesticated food plants and the ways in which they were cultivated and used. Maize was the staff of life, and it was prepared by grinding in flat stone troughs or metates. These metates are found archaeologically among the first evidences of sedentary agricultural life which date in the second millennium B.C. The ground maize, mixed with limewater, was baked into thin flat cakes, or tortillas. There are archaeological clues that maize flour was so cooked in ancient times, and these tortillas are the standard fare for the Mexican and Guatemalan peasantry today. Beans, squash, maguey, potatoes, cacao and many other food plants in addition to maize were raised by the ancient Middle Americans.

Besides the common possession of domesticated plants, the Middle American Indians shared such complex traits as stepped pyramids (used as platforms for religious buildings), a ceremonial ball game played by two teams with a rubber ball, certain pottery forms (including the pan bowl, grater bowl and *incensario*), a culture-hero deity represented as a feathered serpent, and a 260-day religious calendar.

Cultural-Geographical Divisions. — Notwithstanding the culture-area unity of Middle America, the region can be divided into several cultural-geographical divisions, each nith its own interrelated but distinguishable pre-Columbian past. We have defined ten such subareas (see fig.). They may be summarized as:

1. The *Northwest*.—This subarea was marginal to the centres of civilization farther south and probably was not brought under strong influence from these until the Classic period. In early post-Columbian times it was held by peoples of Uto-Aztecan speech such as the Cora, Huichol and Acaxee.

2. The *Northeast*.—Although marginal to centres farther south, the Northeast subarea appears to have been influenced by them from Formative period times. The Huastec, a Maya-speaking tribe, is the best-known group in the subarea.

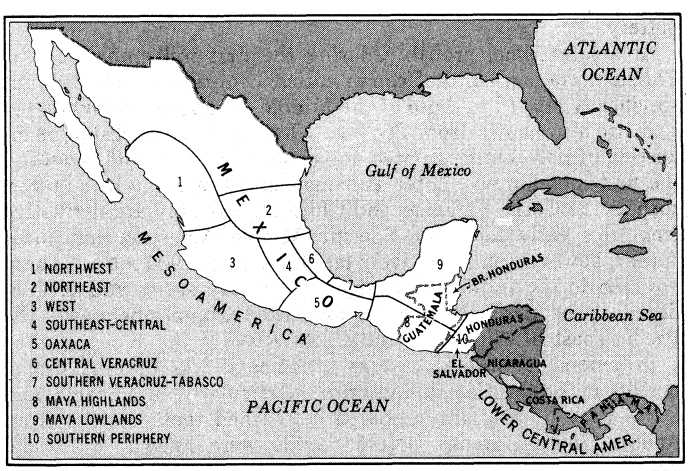
3. *The* West. — This subarea gives clues of a complex internal history interrelated at times with developments in the Valley of Mexico. In the 16th century it was the home of the Tarascan empire.

4. The' Southeast-Central. — With the Valley of Mexico as its centre, this subarea is one of the most important in Middle American culture history. Following a long Formative period development it mas the seat of the Teotihuacán, Toltec and Aztec civilizations. all of which profoundly influenced the rest of the Middle American area.

5. *Oaxaca*.—Oaxaca was the centre of early high cultural developments in the Formative and Classic periods. At the historic horizon the Zapotecs and Mixtecs held the subarea.

6. Central *Veracruz*.—In the 16th century the subarea of the Totonacs, whose forebears may have been the builders of Tajin, a great politico-religious centre of the Gulf coast.

7. *Southern Veracruz-Tabasco*.—The subarea is defined by the "Olmec" art style, probably the earliest of the great styles of Middle America. The late prehistoric inhabitants of the territory, Nahuatl (Uto-Aztecan-speaking) and Popoluca (Oto-Manguean) tribes. do not appear to have been responsible for "Olmec" art and civilization.



MAP OF MESOAMERICAN ABORIGINAL CULTURE AREA. SHOWING THE TEN CULTURAL-GEOGRAPHICAL REGIONS

8. The Maya Highlands. — The upland basins of Chiapas and Guatemala saw a very early Formative period occupation of settled village farmers. It nas there that the Classic, Postclassic and Historic period highland Maya lived.

9. The *Maya* Lowlands. — In the jungles of northern Guatemala, adjacent Mexico and British Honduras the lowland Maya civilization reached its zenith. The Chol Maya occupied the south, the Yucatec the north.

10. The Southern Periphery. — The Rlaya probably moved during the Classic period into Salvador and western Honduras where they innuenced and impinged upon local peoples such as the Lenca and Jicaque. In late Classic or Postclassic times the Uto-Aztecan-speaking Pipil invaded Salvador from Mexico.

Periods. — Chronological periods in Middle American prehistory and archaeology are based upon geological estimates, radiocarbon datings, native calendars, legendary histories, ethnohistoric accounts and archaeological stratigraphy and cross-dating. There is dispute concerning the interpretations put upon these various sources of evidence. The dates offered below conform to the general consensus.

Early Hunting period (?–7000 B.C.)	The earliest remains of man in Middle America. Pleistocene environments and the hunting of large, now extinct, mammals.
Food-Collecting and Incipient Cultivation period (7000–1600 B.C.)	Post-Pleistocene era of small game hunting, plant collecting and the first plant domestication.
Early Formative period (1600–800 B.C.)	The beginnings of village farming and of a way of life characteristically Middle American.
Late Formative period (800–100 B.C.)	The rise of the complex cultures of Middle America.
Classic period (100 B.C.–A.D. 900)	The florescence and crystallization of the great native civilizations of Middle America.
Postclassic period (A.D. 900–1520)	The collapse of the Classic world and the rise of new civilizations, of which the Aztec empire was one. Terminated by the Spanish conquests of 1520–1550.

The date of A.D. 900 for the close of the Classic period follows the Goodman-Thompson correlation of the Maya and Christian calendars. The Spinden correlation would set the close of the Classic period back 260 years.

Early Hunting Period. — It is assumed that the first inhabitants of Middle America were early American Indians, of Asiatic and Mongoloid derivations. who migrated into the area at some time during the final, or Wisconsin. stage of the Pleistocene. It is probable that such early immigrants were huntsmen following herds of large mammals, including the mammoth. Human artifacts and mammoth bones have been found together, in the same geological strata. in the Valley of Mexico at Santa Isabel Ixtapan. These strata date from the terminal substage of the Wisconsin glacial advance, and the associated radiocarbon readings are approximately 9000 B.C.

Food-Collecting and Incipient Cultivation Period. — With the increased dryness and change of fauna following the glacial retreat of the Wisconsin substage, the inhabitants of Middle America were forced to turn from big game hunting to other means of subsistence. These were the hunting of smaller game and the collecting of wild food plants. From dry cave refuse in Tamaulipas, in the Northeastern subarea, this mode of existence is recorded in new types of projectile points, carrying baskets. dried plant remains and crude stone implements for grinding these plant-seed foods. Along with wild plant collecting. some plants. including squash, were cultivated as early as the Infiernillo phase (c. 7000–5000 B.C.). Cultivation of plants increased gradually, with the addition of beans in the Ocampo phase (4000–3000 B.C.) and a primitive maize in the La Perra phase (3000–2500 B.C.). Cultivated plants are estimated to have provided about 30% of subsistence in the subsequent Guerra phase (1800–1600 B.C.).

Early Formative Period. — By 1600 B.C. some village communities in Middle America were sustained largely or wholly by agriculture. It is not clear where this development first took place. Although the sequences in the Tamaulipas caves show a slow and steady transition from incipient to full cultivation, it is likely that this subarea was marginal to village farming cultures located somewhere farther south in Middle America. The Early El Arbolillo I phase, of Central Mexico, the Chiapa I phase, of Chiapas, and the Ocos and Arévalo phases, of Guatemala, are among the earliest of the Early Formative period cultures. All of these phases have pottery, a trait unknown in the Food Collecting and Incipient Cultivation period. In addition to pottery. handmade figurines, usually in the human female form, are common to the Early Formative period phases. Some of the Early Formative archaeological sites, such as those of central Mexico or Tamaulipas, show no evidences of ceremonial building or artificial mound construction. Others, particularly those farther south, have such structures.

In general, there is widespread similarity among Early Formative period phases in ceramics and figurines, and this suggests that such traits may have been diffused through Middle America from a single source. It seems most likely that this source was located in the southern part of the Middle American area although. as yet, this cannot be demonstrated. Nor can it be certain that ceramics and pottery figurines had their new world origins in Middle America. It is probable, however, that these origins are to be found either in southern Middle America or northwestern South America.

Late Formative Period. — The Late Formative period was a time of transition from the simple agricultural village to more complex societies organized around politico-religious capitals or nuclei. It has been noted that in the Early Formative some village communities had mounds which probably served as platforms for temples or ceremonial buildings. In the Late Formative period such constructions were larger and more elaborate and were often clustered together into ceremonial centres which functioned as political and sacred capitals of multivillage territories. Along with this development of the ceremonial centre came the beginnings of monumental art, writing, and calendrics. La Venta, in the Southern Veracruz-Tabasco subarea, is an outstanding centre of the Late Formative with carved stone altars and steles, pyramidal mounds and richly furnished burials, all dating from 800 to 400 B.C. Slightly later, in the same subarea, are the calendric inscriptions at Tres Zapotes which date toward the close of the Late Formative. In Oaxaca, the carved steles and hieroglyphics of the Monte Albán I phase are approximately contemporaneous with late La Venta and Tres Zapotes.

Another Late Formative period trend which is as significant as the elaborations in ceremonial architecture, art and intellectual achievement is urbanism. This has been noted particularly in upland terrain. In the Valley of Mexico a living community two square kilometres in extent is identified with the Tzacualli, or Teotihuacin I, phase. Similarly, at Kaminaljuyu, in the Guatemalan basin, there is a large urban zone, indicated by deep and extensive occupation detritus around the main temples of the Miraflores phase.

Classic Period. — The characteristic Middle American aesthetic and religious patterns which began in the Late Formative were crystallized in the Classic period. In the Maya Lowland subarea polychrome ceramics, the use of the corbelled vault in temple construction, and the foreshadowings of typical Maya art and the probable beginnings of Initial Series calendrics all belong to a Protoclassic subperiod (100 B.C.–A.D. 300). The full Maya artistic, architectural and calendric-hieroglyphic traditions are then ushered in during an Early Classic subperiod (A.D. 300–600). Tikal, Uaxactun and Copán all attained their first glories in these centuries. In the Late Classic subperiod, between A.D. 600 and 900, ceremonial centers in the Maya Lowlands proliferated in number as did the carving and erection of the inscribed and dated steles and monuments.

Elsewhere in Middle America the Zapotecan traditions were brought to full flower in the Monte Alban IIIA phase; the great site of Tajin flourished in Central Veracruz; and from the thriving urban capital of Teotihuacán, in central Mexico, influences radiated out to all quarters of the Middle American area.

The breakdown of the Classic period civilizations began with the destruction of the city of Teotihuacan at about A.D. 700. This metropolis appears to have fallen before the warlike Toltecs, peoples of Uto-Aztecan speech aho invaded central Mexico from the north and who established their capital at Tula, in Hidalgo. Between A.D. 700 and 900 southern Middle America was disturbed by wars and migrations, and the old regional cultures were seriously disrupted. These events were probably correlated with the further expansion of Nahua (Uto-Aztecan) tribes out of central Mexico and into Chiapas, Guatemala and Salvador.

The Postclassic Period. — Four trends characterized the Postclassic period. First, there was a completion of the breakup of the old regional Classic period cultures with their distinctive art and architectural styles and religious traditions. Second, the new Postclassic cultures displayed more secular orientatibn. Third, fortifications, fortified sites and an increase of warlike themes in art bespoke a more militaristic attitude throughout much of Middle America. Fourth, the urban-type community, which first appeared in the Late Formative and was known through the Classic period, was emphasized even more than previously.

In the later Postclassic period, Tenochtitlán, the Aztec capital, located where Mexico City now stands, became the dominant force in Middle America. An Aztec state or empire reached from coast to coast through central and south Mexico; however, many tributary nations were held by the Aztecs in rather loose bonds, and when Cortés marched from Veracruz to Tenochtitlán he was aided by tribes anxious to free themselves from the Aztec yoke. In the Maya Lowlands the Toltec-controlled centre of Chichén-Itzá lost its position of leadership at about A.D. 1200. Thereafter, there seems to have been something of a Maya resurgence with the Yucatecan capital being established at the walled city of Mayapbn.

Lower Central America. — This region — eastern Honduras, Nicaragua, Costa Rica and Panama — lies outside of the Middle American culture area (see fig.). For the greater part, its peoples, languages and cultures are more closely allied with northwestern South America than with upper Central America and Mexico.

At the historic horizon, in the 16th century, tribes of Chibchan linguistic affiliation lived in what is now Panamá, Costa Rica and most of Nicaragua. These tribes, from south to north, included the Cuna, Guaymi, Boruca, Talamanca, Ulva, Sumo, Matagalpa and Miskito. In central and eastern Honduras were the Lenca, Jicaque and Paya The language of the Lenca appears distantly related to that of the Mayan and Nahua tribes, but Jicaque and Paya are unaffiliated languages. Along the west coast of Nicaragua and extending down into northwest Costa Rica were tribes of Middle American linguistic ties such as the Chorotega (of Macro-Oto-Manguean language stock) and the Nicarao (of Nahua or Uto-Aztecan stock).

Earliest evidences of human occupation in lower Central America come from Panama, where shell mound food-collectors and fishers lived at about 4000 B.C. Their way of life changed but little over the next two or three thousand years, although in this time they acquired the art of making simple plain or incised pottery.

At a later time, probably during the first millennium of the Christian era, agricultural communities, comparable although not specifically related to those of the Middle American Formative period, are also known from Panamá. This horizon marks an introduction of polychrome painted and modeled pottery and, possibly, the first metallurgy. Later Panaman and Costa Rican cultures, such as the Coclé, Veraguas and Chiriqui, probably are derivative from this early horizon. Specific Middle American influences appear, however, on a relatively late level (after 900 A.D.). These are seen in the forms and designs of pottery styles and are believed to be derived from Nahua tribal migrations down the Pacific coast of Nicaragua and Costa Rica.

In general, goldwork, cast as ornaments, was of outstanding quality in Lower Central America, particularly in Panamá and Costa Rica. Metallurgy apparently reached these regions from Andean South America before metals were known in Middle America.

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MIDDLESBROUGH, a municipal, county and parliamentary borough in the North Riding of Yorkshire, Eng., 51 mi. W. by N. of York by road. Pop. (1961) 157,308. On the south bank of the Tees estuary, 5 mi. from its mouth in the North sea, it is the centre of one of the most important iron and steel districts in the world.

Where Middlesbrough stands there were a small chapel and priory founded by Robert de Brus of Skelton castle. These were dedicated to St. Hilda and were given, with some lands, by de Brus to the abbey of St. Hilda at Whitby in 1119. The priory fell into ruins at the time of the Reformation and no trace remains. In 1801 Middlesbrough consisted of a few farmhouses with a population of 25; the neighbouring parish of Acklam, long since absorbed, had a greater population. In 1829, a company .styling itself the Middlesbrough Owners bought 500 ac. of land and began building. In 1830 the Stockton and Darlington railway was extended to Middlesbrough to facilitate the shipment of coal and the town mas established as a port; four years later the growing town was lighted with gas and in 1840 a public market was established. In 1841 the population was 5,709. In 1842, the opening of the docks gave it additional importance; by 1850 blast furnaces were erected and soon the whole district became a thriving iron centre. Ironstone was mined in the neighbouring Cleveland hills; limestone and coal were at hand, transport mas made easy by the presence of the railway, and the navigable riverway meant cheap facilities for export. The town grew so rapidly that in 1853 Middlesbrough was given a charter as a municipal borough; it was made a parliamentary borough in 1867 and a county borough in 1888.

Iron and steel production and fabrication is the most important industry, but the chemical industry has expanded rapidly and two of the largest plants in the commonwealth are sited on Teesside. There is a thriving shipbuilding industry and some of the world's largest tankers, as well as all other types of shipping, have been launched into the Tees.

The entrance to the Tees river is protected by two breakwaters: the South Gare, which was begun in 1863 and took 24 years to build, is more than 2½ mi. in length; and the North Gare. which has a length of 3,330 ft. Extensive dredging operations have been carried out in the river. In 1863 the depth of water on the Bar was 34 ft. at low water of ordinary spring tides; by 1943 it was 24 ft. at low water. The Middlesbrough dock is the property of the British Transport commission and was considerably enlarged in 1926. Its area is 25½ nc.; the entrance is 80-ft. wide and total length of quayage is 6,842 ft. In 1956 the Tees Conservancy commission was constructing new deepwater docks and had already completed a wharf at which tankers discharge to storage tanks. About 6,000 ac. of land have been reclaimed from the foreshore of the Tees, much of it by the deposit of slag from the iron works. All the reclaimed land on the south side has been sold for the construction of iron and steel works, shipbuilding yards, dry docks and deepwater quays. A vertical lift-type bridge, the first of its kind in the country. over the Tees at Newport, was opened in 1934.

Middlesbrough, being the main port of the Tees river. deals with the bulk of the trade of the region. Its chief exports are manufactured iron and steel, machinery, chemicals, pig iron, motor vehicles and bricks. Its imports are chiefly ores—iron and manganese—iron and steel, sand, cement and timber. There are direct sailings to and from all parts of the world.

See Tees Conservancy Commission, ***The River*** Tees. *Official Handbook. . .* (Cheltenham, London, 1954). (E. C. P.)

MIDDLESEX, LIONEL CRANFIELD, 1ST EARL OF (1575–1645), was originally a London merchant, early interested in customs farms and deals in crown land. Lending money extensively, he came into contact with the Howards, and was used by Henry Howard. earl of Northampton, as business adviser to the government. In 1613 he was knighted and became surveyor general of customs. Abandoning trade, he began his career as an administrator. In 1616 he became a master of requests. Enjoying the patronage of the duke of Buckingham and backed by Francis Bacon, he was chief executive agent of the privy council. then attempting to reduce expenditure. After making successful economies in the royal household, he was appointed master of the wardrobe in 1618 and a commissioner for reform of naval expenditure. In 1619 he became master of the court of wards. In 1620 he married Anne Brett, cousin to Buckingham. Ambitious and resourceful. he took a leading part in the impeachment of Bacon. In, July 1621 he was created Baron Cranfield and in September was appointed lord treasurer. A year later he was created earl of Middlesex. His economy drive and overbearing temper made him disliked and his opposition to the war against Spain exposed him to attack. His impeachment was instigated by Buckingham, aided by the prince of Wales. Found guilty on charges of corruption, he retired into private life.

Although it came to be recognized that his fall had been engineered by faction, he was never employed again, though he was readmitted to the house of lords in 1640. He died in London on Aug. 6, 1645. As a merchant and as minister of the crown, he built up a considerable fortune, buying land extensively. His daughter. Frances, married Richard Sackville, 5th earl of Dorset. On the failure of Middlesex's male line, his lands passed to the Sackvilles. (M PH)

MIDDLESEX, a county of England, bounded north by Hertfordshire, east by Essex, southeast by the county of London, south by Surrey, and west by Buckinghamshire Excepting Rutland, it is the smallest English county, with an area of 232.3 sq.mi. and a population (1951) of 2,269,315. It lies entirely within the Thames basin and within the geological region known as the London Basin. South of an irregular line running from Uxbridge to Hyde park and then to Tottenham there are gravel deposits which rise in terraces from the Thames and its tributary the Lea. North of the line, the London clay emerges from under the gravel to form undulating country around Harrow and Elstree and, over the Hertfordshire border, Chipping Barnet. The highest ground is in the north rising to 506 ft. near Bushey heath. with projections southward toward Hampstead and Harrow which are topped by remains of the sandy and pebbly Bagshot beds. Glacial deposits are also present; *e.g.,* pebbly beds at Stanmore heath. clay and sand at Finchley. chalky boulder clay at Southgate. while the Reading beds emerge in the northwest near Harefield. The uest is watered by the Colne, Crane and Brent rivers and the east by the Lea river.

Early Settlement **and** History.— The Thames river is the key to the history of the development of the county of Middlesex and implements and weapons of all periods have been found in its banks. The lower Thames valley provides opportunities for the study of the Stone Age and the deposits of gravel laid down by the river have produced many flint implements. The Pleistocene Ice Age provided periods of arctic climate alternating with milder spells and the swollen rivers deposited materials eroded by the melting glaciers of the north. From the Middle Stone Age (c. 8000 B.C.) traders and settlers used the Thames as their highway in order to avoid the interior country which was either marshy or covered with impenetrable forests. The earliest settlement to be established belonged to the Iron Age (c. 300 B.C.) at Brentford (Old England) and "Caesar's camp" at Heathrow. Bronze-Age burials have been found at Sunbury, Littleton reservoir and Ashford.

In the 1st century B.C. Belgic tribes had established themselves in southeastern England, the Middlesex formed part of the Cassivellauni territory. It is probable that the invading army of Julius Caesar used a route afterward to be known as Watling street to reach the Cassivellauni stronghold near Wheathampstead (Herts). The Romans had stations at Staines and Brentford and large pottery works at Sulloniacae (Brockley Hill). They also built Ermine street. which led from the City of London to Stamford, and the London-Silchester road through Staines. The Roman site at Staines was on Greenfield common.

The Roman order in Middlesex finally collapsed in the early part of the 5th century and 100 years later the East Saxons began to colonize the area which soon after admitted the supremacy of Mercia. Being thus positioned between the East and the West Saxons it obtained its name, the earliest record of which is in a charter of 704. Evidence of Saxon occupation has been found at Hanwell and Shepperton. The county suffered much from the Danish invasions to which the City of London provided the main resistance. The exact purpose of the famous earthwork called Grims dyke, that ran ,from south of Pinner green to Wealdstone, is unknown.

From Roman times the City of London has dominated Middle-

sex so that it has never had a county town, although the claims of Brentford have been put forward based, no doubt, on the fact that it was the polling place Assizes for the county have never been held within it and more serious offenses were tried at the Old Bailey on the delivering of the jail of Newgate. Two sheriffs were appointed by the City of London. and Middlesex was included in their area This arrangement continued down to 1888 when the county of London was formed and Middlesex was deprived of 50 sq mi of its area. nhich was thrown into the county of London. A sheriff for Middlesex was then appointed

The county experienced the hardship consequent upon civil disturbances; *e.g.*, the Barons Wars against John, and the Peasants' Revolt. During the Great Rebellion, Hounslow heath. Colnbrook and Uxbridge provided camping grounds for opposing armies. Brentford was the scene of Prince Rupert's brilliant cavalry charge. The Crown hotel at Uxbridge, used without avail to discuss terms of peace, is still called "Treaty house."

Architecture. — Suburban Middlesex is so much the product of the 20th centurv that it is hard to believe that once it formed the country retreat-of royalty, of persons attached to the court and of wealthy London merchants. The most outstanding building is Hampton Court palace but there also exist examples of many stately mansions; *e.g.*, Osterley, Syon and Swakeleys, while fine specimens of 18th-century architecture are to be found at Hampton, Twickenham, Brentford! Chiswick, Enfield, South Mimms and Harefield interspersed among arterial roads and semi-detached villas. Here and there an old village centre is to be found hemmed in by housing estates, or there is a mediaeval church, a tithe barn, a village green or a riverside terrace, but historic Middlesex does not easily reveal itself.

Communications, Agriculture and Industries. — Growing London attracted improved communications — roads. railways and canals — and the transport services pushed the real countryside farther and farther away, replacing it with a gargantuan urban spread so that approximately 70% of the county is now built up. There are no rural districts. In the latter 1950s only a fifth of the county was covered by crops and grass and the numbers of animals — cattle (7,340), sheep (3,554) and horses (454)—were the lowest for English and Welsh counties. But on the Lea and Thames alluvium 3,623 ac. were devoted to market gardening, especially green vegetables. Middlesex, in common with other counties on the periphery of London. provides the necessary domain fqr a great capital. There are the airfields, the reservoirs. the gasworks, railway sidings. laundries, factories and dormitories that serve the metropolis, all competing for the limited amount of available land confined nithin the encircling metropolitan "green belt" in which the outer reaches of the county lie.

Population and Administration. — The population of Middlesex has increased from 70,827 in 1801 to 2,269,315 in 1951. Middlesex in its turn adds to the congestion of central London so that one of the most pressing problems facing not only Middlesex but the whole of the Greater London region, is a decentralization of people and work into the surrounding country beyond the "green belt." It is an important feature of the county development plan, prepared under the Town and Country Planning act, 1947, to assist this program of dispersal.

Before the passing of the Local Government act of 1888, Middlesex had been administered from Clerkenwell, with sessions held at least twice a year at Westminster. Under this act the site of the present Guildhall in Parliament square was excluded from the area handed over to form the new county of London. so that sessions of the peace for Middlesex could be held there. It is essentially the administrative centre of the county and the council meetings are held there. County council buildings in Westminster have now spread into Great George street, Dartmouth street, Vauxhall Bridge road and other places.

There are 18 municipal boroughs and 8 urban districts. The county is within the metropolitan police district and within the jurisdiction of the central criminal court. The county is divided into 8 petty sessional divisions:—Ten extra-metropolitan parliamentary divisions each return one member to parliament, three parliamentary boroughs each return one member and two parliamentary boroughs each return two members.

The whole of the present county is under the ecclesiastical jurisdiction of the bishop of London and mainly in the archdeaconry of Middlesex and the more modern archdeaconry of Hampstead. A few places were exempt from such jurisdiction and were peculiar of the archbishop of Canterbury by virtue of the fact that he owned the respective manors. The principal public schools within the county are Harrow. Highgate and Mill Hill. There are also five teachers' training colleges. Many of the 57 grammar schools are of ancient foundation.

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(W. H. C. LE H.)

MIDDLETON, EARLS OF. JOHN MIDDLETON, 1ST EARL OF MIDDLETON (*c.* 1619–1674), belonged to a Kincardineshire family which had held lands at Middleton since the 12th century. In early life he served as a soldier in France; later he fought against Charles I. being especially prominent at the battle of Philiphaugh. He held a high command in the Scottish army. In 1656 the king made him an earl, four years later commander in chief of the troops in Scotland and lord high commissioner to the Scottish parliament. Owing to serious dissensions with the earl of Lauderdale he was deprived of his offices in 1663. He mas (166;) governor of Tangier. where he died in June 1674.

His eldest son CHARLES, 2ND EARL OF MIDDLETON (c. 1640–1719), held several offices under Charles II and James II, being envoy extraordinary at Vienna, joint secretary for Scotland. and from 1684 English secretary of state. In 1693 he joined the exiled king at St. Germain, where he became his secretary of state.

Sre A. C. Biscoe, *The Earls of Middleton* (1876).

One of Middleton's kinsmen was SIR CHARLES MIDDLETON, Bart. (1726–1813), comptroller of the navy from 1778 to 1790. In 1805, at a most critical time, although 80 years old, he was appointed first lord of the admiralty by William Pitt and was created Lord Barham. It was his experience, industry and energy which made possible the great campaign which ended at Trafalgar. He resigned office in Jan. 1806 and died on Jan. 17, 1813. His barony passed through his daughter Diana (1762–1823) to the Noels, earls of Gainsborough, by whom it is still held.

MIDDLETON, ARTHUR (1742–1787), U.S. politician and signer of the Declaration of Independence. was born at Middleton Place. S.C.. on June 36. 1742. His family was one of the most prominent in the colony. The grandfather, Arthur Middleton (1681–1737), was president of the council in 1721–30 and as such was acting governor in 1725–30, and the father, Henry Middleton (1717–84). was speaker of the assembly in 1745–47 and again in 1754–5j. a delegate to the continental congress in 1774–76, and its president 1774–7j. Like most wealthy South Carolinians of the 18th century. Arthur Middleton was educated in England—at Hackney, at Westminster school and at St. John's college. Cambridge. In 1773 he returned to South Carolina, and in the controversies between the colonists and the home government became a leader of the Whigs. He was a member of the provincial council of safety in 1775–76, and a delegate to the continental congress in 1776–77. He was captured by the British at Charleston in May 1780, was exchanged in July 1781, was again a delegate to congress in 1781–83, and later served in the state legislature. He died on Jan. 1, 1787, near Charleston.

See Benson J. Lossing, *Biographical Skrtches of Signers of American Declaration of Independence* (1854); C. F. Jenkins, *The Completed Sets of the Signers of the Declaration of Independence* (1925).

MIDDLETON, CONYERS (1683–1750), English writer, was born at Richmond. Yorks., on Dec. 27, 1683. He graduated from Trinity College, Cambridge, took orders, and in 1706 obtained a fellowship, where he soon resigned. In 1717 a dispute with Richard Bentley involved him in an acrimonious contro-

versy. He wrote "Remarks" and "Further Remarks" on Bentley's *Proposals for a New Edition of the Greek Testament.* In 1723 he was involved in a lawsuit by personalities against Bentley, which had found their way into his otherwise judicious tract on library administration, *The Present State of Trinity College* **(1719).** Observations made during a visit to Italy on the pagan origin of church ceremonies and beliefs were embodied in his *Letter from Rome, Showing an Exact Conformity Between Popery and Paganism* **(1729).** In his remonstrance with Daniel Waterland on the latter's reply to Matthew Tindal's *Christianity as Old as tlze Creation,* Middleton laid himself open to the charge of latitudinarianism. His next important work, a *Life of Cicero* (1741), enhanced his reputation at the time, but was in fact largely borrowed from William Bellenden's *De tribus luminibus Romanorum.* His chief writings are the *Introductory Discourse* **(1747)** and the *Free Inquiry* **(1748)** "concerning the miraculous powers which are supposed to have subsisted in the church from the earliest ages." On July **28, 1750,** he died at Hildersham, near Cambridge.

MIDDLETON, THOMAS (1580–1627), English dramatist, drew men as he saw them, like Chaucer, with comic gusto or searching irony. The son of a London citizen, he was baptized on April 18, 1580, at the church of St. Lawrence in the Old Jewry, London. By 1600 he had spent two years at Queen's college, Oxford, and had published three books of verse. He learned to write plays by collaborating with Thomas Dekker, John Webster and other authors for the producer Philip Henslowe. Soon he was pouring forth high-spirited comedies, acted by boy players at St. Paul's and Blackfriars. Later he wrote for many theatres, including the Swan and the Globe. As a popular playwright who was also a freeman of London, he was often commissioned to write and produce lord mayor's pageants and other civic entertainments, and in **1620** he was appointed city chronologer. His chief stage success was *A Game at Chesse* (1624), in which the Black King and his men, representing Spain and the Jesuits, are checkmated by the White Knight, Prince Charles. This political satire drew crowds to the Globe until the Spanish ambassador protested and James I suppressed the play. Middleton lived at Newington Butts, Surrey, and he was buried there on July **4, 1627.**

His masterpieces are two tragedies. *Women Beware Women* (1621?, publ. 1657) and *The Changeling* **(1622,** with William Rowley, publ. **1653).** The first recalls Webster's *The White Devil* in the subtle plot by which the duke of Florence (Francesco de Medici) entraps Bianca and in the sudden revenges by which each crime is paid for in blood. The dramatic scene of a chess game which symbolizes the duke's success is characteristic of the tragic irony by which the black characters always outwit the white until in the end the white characters themselves turn black.

The Changeling is a still more powerful study of crime and its psychological effects, though it would be a better play without the intrusive underplot written by Rowley. Beatrice-Joanna, a willful and passionate girl, clears the way to marrying for love by arranging a murder, only to find herself at the mercy of the murderer, De Flores, who has no mercy; "Can you weep Fate from its determined purpose? So soon may you weep me." She is "the deed's creature."

His comedies picture a society dazzled by money, in which most men are out for what they can get, no matter how. *Michaelmas Terme* (1605?, publ. 1607) is one of the richest in irony. The crafty London merchant Quomodo delights in the skill with which he entangles a young gentleman and takes over his country estate; then, like Ben Jonson's Volpone, he tries one scheme too many and falls into the pit he has dug. In *A Trick to Catch tlze Old-one* (1606?, publ. **16081** two rival usurers; Lucre and Hoard, are so eager to score over each other that both are taken in by Lucre's clever nephew! whose strategy later furnished a plot for A *New Way to Pay Old Debts* by Philip Massinger. Sir Bounteous Progress in *A Mad World, My Masters* (1604?, publ. **1608)** is a delightful old country gentleman who prides himself on his generosity to all except his grandson and heir, Dick Follywit. The madcap heir helps himself to a share in the family wealth by masquerading as a lord, a robber and the leader of a company of players, but the old knight has the last laugh and forgives all when his mistress turns, up as Follywit's new wife.

A Chast Mayd In Cheape-side (1613?, publ. **1630)** is a still more exuberant comedy with hilarious scenes making fun of naive or complacent London citizens. These racy comedies of London life are essentially masculine, realistic and antiromantic. Even when the main character is a woman, for example Moll in *The Roaring Girle* (1604–10?, with Dekker, publ. 1611), she is a masculine spirit who prefers her freedom to marriage. She is drawn from an actual Moll Cutpurse who dressed as a man and took tobacco on the stage. Another spirited woman is the wife in *No Wit, No Help Like a Woman's* (1611?, publ. 1657), who restores the family fortunes by playing the dashing gallant so well that she outwits the fortune-hunting suitors of Lady Goldenfleece and wins the lady for herself and finally for her brother.

The tragicomedies are farfetched in plot but strong in dramatic situations. Charles Lamb praised A *Faire Quarrell* (1616?, with Rowley, publ. **1617)** for "the vigorous passions: and virtues clad in flesh and blood." Captain Ager, with his conflicts of conscience, is one of Middleton's few heroes. *The Witch* (1610–16?, publ. 1778) is a less successful revenge play. Hecate and other witches sing two songs which were also used in *Macbeth,* where the speeches of Hecate were probably added to Shakespeare's play by Rliddleton. *The Spanish Gipsie* **(1623)** was printed in **1653** as by Middleton and Rowley, though some critics believe that John Ford was also part author. The play dramatizes two stories by Cervantes. *The Force of Blood* and *The Little Gipsy.*

"Middleton," writes T. S. Eliot, "was a great observer of human nature, without fear, without sentiment, without prejudice." *(Selected Essays;* publ. by Faber and Faber. **1951.)** A dramatist rather than a poet, he had the dramatist's power to imagine natural characters and to bring them to life.

Most of Middleton's other plays are comedies: *The Phoenix* **(16031,** publ. 1607), where the disguised prince suggests Shakespeare's *Meaaure for Measure; Your five Gallants* (1605?, publ. 1607), a rogue's gallery of gentleman-sharpers; probably *The Puritaine* (1606?, publ. **1607** as by "W. S."); *More Dissemblers besides Women* (1615?, publ. 1657); *The Widdow* (1616?, publ. **1652);** and *Anv Thing For A Quiet Life* (1621?, publ. **1662).** His tragedy *Hengist, King of Kent* (1616–20?), was printed in **1661** as *The Mayor of Quinborough.* He collaborated with Dekker in *The Honest Whore* **(1604)** and perhaps in *Blurt Master-Constable* (1601, publ. 1602) and *The Familie of Love* (1602?, publ. 1608); with Rowley and Massinger in *The Old Law* (1618?, publ. **1656);** and with Rowley in a masque, *Thr World Tost at Tennis* **(1620).** Opinion is divided on the authorship of *The Revenger's Tragedy* (1606?, publ. 1607), traditionally attributed to Cyril Tourneur, and *The Second Maiden's Tragedy* (1611, publ. 1824); the evidence for Middleton is stated by S. Schoenbaum, *Middleton's Tragedies* **(1955).** He wrote in verse *The Wisdome of Solomon Paraphrased* (1597), *Micro-cynicon. Sixe Snarling Satyres* (1599), and *The Ghost of Lucrece* (1600; ed. by J. Q. Adams, 1937); and in prose several pamphlets, including two satires. *The Blacke Booke* (1604) and *Father Hubburds Tales, Or The Ant and the Nightingale* (1604).

Middleton's works were edited by A. Dyce, 5 vol. (1840), and by A. H. Bullen, **8** vol. (1885–86). Ten plays are in the Mermaid series edited by Havelock Ellis with an introduction by A. C. Swinburne (1887–90). *A Game at Chesse* (1929), *Hengist, King of Kent* (1938) and *Honourable Entertainments* (1953) were edited by R. C. Bald. For other editions and criticisms *see* S. A. Tannenbaum, *Thomas Middleton: a Concise Bibliography* (1940); G. E. Bentley, *The Jacobean and Caroline Stage,* vol. iv **(1956);** R. H. Barker, *Thomas Middleton* **(1958).** (M. Es.)

MIDDLETON, a market town and municipal borough **(1886)** in the Middleton and Prestwich parliamentary division of Lancashire, Eng., on the Irk, near the Rochdale canal. **6** mi. N.E. of Manchester. Pop. (1951) 32,607. Area **8.1** sq.mi. St. Leonard's parish church, except for the tower arch which is of the 12th century, was rebuilt in 1524 as a thank offering for the victory of Flodden Field. The Queen Elizabeth grammar school, founded by Thomas Cardinal Langley in 1421, was refounded by the brothers Nowell, two former pupils, by letters patent in 1572. Chief industries are cotton spinning, calico printing, dyeing and bleaching, chemical manufacture, engineering and jam making.

MIDDLETOWN, a city of Connecticut, U.S., in Middlesex county, is on the west bank of the Connecticut river, 15 mi. S. of Hartford. It was settled in **16jo** and was incorporated as a town in **1651.** It occupies the site of the ancient Indian village of Mattabesec (or Mattabesett) but was given its present name in

1653. The city of Middletown was chartered in 1784, making it one of the oldest cities in the United States. The city and town were consolidated in 1923.

Middletown was a seaport and a shipbuilding centre in the 18th and 19th centuries. a base of the "triangular trade" before the American Revolution and later of the China Clipper trade. The coming of the steamship brought about a decline of its traffic. It is a manufacturing and trading centre (rubber footwear, textiles, marine hardware, power tools, paper boxes, brake linings, cotton webbing, patterns and automobile accessories). Commercial river traffic, once important as a means of communication, is confined almost exclusively to transportation of coal and oil. Middletown is the seat of Wesleyan university, established in 1831 by the Methodist Church but now nonsectarian. Located in Middletown are a state mental hospital and a state school for delinquent girls. In 1955 the Atomic Energy commission erected an experimental laboratory in Middletown. Since 1890 a large Italian and Polish immigration has changed the character of the population substantially. For comparative population figures *see* table in CONNECTICUT: *Population.* (E. E. SR.)

MIDDLETOWN, a city of Orange county, N.Y., U.S., on the Wallkill river, 65 mi. N.N.W. of New York city. The chief industries are dairy, fruit and vegetable farming and the manufacturing of cosmetics, saws, valves, clothing and leather goods. It is also a summer resort centre. Orange County Community college, opened in 1950, is located there. The New York State Homeopathic hospital for mental diseases, founded in 1874, and two other hospitals provide medical facilities. The village of Middletown, until 1798 part of Ulster county. was first settled by farmers about 1756 and organized in 1785 around the local Congregational church. Its name was derived from its location on the Minisink road midway between the Hudson and Delaware rivers. The town prospered as the centre for a number of turnpike companies and as the terminal of the Erie railroad after 1843. The now defunct New York, Ontario, and Western railroad, organized in 1879, had shops there. Middletown was incorporated as a village in 1848 and chartered as a city in 1888. For comparative population figures *see* table in NEW YORK: *Population.* (E. M. A.)

MIDDLETOWN, a city of Butler county, Ohio, U.S., on the east bank of the Miami river, midway between Dayton and Cincinnati, whence comes the name. Founded in 1802, Middletown soon became a trading centre for a rich agricultural region that produced an abundance of corn, wheat, livestock, tobacco, fruits and vegetables. Local products found markets in Cincinnati and New Orleans by freight wagons, river flatboats and the Miami-Erie canal boats. Later, four railroads passed through the city: the Baltimore and Ohio, the Big Four, the Erie and the Pennsylvania. Tobacco, paper and steel made the city important industrially. In 1900 George M. Verity built a mill in Middletown that produced sheet steel from ore to finished product by the continuous rolling process. The tobacco factories later disappeared, but paper and steel mills continued to flourish. Airplane products are also manufactured. Incorporated as a city in 1883, Middletown adopted a council-manager form of government in 1949. For comparative population figures *see* table in OHIO: *Population.* (W. E. SH.)

MIDDLETOWN, a town of Rhode Island, U.S., 26 mi. S.E. of Providence, on Aquidneck Island; it derives its name from its location between the other two towns on the island, Newport and Portsmouth. Middletown is closely related both historically and presently to Newport (*q.v.*), from which it was set off and incorporated as a separate town in 1743. Predominantly agricultural, it is known for its fine dairy farms and blooded stock. Bounded on both sides by Narragansett bay. it is a resort town with excellent ocean beaches and is also increasingly a residential area for Newport. St. George's school, a private school for boys, founded in 1896, is located there.

The most interesting historical site is Whitehall, the residence built in 1729 by George Berkeley. Irish poet and philosopher, dean of Derry and later bishop of Cloyne. An intimate of Addison, Steele, Swift and Pope, Berkeley was a man of great intellect and charm and did much to promote the cultural growth of Newport during his two-year visit. While there he wrote his "Alciphron, or the Minute Philosopher." The town has other early 18th century residences of distinction which add to its attractiveness. For comparative population figures *see* table in RHODE ISLAND: *Population.* (W. D. MZ.)

MIDDLE WEST, THE, also frequently called the midwest, the northern portion of the central United States, is usually defined to include the states of the north central region of the census bureau: Ohio, Indiana, Illinois. Missouri, Michigan, Wisconsin, Iowa, Minnesota. Kansas, Nebraska, North and South Dakota. Missouri and all or most of the western tier of states are sometimes excluded. The term "middle west" came into general use with the settlement of the far west.

Identification of the middle west as a region or section rests on geographical. historical, economic and other grounds. The region exhibits great diversity in climate, soil and resources. Although it has no large deposits of oil or precious metals, it does possess a vast extent of rich farming land, an excellent river and lake system, extensive forest lands principally in the lake states, and enormous deposits of base metals and minerals, notably iron, limestone and coal.

The Beginnings. — Settlement north of the Ohio river, which marks the southeastern boundary of the middle west, began slowly. The few land seekers who crossed the Appalachians before the Revolution settled mostly in Kentucky and Tennessee. During the Revolution, states with no claim to western lands insisted that those lands should become the common possession of the United States. By 1783 enough states had agreed to cede their western lands north of the Ohio to the national government so that the creation of a public domain was assured. Kentucky and Tennessee, as extensions of Virginia and North Carolina, were settled under regulations of their parent states but the region north of the Ohio was occupied under rules laid down by congress. In 1785 congress adopted a land law providing that Indian title be extinguished and the lands surveyed before being offered for sale. The survey system provided that the land be laid out in rectangular townships, six miles square. Each township was to be divided into 36 sections of 640 ac.; these in turn could be subdivided into halves, quarters, etc. The land was to be sold at auction at a minimum price of a dollar an acre, with alternating townships offered in their entirety, intervening ones in lots of 640 ac. One section in each township was to be reserved for the benefit of the common schools. Congress sought to assure compact settlement and wide distribution of the land.

Seven tiers of townships lying immediately west of the Pennsylvania border were designated for survey and sale but bureaucratic deliberateness and Indian hostility prevented prompt action. Meanwhile numerous land speculators sought large grants west of the surveyed land. The most energetic of these, the Ohio company organized by New Englanders, arranged a large purchase on the Muskingum river. Congress, at the insistence of the company, adopted a plan of government for the territory in the famous Northwest ordinance of 1787. This ordinance prohibited slavery, guaranteed trial by jury and other civil rights, and provided for the later formation of states. Under the first stage of government, the district, the government was controlled by officers appointed by the central government. When the adult male population reached 5.000, a second or territorial stage, which permitted an elective legislature, could be entered. When the total population reached 60,000, the territory was eligible to draft a constitution and enter the union on a basis of equality with the other states. Three to five states were to be erected in the Northwest territory. Although often hailed as a great liberal document, the ordinance in the district stage allowed settlers fewer political rights than the English colonists had before the Revolution. The saving feature of the plan consisted of permitting the territory to grow to statehood.

Territory to Statehood. — For a decade after 1783 Indian hostility discouraged immigration. A small settlement at Marietta, in nhat later became Ohio, and a few scattered along the river as far south as Cincinnati marked the beginning of white occupation. After two disastrous attempts had been made to quell the Indians, troops under Gen. Anthony Wayne decisively defeated

them at Fallen Timbers near the rapids of the Maumee in 1794 and the next year the treaty of Greenville brought peace to most of what became Ohio. By 1800 the rush of people to the middle west nas beginning in earnest. Thereafter the spread and direction of settlement is roughly charted in the dates of admission of the states: Ohio entered the union in 1803; Indiana in 1816; Illinois, 1818; Missouri, 1821; Michigan, 1837; Iowa, 1846; Wisconsin, 1848; Minnesota, 1858; Kansas, 1861; Nebraska, 1867; North and South Dakota, 1889.

In 1796 congress, in revising the land law of 1785, raised the minimum price an acre to $2.00. Four years later it reduced to 320 ac. the minimum amount that could be purchased and allowed four years to complete payment. In 1800 the Northwest territory had a population of 51,000 compared with about 2,600,000 each in the northeastern states and the south. By 1840 population of these two sections had doubled; that of the middle west had increased almost sixtyfold to 3,300,000. By 1870 the population of all three sections was roughly equal—a condition that would continue for many decades.

Unlike the region south of the Ohio, which drew settlers largely from the older southern states, the Ohio valley was attractive to immigrants both from the older states and from Europe. Germans, Irish, Scandinavians and others joined the push into the region, contributing to the heterogeneity of the population.

With relatively little waste land in the region, productive farms soon blanketed the area. With growing markets in the south, east and Europe, the great problem was to find ways to reach these markets with the farm produce. Bulky commodities such as corn and wheat could be marketed locally or down river as grain or flour. Corn could also be sent to market as pork, beef or whiskey. In the first decade of the 19th century, farmers in the Scioto valley fattened cattle on corn and drove them across the mountains to eastern markets, thus initiating a business that would continue until railroads made such long drives unprofitable. Hogs were sometimes driven but more often were slaughtered locally and the meat processed and barreled for river shipment.

In the second decade of the century steamboats came into extensive use on the rivers. Agricultural and related commerce of the interior further increased with completion of the Erie canal in 1825. The success of this canal and the need for more transportation induced the states of Ohio, Indiana, Illinois and Wisconsin to launch ambitious canal building projects all aimed at connecting the Great Lakes with the Ohio or Mississippi rivers. By the 1850s railroads had begun to capture the carrying trade of the upper Mississippi valley and during this decade New York displaced New Orleans as the great ocean port of the middle west. The superintendent of the eighth census, in reviewing the grain trade of the United States up to 1860, declared it to be "one of the chief marvels of modern commercial history . . . the leading agency in the opening up of seven-eighths of our settled territory." Without the great European demand for American foodstuffs, he declared, "Capitalists could not have been encouraged to construct our immense canals, and lines of railroads, nor to have built our fleets of grain-carrying vessels to traverse the lakes and seas."

The richly productive farms also called into existence innumerable rural villages to serve their immediate needs and cities, many located along the waterways, to supply machinery and to collect, process and market the vast flood of meat and grain. Cincinnati became known to the world in the 1820s as Porkopolis. Later Carl Sandburg heralded Chicago as "Hog Butcher for the World" and "Stacker of Wheat." (Chicago Poems, Henry Holt and Co., New York, 1916.) Slaughtering and meat processing plants, flour mills, breweries, distilleries and a host of other industries emerged. Chronic labour shortage, rich soil, large fields and growing markets combined to encourage both invention and the widespread use of farm machinery. Before 1860 the McCormick brothers, for example, moved to Chicago and Jerome I. Case, manufacturer of threshing machines, located in Racine, Wis. Others established themselves in this area. By 1860 approximately half the farm implements produced in the United States were being manufactured in the middle west. Similarly machine shops provided equipment for the lumber camps and the burgeoning sawmills of the lake states. They continued to supply the industry when it moved to the Pacific northwest. Even after the rest of the nation was settled, the middle west did not lose its primacy. In the second half of the 20th century, seven of the ten leading agricultural states were in the middle west and three (Indiana, Illinois and Iowa) contributed about one-sixth of the total national value of farm produce. Of the six leading manufacturing states, three (Illinois, Michigan and Ohio) were in the middle west.

The middle west is the region of checkerboard patterns on the land. The air traveler going west knows when he reaches Ohio because for the first time he sees farms that still retain the rectangularity imposed by the first surveys. The square townships spread westward to the great plains and beyond. The survey township tended to become the basis for the smallest unit of civil government. Elections were held, taxes levied, roads laid out and built in relation to township and section lines.

Education.—With 40 to 150 farms and a village or two in a township, and land reserved for support of schools, the establishment of common schools was relatively easy. Perhaps to a greater extent than anywhere else in the nation, a situation existed peculiarly favourable for the creation of a uniform, tax-supported common school system. Also important was the development of state universities, which in the middle west attained a distinction not achieved in the older states. Organized early in the political history of the state, they were shaped partly in imitation of older universities, partly to serve the practical needs of the frontier communities. Thus Greek, Latin and moral philosophy appeared in the same curriculum with surveying, chemistry and normal training. Something akin to the "elective system" appeared by the 1850s although it went unpublicized until Harvard adopted it more than a decade later. Moreover, a system of middle or high schools mas called into existence largely to serve as preparatory departments for the state universities. Thus was created a system of public education that extends from the elementary school through the university.

Politics.—In politics the middle west was tied initially more closely to the south than to the northeast and tended to support the Democratic party. As that party came to be the voice of the southern slave owners in the 1840s, middle westerners, unhappy with both Whigs and Democrats, helped create the new Republican party and contributed heavily to the Republican presidential victory in 1860. The region supported the Union with men and material during the Civil War and for decades thereafter held the Democratic party responsible for the war. The Republican party ruled supreme in most of the middle western states much of the time from 1865 until the great depression of the 1930s.

But the region was not without political ferment. Before the Civil War there were rural protests against railroad rates. Immediately after the war a host of splinter parties, some within the Republican party, appeared, dedicated to bringing railroads, grain elevators, and sometimes banks and corporations under state regulation. When, in the late 1860s, Oliver H. Kelley and associates formed the Patrons of Husbandry, also called the Grange (*q.v.*), the protesters found a focus and a vehicle for united action. Grangers captured the state government and wrote regulatory laws in most of the middle western states in the early 1870s and the U.S. supreme court upheld the right of states to regulate. The middle west also contributed support to the greenback (*q.v.*) movement and in the 1890s provided leaders and support for the Populist party. This party offered a comprehensive list of reforms which, although rejected by the voters in 1892 and 1896, found its way in succeeding years, into the platforms of the major parties and later into the law of the land.

In the 20th century the region continued to furnish reformers, conspicuous among whom were Robert M. La Follette, Wisconsin; Albert B. Cummins, Iowa, and George Morris, Nebraska, all nominal Republicans. Nor had agrarian protest ended. In 1916 the Nonpartisan league arose in North Dakota, protesting against the familiar monsters: railroads, elevators and banks. During the great depression. the middle west was the land of the farm holiday, and milk strikes. The sit-down strike was introduced in the U.S. and the C.I.O. was born in the middle west in the same years.

During and after World War I, the region came to be known as the isolationist middle west.

The Nature of the Land.—Although often described as the most materialistic part of the country, intent upon work and money-making, the middle west made substantial contributions to the literature, art and architecture of the nation and the influence of men such as Twain, Hemingway, Frank Lloyd Wright and many others transcends national boundaries.

The middle west, whatever else it is, is a region of material abundance, variety and practical unorthodoxy.

BIBLIOGRAPHY.—The historical beginnings of the middle west are sketched in B. W. Bond, Jr., *The Civilization of the Old Northwest . . . 1788–1812* (1934); R. C. Buley, *The Old Northwest: Pioneer Period 1815–1840* (1950); and H. C. Hubbart, *The Older Middle West, 1840–1880* (1936). Contemporary aspects are presented in R. B. Nye, *Midwestern Progressive Politics* (1951); G. Hutton, *Midwest at Noon* (1946); and J. J. Murray (ed.), *The Heritage of the Middle West* (1958). For literary contributions of the region *see* R. L. Rusk, *The Literature of the Middle Western Frontier* (1925). (V. C.)

MIDDLEWICH, an urban district in 'the Nantwich parliamentary division of Cheshire, Eng., 20 mi. E. of Chester by road. Pop. (1951) 6.736. Area 3.1 sq.mi. It lies in rich agricultural country near the Dane river, having water communications with the Trent and Mersey canal. and the Shropshire Union canal. The church of St. Michael and All Angels, in Decorated and Perpendicular styles, retains some Norman portions. Old buildings and fine timbered houses occur in the neighbourhood. Middlewich shares in the salt industry common to several neighbouring towns such as Northwich and Winsford. Other industries are chemical works. silk thrusting, joinery and wholesale clothing.

MIDDLINGS, a term applied to various commercial products which may be regarded as occupying a middle position between two other articles. This idea covers the origin of the term when it is applied to wheaten products. Prior to the middle of the 19th century millers used millstones for grinding wheat, and sought at one operation to obtain as much finished flour and finished by-products, *e.g.*, bran, as possible. But they could not by such means avoid making a granular intermediate product, which they called "middlings." This was sold with or without further treatment either for use ultimately as human food or as pigs' food. These alternative purposes are reflected in the present confusing uses of the term. When modern methods of milling were introduced, and particularly when the machines known as "purifiers" were first used, millers were enabled to obtain from "middlings" flours of the greatest excellence, so they then sought to make as many as possible. Ultimately they adopted methods of "gradual reduction" and at an early stage of the milling process are able to granulate the kernel of the wheat berry. (*See* FLOUR.) These granular products known as semolina (*q.v.*) middlings and dunst are essentially the same in constitution! differing only as to size of particle. For example, semolinas will pass through a mesh of say 20 per lineal inch, middlings through a mesh of say 56 per lineal inch, and dunst through a mesh of say 88 per lineal inch. Middlings so produced are, during the later stages of milling, resolved into finished flour and finished by-products. With recent changes in marketing the term may cease to apply to a by-product of milling. (A. E. Hu.)

MIDGET is a type of dwarf in which the bodily proportions remain relatively normal. *See* DWARFISM AND GIGANTISM.

MIDHAT PASHA (1822–1884), Turkish statesman, the son of a civil judge, was born at Constantinople in 1822. His father trained him for an administrative career, and at the age of 22 he was attached as secretary to Faïk Effendi, whom he accompanied in Syria for three years. On his return to Constantinople Midhat was appointed chief director of confidential reports, and after a new financial mission in Syria was made second secretary of the grand council. His enemies caused him to be given the nearly impossible task of settling the revolt and brigandage rampant in Rumelia. His measures were drastic and their success was startling and the government made him an official of the first rank and restored him to his place in the grand council. He restored order in Bulgaria in 1857. In 1860 he was made vizier and pasha, and entrusted with the government of Nisch, where his reforms were so beneficial that the sultan charged him, in conjunction with Fuad Pasha and Ali Pasha, to prepare the scheme for adapting them to the empire which was afterward known as the law of the vilayets. He organized the council of state in 1866, and was then made governor of Baghdad, where his success was as decisive as at Nisch, but attended with much greater difficulties. In 1871 the antireform influence of the grand vizier, Mahmoud Nedim, seemed to Midhat a danger to the country, and in a personal interview he boldly stated his views to the sultan, who appointed Midhat grand vizier in place of hlahmoud. Too independent, however, for the court: Midhat remained in power only three months, and after a short governorship of Salonica he lived apart from affairs at Constantinople until 1875.

While sympathizing with the ideas and aims of the "Young Turkey" party, Midhat was anxious to restrain its impatience, but the sultan's obduracy led to a coalition among the grand vizier, the war minister and Midhat Pasha, which deposed the sultan in May 1876, and he was murdered in the following month. His nephew Murad V was in turn deposed in the following August and replaced by his brother, Abdul Hamid II. Midhat Pasha now became grand vizier, reforms were freely promised, and the Ottoman parliament was inaugurated with a great flourish. In the following February, however. Midhat was dismissed and banished for supposed complicity in the murder of Abdul Aziz. Again recalled in 1878, he was appointed governor of Syria, and in August exchanged offices with the governor of Smyrna. But in the following May the sultan again ordered him to be arrested, and although he effected his escape and appealed to the powers, he shortly afterward surrendered. claiming a fair hearing. The trial took place in June, when Midhat and the others were sentenced to death. On the intercession of the British government the sentence was commuted to banishment. The remaining three years of his life were spent at Taif. Arabia, where he died. probably by violence, on May 8. 1884. To great ability, wide sympathies and patriotism he added absolute honesty. (G. F. B.)

MIDHURST, a town in West Sussex, Eng. on the Rother river. 12 mi. N. of Chichester by road. Pop. (1951) 1,895. The name of Midhurst (*Middeherst*) first occurs in the reign of Henry I. It was definitely called a borough in the reign of Edward I and was governed by a bailiff until early in the 19th century. In an act of 1883 it was mentioned as one of the towns which had long ceased to be municipal. It is now a parish of the Midhurst rural district. Midhurst sent two members to parliament from 1311 to 1832 and one from 1832 to 1885; Charles James Fox entered parliament in 1768 as its member. In the reign of Henry VI a market was held by the burgesses every Thursday and a fair on Whit-Tuesday, by grant of Sir John Bohun. The church of SS. Mary Magdalen and Denis is Perpendicular with a Norman tower and there are many old houses including a partly 15th-century inn. The grammar school was founded in 1672. In Cowdray park are the ruins of Cowdray house (1530), which was destroyed by fire in 1793. Three miles north at Lord's common is the King Edward VII Sanatorium for tuberculosis.

MIDIAN. One of the peoples of N.W. Arabia whom the Hebrews represented as sons of Abraham's wife Keturah. The Midianites appear in connection with the gold and incense trade from Yemen (Isa. lx, 6), and the trade between Egypt and Syria (Gen. xxxvii. 28. 36); also as warriors invading Canaan from the eastern desert, and ravaging the land as similar tribes have done in all ages when Palestine lacked a strong government (*see* GIDEON). Again, they are described as peaceful shepherds. and the pastures of the branch of Midian to which Moses' father-in-law belonged, lay near Mount Horeb (Exod. iii, 1) (*see* BALAAM; EDOM; KENITES).

MIDLAND, a city of Michigan, U.S., and the seat of Midland county, is 18 mi. W. of Bay City. In the 19th century it was a booming lumbering town. In 1888 the chemist Herbert H. Dow (*q.v.*) came to Midland, where he founded the Dow Chemical company; after 1900 both the town and company continued to expand. Other industries include oil and gas, agriculture and dairy products; and the manufacture of concrete, plastic toys, silicones and fibre drums. Much of Midland's natural beauty was

restored when Dow created 70 ac. of beautiful orchards, rolling lawns and gardens, and artificial ponds surrounded by pine stump and local rock fences. Following Midland's centennial in 1950 there was a flourish of new buildings: churches, schools, homes, libraries, industrial, stores, additional hospital space and a community centre. Many of these, including the First Methodist and St. John's Lutheran churches, were designed by the architect Alden B. Dow, son of H. H. Dow. For comparative population figures *see* table in MICHIGAN: Population. (K. C. C.)

MIDLAND, a city of western Texas, U.S., and seat of Midland county, is on the southern edge of the high plains midway between Fort Worth and El Paso. Its mean annual temperature is 63° and its average annual rainfall is 16.6 in. Midland was started in 1884 as a depot on the Texas-Pacific railroad and was incorporated as a city in 1906. It has a council-manager form of government which went into effect in 1947. Farms, located largely in the northern part of the county, produce cotton, grain sorghums, swine and sheep. Midland is the hub of a 12-county ranching region famous for fine Hereford cattle.

Midland is also the headquarters for the Permian basin, an extensive area holding a sizable part of the nation's known oil reserves. Oil was discovered'in the basin in 1923; three years later the industry began moving into Midland. With over 65,000 producing wells in the basin and about 650 company offices in the city, Midland was one of the nation's ranking oil centres. Other industries include a chemical plant, tool and machine shops, cottonseed-oil mills, compresses and potash mining. Midland is also the trade and financial centre for the area. Midland has a public library with over 8,000 volumes on geology, an annual rodeo and fair, a community theatre, a symphony orchestra, and over 900 ac. in parks. As a result of the oil development, the population increased rapidly, especially after 1940; in 1960 the population was 62,625 of which about 90% were native-born white. (E. WE.)

MIDLETON, WILLIAM ST. JOHN FREMANTLE BRODRICK, 1ST EARL OF, cr. 1920 (1856–1942), British statesman, son of the 8th viscount, was educated at Eton and Balliol college. Oxford. and was president of the Oxford union. He entered parliament, 1880. He was secretary of state for war (1900–03) and for India (1903–oj). He lost his seat for the Guildford division in 1906. In March 1907 he was made an alderman of the London County council. In that year his father died, and he entered the house of lords. He was prominent as leader of the southern Unionists of Ireland, in virtue of his position as a landowner in County Cork. In the Irish convention of 1917–18 this group separated itself from Ulster, and expressed readiness to concede a unitary home rule government for Ireland, with safeguards for the minority. Lord Midleton died Feb. 13, 1942.

MIDLOTHIAN, a county in southeastern Scotland. The ancient county is now divided into the county of the city of Edinburgh (*q.v.*) and the administrative county of Midlothian. The area is 366.2 sq.mi. and the population in 1951 was 565.735.

The county lies around the western, southern and eastern sides of the city of Edinburgh and reaches the Firth of Forth at Musselburgh. It extends ; or 6 mi. from the city boundary to the south, west and east, and about 20 mi. to the southwest and east-southeast. The two principal parts thus formed are separated by the narrow range of the Pentland hills which (highest point 1.898 ft.) cross from Peeblesshire to the southern boundary of the city. Generally rounded and grass or heath-covered, these hills are mainly formed from an elevated mass of lavas and tuffs of the Old Red Sandstone age. The Moorfoot hills in the southeast of the county are a little higher than the Pentlands but similar in appearance. They are part or' the dissected plateau of the Silurian age which forms the southern uplands of Scotland. They are drained by the Gala water to the Tweed. Between these two hill ranges lies a rift valley 9-mi. wide—a shallow syncline of Carboniferous strata which include the county's principal coal measures. This is the most densely populated and fertile part of the county which, rising gradually to the southwest. becomes open moorland at 900 ft. on the borders of Peeblesshire. It is drained into the Firth of Forth by the North and South Esk and the Tyne rivers. The escarpments of the Moorfoot and Pentland hills, facing over the valley, dominate its scenery. To the west of the Pentland hills, but rising more gradually toward them, lies a plateau of Calciferous-age strata which includes valuable oil shales. It is highly faulted and has many igneous intrusions. It drains northeast partly to the Water of Leith and partly to the Almond river which forms the county boundary with West Lothian. There are no natural lochs in the county! but a number of artificial reservoirs in the Pentland and Moorfoot hills supply water to the city and county and also to the Union canal (not used except as a source of water for industry).

On many hilltops are remains of fortified settlements (*e.g.*, Kaimes hill), forts (*e.g.*, Dalmahoy hill and Corsehope hill), or cairns (*e.g.*, Carnethy hill). Among other archaeological remains are mounds, the foundations of a broch, parts of stone circles and some standing stones such as the "Cat Stane" near the Almond. During the Roman occupation Inveresk was an important settlement; remains including pavements and a bathhouse have been excavated. The main Roman road from England—Dere street—entered the county over Soutra hill and probably ran into Inveresk and thence to Cramond. On the other side of the Pentland hills is Castle Greg. another fort site believed to be Roman. An earth house excavated at Crichton Mains contained many stones bearing Roman marks. suggesting that there had been another Roman camp in the vicinity.

From the historical period there are many ecclesiastical buildings including some remains of the great Cistercian monastery at Newbattle and the church of the Knights Templars at Temple. There are two churches dating in part from the 12th century, one from the 13th century and. among later buildings of interest, the elaborately decorated 15th-century Rosslyn chapel is perhaps the chief. Little secular building from before 1400 survived invasions from England but there are numerous later castles and houses and a number of old bridges.

Agriculture in Midlothian ranges from intensive market gardening—practised particularly on the raised beaches between Dalkeith and the coast—to sheep farming in the hills. In 1952 the main crops were: oats (17,609 ac.), barley (8.14; ac.), potatoes (5,509 ac.), swedes (5.338 ac.) and wheat (4,187 ac.). About 1,400 ac. were under fruit and vegetables. Livestock included 164,695 sheep, 37,644 pigs, 15.443 dairy cattle, 8,718 beef cattle and 108,-108 poultry. The number of pigs and cattle had increased by 60% and 20% respectively since 1938. The average size of holdings in 1952 was 102 ac. (a drop of 10% since 1938) and of the total of 1,036 more than half were of 50% or less.

Coal mining is the principal industry, employing 11,000 men (about 40% of all men employed in the county) in the mid 1950s. The main coalfield lies in the valleys of the Esk rivers but there is a smaller one in the Calders. The National Coal board in 1956 was expanding output in the former by sinking several new shafts. Also mined in the Calders is oil shale which is the basis of an oil extraction and refining industry employing in all 1,500 workers (*see* CALDER). Fireclay, roadstone, sands, limestone and sandstone are extracted. employing about 400 workers. Brick manufacture employs joo workers.

The largest manufacturing industry is papermaking. Nine mills were operating in the mid 1950s with more than 2,500 employees, the main centres being Penicuik. Lasswade, Musselburgh and Currie. The main engineering establishments (2,200 workers) are wireworks in Musselburgh. hydraulic and marine works at Loanhead and a foundry at Dalkeith. Textiles employ 1,400 workers. Carpets are made at Roslin. Bonnyrigg and Eskbank and nets at Musselburgh. There are also a number of large industries producing flour, oatmeal. ales and other foods.

The main roads and railways in the county radiate from Edinburgh. In the eastern part Dalkeith also is a road centre.

The population of the administrative county in 1951 was 98,974. There are five small burghs with populations (1951) as follows: Bonnyrigg and Lasswade 5.432, Dalkeith 8.786. Loanhead 4.882, Musselburgh 17,010. Penicuik 4,256. The Landward part of the county is divided into eight county districts. The administrative county is a single parliamentary constituency (1955) with the exception of the burgh of Musselburgh which is part of Edinburgh

(East) constituency. (J. McB.)

MIDNAPUR, a town and district in the Burdwan division of West Bengal, India. The town, 67 mi. W. of Calcutta, is on the Eastern railway, connecting with Howrah (Calcutta) via Kharagpur junction. Pop. (1951) 45,476.

MIDNAPUR DISTRICT has an area of 5,259 sq.mi. and had a population in 1951 of 3,339,022. The greater part consists of a large open plain under cultivation but the country along the western boundary, known as the Jungle Mahals, is undulating and in the northeast corner some hills rise to more than 1,000 ft. The eastern and southeastern parts are swampy, richly cultivated and thickly populated. The west, which has a lateritic soil partly covered by jungle, is sparsely inhabited. The chief rivers of the district are the Hooghly and its three tributaries, the Rupnarain, the Haldi and the Rasulpur; the Rupnarain's subtributary the Silai; and, in the south, a 60-mi. loop of the Subarnarekha. The main line of the Eastern railway passes through the district from east to west; from Kharagpur the East Coast section goes to Madras and the line via Midnapur town branches off north to Chota Nagpur. Kharagpur contains the railway workshops and had a population in 1951 of 129.636. There are two canals, the Midnapur Main canal and the Hijli tidal canal. Silk, mats and brass and copper utensils are manufactured.

The early history of Midnapur centres round the ancient town of Tamluk. In the 16th century it was eclipsed by Hijli, which had Portuguese and Dutch settlements. In 1687 Job Charnock, the founder of Calcutta, occupied Hijli and sustained a long siege by the Mogul forces. The British administration of the district dates from 1760, when Mir Kasim ceded it to the East India company with Chittagong and Burdwan when he became nawab of Bengal.

MIDNIGHT SUN: see NORWAY: The "Midnight Sun."

MIDRASH, lit. "exposition" (cf. 2 Chron. xiii, 22: xxiv, 27) or intensive study (*derūsh*) of the spirit of a passage, frequently used of homily and parable in opposition to literal interpretation (Peshat): term applied to certain methods of scriptural exegesis and to a class of Jewish writings illustrating these methods. The importance of Midrash to an understanding of Judaism is being recognized more generally. It is now realized that Judaism must be studied from its own sources and that apocrypha and apocalypse, though exceedingly valuable for the light they shed on dissenting sects or shades of quasi-orthodox opinion, do not reflect normal Judaism. These extracanonical books were excluded just because they were abnormal. The last generation, which was occupied in their recovery and study, tended to overstate their application. Today stress is laid on material which bears the warrant of unbroken tradition and which is therefore a more faithful mirror of the main body of Judaism.

This material may be divided into three groups: (1) the rules of the traditional law, or Halakhah, which is systematized in the *Mishnah* (see TALMUD); (2) the Midrash of the schools, often called Halakhic (see HAGGADAH) or Tannaite (*i.e.*, Mishnaic) Midrash: this may be defined as the scholastic deduction of the traditional from the written law and consists of several works differing in character and style from (1) and from (3), the Haggadic (see HAGGADAH) or homiletical Mzdrashim, which are collections of short sermons, of an ethical rather than of a legal nature. The Haggadic Midrash was highly esteemed but it aas not so authoritative as the Halakhic. This was natural from the essential difference between the two. Halakhah may be dull and legalistic but it is sober, whereas Haggadah is rarely dull, often highly imaginative and edifying, but it does not insist on sobriety. It includes many elements of extreme interest in folklore, archaeology and history. For example, I, Ziegler's *Königsgleichnisse* des *Midrasch* (Breslau, 1903) shows how vividly the Midrash illustrates the life and manners of Imperial Rome, especially in the provinces.

The Halakhah is deeply spiritual and is designed to stress the divine immanence, simple piety and the saintly life. The parables are mostly homely and the sayings terse, frequently in Aramaic, at one time the vernacular, and not in Hebrew, the language of the schoolmen. But there is also unrestrained fantasy; e g, stories of the Sindbad the Sailor type, which were not meant to be believed literally. Naturally great play with these has been made by opponents of the Jews, but the authority of the Haggadah has never been absolute. It stands in the same relation to theology as a mediaeval miracle play to canon law or decretals. Thus, on July 20–24, 1263, at the great disputation at Barcelona, Sp., between R. Moses b. Nahman and the Dominican Pablo Christiani, the former disarmed his opponent by repudiating the Haggadah, on which Pablo had based his case, and by declaring that the fables were merely points in sermons, expressing at most the individual opinions of the preacher and lacking the sanction of authority.

Nevertheless, the extent of the fantastic must not be exaggerated. In addition to strict truth and sheer fiction (*e.g.*, between a genuine fact of archaeology or lexicography, recovered in a parable or exemplified in a saying, and an angelic digression of apocalyptic exuberance) there is an intermediate portion which must neither be categorically denied nor accepted absolutely. This element has been described as pragmatic historiography. There are three types of historical writing, the genetic or scientific, the purely narrative and the pragmatic. Religious historians write pragmatically, but this does not mean fraudulently. Their mental environment subconsciously influences them and they tend to prefer that record which appeals to their own age. They expect to find in the past elements mature only in their own day. But ancient historians must not be brushed aside because they fail to conform to modern standards. Their writings must be carefully tested. This is the way to treat the quasi-historical portions of Midrash. Here we find subjective, history but earlier examples may be seen in the Bible, by examining Chronicles, which is a "Midrash" to Kings. Thus the life of Joash in II Chron. xxiii differs in some details from that in II Kings xi and affords an illustration of the chronicler's methods. (On the Midrashic nature of Chronicles, see W. A. L. Elmslie's Introduction in Camb. Bible, Chronicles, 1916.) Probably the chronicler had access to sources now lost and in the account of Joash a Midrash is actually mentioned. But such Midrashic compilations can be traced even before his date (4th century B.C.).

Pragmatic historiography is exemplified in the various Deuteronomic writers. Similarly the relation between Genesis and the Book of Jubilees should be noted. The Apocrypha to some extent fills the gap between the Old Testament and the Rabbinic *Midrashim,* but, as has been stated, it must be used with care. Judiciously used. the Midrash and the Apocrypha may sometimes present a clue to a lost line of tradition; this tradition may or may not be valuable historically but its recovery is of interest, since it lay before the particular O.T. writer who discarded it or used it only incidentally. Thus, Gen. xlviii, 22, contains a cryptic allusion to the capture of Shechem. In Jubilees xxxiv (about 2nd century B.C.) a story of this war is detailed and similar accounts are preserved in various Midrashim. It is unlikely that these were mere elaborations of Gen, xlviii, 22: it may be inferred that an extracanonical tradition continued to survive the compilation of Genesis and ultimately assumed the exaggerated forms now extant. Again, Jewish traditions of Abraham in Ur of the Chaldees recur in the Targums, Midrashim and Jubilees (ch. xii, ed. Charles, p. 91; cf. also Judith, v, 16 seq.). The legends of his escape from a fiery furnace may have a philological basis, for *'ur* can be interpreted as fire, but the allusion to the redemption of Abraham in Isa. xxix, 22, seems to indicate that older tradition was fuller than the present records in Genesis.

Midrashic exposition was based on the theory of progressive interpretation. Every word of the scriptures had a definite meaning, nay, no single letter was otiose; moreover, every word had "70 aspects." This means that generation after generation would extract new lessons, all of which were deemed latent or implicit. Some of these interpretations were arbitrary but more often the arbitrariness lay not in the teaching but in the deduction. When it was desired to point a moral or elicit a law, not always the best exemplar was adopted. Thus faulty proof rather than faulty inference is illustrated when the rare word *Be-mikhsath,* "in-number" (Exod. xii, 4), was used to confirm the Halaklzah that the man who killed the paschal lamb must know how many people

were about to share it. (Jew. *Enc.* viii, 570.) Many cases of apt deduction can be adduced and deductions, similarly apt or farfetched, occur also in the N.T. Thus, emphasis on a single word is illustrated by Gal. iii, 16, where the argument rests on the word "seed" (and not the plural "seeds") in the proof-text and the same word in rabbinical writings is used to support other arguments (*cf.* Mishnah, Sanhedrin, iv, 5; see A. Geiger, Z.D.M.G. 1858, pp. 307 seq.; S. R. Driver, Expositor, ix, pp. 18 seq. [1889]). By allegorical method Isa. lxi is applied to Jesus (Luke iv, 16–22).

The more important Midrashim are:

A. Halakhic or Tannaite Midrashim:

1. *Mekhilta,* on Exodus. This begins at xii, the first legislation (the ordinance of the Passover). The later portions of Exodus are not commented on (since they are historical) in the present work, but there is reason to believe that the original was fuller. This famous Midrash was of the school of R. Ishmael, but it was concluded in the school of the patriarch Judah in the 2nd century A.D. (Text, M. Friedmann [Vienna 1870]; I. H. Weiss [Vienna, 1865]. German trans., J. Winter and A. Wiinsche [Leipzig, 1909].)

2. Another recension of the *Mekhilta,* cited by mediaeval authors, was that of Simeon ben Yohai—ed. D. Hoffmann (1905).

3. *Midrash* hag-Gadol, a composite work on the Pentateuch, compiled in the 13th century, recently discovered in Arabia, contains much lost material. The Midrash is edited in part. (S. Schechter [Cambridge. 1902]; D. Hoffmann [Berlin, 1913].)

4. Sifra (de-Be *Rab*), on Leviticus, which it follows almost verse by verse. Probably redacted by R. Hiyya in the beginning of the 3rd century A.D. (Text, M. L. Malbim [Bucharest, 1860]; I. H. Weiss [Vienna, 1862]. Latin trans. [faulty in parts] in Ugolinus [Thesaurus] xiv.)

j. Sifre, on Numbers and Deuteronomy (2nd and 3rd centuries). (Text, M. Friedmann [Vienna, 1864]; H. S. Horovitz, Part I [Leipzig, 1917]. German trans. [on Deut.] G. Kittel [Stuttgart, 1922].)

B. Haggadic Midrashim:

1. *Midrash* Rabba, on the Pentateuch and Five Rolls. Ed.-princeps (Constantinople, 1512); frequently reprinted, Crit. ed. of Genesis Rabba by J. Theodor (unfinished), (Berlin, 1903– Germ. trans., A. Wünsche, Bibliotheca Rabbinica [Leipzig, 1880–]).

2. *Tanhuma* (2 recensions) on the Pentateuch, one of the oldest *Midrashim:* mentioned once in the Talmud. (Text, ed. S. Buber [Wilna, 1885]; the other recension [Constantinople, 1520–22].)

3. Pesiqta (de *Rab Kahana*), 33 homilies on the festivals (lectionary, etc.). (Text, ed. S. Buber [Lyck, 1868]. German trans. A. Wunsche [Leipzig, 1885].)

4. Pesiqta *Rabbathi,* a similar but separate collection of 51 homilies, of which 28 have a Halakhic exordium. (Text, ed. M. Friedmann [Vienna, 1880].)

j. Midrash *Shohar Ṭōbh* on Psalms, text (Warsaw, 1875).

6. Yalqut, or "Wallet," title of several midrashic collections.

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MIDSHIPMAN, the title used in the Royal Navy from about 1660 for "young gentlemen" in training at sea to qualify for service as commissioned officers. Continental and U.S. navies from their foundings adopted the title and system. The equivalent French title is aspirant, the Spanish, *guardia* marina. By the latter half of the 20th century, all British midshipmen were students at the Britannia Royal Naval college, Dartmouth, while midshipmen of the U.S. navy attended the United States Naval academy at Annapolis, Md.

Royal Navy.—As lord high admiral of England, James, duke of York, believed it was necessary to train "sea officers" and to start early. Before his time there was no corps of professional naval officers. With the approval of his brother, Charles II, James inaugurated the first step in a development which took about 200 years.

Until about 1720 midshipmen were in theory volunteers, accepted aboard ship with a letter of service, which led them to be called "king's letter boys." Kipling, Taffrail (Dorling, H. T.), Bartimeus (Lewis Ritchie) and other writers affectionately used the term "snotty" for midshipmen.

The system underwent many changes. The entering age varied. The title "naval cadet" was introduced to denote a rank below midshipman. A naval academy, established at Portsmouth in 1729, was reorganized in 1773 and renamed the Naval college in 1806. In 1837 the boys went to sea directly and had schoolmasters to aid the ships' officers in their instruction. But in 1857 the afterward famous training ship "Britannia" was established. The Royal Naval college at Osborne was used until 1921.

In May 1953 the officer entry to the Royal Navy was changed to a new system. Cadets were to enter between the ages of 17 years 8 months and 19 years. The new course at Dartmouth required about two and one-half years. Cadets joined on a common entry basis and specialized later. After one year as cadets, including sea training in the Dartmouth training squadron, they were promoted midshipmen, but continued to receive training as well as professional and academic instruction. Upon leaving Dartmouth, where they served as cadets and midshipmen, they were promoted acting sublieutenants and went to sea for 18 months of further instruction in ships of the fleet. No longer were there any midshipmen serving afloat. This was a sentimental loss to the Royal Navy because many of the most brilliant officers in the history of the service first distinguished themselves for gallantry and seamanship while midshipmen.

Midshipmen in the U.S. Navy.—In the early days of the U.S. navy, during the Revolution, the Barbary Wars, War of 1812 and Mexican War, many young men distinguished themselves while in the rank of midshipman. Until 1845 all service as midshipmen was in seagoing ships. David G. Farragut became a midshipman at the age of 9, and was promoted to lieutenant at 24. Usually, however, the age at entrance was 14 to 20.

The United States Naval academy was established at Annapolis, Md., by George Bancroft, the historian, then secretary of the navy, in 1845. Congress provided that midshipmen should be appointed to the academy by senators and representatives. This policy, which already applied to the United States Military academy, had the advantage of bringing in young men from all sections of the country, in proportion to population, thus making the navy a national rather than a sectional institution. In the beginning a midshipman spent one year at Annapolis, three years at sea and another year at Annapolis for study and final examinations. Upon passing these examinations he was promoted to "passed midshipman."

In 1862 the grade of ensign was established as the equivalent of the rank of second lieutenant in the army and the passed midshipmen were given the rank of ensign.

At various times the students at the naval academy have been called in turn acting midshipmen, midshipmen, cadet midshipmen and cadet engineers, naval cadets. and, again, since 1899, midshipmen. From 1873 to 1912 the course was six years, the last two years being spent at sea, followed by final examinations. Since June 1912 the course has been four years. Graduates are commissioned ensigns in the line or staff corps of the navy, or second lieutenants in the marine corps, army or air force. A candidate must not be younger than 17 nor older than 22 on July 1 of the year he enters. (J. B. HN.)

MIDWAY, THE BATTLE OF, on June 4–6, 1942, is generally regarded as the turning point of the Japanese-U.S. conflict and the most decisive battle of World War II in the Pacific. The fighting took place in the waters north and west of Midway islands, part of a circular coral atoll. 3 mi. in diameter, about 1,300 mi. N.W. of Honolulu.

The commander-in-chief, Japanese combined fleet, Admiral Isoroku Yamamoto, realized that to win the war, Japan had to defeat the U.S. fleet in a truly decisive battle in 1942 before it could be strengthened, or else lose the war. He reasoned that an attack on Midway mould bring the American fleet to the scene and produce the naval showdown he wanted. Admiral Chester W.

Nimitz, commander-in-chief, U.S. Pacific fleet and Pacific Ocean areas, interpreted that an attack was coming and estimated the Japanese forces which would appear against Midway with surprising accuracy.

The battle preliminaries began on the morning of June 3, when a considerable Japanese force was sighted and tracked by C.S. patrol planes, approximately joo mi. W. of the atoll following an easterly course. Late in the afternoon of that day, the force was bombed by a squadron of B-I7s but no hits were scored. On the morning of June 4 contact mas made with Japanese carrier aircraft heading toward Midway, and immediately thereafter two carriers and the main Japanese forces were sighted in the same vicinity. The Japanese planes then attacked Midway. In the air battle that followed, 17 American defending planes were lost and 7 others badly damaged; the Japanese lost about 30 planes in the attack. Subsequently U.S. army, navy and marine corps planes from Midway and the carriers "Enterprise," "Hornet" and "Yorktown" made attacks on carriers, battleships and other vessels in the Japanese invading force. eventually inflicting serious damage to Vice-Admiral Chuichi Nagumo's flagship "Akagi" and the carriers "Soryu" and "Kaga." The "Soryu" was later torpedoed by the submarine "Nautilus." Planes from an undamaged carrier "Hiryu" attacked the "Yorktown" and although practically annihilated, they succeeded in making three bomb hits, two of them serious. Then folloued a torpedo attack from the air. and the "Yorktown" was hit by two torpedoes. Subsequently orders were given to abandon ship. About two hours later, planes from the "Enterprise" attacked the "Hiryu" and left it a mass of flames. Soon a squadron from the "Hornet" arrived, and the "Hiryu" was blazing so furiously that they were able to concentrate on a nearby battleship and cruiser, both of which were hit. By the end of the day, the Japanese were in full retirement.

The next morning, June 5, aircraft from the "Enterprise" and the "Hornet" made an ineffective attack on a Japanese light cruiser, and planes from Midway discovered and attacked two Japanese cruisers leaving one in a crippled condition. Poor visibility prevented further operations.

On June 6 "Hornet" planes located a Japanese force consisting of tuo heavy cruisers and three destroyers and made damaging hits on the two cruisers. Planes from the "Enterprise" also scored hits on these two cruisers, and later in the day "Hornet" planes successfully attacked two more cruisers and a destroyer. On the same day, in an effort to save the "Yorktown," which had been taken in tow, the destroyer "Hammann" went alongside to put on board a salvage party. During this operation, the "Yorktown" was struck by two torpedoes and the "Hammann" by one. The "Hammann" sank in four minutes and the "Yorktown" rolled over and went down early the next morning.

Losses in the Battle.—Japan lost four of its best carriers, and one powerful cruiser with a second cruiser seriously damaged, but its most serious loss was in carrier pilots. Never again during the war did Japan send such able fighters into aerial combat. About 250 Japanese carrier planes were lost. The U.S. lost the carrier "Yorktown" and one destroyer. About 50 carrier pilots and 40 marine, navy and army pilots from Midway were lost together with about 50 aircrewmen. The number of carrier- and shore-based aircraft lost totaled 151.

Results of the Battle.—Midway was not captured and the Japanese occupation force turned back on the orders from Admiral Yamarnoto without attempting a landing. The loss ratio in ships was about 4 to 1 against the Japanese. Japan lost the great striking power it had possessed in carrier force, and a potential threat which had influenced all U.S. strategic planning was reduced to manageable proportions. This battle restored the balance of naval power. marking the turning point in the Pacific war.

See also WORLD WAR II: The War in the Pacific.

MIDWAY ISLANDS, a circular atoll in the central Pacific ocean at the western end of the Hawaiian chain about 1,300 mi. N.W. of Honolulu, and just east of the international date line. (Lat. 28° 13′ N., long. 177° 23′ W.) About 6 mi. in diameter, the atoll encloses two islands, Eastern and Sand ($1\frac{1}{4}$ and $1\frac{3}{4}$ mi. long respectively). Area of Midway Islands is 2 sq mi. Pop. (1950) 416.

First reported and claimed for the U.S. in 1859 by Capt. N. C. Brooks, the atoll was called first Middlebrooks and then Brooks. The name Midway dates from its formal annexation by the U.S. in 1867. The same year a coal depot was established there for transpacific steamers, but was never used. In 1903, Pres. Theodore Roosevelt placed Midway under the control of the U.S. navy department, and Sand Island became a station of the Hawaii-Luzon submarine cable in 1905. Transpacific aviation gave Midway new importance in 1936 when Pan American Airways made the island a regular stop on its San Francisco-Manila run.

In 1940 the U.S. navy began work on a major air and submarine base at Midway. The atoll was shelled by Japanese destroyers on Dec. 7, 1941, but when coast defense guns returned their fire they retired after inflicting minor damage. Midway was the objective of a major Japanese striking force in June 1942, but the atoll itself sufferedonly one air raid, on June 4. The whole battle (June 3–6), characterized mainly by attack of carrier-based planes on one another and on ships, marked the turning point of the Pacific war (see WORLD WAR II: The *War* in the Pacific).

After the war, the development of long-range planes reduced Midway's importance as a commercial air base, and Pan American eliminated stops there in 1950. That year also saw the reduction of Midway's U.S. navy establishment to a housekeeping force. When Hawaii became a state in 1959 Midway was not included.

(J. H. K.)

MIDWEST, THE (U.S. area): see MIDDLE WEST, THE.

MIDWIFERY: see OBSTETRICS.

MIDWIFE TOAD, a European member of the frog and toad group with remarkable breeding habits. The common form of central Europe, Alytes *obstetricans*, is about two inches in length, of dull grayish coloration and plump form, with warty skin and large eyes. Although toadlike, it belongs to a quite distinct family. Discoglossidae. It inhabits most of western Europe. A second species, *A. cisternasii*, occurs also in Spain and Portugal.

JOHN MARKHAM

MIDWIFE TOAD (ALYTES OBSTETRICANS) OF EUROPE

The midwife toad is nocturnal and slow in its movements. It is thoroughly terrestrial. Toward evening the males reveal their presence by a clear whistling note. The breeding season lasts throughout spring and summer, and the female spawns two, three or even four times in the year. Mating takes place on land; the males seizes the female round the waist, and stimulates her cloaca1 region with his toes until the eggs are forcibly expelled. The eggs are large and yellow, and produced in two rosarylike strings, as if strung together by elastic filaments, continuous with the outer gelatinous capsules. While the eggs are being extruded, the male positions himself and discharges milt (sperm-containing fluid) over them to effect fertilization. This having been accomplished, the male twists the egg strings round his legs and returns to his usual retreat, resorting to a short immersion in the water during exceptionally dry nights. When the time for hatching has come, after about three weeks, the male enters the water; the larvae, measuring slightly over a half inch, bite their way through their tough envelope, which is not abandoned by the father until all the young are liberated. The tadpoles grow to a large size before metamorphosis. See also AMPHIBIA.

MIE, prefecture (ken) of Japan facing Ise bay, was formed from the provinces of Ise, Iga, Shima, and two counties of Kii after the Restoration of 1868. Area 2,226 sq.mi., pop. (1955) 1,485,582. The most sacred Shinto shrine of Japan, the Grand Shrine is located in Mie. Shima and Kumano National parks are centres of the tourist industry. Important products include cotton and woolen textiles, Bankoyaki porcelain, lumber, cement, glass, lobster and shrimp, and dairy produce. The prefecture is the chief centre of cultured pearl production. Tsu (*q.v.*) on the

west shore of Ise bay is the prefectural capital. (C. A. MR.)

MIERES, a town of northern Spain, in the province of Oviedo, 12 mi. S.E. of Oviedo by rail, on the Caudal river. a tributary of the Nalon. Pop. (1950) 58,768 (mun.). Mieres is the chief town of a mountainous, fertile and well-wooded region in which coal, iron and copper are extensively mined and sulfur and cinnabar are obtained in smaller quantities. The town contains large iron foundries and chemical works, and has an active trade in fruit, cider, timber and livestock.

MIEREVELT (MIEREVELD), **MICHIEL JANSZOON VAN** (1567–1641), Dutch portrait painter, who was patronized by the royalty of many countries, was born at Delft on May 1, 1567, the son of a goldsmith, who apprenticed him to the copperplate engraver J. Wierix. Antonio van Montfort (Blockland), who had seen and admired two of Mierevelt's early engravings, "Christ and the Samaritan" and "Judith and Holofernes," invited him to enter his school at Utrecht. He remained at Utrecht till the death of Montfort (1583), and then settled at Delft. Devoting himself first to still life, Mierevelt eventually took up portraiture. and the many commissions entrusted to him necessitated the employment of numerous assistants, by whom hundreds of portraits were turned out in factory fashion. The works that are certainly his are remarkable for sincerity, severe drawing and harmonious colour, but comparatively few of the 2,000 or more portraits that bear his name are wholly his handiwork. He went frequently to The Hague, where he entered the Guild of St. Luke in 1625. Mierevelt also executed some mythological pieces. Many of his portraits were reproduced by Dutch engravers. He died at Delft on June 27, 1641.

The Rijksmuseum in Amsterdam. Neth., has the richest collection of Mierevelt's works, chief of them being portraits of princes of the house of Orange. Other portraits by him are in The Hague museum, the town hall of Delft, and in nearly all the leading continental galleries; and in the museums of fine arts of Richmond, Va., and Boston, Mass.

MIERIS, FRANS VAN, THE ELDER (1635–1681), Dutch painter, son of Jan van Mieris and chief member of a family of Leyden painters, was born, according to Arnold Houbraken, at Leyden on April 16, 1635. He was married there in 1657, elected a member of the guild on May 14, 1658, and died at Leyden on March 12, 1681.

Mieris took service with Abraham Torenvliet, a glazier who kept a school of design. In his father's jewelry shop he became familiar with the ways and dress of people of distinction. His eye was fascinated in turn by the sheen of jewelry and stained glass; and, though he soon gave up the teaching of Torenvliet for that of Gerard Dou and Abraham van den Tempel, he acquired a manner that had more of the finish of the exquisites of the Dutch school than of the breadth of the disciples of Rembrandt. He seldom chose panels of which the size exceeded 12 to 15 in.. and never ventured to design figures as large as life. Characteristic of his art in its minute proportions is a shiny brightness and metallic polish. The subjects he treated best are those in which he illustrated the habits or actions of the wealthier classes; but he sometimes succeeded in homely incidents and in portrait, and he occasionally ventured on allegory. He often rivaled Ter Borch in the faithful rendering of rich and highly coloured woven tissues. In the form of his composition, which sometimes represents the framework of a window enlivened with greenery, and adorned with bas-reliefs with figures to the waist, his model is Gerard Dou.

Mieris received valuable commissions from Archduke Leopold, the elector-palatine, and Cosimo III, grand duke of Tuscany. His practice was large and lucrative. If there is a difference between the painter's earlier and later work, it is that the former was clearer and more delicate in flesh, while the latter was often darker and more livid in the shadows.

One of his best-known pieces, a party of ladies and gentlemen at an oyster luncheon, in the Hermitage at Leningrad, U.S.S.R., bears the date of 1659. Another beautiful example, the "Doctor's Visit," in the Kunsthistorisches museum, Vienna, Aus., is dated 1656. In the same gallery is one of his masterpieces. "The Cavalier in a Store." The National gallery, London, has his "Lady With a Parrot," and a self-portrait is in the Detroit (Mich.) Institute of Art.

MIES VAN DER ROHE, LUDWIG (1886–), a dominant figure in the architectural revolution of the 20th century, was born in Aachen, Ger., on March 27, 1886. He had no formal professional education but acquired valuable experience in the Berlin office of Bruno Paul. noted designer, and with Peter Behrens, Germany's outstanding industrial architect, in whose office Walter Gropius and Le Corbusier also worked. After World War I Mies developed a series of radically new projects for tall office buildings and houses with great clarity of structure, daring use of steel and glass and an exquisite feeling for space, proportion and materials. They became points of reference for all modern architects. His Barcelona pavilion, 1929, could well be called a contemporary Parthenon. From 1930 to 1933 Mies was director of the Bauhaus in Berlin, but in 1938 he left Germany to become head of the department of architecture at the Illinois Institute of Technology, Chicago, where he planned the campus layout and buildings. Probably the most coherent institutional group in the United States, it includes Crown hall, a large clear-span steel hall with glass walls that was a new departure in academic buildings. Mies van der Rohe completed in 1951, on the lake front in Chicago, the steel and glass apartment towers that were a dramatic crystallization of his objective architecture based on technology. They received world-uide attention. (DL. B.)

MIFFLIN, THOMAS (1744–1800), American soldier and politician, was born in Philadelphia, Pa., on Jan. 10, 1744. Mifflin was a member of the Pennsylvania house of representatives in 1772–75, and was sent as a delegate to the first Continental Congress. He entered the continental service in June 1775, was appointed quartermaster general in August, became a brigadier general in May 1776 and major general in Feb. 1777. In the autumn of 1777 Mifflin was a leader of the Conway cabal which attempted to replace Gen. George Washington by Horatio Gates. The faction gained sufficient power to secure the appointment of Gates as head and of Mifflin as a member of the board of war.

In March 1778 Nathanael Greene superseded Mifflin as quartermaster general; in October Mifflin was removed from the board of war; and in Feb. 1779 he resigned as major general. He was a delegate in congress in 1783 and in November of the same year was made president of that body. He was speaker of the Pennsylvania general assembly (1785–88), president of the state supreme executive council (1788–90) and the first governor of the state (1790–99).

Mifflin died at Lancaster, Pa., on Jan. 20, 1800.

MIGNARD, PIERRE (1610–1695), French painter, called —to distinguish him from his brother Nicholas—LE ROMAIN, was born at Troyes in 1610, of a family of artists. In 1630 he left the studio of Simon Vouet for Italy, where he spent 22 years, and made a reputation that brought him a summons to Paris. Successful with his portrait of the king, and in favour with the court, Mignard pitted himself against Charles le Brun, declining to enter the academy of which Le Brun was the head and organizing the opposition to its authority. The history of this struggle is bound up with that between the old guilds of France and the new body that Jean Baptiste Colbert, for political reasons, was determined to support. Shut out, in spite of the deserved success of his decorations of the cupola of Val de Grâce (1664), from any great share in those public works the control of which was the attribute of the new academy, Mignard was chiefly active in portraiture. Vicomte de Turenne, Molière, Jacques Bossuet, the marquise de Maintenon (Louvre), the duchesse de la Vallière, the marquise de Sévigné, the marquise de Montespan, the marquise de Seiguelay (National gallery, London)—all the beauties and celebrities of his day sat to him. His readiness and skill, his happy instinct for grace of arrangement, atoned for want of originality and real power.

With the death of Le Brun (1690) the situation changed; Mignard deserted his allies and succeeded to all the posts held by his opponent. These late honours he did not long enjoy; in 1695 he died u hile about to commence work on the cupola of the Invalides.

His best compositions were engraved by Gérard Audran, Gérard Edelinck, Antoine Masson, François de Poilly, etc.

MIGNE, JACQUES PAUL (1800–1875), French Roman Catholic priest, editor and publisher of theological literature! was born at St. Flour, Cantal, on Oct. 25, 1800. He studied theology at Orléans, was ordained priest in 1824 and placed in charge of the parish of Puiseaux, in the diocese of Orléans. In 1833 he went to Paris and started *L'Univers religieux.* Three years later at Petit Montrouge near Paris he opened the great publishing house mhich brought out in rapid succession numerous religious works at popular prices. Among the best known of these are: *Scripturae sacrae cursus completus,* and *Theologiae cursus* (each in 28 vol., 1840–4jj; *Collection des auteurs sacrés* (100 vol., 1846–48); and *Encyclopédie tlze'ologique* (171 vol., 1844–66). The most noteworthy by far, however, is the *Patrologiae cursus completus,* superintended by the learned Benedictine J. B. Pitra and comprising: *Patrologia Latina,* including the works of Latin ecclesiastical writers up to the time of Innocent III (217 vol., 1844–55; 2nd ed., 1878 ff.); and *Patrologia Graeca,* including Greek writers to 1439 (162 vol., Greek text and Latin translation, 1857–66). The vast scope of the *Petrologiae cursus completus* leaves it still unique and valuable, where other editions of special works do not exist. The indexes in three volumes are arranged so that any reference in the patristic writings may be found easily.

In Feb. 1868 a great fire destroyed the whole of Migne's printing premises, but he established a new house in Paris, which was purchased in 1876 by the publishers Garnier Frères. He died in Paris on Oct. 2j, 1875.

MIGNET, FRANÇOIS AUGUSTE MARIE (1796–1884), French historian. was born at Aix-en-Provence on May 8. 1796, and died in Paris on March 24. 1884. François studied at Avignon in the *lycée* where he was afterward professor (1815); he returned to Aix to study law, and in 1818 was called to the bar.

His *Essai sur les Institutions de Saint Louis* was crowned in 1821 by the Académie des Inscriptions et Belles Lettres. He then went to Paris, where he was soon joined by his friend and compatriot, Adolphe Thiers, the future president of the French republic. He became a member of the staff of the *Cozrrrier Français,* which carried on a fierce warfare against the Restoration. In 1830 he founded the *National* with Thiers and Armand Carrel. He then became director of the archives at the foreign office, where he stayed till the revolution of 1848, when he was dismissed. He had been elected a member of the Académie des Sciences Morales et Politiques, re-established in 1832, and in 1837 was made the permanent secretary; he was also elected a member of the Académie Française in 1836.

With the exception of his *Histoire de la révolution française* (1824), a political manifesto, all his early works refer to the middle ages, For a long time he was occupied with a history of the Reformation, but only one part of it, dealing with the Reformation at Geneva, was published. His *Histoire de Marie Stuart* (2 vol., 1851) is well worth reading; the author made liberal use of some important unpublished documents, taken for the greater part from the archives of Simancas, Spain. He devoted some volumes to a history of Spain; which had a well-deserved success—*Charles-Quint, son abdication, son séjour, et sa mort au monastère de Yuste* (1854); *Antonio Perez et Philippe II* (1845); and *Histoire de la rivalité de François I et de Charles Quint* (187j). At the same time he had been commissioned to publish the diplomatic acts relating to the War of the Spanish Succession for the *Collection des documents inédits;* only four volumes of these *Négociations* were published (1836–42), and they do not go further than the peace of Nijmwegen; but the introduction is celebrated, and Mignet reprinted it in his *Mémoires historiques.*

MIGNON, ABRAHAM (1640–1697), Dutch painter of still life, was born at Frankfurt. His father. a merchant. placed him under the still-life painter Jacob Merrel. by whom he was taken to Holland about 1660. He then worked under Jan de Heem at Utrecht, where in 1675 he married the daughter of the painter Cornelis Willaerts. Sibylle Merian (1647–1717). daughter of the engraver Matthäus Merian, became his pupil and achieved distinction as a flower painter.

He died at Wetzlar or at Frankfurt in 1697.

Mignon devoted himself almost exclusively to flowers, fruit, birds and other "still life," though at times he also attempted portraiture. His flower pieces are marked by careful finish and delicate handling. His favourite scheme was to introduce roses against a dark background.

MIGNONETTE or MIGNONNETTE (*i.e.,* "little darling"), the name given to a popular garden flower, *Reseda odorata* of the mignonette family (Resedaceae), highly esteemed for its delicately fragrant perfume. The mignonette is generally regarded as an annual and is a plant of diffuse reclining twiggy habit. scarcely reaching a foot in height, clothed with somewhat blunt lanceolate entire or three-lobed leaves, and bearing long spikes—technically racemes—of rather insignificant floners at the ends of the numerous branches and branchlets. The plant thus naturally assumes the form of a low dense mass of soft green foliage studded over freely with the racemes of flowers, the latter unobtrusive and likely to be overlooked but for their diffused fragrance It is a native of Egypt and was sent to England from Paris in 1742; ten years later it appears to have been sent from Leiden to Chelsea. The small six-petaled flowers are somewhat curious in structure: the two upper petals are larger, concave and furnished at the back with a tuft of club-shaped filaments, which gives them the appearance of being deeply cut, while the two lowest petals are much smaller and undivided; the most conspicuous part consists of the anthers, which are numerous and brownish-red, giving the colour to the inflorescence. Though practically an annual, as noted above. since it flowers abundantly the first season and is destroyed by the autumnal frosts. and though recorded as being annual in its native habitat by René Desfontaines in the *Flora Atlantica,* the mignonette, like many other plants treated as annuals, will continue to grow on if kept in a suitable temperature.

Mignonette is not a very useful decorative plant, being grown almost exclusively for its fragrance. This, however, is fleeting, especially after picking. Better than the typical plant in prolonging fragrance are the varieties Machet, Golden Machet, Golden Sunset and Red Monarch.

In classifying the odours given off by plants, F. A. Hampton ranks the mignonette in the class of which he makes the violet the type and identifies the origin of the scent as irone.

The outdoor cultivation of mignonette as an annual is common in the United States and England, and demands arose to produce its blooms throughout the year. As the plant is not frost hardy its winter culture is confined to the cool greenhouse and millions of flowers are so grown in the United States and England. The simplest greenhouse method is to sow seeds in July, another lot in August and a final lot in September, for a succession of bloom. The house must be kept shaded and at a temperature of about 6j°. The plants need frequent watering and must not dry out.

The genus *Reseda* contains about 65 species, natives of Europe, Africa and west Asia. *R. luteola,* commonly called dyer's rocket or weld, yields a yellow dye. *R. alba* is a fine biennial about two feet high. nith erect spikes of whitish flowers. Both are naturalized in Sorth America. (N. TR.)

MIGNONS, LES. In a general sense the French word *mignon* means "favourite," but the people of Paris used it in a special sense to designate the favourites of Henry III of France, frivolous and fashionable young men, to whom public malignity attributed dissolute morals. The best known of the *mignons* were the dukes of Joyeuse and of Epernon.

MIGRAINE. Hemicrania, migraine, megrim, brow ague and sick headache are various terms employed to describe this disorder. An attack may come on suddenly, but, in general, begins with a dull aching pain in the brow or temple, which steadily increases in severity and extent, but remains usually limited to one side of the head. It attains at times an extreme degree of violence, and is aggravated by movement, loud noises or bright light. There is more or less nausea, and when the attack reaches its height vomiting may occur, after which relief comes, especially if sleep supervenes. An attack of this kind may last for a few hours or for a whole day, and after it is over the patient feels

comparatively well. It may recur periodically, or, as is more common, at irregular intervals. During the paroxysms, or even preceding them, sensory disturbances may be experienced, especially affections of vision. such as ocular spectra, hemiopia, diplopia. etc. *(See* NERVOUS SYSTEM.)

MIGRATION. Migration is an outstanding feature of human life. Moving from place to place in search of means of subsistence or to escape a stronger foe, men from times immemorial have spread over the greater part of the earth's surface. Within recorded history human migrations have transformed the entire aspect of lands and continents and the racial, ethnic and linguistic composition of their inhabitants. In the course of 400 years—a very short period in human history—the Americas. Australia and Oceania, the northern half of Asia and parts of Africa became white man's .lands. The map of Europe, too, is the product of many migrations—not only of the so-called "great people's migration" which accompanied the fall of Rome. Even long afterward—as late as A.D. goo—there was not one German in Berlin, not one Russian in Moscow, nor one Hungarian in Budapest; Madrid was a Moorish settlement; no Turks lived in Ankara, and the few in what is now Istanbul were slaves and mercenaries.

To roam in search of food is the first reaction of man—as of beasts—to food scarcity. People in flight from famine-stricken areas were a constant feature of life in medieval Europe. In China, frequent crop failures and floods mere still forcing large numbers of people to abandon their homes and become vagrants at mid-20th century. The Russian famines which followed the Revolution and Civil War (1921–22) and collectivization (1932) rivaled the great catastrophes of former times, with millions of peasants fleeing their barren fields and thousands dying by the wayside. Even in the United States as late as 1934–35, ruined farmers from the dust bowl of the great plains fled in their automobiles to California. It is not easy to allocate to nature and to human hands their proper share in producing these famines. Destruction of means of subsistence by wars and revolutions has been a usual cause of emigration. A gradual exhaustion of soil and of other resources is equally a factor. Loss of markets and resulting unemployment play a similar role in industrial countries of Europe.

Migratory movements are essentially the result of differential population pressure, to use the terminology of Warren S. Thompson *(Danger Spots in World Population,* 1929). They are expressions of a trend toward equalization of economic density, which is the ratio between the number of inhabitants and the resources at their disposal. Migratory tendencies of a population may be stimulated when the available means of subsistence have been reduced. in consequence of worsened climate or other calamities. Still more prominent has been the part played by the growth of population itself. Legends of peoples of all continents have preserved the memory of their ancestors having been compelled to leave their original home because the land became too confined for them. For the greater part of the long history of man he has been merely a collector of food or a hunter. Where game was plentiful or wild vegetable food abundant he could live in moderate sized communities; but normally any country would be very sparsely inhabited, and there would be a necessity for migration when the population grew too numerous for the food supply. The size of a cattle-breeding tribe is limited by the grassland available for its herd. If the limit is surpassed, the tribe must split up to search for new pastures, as described in the Bible's story of the separation of Abraham and Lot: "The land was not able to bear them, that they might dwell together" (Gen. xiii, 6).

With the evolution of agriculture out of the earlier mixed economy a decisive step was taken toward a settled civilization. The old-time agriculturist—such as, for instance, the European medieval peasant—was usually considered the incarnation of immobility. However, research proved that this traditional image was a myth. Craving for land kept the peasant moving. Lack of manpower and equipment needed in the struggle against hostile natural environment accounts for the paradox of scarce cultivable areas amidst empty continents. "Culture must have been born not where there was the richest land, but where it was the easiest land to work . . . a soil in which a poor and crude agriculture could be started with the inefficient tools and weak social organization of a neolithic people." This statement made by Owen Lattimore *(Inner Asian Frontiers* of *China,* Amer. Geo. Soc., 1940) with regard to China must be applied to all agricultural origins. The American Indians first cultivated inferior soils because they were easier to work. The culture of Egypt originated not in the richest terrain of the Nile delta. but far upstream. It is also assumed that in the whole Mediterranean area cultivation and settlement began from the steppe and semisteppe, though its woods were relatively easy to conquer. In the rest of Europe, up to the 11th century, not man but nature determined the habitable and cultivable areas ahich consisted of some scattered glades in an immense forest. of a few dry places surrounded by deep marshes. More than half the territory of France. two-thirds of the Netherlands and Germany and four-fifths of England were untilled. In spite of improved metal implements, heavy timber and jungles continued to deter the soil-tiller. There were not enough hands to master unfriendly nature, because surplus populations, as soon as they sprang up, were exterminated in the never ceasing feudal wars.

Indeed, not every increase of the number of inhabitants means an aggravated economic density and stronger requirement for migratory outlets. even though up to contemporary times population growth usually has acted as a very strong factor in migratory trends. Up to a certain limit a larger population is a prerequisite for fuller development of resources and rationalized production. Much effort has been spent to determine this limit—the so-called optimum population—beyond which the law of diminishing returns would force down the standard of living. Actually the flow of migrants has been determined by the desire for a place offering better living opportunities and the possibility of reaching it. Economic considerations are most often decisive, but they are not the only ones. "Better living conditions" may also consist in greater security from aggression; many a poor country attracted migrants by its protected situation. The most varied ethnic groups which have been found in mountains of difficult access—such as the Pamir and the Caucasus—are fragments of hunted peoples. Venice was peopled by refugees who in the 5th to 7th centuries sought a shelter from invading barbarians in the impregnable shallows and mud banks of the lagoons. The medieval walled cities attracted people as asylums in the constant state of war even before the cities had become centres of industry and commerce.

Migrations also have taken place to gain freedom from social, political or religious bondage, like the exodus of the Hebrew bondmen from Egypt, the voyage of the "Mayflower" and the migration of the Flemings and Huguenots into Britain. Religious enthusiasm may stimulate shifts of populations as seen in the histories of Buddhism, Christianity and Islam. However, even in such movements ostensibly directed by idealistic purposes the power of materialistic motives should not be underestimated. The eruption of the Arabs after their conversion to Islam in the 7th century was long considered as a pattern of a holy war, yet modern critical scholars rather accept the point of view of an Arab poet: "No, not for Paradise didst thou the nomad life forsake; rather, I believe, it was thy yearning after bread and dates." In other instances nhere no economic reasons could be attributed to the migrants, greed was the motive of those nho forced them to move. The Huguenots who fled from France under Louis XIV to profess their Protestant faith in freedom constituted the most prosperous part of the nation, but it was precisely their wealth that lured their persecutors. Similarly the German Jews would have no economic reasons for leaving their country. but expropriation of their property and economic positions made Hitler's appeal tempting to German masses.

As a rule, population changes caused by migrations are not the result of sudden mass influxes, but of slow and gradual displacements. The British geographer E. G. Ravenstein. who was first to advance this thesis with regard to the special case of internal population shifts in England, showed that short-distance migra-

tions are the rule; long-journey migrants are the exception and probably do not constitute a quarter of all migrants. In a fuller development of this general proposition it was observed by S. A. Stouffer that the distance covered by the migrant is influenced by the opportunities which he meets on the way. Progress in transportation greatly widened the range of migrations. However, the censuses taken in 1925 in Germany and in 1940 in the United States. which for the first time collected information on past residence at a fixed date, revealed the persistent predominance of short-distance moves. In the United States every eighth person had made a change of residence in a j-year period (in Germany every fifth in 11 years), but nearly two-thirds of them had moved within the same state (or province in Germany) and of the rest almost one half had gone to a contiguous state.

The combined effect of short-distance migrations results in great population shifts. Ravenstein called it the fundamental "law of migrations." As a result of migrations which usually cover only a short distance, "there takes place a universal shifting or displacement of the population which produces 'currents of migration' setting in the direction of the great centres of commerce and industry which absorb the migrants. . . . The inhabitants of the country immediately surrounding a town of rapid growth, flon into it; and gaps thus left in the rural population are filled up by migrants from more remote districts, until the attractive force of one of our rapidly growing cities makes its influence felt, step by step, to the most remote corner of the Kingdom." Thus, in the last quarter of the 18th century and during the 19th century, a series of short-distance centripetal migratory movements in England caused a continuous population displacement from the south and the east in the direction of the new industrial centres of the noith and the northwest. A displacement by short successive movements recurred in the interwar period, but this time the current went southeastnard.

This approach may be applied on a larger scale to all kinds of migration, past and present. It is the combined force of migratory movements, great and small, which produces the great shifts of population. The accumulation of results manifests itself in time and in space. The movements of peoples which are sufficiently dramatic for the ordinary historian to record are often of less importance than the quiet, steady drift of a population from one area into another, as, for example, the emigration from Europe to America in modern times. The process of migration constantly breaks up existing entities and causes the formation of new groups. The migratory movement is at once perpetual, partial and universal. It never ceases, it affects every people, but at a given moment it mostly sets in motion only a small part of each population group; hence the illusion of immobility. In actuality, there is never a moment of immobility for any people, because no migration remains isolated.

The encounter of a tribe, moving in search of food, with another tribe meant conflict and the exodus of the loser. Human masses driven by the scourge of war—such as the Celts of Britain who in the 5th and 6th centuries took refuge from the Anglo-Saxon invasion in the peninsula subsequently called Brittany, or the Anglo-Saxons who were pushed across the Tweed by the Norman conquest of 1066—are a common feature of history up to the 18th century. when protection of the civilian population generally became the rule. In the mars of the 19th century. emigration was caused rather by deteriorated economic and moral conditions in the conquered area. When. in 1871, Alsace-Lorraine was annexed by Germany, nearly 500,000 of its inhabitants opted for France and accordingly had to leave their homes. As a matter of fact they were driven away by the spectre of the imminent Germanization. The gap produced by their exodus was filled up through an influx of officials and workers from inner Germany. However. the 20th century brought Europe back to barbarian times when during World War II panic-stricken civilian populations fled before the advancing Germans.

The interconnection of various migratory movements tends to combine them into great migratory currents. Peaceful migration, internal and international, wartime invasion. political emigration and colonization contribute to the formation of the migratory current which sweeps across land and sea, and gives a characteristic shape to a historical period. Migratory currents follow the line of least resistance. But the latter depends not only on groups and nations involved, for migrations have also been greatly influenced in their course by geographical conditions, whether furthering a peaceful traffic or an armed advance, or impeding them. Mountain ranges. forests, jungles, swamps and deserts have deflected a migratory current both as topographic barriers and even more as providing only poor means of subsistence. Rivers have often constituted "natural frontiers"; on the other hand, the advantages of river navigation—up to recent times the best routes for traffic—and the attraction of river valleys greatly contributed in directing the expansion of peoples along rivers. However, the dependence of migrations on natural conditions is a relative one; it changes with the technological progress and according to peoples' specific abilities.

The sea has played the double role of the most formidable barrier for migratory currents and a far-ranging highway. It was a long time from the use of floating logs and rafts to the first seaworthy vessels. Inhabitants of the coast who had developed seafaring abilities early could master mediterranean seas and even advance into the ocean from island to island.

MEDIEVAL MIGRATIONS

The period known as the middle ages—about 1,000 years long—opened and closed with increasingly active migratory currents which flowed into the Mediterranean area and destroyed, respectively, the western Roman and the eastern Roman or Byzantine empire. There is a persistent controversy about the extent to which Rome's fall was attributable to barbarian invasion and to internal factors. The view that the external force only dealt the finishing blow to the moribund empire apparently was strengthened by modern research showing how small were the numbers of the Germans who, in the 5th century, invaded Roman territories in closed tribal formations. According to F. Lot, no German tribe within the empire numbered more than 100,000 men, women and children. Usually the contingents were much smaller. However, this does not affect the significance of the continuous influx from the east and the north which had started many centuries before the collapse. The expansion of Rome's frontiers was accompanied by the establishment of Roman colonies in the conquered countries. but even more by a flood of slaves brought in from these countries. Their number kept growing, while the Roman stock was spent in military service. When Rome shifted to a defensive warfare, the influx into the empire continued, though its character changed. The Germans were first serfs, then soldiers of the Roman empire who as early as the 3rd century A.D. had risen to high commands. The "great people's migration" proceeded in a long succession of German tribes, moving and pressing one against another, under the imperative thrust of the nomad Huns who themselves were expelled from Mongolia by other nomads.

In the course of the following centuries the steppes extending from central Asia to the confines of Mongolia continued to be the breeding ground of nomad eruptions. Nomads never could compete in numbers with sedentary nations, but their way of life permitted rapid movement and mustering of relatively large forces. Looking for new grazing grounds and attracted by the relative wealth of sedentary nations, or themselves pushed by primitive tribes of Manchuria and Siberia, the Asian nomads time and again brought into movement long series of peoples, both nomad and sedentary. Their greatest lure was neighbouring China—the outstanding centre of sedentary civilization. The attraction of the countries of the middle east was only secondary, and in still lesser degree was the attraction of distant and poor Europe. However. China became accessible mainly in times of civil war or when it neglected the northern frontiers and its population expanded to the south. In other times the restored strength of the Celestial empire expanded its rule into the steppe and in this way started new waves of moving populations.

Another, rather sporadic, point of departure of migratory currents was Arabia. The last and greatest outburst of Arabs

started in the 7th century, after they were united under the banner of the Islam. The Arab conquest in the west comprised Egypt, the rest of North Africa and Spain; in the east. Syria, Persia and the bordering regions. In both directions the Arabs swept along mith them the vanquished foe — Berbers and Iranians who formed the majority of the Arab armies. Furthermore, the Arab stream set in motion populations not touched by the conquest, such as the Hungarians. The reason for the Hungarian emigration from Asia is given by Louis Halphen as follows: "We may believe that the great ethnic turmoil which took place in Turkestan in the 8th century, after the Arab conquest of Bactria and Sogdiana did not fail to influence their exodus" (Les barbares, 1926).

In the west, too, the Arab conquest had an indirect continuation. The seizure of the western Mediterranean area by Moslems transformed the economic basis of France and predetermined the route of evolution and expansion of the Frankish monarchy. As Henri Pirenne said, without Mohammed, no Charlemagne. During Charlemagne's go-year war against the heathen Saxons there was a continuous flight of the latter to Scandinavia. It was conjectured by Gibbon and Toynbee that this provoked the Norman (Scandinavian) expeditions which culminated in the Norman establishment in northern France (Normandy). But if so. it rather would indicate the last contributing cause. whereas the deeper reasons lay in a relative overpopulation of Scandinavia, with its scarcity of land free from heavy woods.

In the 10th century a strong migratory current originated in Mongolia. The nomad people of Kitan gained control over Mongolia and conquered northern China during a period when the Chinese were completing the conquest and settlement of the southern marches. First, the establishment of the Kitan power and then China's recovering strength under the Sung dynasty "forced the (Turkish) nomads of Mongolia to flow off to the west and to expand at the other end of Asia, taking advantage of the decline of the Abbasid Empire" (*i.e.*, Arab caliphat). (Halphen, *op.cit.*) They advanced. wave after Nave, until finally the increasing Turkish immigration into the caliphat was transformed under the Seljuks into Turkish domination. The Turkish tribesmen who kept entering from the northeastern marches were sent farther to the west to conquer Asia Minor.

A European movement of colonization to the east continued until the 14th century in spite of the new torrent which rolled in from Asia. This was the greatest Mongol eruption — under Jenghiz Khan and his successors—which in the 13th century overflowed China, the middle east and eastern Europe up to Bohemia and Hungary. The Mongol flood soon receded from Europe beyond Russia, and the depopulation it had caused favoured European migration to the east. The Russians, who had been evicted by the forerunners of the Mongols from the fertile lands of the south, now had to abandon them completely and to retreat to the upper Volga basin, pushing back the forest and the Finnish population.

The Mongol invasion was a conquest rather than a migration, but it put in movement all the peoples of the steppe. In particular. the streams to the west consisted mainly of various Turkish nomads subdued by the Mongols and carried along with them. Among the other Turkish, tribes pushed westward by the conquerors were those which subsequently became known as the Ottoman Turks. In the 14th century these tribes started to infiltrate the Balkans from Asia Minor out. partly in the service of rival Greek and Slavic princes, partly as conquerors. This movement culminated in 1453 in the capture of Constantinople. which was followed by an expansion stopped only before Vienna. The lasting Turkish pressure mas not only an essential factor in the political life of Europe; it deeply affected the migratory trends on the European continent. A connection can even be assumed between the Turkish invasion and the discovery of America. The Ottoman conquest barred the old ways of commerce with India and forced Europeans to seek new routes across the ocean. And the Greek refugees who streamed from the moribund Byzantine empire to Italy helped to lay the ideological and technological bases for bold ventures into the mysterious seas.

MIGRATIONS IN MODERN TIMES

The Ottoman conquest was the last Asian mass invasion of Europe. The Manchu conquest of Mongolia and China in the first half of the 17th century, again thrusting one nomad people against another, started a mass migration of western Mongols or Kalmyks to the nest. However, this new Mongol invasion of some 100.000 men, women and children, which continued for a century in a series of waves and penetrated as far as the lower Volga, lost its aggressive strength in breaking against the power of Russia. Siberia, conquered in the 16th and 17th centuries, was firmly held by Russia; but its colonization proceeded slowly. In 1796–97 the Russian population of Siberia was estimated at 576,000. Up to 1880, deportation supplied more than half the migrants. The movement assumed the character of peasant mass colonization only after the abolition of serfdom in Russia (1861) and even more after the opening of the trans-Siberian railway (1896). For the period 1801–1914 the outflow of population from European into Asiatic Russia may be estimated at 7,500,000, of whom about 4,000,000 migrated in the last decade before World War I. Under the soviet government agricultural colonization was increasingly replaced by migration for employment in industry. The total of migrants to the eastern territories of the U.S.S.R., not including the unknown millions of deportees in concentration camps, amounted to 6.000.000. Still larger was the migration from rural areas of the U.S.S.R. to the cities, which in 1926–39 amounted to 23,000,000.

The 14,000,000 migrants who crossed the Urals before World War II represent one of the greatest population streams of all times. Still larger was the European overseas emigration which brought more than 60,000,000 Europeans to other continents. The great geographical discoveries opened to Europe vast continents containing unlimited natural resources. However. European nations made use of these possibilities slowly. Colonies. including the greatest in the Americas, attracted mainly adventurers, merchants and persecuted groups; others went overseas chiefly against their mill as deportees. Before the 19th century enslaved Africans formed the majority of newcomers who crossed the Atlantic. The total number of slaves shipped from Africa for the western hemisphere was variously estimated at 10,000,000 or at a still higher figure. Emigrants to the Americas from Spain, which had a head start on the other European nations, totaled no more than a few hundred thousand up to 1790. One estimate of 200.000 German emigrants to the new world by about the same date is certainly exaggerated. Approximately 25.000 emigrants left France for Canada; by 1760, the date of the British conquest, Canada's population of European stock numbered 70,000. The white population of all other French colonies on the eve of the French Revolution has been calculated at 74,000.

Still less numerous was emigration from the other countries of continental Europe. Not that there was lack of human material; although Europe around 1750 had one-fourth its population of two centuries later, surplus populations constantly created by economic and political conditions became vagrants or were absorbed by the armies and by continental migrations (*i.e.* migrations over land frontiers). Certainly, the whole social structure, the land tenure system and the guild organization of crafts and commerce. hindered men from making a living in a foreign country. There were, however, particularly in Prussia. Austria-Hungary and Russia, great projects of internal colonization and manufacturing, to which foreigners were invited from the more advanced western countries. Thus, the main migratory current in this period proceeded by stages to the east; overseas emigration was a secondary branch, restricted by lack of capital and technical facilities. Before the 19th century the only overseas mass emigration originated in the British Isles. The movement began slowly in the 16th century. The first British settlements overseas date from the 17th century. when colonies were established in Virginia, Massachusetts, Bermuda and Barbados. In the 17th century about 250,000 left the British Isles for the new world. With the termination of land confiscation and distribution to English masters in Ireland. American colonies became the main field of expansion. Economic and technical progress enabled England to

perform this task. During the 18th century the total of British emigrants amounted to about 1,500,000.

The great flow of European overseas emigrants began in the 1830s, when their number surpassed 100.000 annually. Affecting one nation after another, emigration shortly before World War I reached a peak of nearly 1,500,000 annually. The main destination was the United States; secondary goals were the other American countries and Australia and South Africa. Concurrently with the emigration to other continents was the even greater flow of people to the cities. Thus, the number of Germans who during 1870–1910 went overseas was 2,800,000; in the same period Germany's urban population increased by 24,000,000. Instead of draining off Europe's population, the steady stream of overseas emigrants promoted its unprecedented growth through removal of excess populations and improved economic conditions, while birth control lagged considerably behind reduced mortality. Migration was an integral part of the process of industrialization; overseas colonization supplied the European industry with food, raw materials and markets for finished products, and internal rural-urban migration furnished the needed manpower. Conversely, industrialization progress, first in the old and then in the new world, provided the means by which the continents were occupied by the white race.

But changes which were in preparation before 1914 became manifest after World War I. The kxhaustion of the most profitable and sparsely populated lands, the rural exodus in the Americas and Australia. the development of local industries, the arrested expansion of European exports and of the European market for colonial products and. finally, the barriers erected against immigration closed the era of the great colonizing migrations.

(E. Ku.; X.)

MIGRATION TO THE UNITED STATES

The population of the United States in 1790 was about 4,000,000. By 1958 it was more than 170,000,000. Immigration from Europe to America was mainly responsible for this growth.

The number of immigrants who entered the United States previous to 1820 is not accurately known, but it is supposed to have averaged from 5,000 to 6,000 a year; the total number of immigrants from the time of the foundation of the national government down to 1820 was probably not more than 250,000. The total number of immigrants from 1820 to 1955 was 40,034,000, of whom 34,900,000 came directly from Europe.

In 1820 the number of arrivals was 8,385. and by 1830 it had reached more than 20,000. During the decade 1830–40 some 60,000 immigrants annually were admitted, while from 1840–46 the average number was about 90,000.

In 1847 the great tide of immigration began with an enormous influx from Ireland. following the potato famine, and two years later political troubles led to heavy immigration from Germany. From 1847 to 1854 immigration ranged between 250.000 and 400,000 per annum.

During the ten years 1847–56 approximately 3,000,000 immigrants entered the U.S.—twice the total number that had arrived during the previous 70 years. Immigration slackened during the Civil War period, but increased again thereafter, until by 1890 the total number of immigrants admitted to the United States had reached a figure of more than 15,500,000.

The financial crisis of 1893 temporarily checked immigration, but the upward trend was resumed, and during the 24 years 1891–1914 the total number of immigrants was 16,500,000. In each of the six years, 1905–07, 1910 and 1913–14 thr number exceeded 1,000,000. The greatest number of immigrants arriving in any one year was 1,285,000 in 1907. These figures include numbers of people who did not remain permanently in the Cnited States; such re-emigrants are believed to amount to 30%.

The ethnic composition of the immigrants had repeatedly changed. A distinction was usually made betneen the "old" immigration from northwestern Europe and the "new" immigration from southern and eastern Europe. Actually the old immigration consisted of diverse strata of newcomers, who in part were culturally different from the older U.S. population. The original component of the old immigration came from the British Isles; in 1841–50 it still constituted two-thirds of all immigrants and comprised the majority of them even in the next two decades. Yet this oldest immigration greatly differed from the colonial population: the latter was overwhelmingly Anglo-Saxon (the numerous colonists from North Ireland were Scottish-Irish Protestants); the former was chiefly Irish. In the period 1821–60 the Irish made up 70% of the immigrants from the British Isles. After that the Irish immigration in general declined and was surpassed by the English and Scottish.

Another "old" immigration came mainly from Germany and Scandinavia. In the 1840s it assumed a mass character amounting to nearly one-third of the European immigrants. In the 1880s, the immigration from Germany and Scandinavia, with annual numbers of more than 200,000, greatly surpassed that from the British Isles. But by the following decade the whole "old" immigration was outstripped by the flood from southern and eastern Europe. The "old" immigration during its maximum decade 1881–90 was less than 4,000,000, the "new" surpassed 6,000,000 in 1901–10 (70.8% of the total). In the five years 1911–15 out of a total immigration from Europe of 3,796,000, the number from southern and eastern Europe was more than 3,000,000 or 79% of the total. Their main countries of origin were Italy, Austria-Hungary and Russia; Poles and Hebrews were the most numerous among the various ethnic groups sent by the two last named empires.

TABLE *I.—Total Immigration into the U. S. and Immigration from Europe during 1820–1950, by Decades*

Immigration Restriction.— Political ideology of a nation of immigrant stock combined with a feeling of unlimited opportunities made the U.S. approach favourable to immigration. One of the grievances stated in the Declaration of Independence was that the king "has endeavoured to prevent the population of these States; for that purpose obstructing the Laws for Naturalization of Foreigners; refusing to pass others to encourage their migrations hither, and raising the conditions of new Appropriations of Lands." But there mas also a substantial opposite tendency which, from the very first decades of the national government, repeatedly broke out in organized attacks on the immigrant. The most violent nativist agitation was not against the eastern and southern European group so much as it was a mid-century movement against the Irish "Papists" and the German "red republicans." This movement was short-lived, but nativism reappeared again as the flood of "new" immigrants engulfed the United States. The low cultural level of immigrants was now still more apparent than in the days of the Irish influx because meantime the U.S. masses had greatly advanced. However, the anti-immigration movement this time was primarily based on economic grounds. Agricultural mass migration to the west

was approaching its end. By. 1890 the free public lands were practically all gone and the frontier had disappeared. There was a growing influx from the countryside to the city. Trade unions resenting the competition of cheap and docile labour from Europe probably were the most influential among supporters of restrictive measures, aimed at separating the "undesirable" from the "desirable" immigration and reducing its total volume.

However, up to World War I the only restrictions imposed upon the white immigration were: (1) the exclusion under the Immigration act of 1882 and subsequent legislation of certain undesirable classes; *e.g.,* criminals, paupers and physical and mental defectives, etc.; (2) those imposed by the Alien Contract Labour law of 1885 forbidding the entry of any person under a contract made previously to perform labour or service of any kind in the United States.

Restrictionist tendencies were strengthened during World War I, and a clause was inserted in the Consolidating Immigration act of 1917 prohibiting the entry of illiterates over 16 years of age. The literacy test was believed to be at once restrictive and selective in its action, but it failed to produce the desired effect; 430,000 immigrants entered the United States in 1920 and more than 800,000 in 1921. Since it became apparent that higher standards of admissibility could achieve neither a substantial limitation of the total immigration nor an exclusion of certain ethnic groups, the quota system was adopted to attain these results directly.

The United States Immigration act, 1921, limited "the number of aliens of any nationality who may be admitted under the immigration laws to the United States in any fiscal year . . . to 3 per centum of the number of foreign-born persons of such nationality resident in the United States as determined by the United States census of 1910."

This fixed the total annual immigration at 357,803 and that from Europe at 353,747, approximately one-third of the number of European immigrants during the years 1913 and 1914.

This act not only limited the aggregate numbers of immigrants. It was also selective in character, in that its effect was to reduce the proportion of immigrants from southern and eastern Europe to less than half the total, *viz.,* 198,000 from northern and western Europe and 158,000 from southern and eastern Eurooe.

The act of 1921 was only a temporary measure in order to allow time for framing a more permanent policy of restriction. This was embodied in the Immigration act of 1924 (the "Johnson act").

Immigration Act of 1924 and Revisions.—The main provisions of the act were as follows:

(1) In any year there should be admitted to the United States not more than 2% of the number of foreign-born individuals of any nationality resident in continental United States as determined by the United States census of 1890. This constituted each country's quota. The minimum quota of any nationality was set at 100.

(2) Certain classes of immigrants were exempted from the quota arrangements; *e.g.,* the dependents of previous immigrants naturalized in the United States, and certain other individual desirable types. Immigrants from other countries on the American continent did not come under the law at all if born in one of those countries, but if born elsewhere they could be admitted only as part of the quota of their country of birth; *i.e.,* a person born in Great Britain could be admitted from Canada only if included in the British quota.

(3) Aliens ineligible to become naturalized citizens under the United States naturalization laws were not admitted except under existing treaty stipulations. This provision excluded the Japanese. Japanese immigration had previously been governed not by a iormal treaty, but by a gentleman's agreement under which the Japanese government agreed to limit the entry of its subjects into the United States. The exclusion of Chinese immigration was repealed in 1943 with allocation of a quota of 100 persons. The same token quota was given in 1946 to natives of India

(4) The act also provided that after July 1, 1927, the total number of immigrants in any one year was to be reduced to a total of 150,000, the quota of each nationality being the proportion of 150,000 determined by the ratio between the number of inhabitants having that national origin to the total population of the United States in 1920. This was known as the "national origin" plan, intended to give immigrants from the various countries representation approximately proportional to the number of people of their own nationality domiciled in the United States. Congress postponed the operation of the national origin plan and it came into eiiect in 1929. The total permissible quota immigration somewhat exceeded the 150,000 maximum, since all quota countries were assigned an annual minimum of 100.

The Immigration and Nationality act of 1952 simplified the national origins formula of the 1924 act by basing the annual quota on a flat one-sixth of one percent of the population in the 1920 census. This act became effective Jan. 1. 1953, with new quotas totaling 154.657.

Quota-Immigration.—The intention of the quota system has been stated as follows: (1) to reduce the number of immigrants so as to afford an opportunity for assimilation; (2) to allow immigration on a scale designed to preserve a reasonable degree of homogeneity in the population of the United States. The first goal was achieved by a drastic reduction of the total number of immigrants, which at its highest had exceeded 1,000,000 a year, to an allowed maximum at first of 358,000, then 165,000, and finally 154,000. Actually the progressive restriction was still sharper, since a large and increasing percentage mas assigned to nations unwilling to make full use of immigration facilities. Quotas were at first calculated according to the national distribution of the foreign-born population in 1910. Then the distribution as in 1890 was substituted, because it would correspond better with the ethnic composition of the total United States population. Finally, the ethnic composition was calculated on the basis of a research of dubious scientific value. The practical result of these theoretical efforts was that northwestern Europe, which supplied only 20% of European immigrants in 1910–14, was allocated provisionally 55% and finally 86% of the European quota. There was an emotional prejudice in favour of the "Nordic race" (the French element formed an unsignificant fraction among immigrants' from northwestern Europe), but the real objective of the legislation "was to reduce immigration from those countries which had been the major source of immigration in the immediate prewar years and which, in view of their state of development, might have been expected to be the sources of the heaviest future migration." (Dudley Kirk, *Europe's Population* in *the Interwar Years,* 1946.)

In the 20 years before World War I, 14,750,000 immigrants entered the United States. According to the national origins quota system somewhat more than 4,800,000 quota immigrants could have been admitted between 1930 and 1955. Actually 1,563,000 quota immigrants were admitted. Various factors contributed to produce this result. Northwestern European nations used on the average only one-fifth of their relatively high annual quota. Instead of being selective the quota system proved to be sharply restrictive. When the depression of the 1930s set in, even the quotas for southern and eastern European countries often remained unfilled. In 1932–35 the United States had a migratory loss of 138,911. The influx of refugees from Nazi Germany just balanced this loss until the outbreak of World War II. During the war immigration slackened. Its revival after the end of the war was mainly due to two particular groups of immigrants: war brides and displaced persons admitted in numbers exceeding the existing annual quotas.

Table III shows the immigrants into the United States divided by classes. From the number of quota immigrants shown in this table it can be seen that the annual quota of approximately 154,000 is still not being filled. In the year ending June 30, 1956, 57,142 places in the quota were not used. Of these unused places, 53,104 were accounted for by England and Eire. Transfer of a country's unused quota to another country is not permitted nor can an unused quota be carried over from one year to another.

Nonquota Immigration.——After the establishment of the quota system the nonquota immigrants constituted an important part of the immigration. For the period 1925–49 their number amounted to 1,349,000 or 45% of the total immigration. The great majority were immigrants born in the independent countries of the western hemisphere. Wives, husbands and minor children of citizens of the United States, and ministers and professors formed two other groups of nonquota immigrants. The number

TABLE III.—*Immigrants Admitted to the United States, by Classes, 1950 to 1955*

	1950	1951	1952	1953	1954	1955
Total immigrants	249,187	205,717	265,520	170,434	208,177	237,790
Quota immigrants	197,460	156,547	194,247	84,175	94,098	82,232
Nonquota immigrants	51,727	49,170	71,273	86,259	114,079	155,558
Spouses and children of U.S. citizens	16,275	11,462	19,315	22,543	30,689	30,882
Natives of Western Hemisphere countries	32,790	34,704	47,744	58,985	78,897	92,620
Othernonquota	2,662	3,004	4,214	4,731	4,493	32,056*

*Includes 29,002 admitted under Refugee Relief act of 1953. Source: Statistical Abstract of the United States, 1956, Table III.

of persons admitted as relatives of United States citizens was particularly high after the end of World War II, when U.S. soldiers brought home wives whom they had married abroad. The War Brides act, 1945, facilitated their entry into the United States.

In 1946–49 more than 130,000 wives, husbands and children of members of the armed forces were admitted (120,432 wives, 3,495 husbands and 7,712 children).

The types and amounts of nonquota immigration from 1950–1955 are shown in Table III. In this table the increasing importance of immigration from other American countries is seen. It must be kept in mind that the return movement among immigrants from the western hemisphere is particularly large and the net effect is relatively small compared to the net effects of immigration from other areas (Kingsley Davis and Clarence Senior, "Immigration from the Western Hemisphere" in Reappraising our Immigration Policy, *The* Annals of *the Amer. Acad.* of *Pol.* and *Soc. Sci.*, March 1949). Most immigrants into the United States from other American countries come from Canada and Mexico. In 1955, for example, of the 110,000 American immigrants into the United States, 32,000 came from Canada and Newfoundland, 44,000 from Mexico, 26,000 from the rest of North America and the West Indies, and 8,000 from all of South America.

Displaced Persons Act, 1948.—On Dec. 22, 1945, President Truman directed that in applying immigration quotas, preference should be given to displaced persons. However, since nonrepatriable displaced persons originated mainly from eastern European countries, whose immigration quotas were very small, only 38,056 displaced persons were admitted as quota immigrants and an additional 2,268 as nonquota immigrants (wives and children of United States citizens, etc.) during the period 1946–48. The legislative change which alone could enable the United States to carry its share of refugees was introduced by the Displaced Persons act of 1948. The act allowed the admittance of: (1) 202,000 displaced persons during two years without regard to the current quota limitations, but charging them to future quotas of their countries of birth up to 50% of the quota per year; (2) 3,000 displaced orphans as nonquota immigrants; and (3) 15,000 temporarily admitted aliens who might be granted the status of permanent residents. In addition, half the German and Austrian quotas were allotted for two years to ethnic German expellees. In view of the rigid limitations of eligibility, only 123,518 displaced persons were admitted under this act up to the beginning of 1950. These provisions were liberalized by the amended Displaced Persons act of 1950 which also increased the total number of displaced persons to be admitted to 341,000 and that of orphans to 5,000, and established a total of 54,744 for ethnic German expellees. By June 1952, when the provisions of the act expired, 395,000 persons had been resettled in the United States under the act.

Refugee Relief Act, 1953.—This act authorized the issuance of 214,000 special nonquota visas until the end of 1956 to Germans, Italians, Greeks, Far-Eastern and other refugees and expellees from the Soviet and other Communist-dominated countries. As of June 30, 1956, a total of 122,000 visas had been issued and, of these, 102,154 persons had actually entered the United States.

MOVEMENT OF POPULATION WITHIN THE BRITISH EMPIRE AND COMMONWEALTH

From the 17th century the British people maintained their leading position in overseas emigration, except for several years around 1900. Between 1820 and 1914, more than 16,000,000 people left the United Kingdom to settle overseas. From this total must be deducted the number of foreigners who emigrated by way of Great Britain and of whom no separate record was kept before 1852; and also the number of emigrants who returned. On a rough estimate, however, it is probable that the net emigration from the British Isles amounted to 10,000,000 during the 100 years from 1820. The cited figure of 16,000,000 includes about 4,500,000 Irish emigrants. Ireland presents the single instance in the 19th century where the large-scale emigration caused a continual fall in the population (in spite of a considerable natural increase); the population of the whole island dropped from 8,300,000 in 1845 to 4,000,000 in 1905. British emigration was one element in the situation that made England the world's workshop; it was also the safety valve that helped ensure the peaceful course of the nation's political evolution. During the 19th century the great emigration was simultaneous with the vast growth of the British economy, the world expansion of the British empire, and the rapid increase of the population of the mother country.

TABLE IV.—*Overseas Emigration from the United Kingdom, Various Periods* (Annual average)*

	1913	1920–22	1923–30	1931–38	1947–54
Emigration within the British empire	285,046	151,260	115,583	24,498	121,500
To British N. America	190,854	77,521	55,482	3,226	29,600
To Australia and New Zealand	71,204	44,816	40,616	6,202	51,300
Emigration to foreign countries	104,178	68,298	40,046	5,790	19,700
To U.S.A.	94,691	61,149	34,341	1,860	15,600
Total Emigration	389,394	219,558	155,629	30,288	143,800
Total Immigration	85,709	75,149	58,294	54,109	66,500
Balance	303,685	144,409	97,335	−23,821 †	77,300

*For 1913 and 1920 including the whole of Ireland, for the following years exclusive of Eire. †Inward balance.

Source: Central Statistical Office, *Annual Abstract of Statistics* (London: *Her* Majesty's Stationery Office)

The United States was for a long time the chief destination of British emigrants. Between 1815 and 1906 out of every 100 British emigrants 65 went to the United States, 15 to Canada, 11 to Australia and 7 to other parts of the empire. But these proportions changed in later years. The United States still headed the list until 1904, but after that the dominions absorbed the larger portion, *viz.*, 62% in 1910, 70% in 1912, 75% in 1919, 71% in 1920, 74% in 1923–30, 81% in 1931–38, 81% in 1947 and 87% in 1954.

The return movement of British nationals, including large numbers of retired officials, amounted in 1922–30 to 38%, so that the net emigration averaged barely 90,000. The depression reversed the balance; in 1931, for the first time since figures were available, the United Kingdom gained population by migration. The inward balance persisted up to the outbreak of World War II. In 1931–38, 190,000 more British citizens immigrated (*i.e.*, mostly returned) into the United Kingdom from overseas than left it for overseas. There was also a net return of 103,000 British people from the European continent and an influx of more than 150,000 from Eire. Adding refugees from Germany and other countries, the net inward movement during this period was more than 500.000 (650,000 in the ten years 1931–41).

Assisted British Migration.—At the close of the Napoleonic Wars the rapid growth of population and the prevalence of distress led to the adoption of a measure of state-aided migration and to the formation of colonization societies. The first settlements in the Cape of Good Hope and New Zealand were the outcome of this movement. Changed conditions in Great Britain and the acquisition of responsible government by the "colonies," which took over their own crown lands (by the sale of which assisted emigration had been financed). resulted in the gradual abandonment of the policy, and the grant of state aid ceased in 1878. Numerically it had little efiect on British emigration during the 19th century, for of the 8,500,000 emigrants during the period 1815–75 only 350,000 were assisted. It had a very considerable effect, however, in stimulating settlement in the dominions. Between 1858 and 1910 no encouragement was afforded by the British government to emigration although the

question of state aid was again raised during the period of distress in 1884–85. Nor was anything done (apart from the establishment in 1886 of an office—the emigrants' information office—to collect and publish accurate information with regard to the British colonies) to direct migration to the British dominions rather than to foreign countries.

After 1918, however, the British government again endeavoured to encourage oversea settlement (as the movement of population within the empire was officially designated to distinguish it from emigration to foreign countries).

At the close of World War I it was felt that the prospect of settlement overseas would appeal strongly to former soldiers, and the British government granted free passage to ex-servicemen and their dependents who desired to settle overseas within the empire. Under this scheme 86.027 persons were assisted to settle in the dominions.

The conference of prime ministers of the empire held in 1921 recommended co-operation between the home and dominion governments in a comprehensive policy of empire land settlement and empire directed migration. In accordance with this recommendation the Empire Settlement act was passed in 1922. This act, which formed the basis of the British government's policy of state-aided overseas settlement. was renewed in 1937. It empowered the British government to spend up to £3,000,000 per year in co-operation with the government of an overseas dominion or with public or private organizations in Great Britain or overseas in schemes for assisting settlement in the dominions. The contribution of the British government could not exceed one-half of the cost of any scheme.

The assistance granted toward oversea settlement under the Empire Settlement act consisted partly in assisted passages, partly in development or land settlement schemes. Development schemes provided for employment of immigrants to open up new areas for cultivation through forest clearing, road building, etc. Individual land settlement schemes enabled persons prepared in the United Kingdom for farm work overseas to settle on farms of their own in the dominions. It was expected that when the policy got fully under way, the annual migration would considerably exceed 80,000. In particular, Australia undertook to absorb a total of 450,000 British migrants in schemes of settlement and development.

It is generally admitted that the results which attended the working of the Empire Settlement act in 1922–31 were not entirely satisfactory. In spite of an immediate surplus of population in Great Britain and the grant of state assistance on a liberal scale both the total migration from Great Britain and that to the dominions were less than in the period before 1914. The effect of the grant of state aid was to a large extent offset by the severe restrictions which the dominions found it necessary to impose on the classes of persons to whom assistance could be granted. British people in search of overseas resettlement were urban people with a large proportion of skilled industrial labourers. The dominions were, however. unable to encourage the immigration of industrial labourers as such, partly on account of the undeveloped state of their secondary industries, and partly on account of labour's attitude toward any form of immigration except that of agricultural workers. Actually, however, no scheme could run against the trend toward urbanization. Of all the migrants to the dominions during 1922–31 only 14% are known to have settled on the land. Moreover. a considerable proportion of those uho at first settled on the land subsequently left it and obtained other employment. Even if they stayed, the economic effect was not much different. In the state of Victoria, Australia, it was observed that while British migrants with industrial experience were placed on the land at a high cost, local people were leaving rural occupations for the cities.

After 1931, when resettlement possibilities dwindled under the impact of the depression, emigration assistance was almost discontinued.

After World War 11.—After the end of World War II the emigration trend from Great Britain revived markedly. A feeling of economic compression and the recognized military vulnerability of the British stronghold combined in sustaining this trend. By June 1948 some 200.000 persons were registered for emigration to Australia, and many others were waiting for passage to New Zealand, South Africa and Canada. In the dominions, too, there was a change in the approach to immigration. Understanding of the needs and possibilities of an increased population gained ground under the impact of wartime experiences. Engaged in programs of industrial and economic expansion, the dominions encouraged immigration for both economic and political reasons. The influx of British people was favoured, although the principle of excluding any but British stock was no longer followed. The immigration desired was highly selective, but it was no longer confined to agriculturists; it was rather the skilled industrial worker who had become the most desired immigrant.

The revived interest for British settlement in the dominions led to a resumption of assisted migration. In 1947 Assisted Passages schemes to Australia and to New Zealand came into operation, including free passage to ex-servicemen and assistance to other settlers under the authority of the Empire Settlement act.

The British government repeatedly stated its policy of encouraging emigration to other parts of the commonwealth, reserving only the right "to check too great a flow of certain types of highly skilled workers." However, in the discussions of the problem more fundamental doubts were expressed. There was still a general lack of hands in various fields in Great Britain, and by 1948 about 100,000 foreign workers brought in from the continent were employed in the British economy. These conditions, combined with the prospective natural decline of the British population, led the royal commission on population to the conclusion that "continuous large scale immigration would probably be impracticable and would certainly be undesirable." Taking into account, however, the needs of the dominions for manpower and the goal of maintaining and strengthening the British element in the commonwealth, the commission recommendation was "in the long run interests of Great Britain and the Commonwealth as a whole to maintain the flow of emigrants from Great Britain to the other parts of the Commonwealth at as high a level as possible." The best way to do this would be "by combining encouragement of emigration with a policy of selective immigration to make good any shortage that might arise in Great Britain."

MIGRATION WITHIN EUROPE AND ASIA

Freedom of migration, internal and international, was an inherent element of the 19th-century free economy. With progressing industrialization, Europe's great metropolises and industrial centres exerted a growing attraction on the rural population (see URBAN SOCIOLOGY). The ensuing rural depopulation was made good by an influx of agricultural labour from abroad.

In 1870–1914, while peasants from eastern Germany streamed to the Ruhr and to Berlin, Poles from the then Russian and Austrian parts of Poland came to eastern Germany for farm work. This immigration, which on the eve of World War I reached 300,000 a year, was mainly a seasonal movement, but it left a considerable residual. Altogether more than 1 000 000 foreigners settled in Germany between 1880 and 1910, almost half of them in the decade 1900–1910. In southern France, likewise, Italians replaced rural Frenchmen who went to Paris and the northern industrial region. Italians also went to work in mines and factories of northeastern France and Alsace-Lorraine (then in German hands). Numerous immigrants came to these regions also from Belgium, Switzerland and Germany. The total net immigration into France during the years 1876–1911 was evaluated at about 1,000,000.

European continental migration in the 19th century was an element of a system of expanding economy intimately connected with the large and free overseas flow of men, capital and goods. It was different in the interwar period, when Europe almost lost its vast outlets, and when its markets were shrinking. In Europe itself autarchic policy erected even higher barriers for goods and men. But the trend to the west and northwest persisted despite all the barriers and was even stronger than before World

War I, since the United States had closed its gates to the agrarian surplus population of eastern and southern Europe. In spite of all barriers, the migratory current in part managed to flow in the three specific (although intermixed) forms of repatriation, movement of refugees, and recruitment of foreign workers.

Huge masses of anti-Communist Russians fled to the west during and after the Civil War in Russia (1919–22). Mixed with these refugees, whose number exceeded 1,000,000, were 1,265,000 persons who left the Soviet Union as repatriated Poles. After the German collapse in 1918 about 1,250,000 Germans flocked into Germany from the territories lost by the reich, as well as from foreign countries. The largest group, about 700,000, came from former German Poland; their places were taken by 900,000 Poles from other parts of Poland. Likewise, rump-Hungary experienced after 1918 an influx of 400.000 Hungarians from its detached territories. The flight of Armenians and the population exchanges in the Balkans involved more than 2,000,000 people (see REFUGEES).

Part of the refugees. in particular the Russian *émigrés*, rolled slowly over Europe, joining the westward stream of migrants in search of livelihood opportunities. Following the immigration restrictions imposed by the United States and other non-European countries, France became the main destination of European emigration. France's need of additional workers from nbrosd during the interwar period mas a consequence of its heavy war losses superimposed on its stationary population, but it was also a sign of its highly developed economy. France's approach to the refugee problem was basically humane. Notwithstanding all deviations and outbursts of xenophobia. France in the interwar period became the main reception area for foreign workers, as well as for refugees. Numerous workers mere introduced by a system of organized selected and controlled immigration. Only temporarily, in the depression years 1931–36, did France force a partial exodus of resident foreign workers, but the net loss of about 100,000 was more than compensated in the following years. For the whole period 1920–39, 2,473,000 arrivals and 1,027,000 departures of alien workers were registered. The total influx was substantially greater.

In the 1920s France harboured growing numbers of Russian refugees. In 1933–39 it gave asylum to 60,000 Jews from "greater Germany" (which included Austria and Czechoslovakia) —the largest group of a total of 370,000 Jewish and 30,000 non-Jewish refugees who were outside greater Germany when World War II broke out. Finally, in 1939, France received 450,000 Spanish republican refugees; of these, more than half gradually returned to Spain and 200,000 remained. Altogether about 2,300,000 immigrants settled in France between World Wars I and II. Most numerous among these were the Italians (650,000) and Poles (600,000).

After the advent of Hitler, Germany became another centre of immigration. While Germany forced out the Jewish population, its industrial program connected with war preparation attracted 500.000 immigrants, among them 250,000 Sudeten-Germans from Czechoslovakia. In the course of World War II this movement assumed large dimensions in a strange form: more than 8,000,000 foreign workers were deported to Germany from the subjugated countries and an additional 4,000,000 were shifted from one occupied country to another. These were only a part of the human masses uprooted by the German conquest. The total number of Europeans expelled, deported, evacuated and transferred up to 1943 was estimated at 30,000,000. Among these were nearly 6,000,000 deported Jews. almost all of whom were subsequently murdered. Among the uprooted non-Jews, at least 3,000,000 perished at Nazi hands or from hardships. Those who survived for the most part returned to their homes after the end of the war.

It was the German defeat which in 1945–46 opened the way for a final redistribution of Europe's population. The migratory current to the west, formerly obstructed by border barriers, broke through under the impact of war. The main feature of the remodeled map of Europe's population was the expansion of the Slavonic settlement area at the expense of the Germans. The liquidation of German settlements in eastern and southeastern Europe and the expulsion of Germans from the Sudetenland and from the eastern part of Germany. which was incorporated into Poland, brought into rump-Germany nearly 11,000,000 German refugees. The movement was extended on the one hand by 1,000,000 German refugees from the soviet zone to the western zones of Germany. On the other hand, 1,800,000 Czechs and Slovaks were moved into the Sudetenland, while 5,000,000 Poles colonized the eastern German provinces which were annexed by Poland and from which the German population was expelled. The Polish advance to the west coincided with the Russian advance in the same direction. Poland's eastern provinces were incorporated into the Soviet Union, and more than 1,500,000 of their Polish inhabitants were exchanged against 500,000 Ukrainians from the other side of the new boundary. Moreover, millions of officials. workers and peasants streamed from inner Russia into the newly acquired western borderlands. The total of people who in 1944–47 resettled permanently in various population movements may be estimated at 25,000,000.

The immediate postwar situation in Europe was characterized by a lack of hands for the huge work of reconstruction. The only problem requiring solution through emigration seemed to be that of a special group of more than 1,000,000 displaced persons. This was composed of: (1) slave labourers who had been deported by the Germans and were unwilling to return to their Communist-ruled homelands; and (2) refugees from eastern Europe for political or religious reasons. On Dec. 15, 1946, the United Nations general assembly established the International Refugee organization in order to handle the problem of the displaced persons. Before this organization ceased to function and began liquidation in March, 1952, it had registered and cared for more than 1,600,000 refugees. More than 1,000,000 of these were resettled and most of the balance were repatriated.

But behind the problem of war refugees there reappeared, as reconstruction in Europe progressed, the spectre of overpopulated countries requiring migratory outlets. Eastern Europe, it is true, was no longer among these. In Poland the agrarian overpopulation was liquidated by the annexation of eastern German territories and the forced emigration of more than 7,000,000 Germans. Whatever the situation in the other satellites of the U.S.S.R., the question of their migration potential became academic in view of the ban imposed on emigration. The Hungarian revolt of October 1956 produced 167,000 refugees by the middle of Jan., 1957, but these cannot be classed as migrants in the usual sense.

Following World War II, emigration again became a burning question for Italy, with its rapidly increasing population and abundance of superfluous hands. They were only partly represented by the 2,000,000 registered unemployed; still larger was the hidden unemployment among Italian peasants. The United Nations subcommission on economic reconstruction estimated that 3,500,000 of the latter were superfluous in terms of their contribution to agricultural output. In the postwar years the Italian government made every effort to develop emigration and concluded a series of migration agreements. However, the actual number of emigrants remained far below expectations, averaging about 100,000 a year between 1946 and 1953. During the five years 1949–53 there mere 637,000 migrants from Italy to continents other than Europe. Of these, 442,000 went to South America (mostly to Argentina but also to Venezuela and Brazil), 116,000 to North America (Canada and United States), and 78,000 to Australia and New Zealand.

A special case was that of western Germany. where there was danger of growing unemployment because of the influx of 8,000,000 German refugees. Extensive industrial development was advocated, since only increased exports of manufactured goods would allow western Germany (a food-deficit area) to support her swollen population. But the world once before had to pay for permitting Germany to restore her industrial power. Another solution would be German emigration; this was hindered by the reluctance of nations to receive those who so recently had been their ruthless enemies, and by the urgent need for resettlement of displaced persons. However, during 1952–53 there were 74,000

emigrants from western Germany to continents other than Europe, 56,000 going to North America.

Asia.—Nearly half the world's population is concentrated in southern and eastern Asia (China, Korea, Japan, India, Indochina and Indonesia). The density of the population and its rapid increase, combined with low capital investment, created a great pressure on land, and a strong propulsion toward emigration to countries where somewhat better living conditions could be found. However, attempts of Asiatics to migrate to other continents met with sharp resistance. Immigration of Chinese into Australia was restricted by legislation as early as 1855. Subsequently Australia, New Zealand and South Africa by various methods provided for the exclusion of all Asiatics. Canada admitted only 150 Japanese annually, and in 1947 the repeal of the exclusion of Chinese merely enabled those residing in Canada to bring in their families. The restrictions imposed by the United States have been mentioned above and are discussed more at length below. During the interwar period Japanese and Chinese immigrants succeeded in entering Latin-American countries, but there, too, Asiatic immigration was halted entirely or limited to token numbers. In the early 1950s Brazil relaxed its attitude somewhat and in 1954 there were more than 5,000 migrants from the orient to Brazil. While this is by no means an important stream of migration it does represent a change in attitude.

In order to reconcile the urgent need of Asian populations for migratory outlets with the tendency to exclude them from "white" countries, many Asians and some few westerners suggested that millions of Asiatics could be settled as subsistence farmers in the vast tropical and subtropical regions, where European peoples cannot work and thrive on the land. However, the possibilities of pioneer settlement should not be exaggerated. Researches had shown that in the great American colonization the movement of people was intimately connected with the movement of capital. This applied even more forcibly to modern Asiatic migrations. Chinese immigration into Manchuria was started around 1900 by the construction of the Russian railway across Manchuria and the large expeditures of the Russian army of occupation. The Chinese colonization continued along the railways which provided advantageous transport facilities to the market. When in 1932 the Japanese took possession of Manchuria, Chinese immigration, which was temporarily lagging, was again stimulated by the Japanese recruitment and by the created economic opportunities. In the period 1900–1945 the Chinese population of Manchuria grew from 10,000,000 to 40,000,000.

Wherever capital was able or willing to penetrate, immigrants streamed in masses. Malayan rubber estates and tin mines attracted Chinese and Indians. Javanese were employed in large-scale commercial agriculture financed and managed by the Dutch in Sumatra (where one-tenth of the population is Java-born) and other outer islands. Chinese capital sought greater security in Hong Kong. in Shanghai and other foreign concessions, and millions of ordinary people followed, to profit directly or indirectly from foreign and Chinese enterprises. By 1941 the number of Chinese living in other Asiatic countries (not including Manchuria) was estimated at 8,000,000 to 10,000,000, and that of Indians at 3,000,000 to 4,000,000.

The Japanese migration was connected with Japan's own industrial development and political expansion. In 1880–1920 a safety valve was provided by the settlement of Japan's northern islands of Hokkaido, which followed the development of railroads and other communication facilities and of industries, and resulted in a net influx of 1,400,000 people. Still larger numbers of Japanese moved after 1920 to the new areas of the "empire," to work in government and industry. But the main stream went to the cities and industries of Japan proper; supplied by the empire with food and raw material, they absorbed the whole natural increase of the rural population.

During the last years of World War II, 3,000,000 to 5,000,000 Chinese (apart from tens of millions of temporarily displaced populations) migrated before the Japanese advance, westward to nonoccupied China, site of new industries. After the end of hostilities 5,500,000 Japanese were repatriated from the former Japan-held territories and 1,100,000 persons, predominantly Koreans, from Japan proper to their homelands.

MIGRATION TO SOUTH AMERICA

The settlement of South America, like the settlement of North America, has to a large extent been the result of migration. From the time of the Spanish conquistadores of the 16th century to contemporary times there has been a continuous but varying stream of migration to South America.

The number of immigrants probably reached a maximum between 1900 and 1920 but lack of data makes it impossible to estimate the actual number. Argentina had nearly 2,000,000 immigrants between 1901 and 1910 but only 300,000 between 1931 and 1940. Over 1,000,000 persons migrated to Brazil between 1891 and 1900 but fewer than 300,000 between 1931 and 1940. Many countries of South America feel a need to increase their population through immigration, and since World War II Argentina, Brazil, Chile, Ecuador, Mexico, Peru and Venezuela have announced steps to facilitate the immigration of Europeans. The main problems have been lack of transportation and communication facilities in undeveloped agricultural lands.

Brazil and Argentina have probably been most successful in getting European immigrants. Brazil had about 140,000 immigrants in 1952–53, 138,000 of them coming from Europe. During the same two years Argentina had an immigration of 126,000 with 122,000 of them coming from Europe. Italy, Spain, and Portugal are the three main European countries sending migrants to South America.

INTERCONTINENTAL MIGRATION AT MID-20TH CENTURY

In a country where people are permitted to move of their own accord, most migration is for a relatively short distance. The number of migrants decreases as the length of move increases. In the same manner, the number of people who move from one country to another is ordinarily less than the number of people moving within the country. In a similar fashion, the number of moves between countries of the same continent is generally greater than the moves between countries of different continents. Even though the number of moves between continents represents only a small proportion of all migration, these moves are of great interest for many reasons. Among other things, such moves usually represent major changes of culture, language, and ways of living for the migrants involved.

The problems of assimilation are also likely to be greater for migrants from another continent than for migrants from a neighbouring country.

Despite our interest in the migrants between continents, collection of information regarding the numbers and characteristics of such migrants is quite incomplete. The definition of "permanent migrant" differs from country to country, the coverage also varies, some countries omitting migrants traveling by some particular mode of transportation such as road or air; and the methods of collection of data are different from one country to another. Among the sources of migration data for different countries are port statistics, statistics of frontier control, statistics of registration coupons detached from certain documents, passport statistics, and statistics of local population registers. Because of these differences, figures for intercontinental migration are subject to important reservations.

Table Vshows figures for intercontinental migration for 1948–54. These figures must be taken as minimum estimates since they are the number of migrants actually reported and most countries of the world do not make reports of such information. However, most countries with large numbers of intercontinental migrants do make such reports, so the reported figures indicate the major streams of migration across the surface of the globe.

From Table V it can be seen that Europe has remained the major source of migrants for all continents, about 75% of all reported intercontinental migration stemming from that continent. It is also obvious that North America is the major destination of intercontinental migrants, mainly because it is the main destination

of European migrants.

South America is the destination for the next largest number of migrants, attracting more than half as many migrants from Europe as North America attracted. Argentina and Brazil are the main countries of destination in South America.

TABLE V.—*Intercontinental Migration, 1948–1954*

Migration from	Migration (in thousands*) to						
	All Continents	Africa	Asia	Europe	North America	South America	Oceania
All continents							
1948	713	43	103	98	254	142	71
1949	950	25	167	98	301	182	178
1950	916	23	114	158	235	202	184
1951	1,016	27	74	1	398	208	148
1952	886	32	49	173	327	159	147
1953	741	25	40	202	259	126	89
1954					290		
Africa							
1948	20	†	8	8	1	‡	2
1949	53	†	39	10	1	‡	3
1950	42	†	26	11	1	‡	4
1951	44	†	20	20	1	‡	2
1952	34	†	10	20	2	‡	2
1953	29	†	5	21	2	‡	1
1954		†	12		1	‡	
Asia							
1948	61	1	†	39	11	1	8
1949	46	1	†	29	6	1	9
1950	90	1	†	70	8	3	9
1951	86	1	†	58	12	6	10
1952	74	1	†	46	16	2	8
1953	60	1	†	41	12	2	5
1954			†		14	6	
Europe							
1948	533	41	89	†	222	123	58
1949	754	22	119	†	284	166	163
1950	674	21	81	†	217	187	168
1951	748	25	49	†	353	188	133
1952	632	30	33	†	283	152	134
1953	485	24	29	†	232	120	80
1954					267	126	
North America							
1948	43	1	2	26	†	12	3
1949	49	1	3	29	†	14	3
1950	46	1	3	28	†	11	3
1951	51	1	2	32	†	13	3
1952	60	‡	3	51	†	4	2
1953	93	‡	4	84	†	2	3
1954							
South America							
1948	18	‡	‡	14	4	†	‡
1949	22	‡	‡	18	4	†	‡
1950	37	‡	‡	33	4	†	‡
1951	40	‡	‡	34	6	†	‡
1952	43	‡	1	35	7	†	‡
1953	38	‡	1	30	8	†	‡
1954					6	†	
Oceania							
1948	16	1	2	10	3	‡	†
1949	16	1	2	12	2	‡	†
1950	19	‡	1	16	2	‡	†
1951	20	1	1	16	2	‡	†
1952	27	1	2	21	3	‡	†
1953	32	1	2	27	3	‡	†
1954							
U.S.S.R.							
1948	22	‡	1	§	14	6	‡
1949	10	‡	3	§	4	1	1
1950	7	‡	2	§	4	1	‡
1951	26	‡	1	§	24	1	‡
1952	17	‡	‡	§	16	1	‡
1953	3	‡	‡	§	2	1	‡
1954				§	2		

Note: National variations in collection of data make for lack of comparability. The figures given here are minimum figures compiled largely from reports to the United Nations. For a detailed discussion of the sources and methods of collecting migration data utilized by different countries, the tabulations provided, arid an analysis of the principal problems encountered in the collection of this data, see United Nations, Department of Social Affairs, *Problems of Migration* **Statistics,** Population Studies, So. 5 (New York, 1949)

*Figures independently rounded to nearest thousand so may not add to totals.
†Intra-continental migration not recorded.
‡Less than 500 migrants reported.
§Not available.

Very few countries of Asia report migration and nearly all the intercontinental migration shown in Table V is accounted for by migration to Israel. Practically all reported migrants to Africa come from Europe and most of this migration is within the British Empire Australia and New Zealand are the only countries of Oceania reporting migration and over 50% of the migration to these countries comes from the United Kingdom.

For the period covered, most streams of intercontinental migration reached a peak and declined. The future of intercontinental migration depends on the types of agreements reached by the nations involved. (E. KU.; D. O. P.)

Chinese Migration to the United States. — From 1820, when one Chinese entered the United States. until the middle of the 19th century, fewer than 100 Chinese went to the United States; but with the gold rush that started in California in 1849 there began a period of increased Chinese immigration. especially to California, which made Chinese immigration a dominant issue in California politics from 1860 to 1890. For a time the immigrants nere welcomed as cheap labour that was needed for the menial tasks of a pioneering. aggressive community preoccupied with railroad building and gold prospecting; but when unemployment developed, the welcome turned into racial animosity and agitation for state and national restrictive or exclusionary measures.

It was charged that the immigrants were unassimilable and subject to grave personal vices. For their part, the immigrants complained that they were excluded from the rest of society by discriminatory laws and customs.

The Burlingame treaty of 1868 gave Chinese subjects in the United States the right to privileges enjoyed by citizens of the most-favoured nation, but soon this treaty was effectively abrogated by congressional acts, the constitutionality of which was upheld by the supreme court. In 1879 congress passed a bill to exclude Chinese labourers; it was vetoed by the president. In 1882 congress passed an act to suspend Chinese immigration for ten years. An act of 1892 extended the suspension for another ten years. In 1902 the statutory policy became one of permanent exclusion.

In a message to congress, Pres. Franklin D. Roosevelt asked for an end of this policy. and in 1943 congress complied (at that time China was an ally of the United States in World War II and was to be one of the Big Five of the projected United Nations). The Immigration and Nationality act of 1952 repealed all racial exclusionary provisions except that (1) persons who are related by as much as one-half of their ancestry to peoples indigenous to an Asia-Pacific triangle, defined by the act. are charged. for immigration quota purposes, to the countries of Asia, wherever they may have been born or however long their ancestors may have made their homes outside the land of their origin; and (2) a quota limit of 100 was placed on entries from any colony. The former provision assured that immigrants of Chinese descent, regardless of nationality. are not to exceed the annual Chinese quota of 10j.

Despite restrictions, from 1820 to 1949, 397,602 Chinese immigrants were admitted into the United States; and of this total, 50.264 were admitted in the years 1921–1949, the so-called restrictive period of U.S. immigration policy, and 118.393 in the selective period 1881–1920. (M. R. K.)

POLICIES OF MIGRATION

The French Revolution's Declaration of the Rights of Man listed among innate and inalienable human rights the liberty to stay and to move freely. Victorious political and economic liberalism removed the barriers against immigration and emigration (England in 1824 repealed the last, actually inoperative, of her prohibitions on the emigration of artisans), together with other obstacles to human activity. Modern capitalism vigorously pursued the development of natural resources and for this purpose attracted labour from the four corners of the earth. The principle of free competition which (apart from tariff restrictions on the international movement of goods) tended toward lowering of prices of products. also stimulated the employment of the cheapest obtainable labour.

The only deviations from this principle in the 19th century were those affecting coloured people. White men's movements up to World War I were restricted only by costs of transportation. But the whole system of free economy began to be undermined at the turn of the century by the growth of monopolies and by increasing government interference. And when the obsolete passport and visa regulations, resurrected for military purposes during World War I, were retained afterward to filter the inflow and outflow of people, no champion rose to defend the principle of free migration.

Totalitarian governments, in regarding the individual as a unit in national policy, prohibited emigration as interfering with the state's economic and military strength. or alternatively tried to use the emigrants "to extend the borders of the homeland — ideal

borders and maybe even some day, material borders." These words expressed the Italian fascist policy of restricted emigration. A similar goal was the motive of the Japanese emigration to Brazil. Democratic countries: out of consideration for the personal rights of their citizens. abstained from checking thcir emigration, but they did not hesitate to bar the immigration of aliens. The techniques of control established early in the interwar period remained basically unchanged. Reference has already been made to the policy of the United States and the British dominions. Latin American countries also adopted restrictions through variations of the quota system, or in other ways gave favourable treatment to Spaniards and Portuguese and to immigrants of specific occupations. The application of immigration restrictions was sharpened during the world depression of the early 1930s, although legislation was not as effective as the economic factors which for a time reversed the direction of overseas migrations.

Regulation of migration in the first half of the 20th century was almost wholly restrictive. S o positive planning was substituted for the stimulating action of free economic iorces in the 19th century. The limited results of the British Oversea Settlement scheme have been discussed above. Other projects left even slighter traces. The only exception was the Jewish settlement of Palestine, where the idealistic striving of desperate migrants was combined with a huge influx of capital partly driven by necessity, partly volunteered ior nonprofit motives. From the British declaration of 1917 on the creation of a Jewish home in Palestine up to May, 1948, when the state of Israel was established, 460,000 Jews entered Palestine. From the establishment of the state of Israel through 1948–56 approximately 850,000 Jews entered Israel.

It has been observed that international migrations have been little furthered by the creation of world organizations. The League of Nations barely touched the problem with reference to refugees. The International Labour organization (*q.v.*) devoted attention to migration only as a part of its basic activities concerned with the improvement of conditions oi labour. The I.L.O. constitution mentioned among its objectives "protection of the interests of workers when employed in countries other than their own." Accordingly, the I.L.O. dealt primarily with the social and economic protection of migrants, and it made a very good record in this respect. A series of conventions on specific matters adopted by the International Labor conference in the years 1919–36 were followed by the 1939 and 1948–49 Conventions on Employment, dealing with the migrant's travel, health conditions, housing, wages and social security. Organization and compilation of statistics of migration and publication of highly qualified studies of the subject were other important contributions of the I.L.O. But no results were achieved with regard to constructive plans of regulated migration. Tendencies prevailing during the interwar period barred even the consideration of the economic and political implications of the migration problem by international bodies. Only in the late 1930s was a somewhat less negative attitude observed. After World War I1 the change became quite manifest, when the United Nations included the migration problem in its sphere.

A working arrangement of Nov. 1947 divided the functions of the United Nations and the I.L.O. as follows:

(1) The competence of the United Nations was to include (a) the migratory problem from the population point of view (demographic needs, consequences and possibilities); (b) rights and situation of migrants in their quality as aliens, such as naturalization. expulsion, etc.; (c) economic and financial aspects of mieration, and (d) the political and legal aspects of migratory movements as related to their social and economic aspects.

(2) The competence of the I.L.O. was to include (a) the rights and situation of migrants in their quality as workers, such as recruitment. vocational training, care during transportation, employment, working conditions, social insurance, etc., and (b) general assistance and advice to governments on migration schemes.

The functions of the I.L.O. and item (b) of the United Nations' functions in bearing on the protection of migrants raised no difficult political problems. Of greater political complexity were the other functions of the United Nations which substantially pertained to international migration policy in its demographic, economic. financial and political aspects or. to use the language of the United Nations charter (art. 1.3), "to achieve international co-operation" with regard to migration. Certainly. much can be done in this respect by "harmonizing the actions of nations" (art. 1.4).

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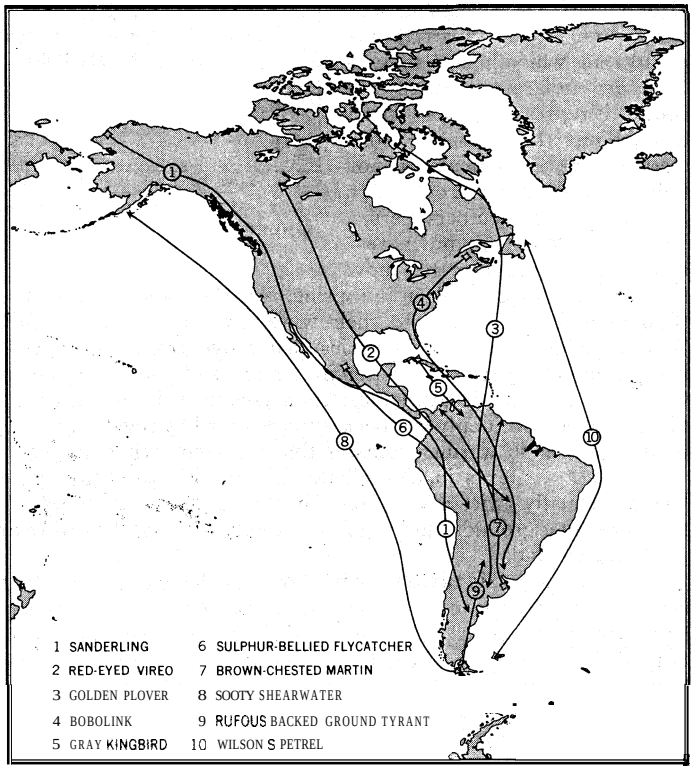
MIGRATION, BIRD. Each fall, with remarkable regularity, millions of birds leave the places where they have bred, or where they were born, and fly to other areas to spend the winter. The following spring they return to their breeding grounds. This seasonal movement to and from the breeding area constitutes migration. Although migration occurs among other animals, in no other group is it so extensive and prevalent as it is among birds. This is undoubtedly due in part to the adaptations of many birds for prolonged flight.

The conspicuous appearance and disappearance of many birds with the seasons was probably known to the first races of prehistoric man, for Paleolithic man, about 40,000 years ago. had taken enough notice of birds to draw them and carve them in rock. In ancient literature there are references to bird migration in the writings of Homer; in the Old Testament; in the Finnish epic poem *Kalevala*, and in the Sanskrit *The* Sacred Books of *the East.* Aristotle not only recorded migration dates but also speculated on the causes of migration.



FROM J VAN TYNE AND A J BERGER FUNDAMENTALS OF ORNITHOLOGY 1959 REPRODUCED BY PERMISSION OF JOHN WILEY & SONS INC

FIG. 1.— POSTBREEDING MIGRATIONS OF TEN AMERICAN BIRDS

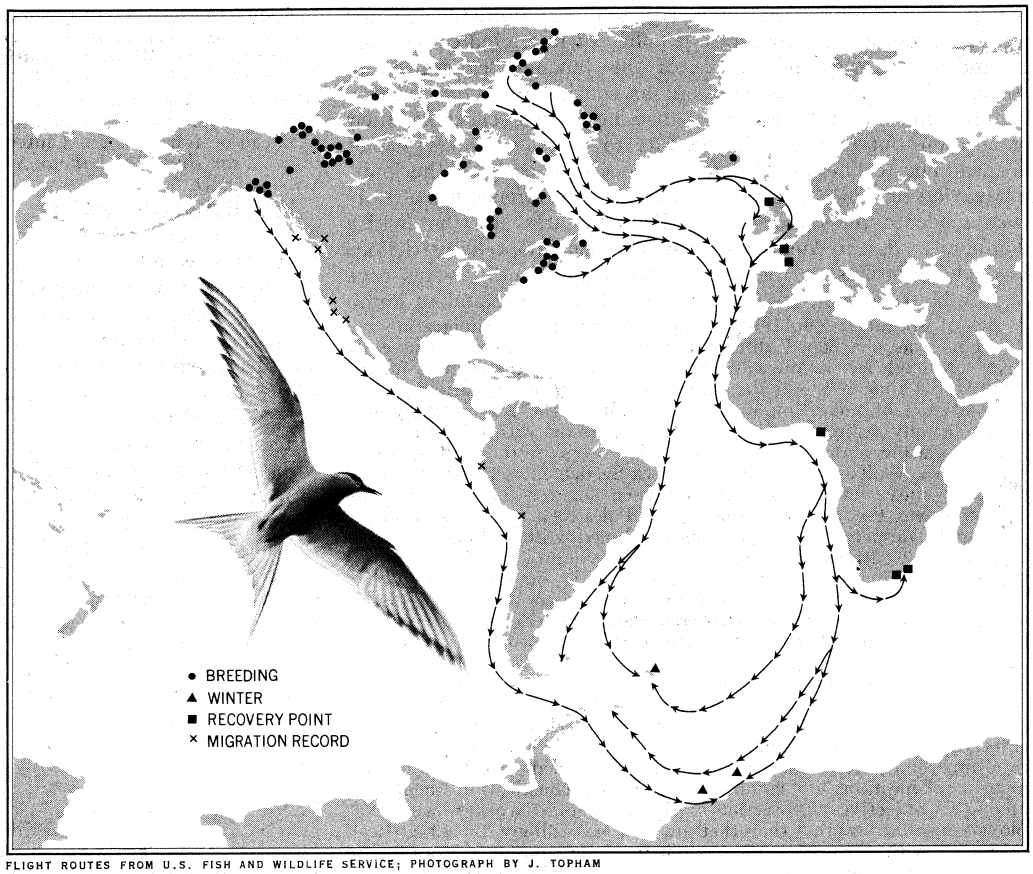
Knowledge of migration increased very little from the time of Aristotle until the 19th century; it was not until about the beginning of the 20th century that it was studied scientifically. The development of banding and ringing techniques for marking and identifying individual birds. improvement in the identification of birds in the field and use of the experimental method both in the laboratory and in the field have yielded many insights into the great mysteries of migration; but many problems remain to excite the imagination of scientists.

GENERAL FEATURES

A World-Wide Phenomenon.— Most observations and studies of bird migration have been made in the northern hemi-

sphere, particularly in North America and Europe. Migration, however, is a world-wide phenomenon and occurs also within the tropics and the southern hemisphere. The occurrence of migration in all parts of the world demonstrates that any geographical area may have unfavourable seasonal aspects that induce birds to seek more favourable climes.

Migratory Status.— Birds may be classified according to their migratory status in a given area. Four major groups are recognized in most parts of the world: (1) permanent residents; (2) summer residents or summer visitors; (3) winter residents or winter visitors; and (4) transient visitants or passage migrants. Permanent residents are those species that are represented in a particular area throughout the year. A further distinction is made between species in which all members are permanent residents and those (partial migrants) in which many individuals are migrant though the species is represented in a locality throughout the year. Studies made on the movements of individuals indicate that in only a few species are all members permanently resident. Summer residents are those species that move to their breeding grounds in the spring, rear their young during the summer and then return to their wintering grounds in the fall. Winter residents are those species that move from their breeding grounds to spend the winter in a more suitable environment where food is readily available. As a general rule, insect-eating birds, whose food supply is especially threatened by severe weather, tend to winter in warmer climates than do seed-eating species.



FLIGHT ROUTES FROM U.S. FISH AND WILDLIFE SERVICE; PHOTOGRAPH BY J. TOPHAM

FIG. 2.— MIGRATION ROUTES OF THE ARCTIC TERN. RECOVERY POINTS REPRESENT BIRDS BANDED AS NESTLINGS IN NORTH AMERICA

Transient visitants include all the species that pass through a locality: usually twice a year: once in the spring, on their way to their breeding grounds, and again in the fall, on their way to their wintering grounds.

Precision of Migratory **Behaviour.**—The movements that occur during migration are not random. Each species has a characteristic geographical distribution during the breeding season (called the summer or breeding range) and also during the non-breeding season (called winter range). The routes followed between these areas are well established and characteristic for the species or for population5 within the species. Migratory behaviour is, therefore, an oriented movement.

From the standpoint of time. also, migration is not random, but occurs primarily in the spring and in the fall in temperate regions (although there may be a few months in which some migratory movements cannot be observed, since species breed at different times and travel different distances between their breeding and wintering areas). In all migrants the times of the year in which migration occurs are fairly precise, more so for the flight to the breeding grounds than that to the wintering grounds.

Finally, migration occurs at specific times of the day. depending on the species. Many small birds— and larger birds that are secretive— that depend on vegetational cover and that are weak fliers are nocturnal migrants; e.g., rails, cuckoos, wrens and thrushes. Many nocturnal migrants are small insectivorous birds; it is thought that migration at night enables them to feed during the hours of daylight when. presumably, their specific insect prey are active. Studies of nocturnal migrants by viewing them through telescopes against the moon, and also by means of radar, show a pronounced pattern of migrational activity, which begins after sunset, increases rapidly until about 11:00 P.M., and then declines rapidly to a minimum at about 4.00 A.M.

Birds that are fast fliers, that live in the open, or that capture their food on the wing migrate primarily by day; e.g., hawks, pigeons, crows, jays, swallows and shrikes. Some large birds migrate by both day and night; e.g., loons, ducks, geese and many shore birds.

In summary, migratory behaviour occurs among many different groups of birds. is spatially oriented and shows a good degree of spatial and ternporal precision. Because of the precision in migratory behaviour. it is possible to describe for many species of birds the breeding range, the wintering range. the route followed and the time, direction and duration of migration.

EXTENT OF MIGRATION

Duration and Distance.— Since the breeding and wintering ranges of many migrants differ considerably, it is not surprising to find much variation in the extent of migration. In the western hemisphere long migrations are known in more than 100 species. Such species usually nest in the United States or Canada and spend the winter in the West Indies or in Central or South America (fig 1).

Of the land birds of North America the nighthawk and the barn swallow have the longest migration routes. They breed as far north as the Yukon and Alaska and winter as far south as Argentina, a distance of about 7,000 mi. Even such extensive flights as these, however, are exceeded by thdse of certain shore birds and other aquatic species. Among the snipe, sandpipers, plovers and their allies, several species nest north of the Arctic circle and winter in South America, traveling as far south as Patagonia. a distance of more than 8 000 mi. Birds such as waders. swifts and swallows, which travel from northern Europe to South Africa, fly 6,000–7,000 mi. in each direction. The longest and most re-

markable of all migrations, however, is that of the Arctic tern (fig. 2) Its breeding range is circumpolar and extends as far north as land exists and as far south as the Aleutian Islands, Great Slave Lake, Massachusetts and northern Europe. When the young are full-grown, all the Arctic terns leave their breeding grounds and a few months later arrive in the Antarctic region. 11,000 mi away!

In addition to these long migrations, short migrations and altitudinal migrations are known among many species of birds. Short migrations, for example, are made by species that nest in southern Canada and the northern United States and winter in the central and southern United States: these include the vesper sparrow, chipping sparrow, grackle, bluebird and woodcock.

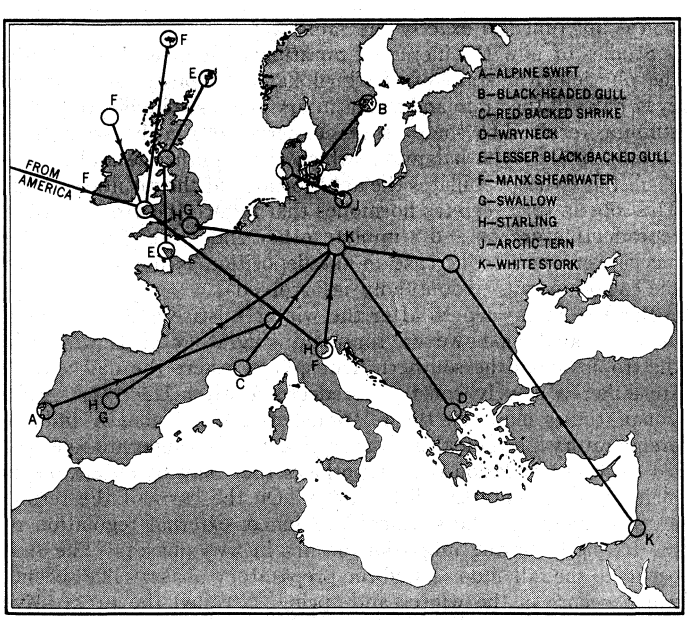
Certain birds that live in mountainous areas adjust to the changing seasons by migrating to the foothills and valleys during winter and returning to the high slopes and peaks with the approach of summer. The old world lammergeier, the Himalayan white-capped redstart and the Californian mountain quail behave in this manner. Such vertical or altitudinal migrations accomplish in a relatively short distance the same objectives, with regard to environmental changes, as the lengthy latitudinal migrations. In the Rocky Mountain region vertical migrations are known to occur among chickadees, rosy finches, juncos and pine grosbeaks. In the mountains of central California the mountain quail nest at altitudes up to 9,500 ft. and winter in areas below 5.000 ft.; an unusual feature of this migration is that the migrants travel on foot in little parties of 10 to 30 individuals and usually in a single file.

A few vertical migrations are upward in the fall, yet none the less adaptive. At higher altitudes in the winter the Rocky Mountain blue grouse avoids predators and secures a diet of needles and buds of fir trees, whereas the Asian ibis-bill finds water kept open by warm springs and swift currents.

Short erratic flights may also occur among several species in response to irregularly occurring stimuli; for example, many birds of the arid Australian interior move nomadically. appearing in a locality after an infrequent and unpredictable rain, breeding and then moving on. Strictly speaking, these flights are not migratory, since the same breeding area may not be used again.

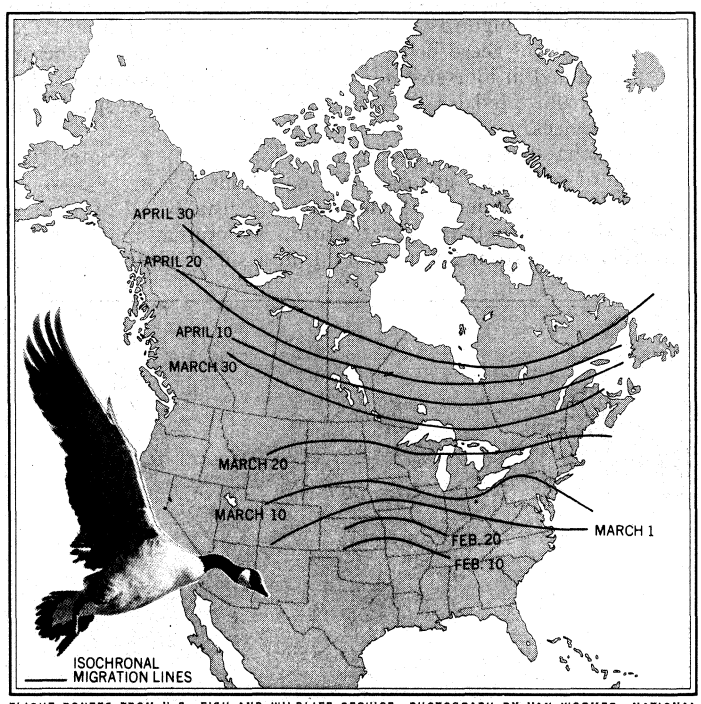
In general, differences in extent of migration reflect different requirements of species on their wintering and breeding grounds.

Routes. — The routes followed by different migratory birds are extremely diverse, depending primarily upon the latitude and extent of the breeding and wintering areas and upon the history of the species. As indicated earlier, knowledge of the routes of migration has been obtained largely through the technique of bird-banding, especially in North America and in Europe. Migration routes are the lanes of travel that are followed generally by a species as a whole and not necessarily by each individual. In species that have extensive winter and summer ranges, migration occurs evenly over a broad front hundreds of miles in width.



FROM G. V. T. MATTHEWS, "BIRD NAVIGATION," 1955, CAMBRIDGE UNIVERSITY PRESS

FIG. 3. — HOMING FLIGHTS OF EUROPEAN BIRDS



FLIGHT ROUTES FROM U.S. FISH AND WILDLIFE SERVICE; PHOTOGRAPH BY VAN WORMER—NATIONAL AUDUBON SOCIETY

FIG. 4. — SPRING MIGRATION OF CANADA GOOSE

This is true for species that migrate at night as well as for those that migrate by day. Day migrants, however, appear to be guided by major topographic features such as seacoasts, mountains and large lakes and rivers, with the result that greater numbers of these migrants occur along these landmarks.

In the western hemisphere the routes of migration occur over large land areas as well as over seas (fig. 1). This is also true in the eastern hemisphere, many birds crossing the Mediterranean on their flights between Eurasia and Africa and some flying over parts of the Indian ocean and the Pacific ocean. Many kinds of small perching birds are known to migrate across at least 600 mi. of sea and some may make even longer journeys. These birds commonly cross such large bodies of water as the Gulf of Mexico, the Mediterranean and the North sea. Some aquatic birds regularly cross the larger oceans.

Many species that breed in North America winter in South America, but no terrestrial South American species that nest in the south temperate zone migrate into North or Central America. In both the new world and the old this is an outstanding difference between migrants that breed in the northern hemisphere and those that breed in the southern. **A** few sea birds and waders, however, do migrate across the equator from breeding grounds in the far south.

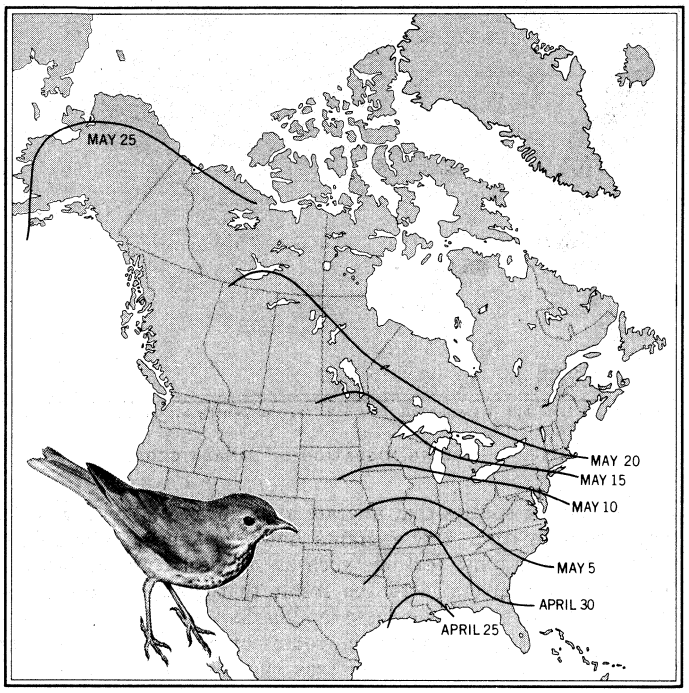
In Europe the general direction of migration in the fall is south and southwest (fig. 3). Some birds, however, move in a southeasterly direction, with a few reaching southern Asia. For most migrants that leave Europe the wintering areas are in northern or tropical Africa.

In Asia migration routes are not so well known, but the following autumnal movements have been observed: westward or southwestward to Europe and Africa; eastward or southeastward to areas bordering the Pacific ocean; and southward to the southern Asian peninsula and the East Indies Islands.

Altitude and Velocity. — Earlier observers thought that birds traveled very high and very fast. Recent information. derived from the use of telescopes, radar and range finders, indicates that

at or near sea level few migrating birds fly above 3.000 ft. and most probably fly below 1,300 ft. Some strong fliers. such as shore birds. ducks and geese, have been recorded at 5,000–9.000 it. In mountainous areas birds reach higher altitudes; *e.g.*, in the Himalayas considerable numbers migrate through passes at 18,000 ft. Cruising speeds for migratory birds range from 20 to about 40 m.p.h. in small songbirds and from 40 to about 60 m.p.h. in larger birds. ducks and geese being the fastest flyers. These velocities are maintained in long-sustained flight. All birds. however. when escaping from predators, can exceed their cruising speeds for short distances.

The flying speed of any individual bird is much greater than the rate of migratory advance of a particular species as a whole. In the spring, species that migrate early usually advance more slowly than those that migrate later. Nocturnal migrants can probably cover from 200 to 400 mi. in a single night. In North America the average daily advance for all birds, recorded as beginning at New Orleans. La.. and ending at southern Minnesota, is approximately 23 mi. a day. North of this area the rate is greatly and constantly accelerated as the breeding grounds are reached.



FLIGHT ROUTES FROM U.S. FISH AND WILDLIFE SERVICE; PHOTOGRAPH BY CRUICKSHANK—NATIONAL AUDUBON SOCIETY

FIG. 5.— MIGRATION ROUTES OF THE GRAY-CHEEKED THRUSH

The migratory advance of a species depends upon many factors. the most important of which seems to be the average climatic conditions along the route. In North America the spring season advances northward more rapidly in the northern interior and along the west coast than it does on the Gulf coast and in the Mississippi valley; as a result birds of a certain species. in their spring migration from Brazil and Argentina, may be as far north as northern California before their counterparts reach Florida. Slow and rapid rates of advance during spring migration are exemplified by the Canada goose and gray-cheeked thrush, respectively (*see* fin. 4 and 5).

FACTORS REGULATING MIGRATION

Birds return to their breeding grounds at essentially the same time each year and show a remarkable precision in the timing of breeding The greater yellowlegs, a medium-sized wading bird. for example which breeds in the Canadian muikegs — after having flown to Patagonia in the fall and back in the spring, a total distance of about 16 000 to 20 000 mi — have hatched their eggs between May 26 and May 29 inclusive over a period of 14 years. Oceanic birds show great precision in their arrival dates on their breeding grounds. Smaller land birds are more influenced by adverse weather conditions, particularly in the beginning of the migration period; nevertheless, their timing is still relatively precise. Since migratory behaviour shows temporal and spatial precision. at least two iundamental factors are operable. The first is the proper timing of the annual stimulus for migration. which has been most studied for the spring migration. The secvnd is the guidance (navigation) of birds to their particular breeding and wintering areas.

Annual Stimulus for Migration. — Changes in food supply. temperature, barometric pressure and other seasonal factors in the environment formerly had been suggested to explain the regularity of migration and breeding. The annual variations in all these factors, however, appeared too great to account for the regularity of migration. Some insight into the intricacies of the annual stimulus was gained in 1924 when William Rowan, a Canadian zoologist, initiated the experimental approach to this problem of timing; later investigators further developed his productive line of research. Rowan reasoned that the most consistent seasonal change was in length of day and that changing day lengths might provide the environmental stimulus for migratory behaviour.

'The factors regulating spring migration have been intensively studied. It has been demonstrated that many northern species, while on their wintering grounds, are affected physiologically by the increases in day length that occur after the winter solstice (about Dec. 21). This physiological change is manifested by an increase in the activity of such endocrine glands as the pituitary and the gonad (testis or ovary), by restlessness and. most characteristically. by an increase in body weight, due primarily to the deposition of iat under the skin and in the abdominal region.

It has been postulated that in some way, presumably by affecting the nervous system, this change in physiological state is responsible for the initiation of the spring migratory flight. The proof that day length and the internal state of the bird are involved in initiating the northward migration has been obtained irom experimental studies of the slate-colored and Oregon juncos. In these studies captive juncos were induced to migrate about two months earlier than usual by subjecting them to artificial increases in day length during December and January.

The stimulus for the fall migration has not been studied extensively, but the data that are available indicate that the fall migration is not timed in exactlv the same wav.

Studies of how the incrkased duration-of light each day alters the physiological state of the bird have demonstrated that the eyes. parts of the brain and the pituitary gland are involved. Light stimulus received by the eyes affects nerve cells in the brain (specifically in the hypothalamus), which then synthesize and release a substance that stimulates the anterior lobe of the pituitary gland. This lobe in turn secretes hormones that induce the growth of the reproductive organs and stimulate other endocrine glands. The mechanism for the increase in fat deposition is not known, but the hypothalamus undoubtedly is involved.

Increase in day length after the winter solstice is not the complete explanation, however, for many migratory birds winter in the tropics or in the southern hemisphere, where the day lengths are either relatively constant or decrease after Dec. 21. Additional studies made on the relation between day length and the premigratory physiological state (in a north temperate species) led to the formulation of a hypothesis that may be applicable to migrants that winter in all latitudes. On the basis of the results of exweriments on the slate-colored junco, external regulation of the timing of spring migration occurs in 'two phases. The first occurs in the fall and is called the preparatory phase. The second, which occurs in the winter and spring, is called the progressive phase: it culminates in migration and breeding. During the first phase decreasing day length is a regulatory factor. This decrease is felt seasonally by birds in moderate northern latitudes and is experienced by transequatorial migrants during their flight, even though the days are lengthening at their wintering grounds. (Why these transequatorial migrants begin their spring migrations at

the proper time is still to be determined.) The first phase regulates the time at which the second phase begins. In the second phase the rate of physiological change, culminating in readiness to migrate, is regulated by the length of the daily photoperiod.

The final stimulus that starts the birds on their way, and that also regulates their flights during the period of migration, is the weather, though its influence is felt in varying degrees depending on the species. Birds tend to move with favourable winds in the spring and fall. During spring migration in eastern North America, migrants move into or through a given area during the interval between the passage of a warm front (with southerly winds) and the subsequent arrival of a cold front (with northerly winds). Arrival of a cold front and northerly winds forces migrating birds to land and tends to inhibit the onset of a new flight of grounded birds. In the fall the opposite conditions prevail, the southward migration occurring predominantly in cool, clear weather, with northerly winds, after the passage of a cold front.

Navigation and Orientation. — Through the study of banded birds it was demonstrated that many individuals tend to return to exactly the same locality in the breeding and wintering areas. This indicates that birds can identify precisely their summer and winter "homes" and that there must be some means by which they find their way from one to the other. The most dramatic proof of the navigational ability of birds has been obtained by removing them from their nests during the breeding season and then releasing them in new areas many miles away. For example, Manx shearwaters, which were removed from their nesting burrows in Wales, returned successfully from release points outside their normal range as far as 930 mi. (air distance) over land or 3,700 mi. over water. the probable route. One of these birds released at Boston, Mass.. returned to its nest 3,200 mi. away in 12 days and 12.5 hours! This bird returned from an area outside the range of the species and probably flew an east-west route, which would be at right angles to its normal direction of migration. Its rate of a little more than 250 mi. per day suggests that it flew by the shortest possible route.

Numerous similar studies demonstrate the ability of birds to find their way back to their homes, but there are great differences among species and individuals in ability to "home." There seem to be three basic niethods of homing, which. in different species, may operate alone or in combination to determine the course of an actual flight. The first is exploration, with a tendency to seek familiar landmarks and to follow guidelines shown by the terrain. The second is orientation in a constant direction, so that birds, when experimentally displaced, continue on a track parallel to their normal migratory route; this may be combined with a tendency to explore or to settle after a fixed time or distance. The third method, which must largely involve long-range homing over the sea, is navigation, the ability to choose a course for home from any position — though this does not necessarily imply any knowledge of the relative position of home.

There has been much speculation about the mechanisms of orientation and navigation, but no convincing experimental evidence to support, and some theoretical grounds to reject, the suggestions, which include terrestrial magnetism and Coriolis force. Since 1940 the experimental approach has been employed extensively and has resulted in great progress in understanding these mechanisms. These experimental studies have involved observations of caged migrants, which show orientation during the migratory season; caged birds that were trained to find food in a given direction; and wild and trained birds that were released under controlled conditions. The results demonstrate clearly that vision is of great importance and that the environmental cues are the sun and the stars. The capacity to choose a given direction is lost or greatly diminished when there is a heavy cloud cover or when the sun and stars are obscured artificially for caged birds. The experimental results leave no doubt that birds can orient well in relation to the sun and the stars, but how they use this ability to navigate is not clear.

Two theories have been proposed to explain orientation and navigation by means of the sun. One, called the sun-azimuth hypothesis, states that the desired direction is determined by means of the horizontal angle measured around the horizon from the downward projection of the observed sun position to the horizon. In this case the sun is used as a compass, and the position of a place is determined by reference to the sun's azimuth position. Birds that have the ability to maintain a certain direction in unfamiliar territory might use such a mechanism.

The second theory, called the sun-arc hypothesis, provides for complete navigation by means of the sun and not just direction finding. The sun-arc is inclined at an angle from the horizontal. This angle, constant for a given place, is a measure of the latitude of that place. The angle is smaller farther north and greater farther south; hence the highest point on the arc is lower or higher in relation to a given home position. This highest point is due south of the observer in the northern hemisphere and is a reference point in space. Since it is reached at local noon, it is also a reference point in time. The speed at which the sun moves along its arc is practically constant at 15° per hour. The distance the sun advances along its arc is greater to an observer in the east than to an observer in the west. The differences in the angle around the arc from the noon position are directly proportional to the change in longitude.

Therefore, the ability of a bird to orient in a familiar locality at any time of day. but before the sun-arc's vertical displacement has changed appreciably with the advancing season, needs involve only a memory of the sun-arc in relation to the horizon, accurate assessment of the sun's altitude and, to avoid ambiguity. rapid determination of whether the sun is rising or falling. None of these requirements presents great theoretical difficulty. It is assumed that a bird is familiar with the sun-arc on its home grounds and that it can determine, by detecting differences in the angle with the horizontal and the angle around the arc at noon, the change in latitude and longitude of a new location in relation to its home grounds. Both theories require that birds have an "internal chronometer," which enables them to determine where the sun would be at a given time of the day in their home grounds. Experimental studies provide good evidence for the existence of such a timing mechanism.

By placing caged nocturnal migrants in a planetarium and observing their orientation under different skies for short periods of time, it was concluded that these birds can use the stars for navigation. The data were few, however. and when they were re-examined by another investigator. it was concluded that the results showed orientation but no evidence for navigation. Observations of birds in other experimental studies and in nature indicate that a view of the stars is not absolutely necessary for orientation.

EVOLUTION OF MIGRATION

Origin of Migration. — The origin and evolution of migration long have been favourite topics for theoretical discussion, for a complete understanding of this amazing behaviour rests on these topics.

Since birds must have been migrating for many millions of years, and since this behaviour continues in so many different types of birds, the species must benefit or else they soon would become extinct. Although migration occasionally is a hazardous venture for a species, the advantages apparently offset the heavy losses that result each year. One of the primary advantages of migration is that it enables a species to occupy alternately two different areas at a time when each area presents favourable conditions, thus tending to prevent overcrowding and excessive competition for food and nesting sites in areas warm the year round; *i.e.*, the subtropics and the tropics.

Older theories of the origin of migration are based on the assumption that migration has resulted from the response of birds to a repetitive event in their racial history, with this response ultimately becoming hereditary. None of the theories advanced by the early 1960s was completely adequate in explaining the origin of migratory behaviour in birds. Two major theories that had some currency earlier were the "ancestral home" theories: the northern and the southern.

Northern "Ancestral Home" Theory. — The northern ances-

tral home theory postulated that nonmigratory birds occurred over the entire northern hemisphere in earlier ages when climatic conditions were more uniform throughout the year and the vegetation provided birds with a constant source of food and nesting sites (This condition exists today in some parts of the tropics, where, it may be noted, many birds are still nonmigratory) However, as seasonal changes in climate became established gradually, perhaps as a result of the advances and retreats of the glacial ice fields, birds presumably were driven southward. When their original nesting sites became available at particular seasons, the birds returned to their ancestral breeding grounds in the north and remained there until thev were forced southward again. It is believed that by constant repetition of this behaviour over many years and by many generations, birds developed the habit of migrating.

This theory, however, can be readily dismissed on the grounds that the birds that were originally forced southward would have become extinct long before the glaciers receded, if they had not already been destroyed earlier on their breeding grounds.

Southern "Ancestral Home" Theory.—The southern ancestral home theory assumed that the ancestral home of all birds was in the tropics and that because of overpopulation birds left to seek new territories to the north. where there would be less competition for food and nesting sites. Pioneering individuals could go as far northward as their food requirements permitted, but would eventually be forced southward with the approach of winter. With the advent of spring. the stimulus for reproduction would drive them northward again. Modifications of this theory postulated causes other than reproduction and homing instinct as the stimuli for the original movements. Postbreeding wandering and search for food, for example. have been suggested as the causes for the northward movement, and adverse seasonal and climatic conditions and search for food as the causes for the southward movement.

This theory, though supported by much of our knowledge of the behaviour of birds and their response to environmental factors, is, nevertheless. inadequate. It fails, for example, to account for the remarkable routes of migration over large bodies of water and for the great distances that separate the breeding and wintering areas of many species. It also fails to explain how the movements involved in the expansion and retreat of the species became hereditary.

Continental Drift Theory.—A more recent explanation of the evolution (but not the origin) of some types of bird migration is the continental drift theory. It postulates that rifting and displacement of continental masses and the consequent development of some ocean basins were factors involved in the evolution of the more highly developed forms of migration, especially in those species that travel great distances and cross large bodies of water.

The evolution of migration according to this theory is envisaged as follows: (1) Before the advent of continental drift many birds were performing short flights between breeding and feeding areas. (2) With the onset of continental drift these areas diverged slowly and were displaced horizontally. (3) Birds, however, because of their innate. well-developed homing behaviour. continued their use of these areas. (4) As the distances increased, only those individuals that had the necessary physiological preadaptations for the long flights survived.

Migratory behaviour, according to this theory, did not evolve into its highly developed forms because it served useful ends but because it was the natural consequence of an inherent behaviour pattern that induced birds to respond to the displacement of continental masses. The adaptive features of migration, such as leaving an area with the approach of winter, would, therefore, be the result of natural selection and not the cause of migration as implied in the theories discussed earlier.

One of the strong objections to the continental drift theory is that the fossil record of birds does not demonstrate the existence of modern kinds of birds in the Cretaceous period. when continental drift began. Since modern birds were present, however, at the beginning of the Eocene and since birds were evolving for about 70.000.000 years before the Eocene, it is not unreasonable to assume that some modern types were present when drift began.

Another objection is that the evolution of the present continents and ocean basins is not known; the geological hypothesis of continental drift. or horizontal displacement, on which this theory of migration is-founded. is itself only a theory. Therefore, until further paleontological and geological data are available. the continental drift theory of the evolution of some types of migratory behaviour can be regarded at best as only a working hypothesis.

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MIGRATION OF ANIMALS. In various groups of animals, including particularly the birds (which are dealt with in a separate section; see MIGRATION, BIRD), mass movements or changes of habitat take place at certain times in their lives which are of a different class from the normal daily wanderings of the same animals round and about a localized area. These migratory movements which are sometimes spectacular either for the numbers concerned or the distance covered, result in a change of habitat which is often, but not always, connected with the breeding season or with a change of food supply. Although best known in birds, similar movements occur in land and marine mammals; in reptiles. amphibia and fishes; and in some groups of invertebrates, particularly the insects. The movement may result in long distances being covered; but in other cases the distance is quite small; the striking characteristic of migration being not the distance moved, but the fact that during the migration the path of the animal concerned is straightened out in one more or less definite direction so that each hour or each day takes it farther from the starting point.

There has been much discussion as to an exact definition of migration. Some prefer a narrow definition, others a wide one. Students of bird migration usually wish to use the word only for an absolutely regular to and fro movement between a breeding area and a nonbreeding area. A. L. Thomson (1926) says "True migrations are changes of habitat, periodically recurring and alternating in direction, which tend to secure optimum conditions at all times." W. Heape (1931) considers that there are two fundamentally different types of mass movement in the animal kingdom; when there is a return movement he uses the term "migration" and considers it to be "gametic" or due to the urge for reproduction; when there is no return movement he uses the term "emigration" and considers it "alimental" or due to the search for food. This, however, immediately raises the difficulty that in many cases the movement must be gametic in one direction and alimental in another, which does not support the idea of a fundamental difference in origin between the two.

For the purpose of this article migration is defined as a periodic, more or less unidirectional, continued movement, assisted by the efforts of the animal and in a direction over which it exerts a control. which results in the animal's passing away from its previous field of operations (C. B. Williams, 1930). This definition includes movements which appear at first sight to be in only one direction, but excludes all drift by the wind or by sea currents, when the animal is only the passive victim of circumstances. When the animals have a long life with annual breeding periods and relatively slow reproduction (as in the birds), the movements are regular and the same individual may perform the movement more than once in each direction. When the animals have a long life but only one breeding period (as in the eel), an individual makes the journey only once each way. When the animals are short-lived with extremely rapid reproduction and changes of numbers (as in the insects), the flights in different directions are often performed by different generations. with perhaps nonmigratory generations in between, and the numbers concerned are vari-

able, sometimes large in one direction and small in the reverse.

The most remarkable problem in migration in all groups is the power of orientation possessed by the migrants which enables them to move hundreds or even thousands of miles more or less in one direction. Various suggestions have been made as to the mechanism of this, but no ansner is known. Some fishes appear to react to currents, but in the air. with both birds and insects, there is no regularity of wind that would guide them any distance, and even in the sea different currents can usually be found at different depths. A "magnetic" sense has been suggested, but no experimental evidence to support this has been brought forward.

In animals which are regularly subjected to severe winter conditions migration seems to have evolved as an alternative to hibernation, but there are a few cases known (see below under bats and insects) where the same species may both hibernate and migrate.

Mammals. — The Alaska fur seals winter in California and in the spring return to the Pribilof Islands, 2,000 mi. away, to breed. Whales also make definite migrations which are being investigated by marking experiments. Among the land mammals the South African springbok in general makes irregular movements; but in Bushmanland, south of the Orange river, there is a regular mass migration of thousands each year from the desert to the mountains for the calving season. The return movement to the desert is not gregarious (Heape, 1931). The Newfoundland caribou moves each autumn, after mating, from the high land to the warmer southern part of the island; in the return movement in the spring the does are heavy with young. The mass movements of lemmings have been known for many years but there has been much dispute if they are to be classed as true migrations. At intervals enormous numbers of these rodents leave the Norwegian mountains and move downhill and to the west: sometimes they reach the sea and are drowned. According to C. Elton (1942) there is a tendency for a recurrence of lemming migration every third or fourth year. Some bats migrate, but the majority of species in cold temperate climates hibernate in caves or protected hollows. In the U.S. at least three species are known to move to the southern states each autumn to return in the spring. Both hibernation and migration can occur in the same species, as a bat marked in a cave near Dresden during the winter was recovered the following summer 468 mi. away in Lithuania (G. M. Allen, 1939).

Fishes.—Migration in fish is complicated by question of fresh and salt water, sea and river currents, depth, the weakness of the young fish and in some cases by the long life before breeding. On the other hand understanding has been helped by great possibilities of marking and recovery (in some cases up to more than 50% of the marked fish), by the possibility of "aging" fish from their scale structure, and by the great economic importance of the investigations resulting in international co-operation.

In general there is an active migration toward a breeding area (usually against the current), and either an active movement or a passive drift away from the breeding area (usually with the current). Some species (such as the plaice and cod) move entirely in salt water, or (as some trout) in fresh water only. Others (such as the salmon) are "anadromous," breeding in fresh water and feeding in salt; while others (such as the eel) called "catadromous" breed in salt water and pass most of their life in fresh. In the cod (*Gadus* callarias) there are several breeding areas; one north of the Dogger bank, one off the Lofoten Islands, one off Iceland, and one off Greenland. Each has its surrounding area to and from which movements occur, but marking experiments have shown that there is an interchange of individuals, particularly between the Iceland and Greenland areas. The salmon (*Salmo salar*) breeds in the upper waters of rivers, usually where the bottom is gravelly. The young remain in fresh water passing through stages known as alevins, fry, parr and smolt. When about tmo years old they make their way to the sea. where they grow rapidly. feeding particularly on mackerel and herring. They remain in the sea for several years and as adolescents they are called "grilse." The return to fresh water is made by grilse and adult salmon. In the rivers they eat little and after spawning they may return again to the sea. There is evidence that salmon return to the same river, and even to the same parts of it in which they were hatched. (See also SALMON AND SALMONIDAE.)

The European eel (Anguilla *anguilla*) is an example of a catadromous migration. When adult, the eels make their way down the rivers to the sea and then cross the Atlantic to a breeding ground in deep water north of the West Indies. After egg laying the adults die. The transparent larvae (leptocephali) gradually make their way, helped by currents, across to the European coast, a journey of about 2,000 mi. which takes about two and a half years. In this journey they change from the flat, knife-bladelike larva to the slender cylindrical elver and then ascend the rivers in enormous numbers. They live in fresh water for from five to eight years before becoming mature. (See Carlsberg Foundation Report 193j.)

Reptiles and Amphibians. — Migrationis not highly developed in these groups. Certain marine turtles visit sandy shores at breeding time and the newly hatched young return to the sea. The vegetarian green turtle (Cheloaia *mydas*) of the West Indies is known to move up to 50 mi. in shallow coastal waters. Some sea snakes come periodically to shore to give birth to their young. Toads are known to move considerable distances to a particular pond and some months later there is a return journey of small toads in the opposite direction. Both newts and frogs are known to make similar movements but the distances covered are not great.

Invertebrates. — Migration is found in the Crustacea in certain land crabs (Geocarcinces) and robber crabs (*Birgus*) which move from inland to the sea at the time of oviposition. In the sea the larvae are hatched out and all young stages are passed; from the sea there is a return of the adults inland, and later they are followed by their offspring.

In the insects, migration is chiefly known in locusts and butterflies. There are about seven species of locusts of which the best known are the "migratory locust" in southeast Europe, south Asia and north Africa, and the "desert locust" in the northern half of Africa and southwest Asia. All species perform long migrations in the adult form before egg laying, and in some cases there is a regular to and fro seasonal movement. B. Uvarov (1928) has shown that the so-called "locusts" are a gregarious migratory form of species which have also a nonmigratory solitary grasshopper form. According to conditions of food supply, and crowding, eggs from one "phase," as it is called technically, can give rise to the other. Thus migrations of locusts can arise from areas from which only the solitary grasshopper phase had existed for many years. The two phases can be distinguished in colour, structure, behaviour and physiology.

In Lepidoptera the best known migrant is the milkweed butterfly (*Danaüs plexippus*) of North America. It is a large butterfly with a long adult life up to about ten months. In the autumn the butterflies in southern Canada and the northern U.S. congregate in masses and fly steadily south to Florida, the Gulf states, Mexico and south California. Here they spend the winter in a state of semihibernation and return again individually to the north in the spring, laying eggs as they go. According to the latitude there are one, two or three generations before the next autumn return to the south. In the old world the greatest migrant is the "painted lady" butterfly (*Vanessa cardui*) which flies each spring in varying numbers from north Africa into central or northern Europe, sometimes even reaching Iceland. Migration is known in more than 200 species of butterflies, including about one-fifth of those found in Great Britain. In moths there are also many migrants, such as the Cotton worm (Alabama argillacea) which invades the cotton belt of the United States almost every year from South or Central America. Migration also occurs in ladybird beetles, in dragonflies and more rarely in other groups of insects.

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MIGRATORY LABOUR, a term used to describe persons and families who travel about in search of seasonal farm employment, mainly in the harvesting of fruits, vegetables, sugar beets and cotton. In the United States, several major streams of migratory movement are identifiable. From their winter homes in Florida and Georgia, family units and groups move northward through the Atlantic states in the summer and return late in the fall; similar streams of workers originate in Texas and spread out through the central states and from the southwest through the Pacific states. These routes identify only general directions of movement. Individual families and small groups may develop routes that diverge substantially from the major streams. Case histories of migratory individuals and families demonstrate that their movements do not always follow an established route; their moves are prompted by hope and rumour as well as by accurate job information or firm offers of employment. Moreover, most families do not continue as migrants indefinitely; as opportunities for steady employment are found, the migrant family settles down. Thus, in part, migrancy is an intermediate stage in occupational and geographic relocation.

It is sometimes said that migrancy exists because of the seasonal labour requirements of agriculture and that people become migrants because they like this type of life. Neither of these is a valid explanation for the existence of migratory labour. Sociological investigations have demonstrated that such factors as occupational displacement, racial discrimination, illiteracy, ill-health and industrial accidents are the basic causes of migrancy. Seasonal farm work provides an opportunity for those who are not prepared for or are not accepted in more desirable occupations.

Migratory labour has also existed in central and western Europe, Australia. Canada and in Central and South America. Women rice workers in Italy. Hungarian wheat harvest workers and English hop pickers are examples. The migratory patterns of such skilled specialists as sheep shearers in Australia and North America are exceptional in respect to effectiveness of planning and favourable earnings. Migratory labour has appeared also in construction, lumbering and mining.

Even though many situations have some or all of the characteristics of migrancy, that of United States farm labour is outstanding in its magnitude, persistency and intensity of associated problems. The problems result from the fact that children are involved, that periods on the road are prolonged, that distances are great and that housing is mainly improvised. Education, child care, health and sanitation are difficult enough under migratory conditions; when they are compounded with poverty and uncertainty of employment the results are often deplorable.

Efforts are occasionally made by local authorities to ameliorate migrancy problems by providing special schools, housing, clinics and child care centres. However, such efforts are severely restricted because community services and facilities are designed primarily for local residents; eligibility is, in fact, customarily based upon a minimum period of residence.

Migratory workers in the United States are excluded from the protection of major national and state statutes, including the Labor-Management Relations act, the Fair Labor Standards act and unemployment insurance. Migratory workers are not unionized and most are not able to meet the residence requirement for voting rights. Consequently, they stand apart as one of the nation's most excluded and unprotected economic groups. *See* also CASUAL LABOUR.

See *Farm Labor Fact Book,* United States Department of Labor, 1959; *Migratory Labor in American Agriculture,* Report of the President's Commission.on Migratory Labor, 1951. (V. FU.)

MIGUEL, MARIA EVARIST (1802–1866), usually known as DOM MIGUEL, whose name is chiefly associated with his pretensions to the throne of Portugal, was the third son of King John VI of Portugal, and of Carlota Joaquina, one of the Spanish Bourbons; he was born at Lisbon on Oct. 26, 1802. In 1807 he accompanied his parents in their flight to Brazil. In 1822 his father swore fidelity to the new Portuguese constitution which had been proclaimed in his absence; and this led Carlota Joaquina. who was an absolutist of the extremest Bourbon type, and hated her husband, to seek his dethronement in favour of Miguel her favourite son. The insurrections which ensued (*see* PORTUGAL) resulted in her imprisonment and the exile of Miguel (1824), who spent a short time in Paris and afterward lived in Vienna, where he came under the teaching of Metternich. On the sudden death of John VI in May 1826, Pedro of Brazil, his eldest son, renounced the crown in favour of his daughter Maria da Gloria, on the understanding that she should become the wife of Miguel. Miguel swore allegiance to Pedro, to Maria and to the constitution which Pedro had introduced, and was appointed regent in July 1827.

He arrived in Lisbon in Feb. 1828, and regardless of his promises, dissolved the new Cortes in March; having called together the old Cortes, with the support of the reactionary party of which his mother was the ruling spirit, he got himself proclaimed sole legitimate king of Portugal in July.

The public opinion of Europe became more and more actively hostile to his reign, and after the occupation of Oporto by Dom Pedro in 1832, the destruction of Miguel's fleet by Captain (afterward Sir Charles) Napier off Cape St. Vincent in 1833, and the victory of Saldanha at Santarem in 1834, Queen Christina of Spain recognized the legitimate sovereignty of Maria, and in this was followed by France and England. Dom Miguel capitulated at Evora on May 29, 1834, renouncing all pretensions to the Portuguese throne.

Miguel lived for some time at Rome. where he enjoyed papal recognition. but afterward retired to Bronnbach, in Baden, where he died on Nov. 14, 1866.

MIHALACHE, ION (1882–), Rumanian statesman, was born on March 3, 1882, at Topoloveni in Walachia. In 1918 he founded in the old kingdom the Peasant (Tsaranesc) party He was minister of agriculture in Alexander Vaida-Voevod's cabinet until March 12, 1920. In Oct. 1926 the National party of Transylvania led by Julius Maniu, the Peasant party of the old kingdom headed by Mihalache and the Peasant parties of Bessarabia and Bukovina combined to form a National Peasant party (Partidul National Tsaranesc) under Maniu's presidency with Mihalache as vice-president. In the Maniu cabinet which assumed the power on Nov. 10, 1928, Mihalache was again minister of agriculture.

He became minister of the interior in the George Mironescu cabinet in 1930, held the same portfolio in the second Vaida-Voevod cabinet (1932) and again in the second Maniu cabinet (1933). He retired from political life when King Carol established his royal dictatorship. During World War II he refused to collaborate with the Germans and took part with Maniu in the liberation movement, and after the Allied victory he was again vice-president of the reconstructed National Peasant party and editor of the nenspaper *Tsărănismul* ("Populism").

In July 1947 he was arrested with Maniu by the Communist-controlled government of Petre Groza. On charges of high treason, conspiracy, fomenting armed rebellion and spying on behalf of the United States government, he was sentenced to solitary confinement for life on Nov. 11, 1947.

MIHAJLOVIC, DRAZA (1893–1946), Yugoslav army officer, leader of the royal Yugoslav underground army during World War II, was born on March 27, 1893, at Ivanjica, near Cacak, Serbia. Educated at the Serbian Military academy, he fought in the Balkan Wars (1912–13) and in World War I. When, on April 6, 1941, Germany attacked Yugoslavia, he was chief of staff of a motorized unit in Bosnia.

After the swift conquest and partition of Yugoslavia, Mihajlovic organized underground *cety* (plural form *ceta,* "band") of resistance in Serbia; but another underground organization controlled by the Yugoslav Communist party and led by Josip Broz Tito (*q* v) was operating mainly in Bosnia and Montenegro. In the autumn of 1941 the *cetnici* (called Chetniks in English) and the partisans fought the Germans together, but their political aims were totally divergent.

On Jan. 12, 1942, Mihajlovic was appointed minister of war of the Yugoslav government in exile. One month later a "Free Yugoslavia" radio station, broadcasting from Tiflis, Georgia. accused him of collaboration with the enemy. In fact he was preparing

for a general uprising in the event of an Allied landing in the Balkans and was also trying to repulse incursions of the partisans into his territory.

Support from London, however, was accorded to Tito who was judged more useful, and in May 1944 King Peter abandoned Mihajlovic.

After the country's liberation Mihajlovic went into hiding but was captured on March 13, 1946. He was tried and sentenced to death for treason, and was shot in Belgrade on July 17, 1946.

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MIKADO, archaic title of the emperor of Japan; literally, the "august gate," the place being used for the personage who was too exalted to be referred to directly. According to the earliest legends, recorded in the 8th century A.D., the dynasty was founded in 660 B C. by the emperor Jimmu, a direct descendant of the sun goddess Amaterasu. Scholars agree that it was probably in the 3rd century A.D. that what eventually became the imperial clan defeated rival chieftains and first asserted suzerainty over the inhabited parts of central and western Japan.

Although by the 6th century the imperial family had lost the military power which gained it hegemony, it had gained something else. The emperor, as high priest of the animistic cult of Shintō (*q.v.*) and as himself of divine ancestry, was invested with an aura of sacred inviolability. The aristocratic and military clans which from the 7th to the 19th centuries held actual power always preferred to rule through, rather than to usurp, the imperial position. Individual emperors were deposed and even murdered in court intrigues; for 60 years in the 14th century there were two courts supported by rival military families; but the imperial institution survived and, by the liberal practice of adoption from collateral branches, preserved its dynastic continuity.

The low point in the imperial family's prestige may be placed in the Tokugawa period (1600–1868) when the court at Kyoto was entirely subordinated to the military government in Edo (modern Tokyo) and limited to purely ritual functions.

The revolution in 1868 is spoken of as the Meiji "restoration," since in destroying the Tokugawa feudal regime and building a centralized nation-state its leaders claimed to be restoring the emperor Meiji to his rightful position as supreme ruler. The emperor was used as a symbol of national unity, and gradually a new cult of state Shintō was created in which patriotism was personalized as loyalty to the emperor and made a sacred duty. The constitution of 1889 vested absolute powers in the emperor. Ministers, judges and chiefs of staff were in theory his personal servants—a system of "legitimized irresponsibility" which contributed to the independence of the military establishment before 1945.

The defeat of Japan in 1945 dealt a mortal blow to the emperor cult and to the official myths of divine origin. In a rescript of 1946. Emperor Hirohito spoke disparagingly of these legends. and in the constitution of that year the emperor. as the symbol of the state with purely ceremonial functions, was deprived of all state power. His position was made similar to that of the British sovereign, and the policy was adopted (while preserving a large element of traditional ceremonial) of building up the imperial family as a model of family and civic virtue on the British pattern. See also JAPAN: *History*. (R. P. D.)

MIKIR, a tribe in Assam, India, inhabiting the hills between Brahmaputra and Dhansiri and calling themselves Arleng. They speak a Tibeto-Burman language akin to the Naga and Kuki dialects, practise shifting cultivation and live in small settlements of little permanence. The headmen of villages are elected and those of several settlements form a regional council with judicial powers. The tribe is divided into patrilineal, exogamous clans and though in the 1960s all clans were of equal status, there is a tradition that the functions of priests and warriors used to be linked with certain clans. Tribal gods are worshipped with animal sacrifices, and Hindu influence has affected religious belief and practice only superficially. Elaborate ceremonies, including dancing and sacrifices, accompany the cremation of the dead and megalithic monuments are erected for prominent men.

See E. Stack, The *Mikirs*, ed. by C. Lyall (1908). (C. V. F.-H.)

MIKKELI (Swedish SANKT MICHEL), a frontier *lääni* (county) in southeast Finland. Pop. (1960) 235,214. Area 8,357 sq.mi. It is a heavily wooded region embracing the southern halves of the great Saimaa lake system and of the historic province of Savo (Savolax), the home country of the east-central Finnish people—Savolaiset. It is centred on the market town, administrative centre and bishopric of Mikkeli (pop. 19,782). Other towns are Savonlinna (Nyslott) (14,728), the railway junction of Pieksämaki (10,633) and the waterway centre of Heinola (10,995). Savonlinna has the largest of Finland's medieval fortresses. Forestry is important, with livestock farming subordinate. Softwood processing and preparation of foodstuffs are the chief industries. There is small-scale limestone quarrying. (W. R. ME.)

MIKKELSEN, EJNAR (1880–), Danish seaman and explorer, was born at Vester Brønderslev, Jutland, Dec. 23, 1880. His imagination was fired by dreams of polar exploration and at the age of 16 he walked the 320 mi. from Stockholm to Göteborg in an unsuccessful attempt to persuade S. A. Andrée to take him on the latter's arctic balloon flight. In 1900, however, G. C. Amdrup took him on the Danish expedition to east Greenland, where he took part in the remarkable journey in a small rowing boat along the dangerous and unexplored Blosseville coast. In 1901–02 he was a member of the Baldwin-Ziegler expedition to Franz Josef Land. After a few years at sea in merchant vessels as mate and master, Mikkelsen led the Anglo-American polar expedition (1906–08); a sledge journey of several hundred miles over the ice of the Beaufort sea established that, contrary to report, there was no land north of Alaska.

Mikkelsen's most famous exploit belongs to the expedition which he led (1909–12) to northeast Greenland to look for reports left by Mylius-Erichsen in 1907. He found these, including valuable geographical information, but when he and his only companion. I. P Iversen, returned to the base on the coast they found their ship crushed by the ice and no sign of the remaining members of the expedition, who had in fact returned home on a sealing vessel. The two men survived a further two winters in Greenland, suffering great hardships, and were rescued by a Norwegian sealer after nearly all hope for them had been abandoned. Mikkelsen then wrote Lost in the Arctic (1913).

After some further years at sea, and as a journalist in Karelia (during the Russian revolution) and South America, Mikkelsen led an expedition in 1924 to establish the Eskimo settlement at Scoresby sound in east Greenland; great importance has been attributed to this measure as a factor in the Hague court's decision in favour of Denmark in the dispute with Norway over east Greenland. Mikkelsen also contributed to the development of the west Greenland fisheries, and in 1932 led a scientific expedition to southeast Greenland.

He later became inspector general for east Greenland (1934–50), a post for which he was suited by his deep feeling for the lot of the east Greenland Eskimo.

His published works include Frozen Justice (Eng. trans. 1922), Mirage in the Arctic (Eng trans. 1955); *Two Against* the Ice (Eng, trans. 1957) and a number of studies of the east Greenlanders. (P. A. B. G.)

MIKSZÁTH, KÁLMÁN (1847–1910), Hungarian novelist, regarded by contemporaries and succeeding generations alike as the outstanding Hungarian writer at the turn of the century. He was born on Jan. 16, 1847, at Szklabonya. He studied law but soon took up journalism, first at Szeged, later in Budapest. In 1887, already a famous writer, he was elected to the national assembly. He died on May 28, 1910, in Budapest.

Mikszáth scored his first success with two volumes of short stories entitled A tdt *atyafiak* ("The Slovak Kinsfolk"; 1881). and A *jó palócok* ("The Good Palocs"; 1882). In 1894 he published his first novel, *Beszterce* ostroma ("The Siege of Beszterce"), the story of an eccentric Hungarian aristocrat. Mikszáth's early art is romantic, and strongly influenced by Jókai. Toward the end of the century he became more realistic. Unlike

Jókai, who pictured a national fairyland, Mikszath was the writer of everyday life, which he described with understanding and sympathy, though he did not hesitate to pillory the shortcomings of society with sharp-witted satire.

The plots of his short stories and even of some of his novels are usually based on anecdotes. Only toward the end of his life did Mikszáth succeed in creating such full-sized novels as his two principal works *Különös házasság* ("A Strange Marriage"; 1900), and *A Noszty fiu esete Tdth Marival* ("The Noszty Boy and Mary Toth"; 1908). The first is set in early 19th-century Hungary and deals with the fight of two lovers against the oppressive forces of society. The second tells the story of a frivolous young noble who tries to make a fortune by seducing a rich middle-class girl. Mikszath's last work, *A fekete város* ("The Black City"; 1910), is his finest historical novel. A critical edition of his works has been published, *Mikszáth Kálmán Összes Munkdi* (1956 *et seq.)*.

See M. Rubinyi, *Mikszáth élete és müvei* (1917); I. Király, *Mikszáth Kálmán* (1952); *A.* Schopflin, *Mikszáth Kálmán* (1941).

(T. Ky.)

MIKULICZ-RADECKI, JOHANN VON (1850–1905), Polish surgeon, was born May 16, 1850, in Cernowicz (then part of Austria, now in Rumania). After taking his medical degree in Vienna in 1875, he became assistant to the great surgeon Theodor Billroth (*q.v.*). In 1882 Mikulicz became professor of surgery at Krakow, moving in 1887 to Konigsberg and in 1890 to Breslau, where he remained until his death.

Mikulicz-Radecki was one of the most versatile and imaginative of the European surgical giants credited with the origin and rise of modern surgery; his lifetime spanned the golden age. He is the eponym for diseases he described and for surgical techniques and tools he devised. The most commonly cited are: Mikulicz's disease, a symmetrical swelling of lacrymal and salivary glands due to growth of lymphoid tissue in these organs; Mikulicz resection of intestine, the exteriorization of a diseased segment of colon as a stage in operative removal; Mikulicz pad, a multilayered gauze sponge or pack commonly used in abdominal operations.

He is identified with the discovery and application of the esophagoscope, the surgical face mask and many surgical instruments. Other subjects of his writings include goitre, cancer, replacement of blood loss, anesthesia and asepsis.

Like Billroth, he was an accomplished musician. He died on June 4, 1905.

(J. H. Md.)

MILAN (Ital. MILANO, Ger. MAILAND, anc. MEDIOLANUM), a city of Lombardy, Italy, and the capital of the province of Milano, stands on the little Olona river, near the middle of the Lombard plain, 400 ft. above sea level, and is 93 mi. by rail E.N.E. of Turin. It is the seat of an archbishop, the chief financial centre of Italy and the wealthiest manufacturing and commercial town in the country. Pop. (1957 est.) 1,354,666 (commune).

The plain around Milan is extremely fertile, because of the richness of the alluvial soil deposited by the Po, Ticino, Olona and Adda rivers, and the excellent system of irrigation. From the cathedral roof, it presents the appearance of a vast garden divided into square plots by rows of mulberry or poplar trees. To the east this plain stretches in an unbroken level, as far as the eye can follow it, toward Venice and the Adriatic; on the southern side the line of the Apennines from Bologna to Genoa closes the view; to the west rise the Maritime Cottian and Graian alps, with Monte Viso as their central point.

Northward are the Pennine, Helvetic and Rhaetian alps, of which Monte Rosa. the Saasgrat and Monte Leone are the most conspicuous features. In the plain itself lie many small villages, and here and there a larger town like Monza, Lodi or Saronno, or a great building like the Certosa of Pavia makes a white point upon the greenery.

The summer is intensely hot and the winter quite cold. Snow is often seen then, and the temperature frequently falls belon freezing.

In shape, Milan is a fairly regular polygon within nhich the still smaller rectangular nucleus of the Roman city may be recognized. From its focus, the splendid Piazza del Duomo, a number of streets radiate in all directions; they are connected by an inner system of streets, constructed just outside the canal which marks the site of the town moat. The arches of Porta Nuova are almost the last trace of this inner circuit, constructed after the destruction of the city by Frederick Barbarossa. The radial streets are connected again by an outer circle of boulevards, just beyond the outer walls of the city, erected by the Spaniards in the 16th century.

In the centre of the city is the cathedral at one end of the Piazza del Duomo, or cathedral square. It is built of brick cased in marble from the quarries which Gian Galeazzo Visconti gave in perpetuity to the cathedral chapter. Begun in 1386, it was then the largest church in existence, and now, after St. Peter's at Rome and the cathedral of Seville, it is the largest church in Europe; it covers an area of 14,000 sq.yd. and can hold 40,000 persons. The interior is 486 ft. long, 189 ft. wide; the nave is 157 ft. high, and the distance from the pavement to the top of the tower is 356 ft. The style is very elaborate Gothic, but the work was continued through several centuries and after many designs by many masters, notably by Giovanni Antonio Amadeo (1447–1522), who carried out the octagonal cupola (the pinnacle of which dates from 1774), and by Tibaldi (Pellegrino di Tihaldo de' Pellegrini), who laid down the pavement and designed a baroque façade, begun after his death in 1609, hut only completed, by Napoleon's orders. in 1805–13. The church is cruciform. nith double aisles to the nave and aisles to the transepts. The roof is supported by 52 pillars with canopied niches for statues instead of capitals; the great windows of the choir have stained glass of 184.4. To the right of the entrance is the tomb of Archbishop Xribert (1045), while beside him rests Archbishop Otto Visconti (1295). In a crypt under the choir lies the body of the cardinal saint Carlo Borromeo, who consecrated the cathedral in 1577. It is contained in a rock-crystal shrine, encased in silver. and is vested in magnificent robes blazing with jewels. The roof of the cathedral is built of blocks of marble, and the various levels are reached by staircases carried up the buttresses; it is ornamented with a profusion of turrets, pinnacles and statues, of which last there are 3,300 of various styles and periods.

There are two noteworthy palaces in the Piazza del Duomo. The first is the former Palazzo Reale dating from 1772, but occupying the site of the earliest mansion of the Visconti and the Sforza; its great hall is a handsome chamber with a gallery supported by caryatids. Built into the palace is the ancient church of S. Gottardo (1330–36), a Romanesque building huilt hy Azzone Visconti in 1328–39, and the scene of the murder of Giovanni Maria Visconti in 1412. Its campanile is a heautiful example of early Lombard terra-cotta work. The second palace is that of the archbishops. with a fine façade. It has a fine court with double colonnades. The Palazzo della Ragione, in the Piazza dei Mercanti. just nest of the Piazza del Duomo. the central point of the mediaeval city. is a brick edifice (1223–38) with portico on the ground floor and a large hall on the upper. Close by to the south is the beautiful Loggia degli Osii, erected in 1316. with two open porticos, one above the other. in black and white marble.

Among the most interesting buildings in Milan is the historic church of S. Ambrogio. The church was built by St. Ambrose in 386–389, but as it stands it is a Romanesque basilica of the 11th–12th century. with a brick exterior. galleries over the facade, and perhaps the most perfectly preserved atrium in esistence. The wooden door belongs to the original 4th-century church; it has carvings with scenes from the life of David. The pulpit is also fine (11th–13th cent.). In a great silver reliquary (modern) in the crypt lie the bones of St. Ambrose. above which rises the high altar. which retains its original reliefs in gold and silver enriched with enamel and gems, the work of one Vuolfvinus, a German (835). The baldachin. with sculptures of the 12th or early 13th century. is borne by four ancient columns of porphyry. with 9th-century capitals. In the tribune are fine mosaics of the 12th century, and in the chapel of S. Vittore in Ciel d'Oro mosaics of the jth. The lofty brick campanile (789–824) is among the earliest in Italy. The court of the neighbouring canonica is by

Bramante. S. Lorenzo, in the south portion of the town, dates from before A.D. 538. but was sever'al times burned down and restored. The chapel of S. Aquilino, possibly part of the original structure, contains mosaics of the 5th or 6th century; while excavations have shown that its foundations, and apparently those of the whole church, rest upon a mass of architectural fragments taken from Roman buildings; the pavement of a bath was laid over them at a later date, and over this again the chapel was built. In plan the church is an octagon, supported at the corners by four square towers in brickwork. The interior with its two orders is a very fine one, and its influence on Renaissance architects has been considerable. The portico outside it with its 16 Corinthian columns is a later addition, using ancient materials. S. Eustorgio, one of the largest Gothic churches in Milan, dates, as it stands, with its campanile, from the 13th century. It has some interesting medieval sculpture and a fine chapel (Cappella Portinari). with a good dome and a beautiful frieze of angels (1462–68), and containing the splendid sculptured tomb of Peter Martyr (see VERMIGLI, PIETRO **MARTIRE),** the masterpiece of Giovanni di Balduccio of Pisa (1339).

S. Vincenzo in Prato (835); S. Satiro. founded in 879; and S. Babila and others are interesting for their Romanesque architecture. The small domed structure on the left of S. Satiro is earlier than the church. while the campanile is part of the original structure. The reconstruction of the church of S. Satiro was Bramante's earliest work in Milan (after 1476). The choir is painted in perspective (there was no room to build one), the earliest example of this device, which was so frequently used in baroque architecture. The octagonal sacristy (before 1488), has niches below and a gallery above, and stucco decorations by Bramante himself (the frieze with *putti* and medallions is by Agostino De Fonduti of Padua). The Cistercian abbey church of Chiaravalle. $5\frac{1}{2}$ mi. south of Milan, is a fine brick building in the plan of a Latin cross, with nave and two aisles with round pillars, with a lofty domed tower. in the so-called Romanesque Transition style, having comparatively slender round pillars and cross vaulting, while the exterior is still quite Romanesque. It was founded in 1135 by St. Bernard and consecrated in 1221. It is interesting as the model for the plan of many other churches in Lombardy; *e.g.,* S. Maria del Carmine and S. Francesco at Pavia. S. Maria Incoronata is unique as a double Gothic church, in the horizontal sense (1451–87).

Of secular buildings of the beginning of the 15th century, the most notable is the Casa dei Borromei. which still preserves its Gothic courtyard. It has a good collection of Lombard pictures. The Gothic church of Santa Maria delle Grazie was built by the Dominicans about 1460. The choir. crossing and dome, with elegant external decorations in terra-cotta and marble, are by Bramante (*c.* 1492). Adjoining the church is the convent, with fine cloisters, by Bramante; in the former refectory Leonardo da Vinci (*q.v.*) painted his celebrated "Last Supper."

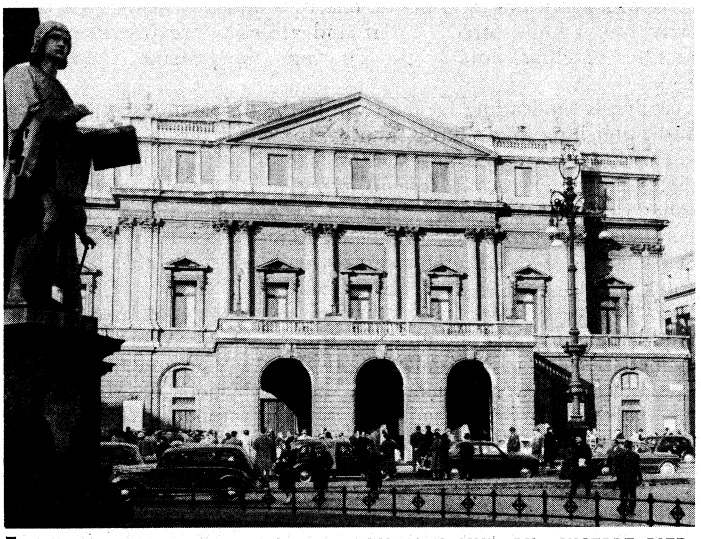
The interior of San Maurizio has effective frescoes by Bernardino Luini and his contemporaries. It was erected by Giovanni Dolcebuono, a pupil of Bramante, to whom is also due S. Maria presso S. Celso (the interior and the baroque façade are by Alessi to whom the fine church of S. Paolo is also due). The renowned Biblioteca Ambrosiana, rich in manuscripts, was erected in 1603–09 by Fabio Manzone, to whom the Palazzo del Senato is also due. There is a picture gallery, in which is Raphael's cartoon for his fresco the "School of Athens" in the Vatican. The Ospedale Maggiore was founded in the reign of Francesco Sforza. The entire edifice is covered externally with terra-cotta; its façade was designed by the Florentine Antonio Averulino and begun in 1457.

The city is rich in works of art. for Milan, with the introduction of the early Renaissance style by Antonio Filarete and Michelozzo di Bartolommeo Michelozzi after 1450, became the home of a Lombard school of sculpture among the chief masters of mhich may be mentioned Amadeo (1447–1522), Cristoforo Solari, and, the last of them. Agostino Busti, known as Bambaia (*c.* 1480–1548) whose work may be seen in the cathedrals of Como and Milan and in the Certosa of Pavia.

Toward the close of the 11th century, the refined court of Lodovico Sforza attracted such celebrated men as Bramante, the architect; Franchino Gaffurio, founder of one of the first musical academies; and the immortal Leonardo da Vinci from whose school came a number of brilliant artists. Later Leone Leoni of Arezzo achieved fame as a sculptor.

The picture gallery of the Brera occupies an imposing palace with a good courtyard by Francesco Maria Richini. It also contains a library of about 350,000 volumes, an institute of science and letters, and an observatory. The Brera gallery possesses Raphael's famous "Sposalizio," many pictures and frescoes by Luini, Gaudenzio Ferrari and Bramantino; and a collection of the works of Carlo Crivelli (fl. 1480), while the Venetian school is well represented by works of Paolo Yeronese, Paris Bordone, Gentile Bellini. Cima da Conegliano, Bonifazio Veronese de Pitati, Giambattista Moroni and Vittorio Carpaccio.

The Castello Sforzesco, or Castle of Milan, stands in the Parco Nord; it was built in 1450 by Francesco Sforza on the site of one erected by Galeazzo II Visconti (1355–78) and demolished in 1447 by the populace after the death of Filippo Maria Visconti. After many vicissitudes it was restored — including especially the splendid entrance tower by Antonio Averulino (1451–53), destroyed by a powder explosion in 1521—in the 15th-century style, and it is now a most imposing pile. Some fine windows with terra-cotta decorations are preserved. It contains medieval and Renaissance tombs and sculptures, including the "Pietà" of Michelangelo. Several rooms bear traces of the decorations executed under Galeazzo Maria and Lodovico Sforza. (*See* LEONARDO DA VINCI.) In the upper rooms is a large collection of Milanese and central Italian ceramics. textiles, furniture. bronzes, ivories: enamels, glass and historical relics, and a picture gallery. Archaeological collections formerly housed there have been transferred to the new archaeological museum in the Corso Magenta.



THE TEATRO ALLA SCALA, MILAN. IT WAS DESIGNED BY GIUSEPPE PIERMARINI (1734–1808) AND WAS OPENED IN 1778. IT WAS RESTORED AFTER IT HAD BEEN BOMBED DURING WORLD WAR II

The Via Dante (1888) runs from the Piazza Cordusio to the spacious Foro Bonaparte and thence to the Parco, a great public garden in which stands the Castello Sforzesco. To the north of the castle is the Arena, a kind of circus erected in Napoleon I's time; while facing the castle on the opposite side of the park is the Arco della Pace, begun by Napoleon in 1806, but finished by the Austrians in 1833. The Piazza del Duomo, the centre of Milan, is connected with the neighbouring Piazza della Scala by the famous Galleria Vittorio Emanuele (1865–67), a great arcade in the form of a Latin cross. with an octagon in the centre, crowned at the height of 160 ft. with a glass cupola; it is roofed with glass throughout. and is 320 yd. long. 16 yd. wide and 94 ft. high. By the end of the 19jos rebuilding had changed portions of the city's centre beyond recognition. with spaciously set blocks of marble-faced buildings sometimes carried out over the pavement in high

arcades; Milan's first skyscraper was erected.

Near the Piazza della Scala is the Museo Poldi-Pezzoli, with valuable pictures, textile fabrics, arms, armour and antiquities. In the middle of the neighbouring Piazza della Scala stands Magni's monument of Leonardo da Vinci (1872). Opposite is the celebrated Teatro alla Scala, built in 1778 on the site of a church founded by Beatrice della Scala, wife of Bernabb Yisconti. After the San Carlo at Naples it is the largest theatre in Europe, and can seat 3,600 spectators. It has an interesting theatrical museum. Looking on to the piazza is the fine Palazzo Marino, the seat of the municipality since 1861; it was built by Galeazzo Alessi in 1 jj8, to whom the side facade and the court are due, but was not completed until 1890, when the main façade was erected by Luca Beltrami. S. Fedele by Tibaldi (1569) is close by. Milan has a state university, a large school of engineering, the Bocconi commercial university, the Catholic university, and numerous other learned and educational institutions. In 1937 the Centro Nazionale di Studi Manzoniani was inaugurated in the poet's former house and in 1948 the National Museum of Science and Technology was opened. Milan has long been a great musical centre; a Verdi museum has been formed. There are many philanthropic institutions, and public charities and services are particularly well administered. Sport and athletics are provided by a number of clubs, notably the Touring Club Italiano, founded in 1894.

Milan is the leading Italian town in the textile industry, printing and publishing. metallurgy, photography and the manufacture of chemicals. It has the biggest European market for silk and it produces machinery for textile. printing, mining. hydroelectric and other works, instruments, airplanes. automobiles, locomotives, paper, glass, furniture, food products and many other types of goods. It has also a big market for cereals, fruit and vegetables and livestock.

History. — (For earlier history see MEDIOLANUM.)—After the establishment of the Lombard capital at Pavia in j69 Milan remained the centre of Italian opposition to the foreign conquest. The Lombards were Arians, and the archbishops of Milan from the days of Ambrose had always been orthodox. Though the struggle was unequal, their attitude of resolute opposition to the Lombards gained for them great weight among the people, who felt that their archbishop was a power round whom they might rally for the defence of their liberty and religion. When the Lombard kingdom fell before the Franks under Charles the Great in 774, the archbishops of Milan were still further strengthened by the close alliance between Charles and the Church, which tended to confirm their temporal authority, and alsc by Charles's policy of breaking up the great Lombard fiefs and dukedoms, for which he substituted the smaller counties. Under the confused government of Charles's immediate successors the archbishop was the only real power in Milan. But there were two classes of difficulties in the situation, ecclesiastical and political; and their presence had a marked effect on the development of the people and the growth of the commune, which was the next stage in the history of Milan. On the one hand the archbishop was obliged to contend against the heretics or against fanatical reformers who found a following among the people; and on the other, since the archbishop was the real power in the city, the emperor, the nobles and the people each desired that he should be of their party; and to whichever party he did belong he was certain to find himself violently opposed by the other two. From these causes it sometimes happened that there were two archbishops, and therefore no central control, or no archbishop at all, or an archbishop in exile. These difficulties developed a spirit of independence and a capacity of judging and acting for themselves in the people of Milan. The terror of the Hunnish invasion, in 899, further assisted them in their progress towards freedom, for it compelled them to take arms and to fortify their city, rendering Milan more than ever independent of the feudal lords who lived in their castles in the country. The tyranny of these nobles drove the peasantry and smaller vassals to seek protection for life and property and equality of taxation and of justice inside the walled city and under the rule of the archbishop. Thus Milan grew populous, and learned to govern itself. Its inhabitants became for the first time Milanese, attached to the standard of St. Xmbrose — no longer subjects of a foreign conqueror, but a distinct people, with a municipal life and prospects of its own.

For further history of the commune, including the significance of the great archbishop Heribert (1018–45), the rule of Milan in Lombardy, the Lombard league and the defeat of the emperor at Legnano, see ITALY: History; LEGNANO; LOMBARD LEAGUE.

After the battle of Legnano, in 1176, although the Lombard cities failed to reap the fruit of their united action and fell to mutual jealousy once more, the city of Milan began to grow in material prosperity. After the Peace of Constance (1183) the city walls were extended; the arts flourished, each in its own quarter, under a syndic who watched the interests of the trade. The manufacture of armour was the most important industry. During the struggles with Barbarossa, when freedom seemed on the point of being destroyed, many Milanese vowed themselves, their goods and their families to the Virgin should their city come safely out of her troubles. Hence arose the powerful fraternity of the "Umiliati," who established their headquarters at the Brera, and began to develop the wool trade, and subsequently gave the first impetus to the production of silk. From this period also date the irrigation works which render the Lombard plain a fertile garden. The government of the city consisted of (a) a parlamento or consiglio grande, including all who possessed bread and wine of their own—a council soon found to be unmanageable owing to its size, and reduced first to 2,000, then to 1,500 and finally to 800 members; (b) a credenza or committee of 12 members, elected in the grand council, for the despatch of urgent or secret business, (c) the consuls, the executive, elected for one year, and compelled to report to the great council at the term of their office.

The bitter and well-balanced rivalry between the nobles and the people, and the endless danger to which it exposed the city owing to the fact that the nobles were always ready to claim the protection of their feudal chief, the emperor, brought to the front two noble families as protagonists of the contending factions—the Torriani of Yalsassina, and the Visconti, who derived their name from the office of delegates which they had held under the archbishops. After the battle of Cortenova, in 1237, where Frederick II. defeated the Guelph army of the Milanese and captured their carroccio, Pagano della Torre rallied and saved the remnants of the Milanese. This act recommended him to popular favour, and he was called to the government of the city — but only for the distinct purpose of establishing the "catasta," a property tax which should fall with equal incidence on every citizen. This was a democratic measure which marked the party to which the Torriani belonged and rendered it hateful to the nobility. Pagano died in 1241. His nephew Martino followed as podestà in 12j6, and in 1259 as signore of Milan — the first time such a title was heard in Italy. The nobles who had gathered round the Visconti, and who threatened to bring Ezzelino da Romano, the Ghibelline tyrant of Padua, into the city, were defeated by Martino, and 900 of their number were captured. Martino was followed by two other Torriani, Filippo his brother (1263–65) and Napoleone his cousin (1265–77), as lords of Milan. Napoleone obtained the title of imperial vicar from Rudolph of Habsburg. But the nobles under the Visconti had been steadily gathering strength, and Napoleone was defeated at Desio in 1277. He ended his life in a wooden cage at Castel Baradello above Como.

Otto Visconti, archbishop of Milan (1262), the victor of Desio, became lord of Milan, and founded the house of Visconti, which ruled the city--except from 1302 to 1310—till 1447, giving 12 lords to Milan On the death in that year of Filippo, the last male of the Visconti house, a republic was proclaimed, which lasted only three years. In 1450 the general Francesco Sforza, who had married Filippo's only child Bianca Visconti, became duke of Milan by right of conquest. Francesco was followed by five of the Sforza family, and from the death of the last (1535) till the War of the Spanish Succession (1714) Milan mas a dependency of the Spanish Crown. At the close of that war it was handed over to Austria, under whose rule it remained until the Napoleonic cam-

paign of 1796 (see ITALY). The Lombard campaign of 1859, with the battles of Solferino and Magenta, finally made Milan a part of the kingdom of Italy.

Because of its industrial importance, Milan was the target of repeated air raids during World War II, first by the British, and after 1942 by both British and Americans.

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MILAN OBRENOVIĆ IV (1854–1901), king of Serbia, was horn at Jassy. Rumania, on Aug. 22, 1854, son of Miloš Obrenović (1829–1861), the nephew of Prince Miloš I (*q.v.*), and Maria Katardži, a Moldavian. Early left an orphan, hlilan was adopted by his cousin Michael (*q.v.*), educated at Bucharest and Paris, and placed on the throne under a regency, in 1868, on the assassination of Michael. In 1872 he came of age, but retained the Liberal regent. Ristid, as his premier. For the events of his rule as prince see EASTERN QUESTION and SERBIA. He proclaimed himself king in 1882.

Milan's Austrophile policy was most unpopular, particularly as taxation had become a burden; military service increased and the king's private life was extravagant and unsavoury. In 1875 he had married Natalie, the 16-year-old daughter of Colonel Ketčko, a Moldavian in the Russian army. After the birth of their son Alexander (1876), relations between the couple became notoriously strained, and the Russophile party rallied round Natalie. In 1885 Milan embarked on an ill-judged. undesired and ignominious campaign against Bulgaria, being saved from disaster only by Austria's intervention. In 1886 the queen withdrew with her son to Wiesbaden. In 1888 Milan recovered his son. circulated nauseous scandals about his wife, and finally extorted a divorce, which was illegal in the eyes of the orthodox church. In an attempt to recover his popularity, he suddenly promulgated a new and liberal constitution (Jan. 2, 1889); but on March 6 abdicated in favour of his son, and retired to Paris. In 1892 he renounced his Serb nationality.

In Jan. 1894 he reappeared in Belgrade, and on April 29 he and Natalie were reinstated and nominally reconciled. the queen returning in May 1895. Appointed commander in chief of the Serb army in 1897. Milan did some really useful technical work, but also inaugurated a cruel persecution of the Russophiles and Radicals. This period was suddenly checked by Alexander's marriage in July 1900. hlilan resigned his post and returned to Vienna, where he died unexpectedly on Feb. 11, 1901.

For bibliography, *see* SERBIA: the works of Georgević, *Das Ende der Obrenović* (1905) and *Die Serbische Frage* (1909) are detailed for Milan's period and written by a partisan; other literature is more occupied with his ill-doing.

MILÁ Y FONTANALS, MANUEL (1818–1884), Catalan scholar, the outstanding hispanic medievalist of his generation. He was born at Villa Franca del Panades, Barcelona, on May 4, 1818, and was professor of literature and aesthetics at Barcelona from 1847 until his death at Villa Franca del Panades on July 15, 1884. He was the author of De *los* trouadores en *España* (1866) and De la *poesía* herdico-popular castellana (1874). an epoch-making work in hispanic studies which revealed its author as a master of scientific method. His views on the history of the Castilian epic and the *romancero* were later adopted and developed by Ramón Menéndez Pidal. His role in the Catalan literary revival was still more important. His works in Catalan include the legend in verse. La *cançó* del Pros Bernat, and the exquisite ballad *La font* de *Na Melior.* (I. M. G.-LL.)

MILAZZO, a seaport of Messina province. Sicily, Italy, on the north coast of the island 30 km. (15.5 mi.) W. of hlessina by road. Pop. (1957 est.) 23.092 (commune). It is mainly built on the low isthmus of a peninsula 3 mi. long; the old town on a hill above contains a Norman castle dating mainly from the 16th century, with parts from the 13th century. Milazzo is on the railway from Messina to Palermo and is the transit port for the Aeolian Islands. The neighbouring plain yields grapes and early fruit. The town is a tourist centre and has a growing industry. The town. the ancient Mylae, was founded in the 8th century B.C. by colonists from Zancle (hlessina). It was taken by the Athenians in 426 B.C.; Gaius Duilius won the first Roman naval victory over the Carthaginians in the bay in 260 B.C.; and on July 20, 1860, Garibaldi defeated the Bourbon forces outside Milazzo. The town suffered from Allied bombing in World War II.

MILDENHALL, a market town of Suffolk. Eng., is on the river Lark. 39 mi. N.W. of Ipswich by road. Pop. (1951) 6,742. The town retains its hexagonal market cross dating from the reign of Henry V and now scheduled as an ancient monument. The church of St. Mary is of the 13th to the 15th century with a tower 112-ft. high. It is distinguished for the open timber hammerbeam roof of the nave.

The Mildenhall Treasure.—This hoard of Roman silver tableware was acquired by the British museum in 1946, having apparently been discovered four years before in the plowing of a field at West Row, 2 mi. N.W. of Mildenhall, near remains of a 4th-century Roman building. Nearly all the pieces, 34 in all, seem to be of 4th-century workmanship, and some are products of Mediterranean factories. Possibly the owners buried their family plate in the troubled days of the barbarian invasions.

The most impressive piece in the hoard is a great dish. 60.5 cm. in diameter. its outer frieze of relief ornament depicting the triumph of Bacchus over Hercules. The same techniques of naturalistic figures in relief with incised detail are found on two platters with heavy beaded borders. There are also four large and two smaller bowls with flanges ornamented in relief. A large flanged dish and a bowl are decorated in a different style. with incised niello work. The dish is perhaps the earliest item in the hoard. although the lid found with it is obviously of later workmanship. A fluted bowl with swing handles completes the larger items in the collection. The smaller pieces are two unusual goblets with very broad bases, possibly for use as plates, five ladles with dolphin handles and eight spoons, three of which have Christian inscriptions and were probably christening spoons.

See T. W. Brailsford. *The Mildenhall Treasure.* 2nd ed. (1955). (R. J. CR.)

MILDEW, a term applied to various minute fungi and also to the spotting, discoloration and deterioration caused by their growth on such materials as paper, textiles, wood, leather, paint and food. The areas of milde growth consist of a network of branching threadlike structures of microscopic size. These mildew threads produce large numbers of microscopic reproductive bodies called spores which are spread about by air currents or other agencies. On reaching suitable material, and under favourable conditions of temperature and humidity, the spores germinate and develop new spots of mildew growth.

The fungi which cause mildew are simple plants, certain types of which live as saprophytes; *i.e.,* they subsist on dead material; whereas. other types such as the downy mildew of grape or the powdery mildew of roses are parasitic and attack living plants. Against these latter, garden and crop plants may be protected by spraying nith suitable fungicides. (See FUNGI; PLANT DISEASES.)

Since the spores of these minute fungi are ever present in air, dust and soil, the problem of mildew prevention involves achieving conditions too cold or dry, or too chemically inhibitory for mildew growth. For example, food may be conserved by refrigeration, clothing may be kept in drying closets, tentage or tarpaulins may be treated with compounds containing copper or other mildew preventives

Mildew stains often respond to simple washing coupled with treatment with mild oxidizing agents such as lemon juice and bleach. All treatment, however, tends to weaken and discolour the fabrics. See LEATHER. (W. H WN)

MILES, NELSON APPLETON (1839–1925), U.S. soldier, was born in Westminster, Mass.. Aug. 8, 1839. He mas engaged in mercantile pursuits in Boston when the Civil War

began, and he entered the army in Sept. 1861, as a lieutenant of volunteer infantry. He served with distinction in the Peninsular campaign, and at Antietam, Fredericksburg and Chancellorsville, where he received a wound which incapacitated him until 1864. He commanded a brigade at the Wilderness and Spottsylvania, and fought in the Cold Harbor and Petersburg operations in 1864–65. In July 1866. Miles was made colonel of a regular infantry regiment. He was promoted to brigadier general (Dec. 1880), to major general (April 1890) and in 1895 succeeded Gen. John McA. Schofield as commanding general of the United States army. He was conspicuously successful (1869–86) in dealing with Indian outbreaks, and he commanded the United States troops sent to Chicago during the railway riots in 1894.

Miles was in nominal direction of military operations during the war with Spain in 1898, though his personal share of the operations was confined to directing the almost unopposed Puerto Rico expedition. He was raised to the rank of lieutenant general in 1900, and retired from active service in 1903. He died in Washington, D.C., May 15, 1925.

He wrote *Personal Recollections* (1896), *Military Europe* (1898), *Observations Abroad* (1899) and *Serving the Republic* (1911).

MILETUS (mod. PALATIA), an ancient city of Asia Minor, on the southern shore of the Latmic gulf near the mouth of the Maeander. Before the Ionic migration it was inhabited by Carians *(Iliad,* ii, 867; Herod, i, 146), and pottery found on the spot proves that the site was inhabited, and had relations with the Aegean world, in Minoan times. Greek settlers from Pylos under Neleus are said to have destroyed the old city and to have built a new one on the coast. Miletus occupied a very favourable situation at the mouth of the rich valley of the Maeander, and was the natural outlet for the trade of southern Phrygia (Hipponax, *Fr.* 45). It had four harbours, one of considerable size, and its power extended inland for some distance up the valley of the Maeander, and along the coast to the south, where it founded the city of Iasus. Its enterprise extended to Egypt, where it had much to do with the settlement of Naukratis (*q.v.*). Very little "Naucratitic" pottery, however, was found on the site, and only in the Athena temple. The Black sea trade, however, was the greatest source of wealth to the Ionian cities. Miletus, like the rest, turned its attention chiefly to the north, and succeeded in almost monopolizing the traffic. Along the Hellespont, the Propontis and the Black sea coasts it founded more than 60 cities—among them Abydos. Cyzicus, Sinope, Dioscurias, Panticapaeum and Olbia. Most of these cities were founded before the middle of the 7th century; and before 500 B.C. Miletus was the greatest east Greek city. Miletus was equally distinguished at this time as a seat of literature. Thales, Anaximander, Anaximenes and Hecataeus all belonged to this city. The three Ionian cities of Caria—Miletus, Myus and Priene—spoke a peculiar dialect of Ionic.

The Mermnad kings of Lydia found in Miletus their strongest adversary. War was waged for many years, until Xlyattes II concluded a peace with Thrasybulus of Miletus; the Milesians afterward seem to have acknowledged the rule of Croesus. On the Persian conquest Miletus passed under a new master; it headed the Ionian revolt of 499 B.C., and was taken by storm after the battle of Lade. *(See* IONIA.) Darius gave up the city to the Carians. The Persians mere expelled from the coast in 479 B.C., Miletus became a member of the Delian league (*q v.*), revolted to Sparta in 412, passed into Carian hands and opposed Alexander on his southward march. succumbing to a siege (334 B C.). It was a town of commercial importance throughout the Greco-Roman period, and received special attention from Trajan. Its harbours, once protected by Lade and the other Tragasaean islands, were gradually silted up bv the Maeander, and Lade is now a hill several miles from the coast. Ephesus took its place as the great Ionian harbour in Hellenistic and Roman times. Miletus became the seat of a Christian bishopric and was strengthened by a Byzantine castle *κάστρον τῶν Παλατίων,* built above the theatre.

Excavation has revealed on the north of the ruins a well-preserved Roman theatre on the site of an older Greek building. Cyriac of Ancona described the building as practically complete in his day (1446). East of this was the ancient north harbour, now silted up, and on the hillside above it stood a large heroon of Hellenistic time. South of the harbour head lies the Hellenistic agora with ruins of large magazines of Doric style. South of these again lie a nymphaeum of the age of Titus, and a senate house of theatral form. On the east opens a great hall surrounded by porticoes and enclosing a high altar of Artemis, once richly adorned with reliefs. The Roman agora lies beyond this again. A straight street leads southwest from the north harbour to the Didyma gate in the wall, which runs across the neck of the peninsula and was rebuilt by Trajan, when he undertook to raise the level of the outer quarters of the city; and streets cross this at right angles in the geometric Hellenistic manner. A sacred way lined with tombs led to Didyma. Two temples were discovered, one, on the southeast, being a sanctuary of Apollo Delphinius. This seems to have been the chief temple of the city. The other temple, an archaic sanctuary of Athena, lies west of the stadium.

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MILFORD, a city of Connecticut, U.S., on Long Island sound near the mouth of the Housatonic river; a part of the Bridgeport standard metropolitan statistical area *(see* BRIDGEPORT). Milford was founded in 1639 by the Rev. Peter Prudden and his followers; the land was purchased from the Paugusset Indians for 6 coats, 10 blankets, 1 kettle, 12 hatchets, 12 hoes, 24 knives and 12 small mirrors. The settlement was named for the English city. Yew Haven colony first rejected Milford's application for membership because six nonchurch members could vote but a later compromise brought Milford into the colony in 1643. Early economic activity centred about farming until a thriving coastal trade developed. In the 1640s Indian attacks threatened the town to such an extent that citizens surrounded the settlement by palisades.

During the American Revolution Milford men drove off a small British landing force. In 1777 Milford inhabitants under Stephen Stow cared for 200 desperately ill American soldiers abandoned by a British ship. Stow himself died, as did 46 soldiers.

From about 1690 to 1818 shipbuilding flourished. Oyster-raising, begun in 1752, continued profitably into the second half of the 20th century. After a lengthy period of slow growth in the 19th century, Milford began to increase rapidly in population after 1910 as it acquired new industries. Leading manufactures include brass goods, electronics and electrical motors, hardware, locks and screw machine products.

Milford was a town from its founding until 1959, when it was incorporated as a city. Despite considerable industrialization Milford retains much old-time New England charm with its tidy central green and fine old homes. For comparative population figures *see* table in CONNECTICUT: *Population.* (A. E. V. D.)

MILFORD HAVEN, LOUIS ALEXANDER MOUNTBATTEN, 1ST MARQUESS OF (1854–1921), also known as PRINCE LOUIS OF BATTENBERG, British admiral of the fleet, was born at Gratz. Austria, on May 24. 1854. the eldest son of Prince Alexander of Hesse. and was naturalized as a British subject in 1868, when he entered the Royal Navy. He had a distinguished career, taking part in the Egyptian campaign (1882) and while still a captain he held the post of director of naval intelligence (1902). As rear admiral he commanded the 2nd cruiser squadron (1905). where he showed great skill as a naval leader and was promoted vice-admiral in 1908. Xfter commanding the Atlantic fleet and part of the Home fleet, he became second sea lord (Dec. 1911). In 1912 he was moved to the position of first sea lord where he was responsible for bringing the fleet to a state of readiness for war.

After a test mobilization in July 1013. he ordered the reserve ships to remain in full commission without instructions from the government, so that the whole fleet was ready for action when World War I began on Aug. 4. Two months later. despite his prevision and the work he had done for the navy. notably in sig-

nals and tactics, press agitation over his German origin brought about his resignation In 1917 he relinquished his German titles at George V's request, assumed the surname Mountbatten and was created marquess of Milford Haven. He died in London on Sept. 10, 1921.

In 1884 he married Princess Victoria of Hesse-Darmstadt and had two daughters and two sons. George (1892–1938), 2nd marquess, and Louis, afterward Earl Mountbatten of Burma *(see* MOUNTBATTEN OF BURMA, LOUIS MOUNTBATTEN).

(W. S. CH.)

MILFORD HAVEN, urban district and seaport in Pembrokeshire, Wales. Pop. (1961) 12,802. Area, 1.6 sq.mi. Milford Haven itself (Welsh: Aberdaugleddau—"the mouth of the two harbours") is, as its Welsh name implies. the estuary of the united East and West Cleddau rivers.

The modern town of Milford Haven, originally a hamlet in the parish of Steynton. was laid out in 1790 by the Hon. R. F. Gréville who saw its location as a convenient port for Irish trade. In the early 19th century a royal dockyard was established at Milford Haven, but in 1814 the dockyard and arsenal were moved to Paterchurch near Pembroke. The growth of the town was further checked 20 years later by the development of Neyland or New Milford, farther east on the Haven, to which the Irish packet service was transferred. Toward the end of the 19th century the town recovered much of its prosperity, becoming the headquarters of a steam trawling fleet and a fish curing station.

Forming the chief point of embarkation for Ireland in the middle ages, Milford Haven played an important part in history on several occasions. It was from there that Henry II set sail for the conquest of Ireland in 1172. In 1399 Richard II landed at Milford Haven from Ireland shortly before his surrender to Henry of Lancaster (afterward Henry IV) in whose reign a French fleet with 12,000 men on board sailed to the Haven and disembarked with the object of assisting the rebellion of Owen Glendoner. Henry Tudor also landed there in 1485 on his return from France to win the crown of England and Wales.

MILHAUD, DARIUS (1892–), French composer, nas born at Aix-en-Provence. Sept 4, 1892 He studied at the Paris conservatoire but his studies were interrupted by World War I, and he became attached to the French legation in Rio de Jnneiro (1917–19). There he met Paul Claudel, who was to write many librettos for him After the war Milhaud formed one of the French group known as "Les Six." and became increasingly interested in polytonal harmony. In 1940 he went to the United States. returning to France in 1947. Milhaud was a prolific composer in an astonishing number of forms. He wrote chamber and piano music, songs, orchestral works, ballets, operas and incidental music for plays and motion pictures.

His moods are as varied as his forms, ranging from the tragic force of his music for Aeschylus' trilogy *Orestes* (1913–25; French version by Claudel) to the humour and parody of the ballets *Le Boeuf sur le toit* (1919) and *Le Train* bleu (1924). *One* of his most impressive works is his opera *Christophe Colomb* (produced in Berlin, 1930), which he wrote in association with Claudel. His later works include the opera *Bolivar* (1943), film music, symphonies, concertos and string quartets.

See D. Milhaud, *Notes sans musique,* an autobiography (1949), Eng. trans. by D. Evans (1952).

MILITARY, NAVAL AND AIR ACADEMIES. Academies for the training of officers for the armed forces exist in most countries. Their origins date from the establishment in Europe toward the end of the 17th century of permanent national navies and armies with the consequent need to build up a cadre of trained officers for them, though the founding of academies themselves did not begin until the latter half of the 18th century and the beginning of the 19th. Until the 20th century training was in the handling of weapons, drilling and management of men, tactics and strategy, and ceremonial. and, for naval cadets, also in navigation and the sailing and fighting of ships. In the 20th century separate air force academies were founded in some countries. With the increasing part played by science, technology and organization in modern warfare the content of the academies' syllabus has broadened. Since World War II the officer cadet has received a good deal of instruction in science and also in general subjects. The academic standard of entry and that eventually attained by the trained officer have become higher and, moreover, many cadet establishments qualify their students for a degree or prepare them to proceed to a university. At the same time, cadets tend to be drawn from much wider social strata than hitherto and are usually trained at the state's expense.

UNITED STATES

West Point.— The United States Military academy was established as a part of the corps of engineers with five officers and ten cadets on March 16, 1802, at West Point. S.Y. The site, 50 mi. N. of New York city, was a key Hudson river military fortress during the Revolution.

Several compelling reasons made the formation of a military academy necessary in 1802. First was the Revolutionary experience, during which the United States had to rely on foreign military technicians. Second, military leaders, including George Washington, felt that the mastery of military technology required extended study and could not be acquired by practice alone. And third, some educational reformers felt that the established colleges were'not furnishing the type of practical education and scientific skills required for American development.

Before 1812, the academy was conducted as an apprentice school for military engineers and, in effect, as the first U.S. school of engineering. The act of April 24, 1812, reorganized the academy and increased the authorized strength of the corps of cadets to 2jo, expanded the staff of the academy, and established a four-year curriculum. This legislative goal was not effective until the superintendency of Col. Sylvanus Thayer (1817–33), who became known as the "father of the military academy" because of his lasting influence upon the West Point physical plant, the library, the curriculum, and the pedagogical method. Under Thayer's leadership the academy produced military technicians whose skills were adaptable to meet the civil engineering needs for the program of internal improvement which accompanied America's westward expansion. The act of congress of July 13, 1866, allowed the selection of a military academy superintendent from branches of the army other than the corps of engineers.

The military academy is under the immediate supervision and control of the department of the army, exercised through the superintendent, in whom is vested the immediate military command of the academy and the military post. The goal of the educational program is to instruct and train the corps of cadets so that each graduate will have the qualities and attributes essential to continued development through a lifctiine career as an officer in the regular army. The four-year course of college level education and training leads to a B.S. degree and a commission as second lieutenant in the regular army. The curriculum is balanced between mathematics and engineering sciences (j5%) and the humanities and social sciences (45%). The law authorizes the appointment of 2,512 cadets as well as four from the Republic oi the Philippines and 20 from the various Latin American republics and Canada.

Admissions information may be obtained from the registrar, United States Military academy, West Point, N.Y.

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Annapolis.— The United States Naval academy, an institution of college grade, is located at Annapolis, Md.; its graduates are commissioned in the navy and marine corps. A principal source of career officers, it was established in 1845 by Secretary of the Navy George Bancroft, initially as a five-year course of which three were at sea. but changed in 1850 to its present structure of a four-year academic course with summer cruises and practical instruction.

Cnder the superintendent are a commandant, who instills military qualities and maintains discipline, and three academic directors who are responsible for instruction.

Candidates are selected by college entrance examination and over-all evaluation, from nominees of the president, vice-president and members of congress. An additional 160 may be appointed each year from the regular navy and marine corps. 160 from the reserve, 75 from sons of service personnel and lesser numbers from other special sources; all these are by competitive examination. Entrants must be between the ages of 17 and 22, be secondary school graduates and be of good health and character.

The course covers mathematics, science and engineering at the level of an engineering college, though without specialization. and English, history, government, economics, one of six foreign languages, meteorology, navigation, naval weapons and operations. hygiene, leadership and physical education. Elective overload courses leading to majors in special fields are available to superior students, and advanced standing is granted for college level work completed prior to entrance. Graduates are awarded the degree of bachelor of science, with a major in special cases.

See also NAVAL SCHOOLS, U.S.

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U.S. Coast Guard Academy.—Located at New London, Conn., this military institution of higher learning is maintained by the federal government and conducted within the authority of the treasury department. Founded by act of congress in 1876, it embraces a four-year curriculum for the professional and academic training of cadet candidates for commissions in the coast guard.

Prior to World War II, the Coast Guard academy had a cadet corps of between 200 and 300 cadets, but in later years, as the coast guard assumed many new peacetime duties, the academy enrollment averaged between 500 and 600 cadets.

Entrance to the academy is restricted to unmarried men between the ages of 17 and 22. Appointment is obtained exclusively through nationwide competitive examinations. There are no political nominations. Examinations are held late in February of each year, and application to take the examinations must be made through the coast guard commandant, Washington, D.C.

Coast guard cadets are paid a small allowance for uniforms, equipment, textbooks, food and other expenses incidental to their training. A cadet is required to make a deposit upon entrance to the academy to defray initial clothing and equipment costs. In exceptional circumstances the superintendent of the academy is authorized to waive this requirement in part. A portion of a cadet's allowance is put aside for the purpose of outfitting him at the time of his commissioning.

The new class enters the academy during the summer. usually the first week in July. The "swabs" (fourth classmen) spend their first summer in becoming indoctrinated to military life. They are introduced to small boats, seamanship and military drill and discipline, in addition to attending their first classes, which include mathematics and history.

Instruction during the four-year course includes mathematics, English composition, physics, geography, navigation, seamanship, chemistry, meteorology, ordnance, materials of engineering and strength of materials, thermodynamics, electrical engineering. power engineering, economics and government, naval architecture and ship design, electronics, gunnery, law, communications, administration and leadership. In addition. each cadet makes annual summer training cruises aboard the three-masted sailing bark "Eagle" and escort cutters. Graduates receive the B.S. degree and are commissioned as ensigns in the U.S. coast guard.

The present home of the Coast Guard academy was constructed in 1932 at a cost of more than $2,000,000 and was expanded just prior to World War II at a similar cost. The buildings are of red brick in the Georgian colonial style, and centre around the administration building, Hamilton hall, named after Alexander Hamilton, the first secretary of the treasury, who founded the coast guard in 1790. The academy occupies a 65-ac. tract of land on the west bank of the Thames river.

U.S. Merchant Marine Academy.—The U.S. merchant marine corps was established in 1938 and the academy at Kings Point. N.Y., about 20 mi. E. of New York city. was dedicated Sept. 30, 1943. Similar in many respects to the other federal academies, it prepares cadets to serve as officers in the merchant marine.

Graduates are licensed as either deck or engineer officers and receive the degree of bachelor of science. They are also eligible to apply for commissions as ensign in the U.S. naval reserve. A candidate for admission to the academy must be an unmarried U.S. male citizen. must be 17 but not yet 22 years of age on July 1 of the year in nhich he seeks admission, be nominated by his congressman, take a competitive examination held annually in March, and meet rigid physical requirements.

After the first year at Kings Point, cadets spend a full year at sea before returning to the academy for their second- and first-class years. The curriculum includes courses in nautical science, engineering. mathematics and science, ship management, history and languages, naval science and ship's medicine

Air Force Academy.—Authorized by U.S. congress in 1954, this military academy accepted its first class of 306 cadets on July 11, 1955, at an interim site at Lowry Air Force Base, Denver, Colo. Its permanent site, occupied in Sept. 1958, is 7 mi. N. of Colorado Springs. The full authorized strength of the academy was 2,512 cadets.

The academy's mission is to train and motivate its graduates for lifetime careers as air force officers. Its four-year academic curriculum, a combination of liberal arts and science courses, leads to a baccalaureate degree. Simultaneously, cadets receive a four-year airmanship course leading to a commission as second lieutenant in the air force and the aeronautical rating of navigator. The airmanship program, conducted throughout the year, includes military, physical and flying training. An extensive intercollegiate athletic program is conducted separately. Physically qualified graduates proceed through a full-scale course in pilot training.

Cadets receive a small salary, out of which they must purchase uniforms, books and personal needs. Food, quarters, medical and dental care and recreation facilities are furnished by the government. Cadets must be at least 17 and less than 22 years old on July 1 of the year they enter. They must never have been married, must be U.S. citizens of good moral character and must be physically qualified for pilot training. Congressional nominees fill 85% of the vacancies of each class. For further information write the registrar, Air Force academy. Colorado.

GREAT BRITAIN

For the early history of British officer training establishments, *see* the articles DARTMOUTH, SANDHURST and WOOLWICH. The age limits for entry to the Britannia Royal Naval college, Dartmouth, Devon, are 17–19, academic qualifications required being of university standard. Young officers spend one year in the college (including a cruise in the training squadron) as cadets before joining the fleet for a year as midshipmen. Seamen and supply officers then return to Dartmouth for a further two years as acting sublieutenants, and engineer officers go to the Royal Naval Engineering college, Manadon, Plymouth, Devon.

The training of officers for the army is carried out at the Royal Military .academy, Sandhurst (near Camberley, Surrey). which is an amalgamation of two establishments—the Royal Military academy (Woolwich, London) and the Royal Military college (Sandhurst). The first course entered the new joint academy in 1947. The combined strength of the Royal Military academy at the beginning of the 1960s was nearly 1,000 cadets, the average age of Sandhurst cadets is 17–20.

There is nothing barracklike about life at Sandhurst. Every cadet has a room to himself, except during his first term when he may share a double room. The cadet lives an academic as well as a military life There are six terms of 12–13 weeks each, to complete a strenuous program. "Serve to lead" is the Sandhurst motto. Its cadets are organized into three colleges and each col-

lege into four companies. The cadets can, too, go on to Cambridge university or to the Royal Military College of Science at Shrivenham, Wiltshire, to obtain a degree.

The Royal Air Force college, Cranwell, Lincolnshire, was formed in 1920. By the start of World War II more than 1,000 officers had passed through it and of these about 400 were left on the active list by the end of the war. The college accepts two classes a year, each numbering about 65. On the three-year course for the general duties branch (pilot) flight cadets' allocation of time is: flying 1,651 hr. (39.3%), general service training 730 hr. (17.40%) and the academic course 1,833 hr. (43.3%).

In all British military academies cadets pay no fees; on the contrary, they receive a pay of from 10*s*. to 12*s*. a day.

OTHER COUNTRIES

France. — In 1802 Napoleon founded at Fontainebleau the École Spéciale Militaire (E.S.M.). In 1808 it was transferred to Saint-Cyr, near Versailles. From its foundation up to 1957 about 51 000 officers graduated from Saint-Cyr and 11.000 of them were killed in action. After the liberation the E S.M. was reformed. reorganized and installed, May 23, 1947, at the military training camp of Coetquidan in Brittany, with the word *interarmes* added to its official name. The new E.S.M.I.A. also absorbed other schools where officers had been trained for the infantry, cavalry, artillery and engineers.

From 1947 the pupils of the E.S.M.I.A. have been divided into three batallions: the 1st and 3rd are known as the Saint-Cyr division and the 2nd as the *corps de troupe* division. Those of Saint-Cyr are composed of pupils who had obtained their *baccalaurkat* at one of the secondary schools and are 18 to 23 years old; the term of study is two years. Having graduated from the E.S.M.I.A. as second lieutenants they serve a third year in a specialized school of the arm of service they have chosen. Those of the *corps de troupe* are noncommissioned officers coming from the ranks. After a term at a special preparatory school they take an entrance examination and, on passing, study at the E.S.M.I.A. for one year, graduating as second lieutenants.

The École Navale of Brest trains officers for the navy. The candidates must be from 16 to 21 years old, have their *baccalauréat* and be single. They must pass an entrance examination. The course lasts two years, at the end of which those who do not satisfy the examiners may be allowed to stay another year, but no longer.

The École de l'Air was opened at Versailles, Nov. 4, 1935, and in 1937 was transferred to Salon-de-Provence. The course lasts from 1½ to 3 years according to specialization.

Spain. — The Academia General Militar was founded in 1882 at the Alcázar of Toledo. Dissolved in 1893, it was restpred in 1927. Again dissolved in 1931 it was restored for the second time in 1940. As the Alcázar of Toledo had been destroyed during the civil war, the academy mas moved to Saragossa, where it is housed in modern buildings specially erected for this purpose.

Training of the *caballeros cadetes* for all branches of the army and for the Guardia Civil lasts two years and the number of pupils admitted each year is limited to about 300. The entrance is by competitive examination for candidates between the ages of 16 and 21, but the upper age limit is extended for those with previous service. The cadets pay monthly about 518 pesetas for their upkeep, but there are exceptions and reductions for various cases. After two years at the Saragossa academy the cadets, with the rank of *alférez* (2nd lieut.), spend a year in a specialized school of the arm they have chosen. Only then are they commissioned with the rank of *teniente* (lieut.).

In the Escuela Naval Militar at Marín (Pontevedra) the yearly enrollment is limited to 60 and the training lasts five years. At the Academia General del Aire at San Javier (Murcia) yearly enrollment is limited to 75 and training generally lasts four years.

Italy. — Admission to the Academia Militare at Modena is competitive, with 600 pupils accepted yearly. The academy is open to pupils from military schools, from secondary schools of general education, and also to serving noncommissioned ranks. Candidates must be age 17 and not over 22 (27 for noncommissioned ranks of the carabinieri). A successful candidate has a two-year course of study at the end of which, as *sotto-tenente*, he is appointed to one of the various branches of the army. There follows a further two years of study at specialized military schools.

The naval academy is at Livorno (Leghorn). The course extends over four years with about 100 new students accepted every year. The air academy is temporarily situated on the Island of Nisida and the flying training is given at Pomigliano d'Arco, near Naples. The course extends over four years, with a yearly enrollment of 70.

German Federal Republic. — With revival of the German armed forces after 1952 special schools for training of officers have been organized. There is a Heeresoffizierschule at Hanover. Every candidate starts by spending from six months to one year in the army as an ordinary recruit. He must also have passed a successful *Maturitätsprüfung* (certificate of examination from a secondary school). As a sergeant he passes a special examination and, if accepted, joins the officers' school as a *Fahnenjunker* (an honorary title, not rank). After a successful year at the school, he goes back to his regiment as a *Fahnrich* (ensign) for a short period and afterward to specialized arm schools for nine months. When back at his regiment he passes another test and only when his commander is satisfied with his intelligence, personality and qualities of leadership does he recommend him to be commissioned as *Leutnant*. The training period takes on the average three years. The same system existed in the old German army.

For training of the officers of the navy there is the Marineschule at Miirwik, near Flensburg. For the air force there is the Offizierschule der Luftwaffe at Neubieberg near Munich. The general system of training is similar to that of the army.

Netherlands. — The Koninklijke Militaire Academie was founded at Breda in 1828. It has a three-year course for cadets between the ages 18 to 21. It trains officers for all arms of the land army including the *marechaussee* (military police). Since World War II it also trains air force officers. The Koninklijk Institut voor de Marine was founded in 1854 at Willemsoord, near Den Helder. For four previous years it was at Breda. From 1803 to 1850 navy officers were trained on board a special ship. The course, entrance methods and age of cadets are the same as for the army. All cadets pay a nominal fee of $140 (£50) a year on a sliding scale of relief.

Belgium. — The Brussels Ecole Royale Militaire trains officers for army, navy, air force and the *gendarmerie nationale*. The candidates must be at least 17; under certain conditions they are accepted up to 25. The academy is divided into two divisions: at the Polytechnique the course lasts five years; at the Toutes Armes, three years. Cadets are commissioned after two years and stay on as officers.

U.S.S.R.—Although the first military academy was founded in Russia in 1698 by Peter I, in the modern sense of the word the first naval academy was founded in 1827 and the first military academy in 1855. The first cadets' corps (*Kadetski Korpus*) or officers' training school was created in 1732. In 1863 the cadets' corps were reorganized as military gimnasia, but in 1882 their curricula were revised and they recovered the former name. On the eve of World War I, Russia had about 30 cadets' corps with a total of about 6,000 pupils. Instruction lasted seven years. The graduates were entitled to enter one of the existing military academies.

In 1918, soon after the Communist revolution, the first Soviet military academy was founded in Moscow. In 1924 its director was Mikhail Vasilievich Frunze (1885–1925), one of the brilliant Red army commanders. After his death the academy was named after him. There are also naval, air, engineering and military political academies. The entry is reserved to officerswho have not only graduated from specialized military schools but also have had a period of service in the armed forces. There is an entrance examination and only candidates with very high marks are accepted.

There are about 30 junior military schools named after Gen. Aleksandr Vasilievich Suvorov (*q.v.*); the first were opened in 1943. There are also two junior naval schools, in Leningrad and Baku, created in 1944 and named after Adm. Pavel Stepanovich Nakhimov (1802–1855). In both military and naval schools

entry is reserved for sons of men who served in the Soviet armed forces. The candidates must have studied for at least four years in a secondary school and be 12 or 13 years old. There is an entrance examination. The instruction lasts seven years and is entirely at the expense of the state.

See also OFFICERS.

MILITARY ACADEMY, UNITED STATES: see MILITARY, NAVAL AXD AIR ACADEMIES

MILITARY AFFAIRS (ARTICLES ON). The survey article WAR discusses the history of warfare in the context of political and social history and international law; it also relates major changes in military theory and practice to industrial and technological developments.

ARMY summarizes methods of organizing. equipping, training and deploying military forces, from the Battle of Marathon to the contingencies created by the 20th century scientific revolution. Parallel histories are given from specialized points of view in LOGISTICS; STRATEGY; and TACTICS.

The various types of military operation dealt with in individual articles include AIR WARFARE; DESERT WARFARE; ECONOMIC WARFARE; GUERRILLA WARFARE; JUNGLE WARFARE: MOUNTAIN WARFARE; PSYCHOLOGICAL WARFARE; and TRENCH WARFARE. Atomic weapons. discussed in AIR WARFARE and in articles listed in AERONAUTICS (ARTICLES ON). are treated also in ATOMIC ENERGY and MISSILES. Other potentials of total war are discussed in BIOLOGICAL WARFARE and CHEMICAL WARFARE.

Among articles dealing nith special branches of the armed services and activities connected with them are ARMOURED FORCES; ARTILLERY; BRIDGIXG. MILITARY; CAMOUFLAGE; CAVALRY; COAST DEFENSE; ENGINEERS, MILITARY; INFANTRY; INTELLIGENCE, MILITARY AND POLITICAL; MEDICAL SERVICES. MILITARY; MILITARY GOVERNMENT; MILITARY POLICE; ORDNANCE CORPS; PROCUREMENT, MILITARY; SANITATION. MILITARY; SIGNAL COMMUNICATION; SIGNAL CORPS: TRANSPORT, MILITARY; TRANSPORTATION CORPS; and WOMEN'S SERVICES, MILITARY.

Methods employed in the training of professional military officers are discussed in MILITARY, NAVAL AND AIR ACADEMIES; OFFICERS; and WAR COLLEGES. TRAINING. MILITARY deals with the training of enlisted men and reserve officers.

The organization of non-professional armies is discussed in CONSCRIPTION; MILITIA; TERRITORIAL ARMY; VOLUNTEERS; and YEOMANRY. Articles on military installations include BARRACKS; CAMP; FORTIFICATION; and PROVING GROUND. Related topics are dealt with in such articles as COLOURS, MILITARY; INSIGNIA, MILITARY; SALUTE; and UNIFORMS.

The systems used for coordination of army commands in various eras and countries are surveyed in STAFF, MILITARY. Similarly, the earlier and present methods for assignment of responsibility and authority to individual military leaders are described in OFFICERS. Articles are devoted to the duties of commissioned and noncommissioned officers—*e.g.*, GENERAL; MAJOR; LIEUTENANT; SERGEANT. The organization of military units is discussed in BATTALION; COMPANY, MILITARY; SQUADRON; etc.

Articles on military equipment include AMMUNITION, MILITARY; ARMOUR. TANK AND AIRCRAFT; ARMOURED CAR; ARTILLERY; BAZOOKA; FLAME THROWER; GRENADES; MACHINE GUN; MINE. LAND; MISSILES; PISTOL AND REVOLVER; PROPELLANTS; RANGE FINDERS; ROCKETS; SIGHTS, GUN; SMALL ARMS, MILITARY; TANK; etc.

The great wars of history, from ancient to contemporary times, are treated in separate articles—for example, GRAECO-PERSIAN WARS; PELOPONNESIAN WAR; PUNIC WARS; THIRTY YEARS' WAR; AMERICAN REVOLUTION; FRENCH REVOLUTIONARY WARS, NAPOLEONIC CAMPAIGNS; CRIMEAN WAR; AMERICAN CIVIL WAR; FRANCO-GERMAN WAR; RUSSO-JAPANESE WAR; WORLD WAR I; WORLD WAR II; KOREAN WAR. Individual articles are devoted also to battles and campaigns of major importance—*e.g.*, MARATHON; CANNAE; HASTINGS. The Battle Of *Hastings* (1066); GETTYSBURG: Battle of *Gettysburg;* MARSTON MOOR, BATTLE OF; ST. MIHIEL: Battle of *St. Mihiel*, 1918. Additional information on the history and organization of armies and the conduct of wars as seen in the historical perspective of individual nations is provided in such articles as FRANCE; GERMANY; GREAT BRITAIN; UNITED STATES (OF AMERICA); RUSSIA; etc. Reference to the Index will show the material on any topic available in specific sections of articles, in addition to complete articles.

Military antiquities are treated in such articles as ARMOUR, BODY; CASTLE; CROSS-BOW; ENGINES OF WAR; GUARDS AND HOUSEHOLD TROOPS; HELMET; LANCE; SWORD; WEAPONS, PRIMITIVE; etc. Biographical articles summarize the careers of outstanding military leaders, from Alexander III the Great to the leading strategists and tacticians of the Korean war.

Articles on related topics are cited in AERONAUTICS (ARTICLES ON); INTERNATIONAL RELATIONS (ARTICLES ON); and NAVAL AFFAIRS (ARTICLES ON).

MILITARY-CIVIL RELATIONSHIPS: see CIVIL-MILITARY RELATIONSHIPS.

MILITARY FRONTIER (Ger. *Militärgrenze*), a former institution and division of the Austro-Hungarian monarchy. When Croatia swore allegiance to the Habsburgs in 1527, after the defeat of Hungary by the Turks at Mohács, southern Croatia was left half-deserted, its inhabitants having fled north before the Turks. The Austrian government built a series of forts in this zone, and organized the remaining population, with immigrant Serbs and Vlachs, into a defense force under military supervision; the costs being borne by the estates of the Austrian provinces proper. This organization was gradually extended, and in 1630 received a formal statute.

By the end of the 17th century, there mere three "generalates," in Karlstadt (Karlovats), Warasdin and Petrinja respectively. The Hungarian and Croat estates deeply resented the existence of this exception from their authority, and constantly demanded its abolition, especially after Prince Eugène's victories had practically ended the Turkish peril; but the "Grenzer" themselves resisted any change, and the Habsburgs had also now become alive to its usefulness as a weapon against the unruly nobles. Instead of abolishing, they extended it; a new Slavonian district was established in 1702, a Szekler, in East Transylvania, in 1764, and a Wallach in 1766; the Frontier now ran from the Adriatic to the confines of Moldavia.

The "Grenzer" gradually became the backbone of the Austrian army. As its bravest, most loyal and best disciplined troops. they fought in all Austria's foreign campaigns, and under Jellačić took a chief share in crushing the revolutions of 1848–49 in Vienna and Hungary. In 1849 the frontier was formed into a separate province, with an area of 15,182 sq.mi. and a population of 1,220,503, mostly Serb or Croat. with some Vlach or Rumanian. In 1851, however, the eastern portion was incorporated with the rest of Transylvania. The Warasdin frontier passed under civil administration in 1871, the Banat in 1872 and the remainder of the Croat and Slovene districts on July 15, 1881. The tradition, however, remained, and even in World War I the Grenzer regiments were comparatively unaffected by nationalist agitation, while a high proportion of Austria-Hungary's highest officers were drawn from the old frontier.

See F. Vanićek, *Spezialgeschichte* der *Militärgrenze* (1875); J. H. Schwicker, *Geschichte* der oe. Militargrenze (1883). **(C. A. M.)**

MILITARY GOVERNMENT. This term may be defined as the administration of occupied territory by an occupying power, including the exercise of executive, legislative and judicial authority. In international law, territory is considered occupied when it is actually placed under the authority of hostile armed forces. The necessity for military government arises from the failure or inability of the legitimate government to exercise its functions. It is immaterial whether the government over an enemy's territory consists of a military or civil or mixed administration: its character and the source of its authority are the same. It is a government imposed by force, and the legality of its acts is determined by the international law of belligerent occupation.

Since it is in connection with belligerent occupation that the general concept of military government was evolved, the definition does not cover cases in which military forces have been stationed in neutral or friendly territory. As a result, the United States and Great Britain make use of the term civil affairs, to

describe relations between military forces located in a friendly country or area and the civil authorities and people of that country or area. These relations usually involve exercise by the military forces of certain authority normally the responsibility of the local government. In this connotation, military government is but one aspect or degree of civil affairs, although the terms have been used interchangeably.

Military government must be distinguished from military law and martial law. Military law is the code which regulates the conduct of members of the armed forces, but does not apply to civilians. Martial lam is the temporary government of the civil population through the military forces without the authority of written law, as necessity may require. It is invoked only in domestic territory, the local government and inhabitants of which are not treated or recognized as belligerents, and is governed solely by domestic law. *(See* MILITARY LAW; MARTIAL LAW).

Up to the 19th century. a conqueror usually considered himself the absolute owner of occupied lands and substituted his own military convenience for all previously existing rules. The Greeks and Romans did. however, recognize some limitations on the power of the occupying military commander, generally showing respect for local law, customs, traditions and religious uses when not inimical to the mission of their forces. Despite these earlier advances. however. practices in occupied areas reverted to barbaric conduct even after the appearance of Hugo Grotius' *De jure belli et pacis* in 162j. Grotius urged the adoption of humanitarian principles during military occupation. Later writers took up this theme and by the 19th century limiting principles gradually found recognition in the instructions which nations issued for use of their own armies as a matter of domestic law.

Early indications of the more enlightened practices were the instructions issued to both troops and the civilian population by Gen. Winfield Scott in Mexico in 1847. A significant landmark was the famous document, *Instructions for the Government of the Armies of the United States in the Field,* prepared by Francis Lieber (*q.v.*) and issued by the war department in 1863. Known as the Lieber code, this was a set of instructions issued to Union forces in the American Civil War to guide their conduct in Confederate territory. But the Lieber code made no provision for any organization specifically designed to administer occupied areas. Military government was conducted in some areas by political appointees and in others by military commanders. Nevertheless, the Lieber code had a widespread effect. It was published without change during the Spanish-American war of 1898, and reportedly many of its provisions were used by Germany during the war with France in 1870. Meanwhile the British had gained considerable experience uith military government problems in France after the Napoleonic wars, in India, Egypt, South Africa and other areas throughout the world.

Following the Franco-German War, several international conventions obligated their parties to observe certain minimum standards in territory under belligerent occupation. Art. 42–56 of the Hague convention of 1907 gained almost universal recognition. and with the Geneva conventions of 1929 and 1949, furnish the modern legal basis for the protection of individual and property rights during military occupation. *(See* also LAWS OF WAR.)

Experience in World War I illustrated only sketchily the principles and techniques which had evolved in the earlier patterns of military government. The Rhineland was untouched by the war; German administrative services were still functioning and continued to operate under orders from the central government. Military government consisted mostly of supervision of local authorities by officers placed in charge of civil affairs at each major headquarters and in each German kreis (the equivalent, roughly, of a British or U.S. county). Its organization was improvised and inadequately prepared for the problems to be faced.

Organizations for civil affairs and military government, planned in advance of tactical operations, were not developed until World War II. Intensive training programs for both U.S. and British military personnel were carried out during the war and it became standard procedure to formulate plans for civil affairs and military government in coordination with tactical plans.

With the invasion of Italy, both U.S. and British military government personnel were included in the first assault forces, and so effective was their work that they won highest praise from tactical commanders in the field. Effective control over the civilian populations and authorities assured the tactical commanders of stabilized conditions in their areas of responsibility.

In addition to the inclusion of civil affairs detachments in all major tactical units, the importance of having civil affairs officers on the staffs of the tactical commanders become so evident that, when the supreme headquarters, Allied expeditionary forces, was organized for the invasion of northwest Europe, civil affairs was made a section of the general staff and was designated the G5 division. Other theatres of operations followed suit, and headquarters at theatre, army group, army and corps were organized with G5 sections on the general staff.

The advances of allied armies in all theatres of war during 1944 resulted in great expansion of measures for controlling civilian populations in the battle areas. Civil affairs detachments operated in all countries of Europe as they were released from the grip of Hitler's armies. Carefully planned military governments were set up in captured areas of Germany and Austria. Long-range plans for the control from Berlin of all of Germany had been under discussion since 1943. In Germany, the entire government had to be rebuilt, and the task of feeding. clothing, housing, transporting and furnishing medical care to 6,500,000 displaced persons had to be handled in the process.

Across the world, other civil affairs and military government units accompanied both army and naval forces into recaptured areas in the Pacific ocean areas and into the Philippines, Japan and Korea. Unlike the situation in Germany, the supreme commander for the allied powers in the Pacific was able to make use of an existing government in Japan, thus making the job primarily one of supervision to see that allied orders were carried out.

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MILITARY LAW is that system of law by which the military establishment of a state or nation is governed. Every well-developed state has found it necessary to prescribe special rules for governing the conduct of its military establishment, and the most important are those which provide a special and distinct penal system within the military structure, different in many respects from that which is applicable to the general populace.

Military law finds its source, to a great extent, in the enactments of the same legislative bodies which provide laws for the entire citizenry, such as the congress of the Cnited States and the parliament in Great Britain. In addition there are certain rules of conduct which find their authority in custom. as does the common law in both Britain and the U.S. **A** further source of military law is international law, both customary and conventional.

Distinct military penal systems have existed from early times. The first known treatise on military law appeared in the 2nd century A.D., and portions of it were included by the Roman emperor Justinian in his *Digest.* Modern military law has been said to have had its origin in the code of articles of Gustavus Adolphus of Sweden (1621). although articles of war were promulgated in England by Richard II as long ago as 1385. Codes of military law, both in Britain and in the U.S., have traditionally been known as the Articles of War, a term used in the U.S. until 1951.

Should a soldier commit an offense which is of a nonmilitary nature, he may be tried by a civil court. since the soldier remains a citizen with all attendant rights and duties, although he has other special duties and is subject to criminal sanctions provided by military law. It is generally true, however. that the military authorities may assert a superior claim and hold the military man for trial by a military court. In the United States, for example, a person in the military service may be delivered to the civil authorities for trial if the military authorities so choose, and rarely will the military authorities attempt to interfere if an

accused person is first apprehended and charged with an offense by civil authorities.

The Uniform Code of Military Justice, governing all of the armed forces of the United States, was enacted by the congress in pursuance of the provision of the U.S. constitution nhich empowers the national legislative body to make rules for the government and regulation of the land and naval forces. The system by which military justice is administered in the United States is not a part of the federal judicial system. and it is not controlled by constitutional provisions applicable to ordinary criminal proceedings. Congress, however, provided by express enactment practically all of the procedural guarantees which the ordinary criminal defendant enjoys, and in some cases the defendant in the military system enjoys other and greater guarantees. An example is found in the fact that throughout the appellate process counsel is furnished the accused. vithout cost even though he possess ample funds.

Persons Punishable Under the Military Code.—The military codes of most countries specifically designate those who may be punished for violation of military law. Generally, such codes apply to members of the armed forces, civilians accompanying armed expeditionary forces in foreign lands and prisoners of war. Under the Uniform Code of Military Justice, 12 classes of persons who come under the jurisdiction of military courts were defined in detail. The United States supreme court in 1956 held that the wives of military personnel, while they are accompanying their husbands on military assignments outside the United States are within the classes of persons subject to trial by court-martial.

There are instances in which the military authorities exercise jurisdiction over all persons in a particular area. but in these instances it is not, strictly speaking, military law which governs. In time of great danger martial law governs all inhabitants within a particular area in which it has been declared, and military government is administered by the occupying military forces in a locality in which the local law has at least been partially suspended because of hostilities.

Military Offenses.—Anglo-American law denounces many offenses which are purely military in the sense that they are incident only to military service. The same is generally true in countries which have modeled their law from the French civil system. For convenience. such prohibited acts usually are styled military offenses. The Uniform Code of Military Justice of the United States lists more than 20 offenses which are of a strictly military nature. These are offenses which have no counterparts in civilian jurisprudence.

Among the offenses so listed are fraudulent entry into the service, unauthorized absence from duty, desertion from the service, failure to obey orders or regulations, misbehaviour before the enemy, disorders and neglects to the prejudice of good order and discipline and. in the case of an officer, conduct unbecoming an officer and a gentleman. The ordinary criminal courts are without authority to try persons for such offenses; trial must be by a military court. As a matter of form, the Uniform Code of Military Justice also enumerates other offenses which may be tried by a military court, such as murder, robbery, assault, etc. One cannot be tried by a military court of the United States except for an offense prescribed by the code.

The situation is generally different in other countries. The military codes of France and Britain, for example, enumerate only the purely military offenses. Although the military court may try a person for a crime other than a military offense, the accused is charged with a violation of the appropriate criminal law of the state. For example, a British or a French soldier who is charged with murder may be tried by a military court if he is serving with the armed forces in the field, but he is charged with a violation of the criminal statute applicable to the entire populace.

Military Trial.—The court by which military justice is administered is known as the court-martial. In the United States there are three types of courts-martial. The general court-martial is composed of at least five members, and in addition there is a law officer who is analogous to a judge; it may adjudge any punishment authorized by military law. The special court-martial is composed of three or more members, and may adjudge punishment which includes punitive discharge (under certain conditions), confinement of not more than six months and a forfeiture of two-thirds of the accused's pay for not more than six months. Members of general and special courts-martial are usually officers, but, if the accused requests inclusion of enlisted men, at least one-third of the court must be so composed. The summary court, which consists of one officer, is not permitted to try officers or certain other specified classes of individuals, and it may not pass a sentence of confinement at hard labour of more than a month, or restriction to a specified area of more than two months or forfeiture of two-thirds of the accused's pay for more than one month. The court-martial is convened by the commander of a military unit or installation, and in the case of a general court-martial authority to convene the court is limited to commanders of major units designated by congress, or of other units or installations specifically authorized.

British military law provides for a general court-martial consisting of not less than five officers which may adjudge any punishment authorized by law; a district court-martial, which shall consist of not less than three officers and which may not try officers or adjudge a sentence which includes confinement of more than two years; and a field general court-martial, which may be convened outside the United Kingdom when it is impracticable to try an accused by the ordinary general court-martial. The field general court-martial is ordinarily composed of not less than three officers, and may adjudge any sentence authorized by law, including death; such a court, however, may be convened with only two members, in which case imprisonment in excess of two years may not be adjudged.

The French military code provides for only one type of court-martial, which within France proper is a somewhat permanent structure rather than one in which the personnel is frequently changed, as is the case under the military law of the United States. The French court-martial consists of seven members; six are military officers, and the presiding member of the court is a civilian judge of the locality in which the court is convened. During active military operations, however, the French court-martial convened in the field is composed entirely of military officers.

Punishment.—The kinds of punishment authorized by military law generally include those authorized by civilian penal codes; *i.e.*, death, imprisonment and monetary fine. In addition, however, punishment peculiar to the military service is authorized, such as restriction to a specified area for a prescribed period of time, total or partial forfeiture of a convicted person's pay and punitive separation from the service. The latter is known by various terms. In the United States, an officer may be sentenced to be dismissed from the service, and an enlisted man may be sentenced to either a dishonourable discharge or a bad-conduct discharge, the latter supposedly having less stigma attached to it. Cruel and unusual forms of punishment are specifically prohibited by the Uniform Code of Military Justice. Other permissible punishments include loss of rank, admonition and reprimand. Reduction in rank usually results upon conviction of an enlisted person of a serious offense, and in time of war an officer may be reduced to enlisted rank.

British military law generally provides the same forms of punishment as those prescribed by the Uniform Code of Military Justice, but a notable addition, in the case of an officer, is that of cashiering. This is a more ignominious form of punishment than dismissal from the service, and normally an officer who has been cashiered cannot thereafter hold an appointment under the crown.

Disciplinary Powers of Commanders.—Almost all military codes of the world provide that a commanding officer may administer punishment to a limited extent which usually is specific in its limitation, without resort to trial by court-martial.

A commanding officer of United States forces may administer nonjudicial punishment for a minor offense which, if imposed upon an officer, may include the withholding of privileges or restriction to a specified area for a period not exceeding two consecutive weeks, or, if administered by one authorized to convene a general court-martial. may include forfeiture of pay of one-half month. Nonjudicial punishment which may be imposed upon an enlisted person may include withholding of privileges or restriction

for a period not exceeding two consecutive weeks, extra duty of a maximum of two hours per day for two consecutive weeks, reduction to the next inferior grade and, in the case of those aboard vessels, confinement of seven consecutive days and diminished rations or confinement on bread and water for three days.

The military law of Britain authorizes a commanding officer to impose upon a soldier, but not upon an officer or warrant officer, such nonjudicial punishment as detention not exceeding 28 days, forfeiture of pay for a period not exceeding 28 days or, in the case of drunkenness, a fine of not exceeding £2. French military law authorizes a commanding officer to impose confinement not exceeding 60 days without trial by court-martial, but the extent of confinement which may be imposed depends upon the command of the officer imposing the punishment, 60 days being the maximum.

In the Soviet military forces, the extent of nonjudicial punishment which may be imposed upon a soldier is dependent upon the grade of the offender. The Disciplinary code of the Soviet army, issued in 1940, provided that in the case of privates a disciplinary penalty might include ordinary confinement not to exceed 20 days, strict confinement not to exceed 10 days, restriction to quarters of up to six weeks, extra detail or reprimand. In the case of a noncommissioned officer, the maximum periods of confinement were reduced, but demotion and partial loss of pay added. Disciplinary punishment could be imposed upon Soviet officers, including generals.

Procedure. — The determination of whether an accused shall be tried by court-martial rests with a commanding officer, usually the commander of an organization in which the accused is serving, or the commander of a higher military unit.

The military codes of the United States, Great Britain, France and most other countries provide that there shall be a thorough and impartial investigation before an accused can be brought to trial by court-martial. This investigation, under the law of the United States, is somewhat analogous to a proceeding before a grand jury, although the accused is given more rights than in a grand-jury proceeding. If the investigation reveals that there is sufficient evidence of guilt and that trial is indicated, the case is referred to an appropriate court-martial.

In the actual conduct of a trial by court-martial, the rules of procedure and evidence are similar to those of civilian criminal trials. The court hears the evidence, and determines innocence or guilt; it also adjudges the sentence, a function which in many civilian jurisdictions is performed by the judge.

The Uniform Code of Military Justice provides that following a conviction the sentence must be approved by a reviewing authority, who is either the commander who convened the court or some other commander authorized to convene a court-martial of the type by which the accused was convicted. The reviewing authority may disapprove findings of guilt in whole or in part, and may reduce the sentence, but cannot increase it; a finding of not guilty is binding upon him and cannot be disturbed. One who has been convicted and whose sentence includes a punitive discharge which is not suspended, or a year or more of confinement, enjoys an automatic appeal to a tribunal in Washington, D.C. (or in an overseas theatre, headquarters), composed of qualified lawyers; this tribunal is known as a board of review, and must include at least three members. If the conviction is affirmed by the board of review, the accused may seek a further review by petition to the court of military appeals, which consists of three civilian judges.

In Great Britain, under an act of 1951, a person convicted by court-martial might appeal to the courts-martial appeal court, a judicial body composed of civilian jurists and headed by the lord chief justice. In exceptional cases, a further appeal could be taken to the house of lords.

Canadian military law provided for an appeal to the court-martial appeal board, a civilian body established by legislation of 1950. The French military code permits an appeal to an intermediate appellate court, composed partially of military and partially of civilian judges. In exceptional cases further appeal may be taken to the highest court in France. The U.S.S.R. likewise permits, in exceptional cases, an appeal from a conviction of a military offense to the highest court in the land.

Later Legislation. — With the enactment of the Uniform Code of Military Justice, which became effective in May 1951, the United States brought into effect a code uniformly applicable to all of the armed services, replacing the Articles of War which had previously governed the army and the air force, the Articles for the Government of the Navy, and the Articles for the Discipline of the Coast Guard. In Canada a uniform code of justice applicable to all of the armed services was enacted as a portion of the National Defense act of 1950.

British military law applicable to the army and the air force was governed by the Army and Air Force (Annual) act until 1955, when a constitutional change dispensed with the need of an annual act. This amended Army act, according to its terms, was enacted to consolidate the Army Discipline and Regulation act, 1879, and the subsequent amendments thereto and also the Army and Air Force (Annual) act. The French military code was enacted in 1928 but a number of amendments were added, particularly after the close of World War II.

Russian military law is found in the penal codes of the republics which constitute the Soviet Union, but the Disciplinary code of the Soviet army, promulgated in 1940, provided uniformity with respect to a portion of the Russian military law. (See also COURT-MARTIAL.)

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MILITARY POLICE is the name given to soldiers who exercise police and other functions in armies. From the very beginning of military history armies have had men to perform military police duties.

United States. — Military police in the United States comprise a separate branch of the U.S. army known as the military police corps. They are distinguished from other soldiers by a blue and white armband with the letters "MP." The insignia of the corps is crossed pistols modeled from the Harpers Ferry arsenal army flintlock pistol, model 1807, calibre 54.

The mission of the military police corps is to maintain law and order, to prevent and investigate crime within the army and to operate confinement facilities. This mission includes the apprehension and return to military control of unauthorized absentees and escaped military prisoners; the retraining and rehabilitation of military prisoners; the control of traffic on military reservations; the physical security of posts, camps and stations; and the protection of the welfare of fellow soldiers. Additional functions, in time of war, include responsibility for the care, custody and documentation of prisoners of war; and evacuation and movement of refugees. The secondary mission of the military police is to engage in combat as infantry when required. The chief of the military police corps, the provost marshal general, is the principal law enforcement authority on the department of the army staff. He formulates military police policies and supervises the technical training and functioning of the military police corps.

In the U.S. army there was no regularly constituted military police corps before 1941, but the traditions of duty, service and security date back as far as Jan. 1776, when a "Provost Martial" was appointed by General Washington "to the army of the United Colonies." Two years later, by congressional resolution, a provost corps was established. In Sept. 1862 a provost marshal general was appointed for the duration of the Civil War. His primary function was the operation of the draft laws, but his subordinates throughout the country were charged also with apprehending deserters, arresting disloyal persons, seizing stolen government property and detecting spies. In 1917 a provost marshal general was again appointed in the war department to administer the selective service law. A provost marshal also was appointed in the American expeditionary forces and on Oct. 15, 1918, a military police corps was activated in the A.E.F. After the armistice, the corps

was dissolved and between 1919 and 1941 military police duties were performed by individuals designated for that purpose at military installations.

The rapid expansion of the army during 1940–41 made obvious the need for a unified, centrally directed military police organization. On July 31, 1941, a provost marshal general of the army was again appointed and the military police corps was established on Sept. 26, 1941. From three battalions and four separate companies, the corps grew to a strength of about 210,000 which included military police organizations for tactical units of the ground and air forces, communications zones, and the zone of interior; escort guard companies for handling prisoners of war; prisoner of war processing companies; and criminal investigation detachments. Although a majority of military police units were disbanded following World War II, the corps built up to 42,000 during the Korean war.

On June 28, 1950, public law 581 authorized the establishment of the military police corps as a basic branch of the army. Its responsibilities are world-wide, wherever U.S. army forces are stationed. Each army in the United States, each overseas command, and every post, camp and station, as well as each major subordinate unit of the field forces, such as division, corps and field army, has a provost marshal who acts as a staff officer to the commander and supervises military police activities.

Training for the officers and enlisted men of the military police corps is provided at the Provost Marshal General's school, Fort Gordon, Ga. In addition to the basic courses, the school provides instruction for its specialized functions. (W. H. MN.)

Great Britain.— In Great Britain the military police are organized as a combatant corps in the army, 15th in the order of precedence and known since 1946 as the corps of royal military police (R.M.P.) At the head of the corps is the provost marshal, one of the most ancient appointments in the army. The provost marshal and his assistants hold offices which date back probably to the 12th and 13th centuries The earliest certain record of a provost marshal is in 1511, when Henry VIII appointed Sir Henry Guildford to the office. Since then the provost marshal and his assistants have been basically concerned with the preservation of good order and military discipline, but their responsibilities have evolved with the changing tasks of the army itself, and now are much wider and more varied.

In June 1855 a permanent corps of mounted police was raised at Aldershot and designated military mounted police in May 1877. The word "police" was an innovation in the British army. In July 1885 the military foot police was separately raised; this division continued until Feb. 1926, when the two corps were merged as the corps of military police. Considerable expansion took place in World Wars I and II; in World War II various specialized wings were formed but since 1945 only four have survived: provost ("red-caps"); special investigation branch (S.I.B.); vulnerable points (V.P., reserve army only); and women's royal army corps (W.R.A.C.) provost.

Provost companies are self-contained and self-accounting, completely mobile and equipped with radio. The basic provost formation is the section consisting of 17 other ranks commanded by a sergeant. Provost companies are formed of a varying number of sections depending on the mission. Field-force companies are included in all major formations; *e.g.,* brigades and static companies in all commands and districts. Specialized companies for duties with dogs, horses and in ports for docks and embarkation work are formed as needed.

Military police duties include the preservation of discipline outside unit lines; road patrols and traffic control; escorts; and antivice duties. In war, in addition to these, there are the duties of prisoner-of-war control; control of stragglers; manning of information posts; refugee control; and prevention of looting. The special investigation branch investigates all serious crime in the army while the women's royal army corps provost has disciplinary duties with the W.R.A.C. The royal military police derive powers of arrest from the Army act, 1955 (s. 74 (4) and 209, and the fifth schedule) and have reciprocal powers of arrest with the royal navy and royal air force police. They have no powers of punishment under the act.

British Commonwealth Countries and Others.—Commonwealth countries have formed military police on the British model; in all. the emphasis is on a military policeman being a soldier first and a policeman second. This is at variance with the French and Netherlands armies where the *gendarmerie* and *maréchaussée* are more closely concerned with security and whose work in the United Kingdom would largely be carried out by the civilian police.

See S. F Crozier, *The History of the Corps of Royal Military Police* (1951) (R. J. R. W)

MILITARY SCIENCE: see MILITARY AFFAIRS (ARTICLES ON).

MILITARY TRANSPORT: *see* TRANSPORT, MILITARY.

MILITIA. A term more easily traced to its classical roots than defined. it derives from the Latin words *miles* ("soldier") and *militia* ("military service"). The definition used here, selected as the best from among many, is: that portion of the manpower of a society which is enrolled on military rosters and at least partially trained for local defense in short terms of service. "For local defense in short terms of service" must be stressed as it sharply distinguishes militia from professional military forces.

Early History.— Up to the middle of the 5th century B.C. all the Greek city-states except Sparta, which was a militaristic society, required military service of all free, able-bodied male citizens, but did not expect long tours of duty in wartime, nor the greater part of a citizen soldier's time for training during years of peace. Such forces were true militia. Then came the wars between the city-states during the 5th and 4th centuries B.C. in which the militia was gradually replaced by professional armies.

Later, Rome followed the same progression; at first, a universal military obligation provided short-term soldiers for the republic, but these were gradually replaced by regulars as the republic turned into an empire. By the end of the 2nd century B.C. the replacement was complete.

Next came the development of feudal military obligation. Although submerged in this, the militia did not die out. On the contrary, in certain quarters it became the forebearer of modern systems. Thus, the militias of Britain and the United States stem from the Anglo-Saxon fyrd (a sort of militia) of that time. Likewise, Switzerland's unique militia organization began to develop toward its modern form in the 14th century.

In the middle ages the familiar progression reappeared. The national states during and after the 13th century set up standing armies and relied on them more and more. The increase in the variety and complexity of weapons which took place after the introduction of firearms in the 14th century tended to make those armies permanent; as the militia found it harder to work with the new weapons, its position deteriorated.

Other factors related to the procurement of men contributed to the deterioration. The standing armies of peacetime were seldom large enough to carry the whole burden of a war, but when expanding their forces for war, rulers sought to avoid the militia because of its short-term and local-use limitations. For long, distant campaigns they called for volunteers and thus weakened the militia. Harder yet on the militia was the development of national conscription. Here was no draft of citizen soldiers carried out by local authorities, but a national levy operated by a national government. Revolutionary France undertook the first such conscription in 1793 (see CONSCRIPTION) because of the imperative need for greater numbers of men than had been required in the wars of the early 18th century and than could be procured by volunteering.

Most other European powers sooner or later followed the example of France. Prussia, in 1814, made a new departure when it extended national conscription into peacetime. By this innovation it developed and maintained a mighty national reserve force which could be mobilized swiftly in time of war. When neighbouring nations saw the strength of the Prussian army as it was demonstrated during the wars of the 1860s and 1870s they followed that lead. Thereafter, only those nations which were strongly defended by geographical barriers or neutralized by political action dared continue to rely on militia.

Early militia service, as has been noted, was based on the idea that all men owed a duty to defend their societies, an idea that has not altered much in the mid-20th century. But by 1870 its application had changed. It gradually ceased to be the basic concept upon which the militia was established, and became instead the foundation for national conscription. The theory changed slowly, but there was an obvious shift in practice with the militia operated largely on a volunteer basis.

In summary, in nearly all times and places militia has been local in character, short in service. and usually defensive in activity. It has been made up mostly of land forces, but also has included naval elements and, in the 20th century, air militia as well. It has traditionally been made up of citizen soldiers who regarded themselves, and were so regarded, as citizens first and soldiers second. For example, the emphasis has been on the "citizen" part of "citizen soldier" in Switzerland but not in Germany, and that is why the armed forces of the former remain to this day a true militia, whereas the Landsturm and Landwehr of Germany, as they existed from the 1860s to 1945, were not.

The Militia in Great Britain and in the United States in Modern Times.—Because of the notable parallel between the militias of Great Britain and the United States, the histories of the two are examined together.

When British settlement began in North America, the militia in Britain was inactive The situation was different in America where the colonists could defend themselves only by banding into militias. Thus, at the founding of each colony the leaders imported professional soldiers to direct militia training and help to make the earliest militias efficient. The smallness of the settlements and the steady pressure of danger made co-operation relatively simple and contributed to efficiency. Indeed, the greater the danger, the higher the efficiency. But, efficient or not, all colonies except Pennsylvania established militias soon after their founding; Pennsylvania, due to its Quaker leadership, passed no militia law for 6j years.

In Britain, the Great Rebellion (1642–52) temporarily stimulated the militia. More important, it brought the first British standing army into being. With this army developed a fear that it could put an end to personal liberty. This fear crossed the Atlantic, took root in the new world and added strength to the inherited idea that militia was the true bulwark of liberty, but without adding strength to militia organization and training.

Less than a century after the first settlements, the intermittent wars between France and Britain (1690–1760) put the colonial militias to a test. The several militias proved themselves poor agencies for the waging of imperial conflict for which they had not been devised. Their poor performance is acknowledged, but they were nevertheless the only partially organized, orderly source from which to draw manpower for war. However haltingly, the militias performed their basic function of local defense. If other means failed, the colonial governments possessed the power to draft militiamen. This rarely used power differed from modern conscription only in the agents who wielded it. What is done in the 20th century by nations was then done by small local governments which were weak and lax in enforcement.

When colonials were needed for distant enterprises, such as the assault on Louisburg in 1745, officials had to call for volunteers, who more often than not came from the militia.

In spite of William Pitt's efforts to reform the militia in 1757, the wars of empire produced few lasting improvements. Consequently, the militias of both Britain and the colonies were in a flabby condition when the American Revolution began. Except for John Paul Jones and an occasional privateer, the Revolutionary forces did not threaten Britain, and the British militia remained unexercised. In contrast, dire necessity soon infused some vitality into the American militia. Faulty as it was, it remained the one source of manpower; without it the Americans could not have kept a force in the field. And the last colonial war had left one decisive benefit; many American officers had acquired enough experience during that war to hold the oft-wavering ranks to their duty.

George Washington was frequently driven to despair by the limitations of militia: ". . . (they) come in," he said, "you cannot tell how; go, you cannot tell when, and act, you cannot tell where, consume your provisions, exhaust your stores, and leave you at last at a critical moment." Even though distressed by them, he continued throughout the war to call on the militias, a reliance which demonstrates that they were indispensable.

If Americans during their revolution presented but slight menace to Britain, the same was not true of their erstwhile allies, the French, during their revolution and the Napoleonic Wars. It was necessary for British militiamen to guard the coast off and on until 1815. But their organization and strength were so poor that had Napoleon been able to cross the English channel they could not have repulsed his assault.

During the years when British militia kept watch against French invasion, American leaders were building reliance on militia into the military policy of the new republic. Most of the states regarded the militias as primarily state forces, but they saw the need to give some power over them, under specified conditions, to the central government. Accordingly, the framers of the constitution in 1787 gave congress the right to call forth militia to suppress insurrections, repel invasions and enforce the law. In addition, congress received authority to organize, arm and discipline the militia, while the states retained the right to officer and train it in accordance with the discipline established by congress. The effect of the military provisions of the constitution was to give the central government authority to maintain professional forces and to grant the states authority to keep a compensatory power in their militias. Like the other powers of government, the military was checked and balanced, authority over the militia being divided between federal government and the states. When the first Militia act was passed in 1792 to implement the provisions of the constitution, it gave ultimate control to the states. As a result, for 111 years a national militia could not exist, nor could the nation use the state militias unless permitted by state authorities.

The War of 1812 was a turning point in the history of U.S. militia. Originally, the New England states refused to send their forces in answer to the president's calls, denying that the conditions for federal use of the militia, as prescribed in the constitution, existed. This stand showed that the militia was an uncertain instrument to use in national conflicts, but did not much reduce the use of it during the war. On the contrary, militia provided the majority of U.S. soldiers. This had two contradictory effects. Because of failures of militia troops, as at Bladensburg, U.S. arms suffered several dangerous defeats. Conversely, because of achievements of militia, as at New Orleans, certain brilliant victories were gained. The end result on postwar policy was likewise contradictory. The militia was glorified in theory but never again used to the same extent in a national war.

After 1815 the militia declined in both Great Britain and the United States. The relative security of the two nations and their preoccupation with economic development perhaps explain the decline. In any case, an important change was in progress. As training and discipline fell off in the militia units in which service was compulsory, Volunteer units (the capital V will be used hereafter to distinguish this sort from "war volunteers"), made up of men who enjoyed military exercise, increased in number and efficiency. As a result, in the United States, some states, beginning with Massachusetts in the 1840s, repealed their compulsory laws and relied on Volunteer units when they needed the services of militia.

Similarly, in Britain in 1852 the basis of the militia was changed. Before that date it had been universal obligation backed by conscription; afterward it became volunteer service supplemented in rare crises by conscription (see VOLUNTEERS). In the United States most of the Volunteer units were a part of the militia, but in Britain they were formed into separate forces, the Volunteers and the Yeomanry or cavalry. In the mid-19th century both bodies drew their membership largely from the upper classes which tended to set them apart from the militia.

Another category of volunteers came into wider and wider use. It was made up of individuals, "war volunteers," who came forward

for a specific conflict. The use of such volunteers grew up because of the need to circumvent the time limitation and local limitation which rendered the militia unfit for national wars. Because of that need, commissioners of array had sought war volunteers in England from time to time since the late middle ages. War volunteers were used in America during the Revolution and during the Indian wars of the 1790s. Their employment lagged in the second war with Britain, but was important in the war with Mexico 30 years later. The trend toward their use continued, and, as a result, they composed the bulk of the forces on both sides during the U.S. Civil War.

Of course, war volunteers often came from the militia system and from the Volunteers. **A** common procurement method nas to assemble a militia unit, state that there had been a call for soldiers and then ask for volunteers. By the time of the U.S. Civil War this method alone could not produce the men required. Accordingly, both belligerents resorted to conscription. Ineffective in practice, conscription was significant as a precedent, for it caused many men to offer themselves as war volunteers. It must be stressed that Civil War conscription was not the traditional draft of militias which the state governments already had the power to operate. On the contrary, it was national conscription.

The Civil War, like the War of 1812, demonstrated that militias controlled by the several states could not be relied on to wage national war. They provided only a semiorganized pool of manpower for both belligerents. Even in this role militia was not perfectly reliable. For example, the governor of Georgia refused the call of the Confederacy for Georgia militia in 1864 because he needed it for defense of the home state.

Meanwhile, in Britain, the militia, which received no such stimulus as the Civil War gave in the United States, made some long-needed improvements. During the 1870s and 1880s, as a result of reforms begun by Edward Cardwell, the regular army was organized for service throughout the empire. Regular regiments were located at a home depot in Britain, at which one battalion remained while another served overseas. The militia was drawn into closer association with the regulars for home defense and supplied third and fourth battalions to its regular regiment. The status of the Volunteers and Yeomanry was not clear.

During the 1880s militiamen who agreed to enter the regular forces in a national emergency were allowed small pay in time of peace. Although this inducement turned the militia into a reservoir of manpower, for the regulars it tended to weaken it as a home defensive force. All the while, Volunteers and Yeomanry were growing less patrician, and in time, as the militia changed into an army reserve, they gradually took over much of the militia's old task of local defense.

In the United States after the Civil War some Volunteer units grew in strength and attained the name of "organized militia." The states used them not infrequently during the 1870s and 1880s to suppress strikes by labour, and so they became strongly representative of the propertied portion of the population. At the same time the organized militia acquired yet another name. "national guard," and by 1896 all but three of the states used this term. The mass of men of military age not in the guard, although known as the unorganized militia, were not really militia at all.

20th-Century Changes.—Relatively minor overseas wars at the turn of the century brought alterations so profound to the militias of both nations that they did not stop until the militias were completely transformed 50 years later. The South African War (1899–1902) started the reaction in Britain. From it resulted the remarkable reforms instituted about 1908 by Lord Haldane, the secretary of state for war. Haldane's changes made the regular army into a small but effective expeditionary force which could be mobilized and transported to the continent within two weeks, and also created a reserve and a special reserve to fill out the expeditionary force when required. The militia was absorbed in these two. Behind the reserves was the territorial army made mainly of Volunteers and Yeomanry. The territorial army resembled what the national guard in the United States later became. It had local roots like the guard, but became a part of the national manpower reserve for war more easily than in the U.S. because the heritage of split control over the militia which persisted in the United States did not exist in Britain.

The war with Spain in 1898 did for the United States what the South African War was to do for Britain. It revealed dangerous weaknesses in U.S. arms; it called forth a talented civilian, Elihu Root, who as secretary of war brought about a set of sweeping reforms. Root's changes, like Haldane's, were based on the need to supplement the regular forces in time of war. The first step was the repeal of the Militia act of 1792 and the enactment of a new one in 1903. The new law gave the initiative to the states. If requested by the governor, the secretary of war could issue arms to the militia, detail regular officers to duty with it, cause inspections by regulars, permit joint maneuvers of army and militia and even pay the costs of training under certain conditions. The broad significance of the new law was that it made a beginning toward forming the state militias into a national reserve force.

The National Defense act of 1916 added to that beginning. Under it the federal government began to pay national guard units for drills during peacetime, provided units met the requirements set by the mar department. The federal government also insisted that the units which it recognized conduct a specified number of drills and encampments each year. (Its relationship to the guards was nearly identical to that of the British government and the territorial army.) In addition, when congress declared a national emergency the president acquired the power to draft the individuals of the national guards of the states into federal service. (See NATIONAL GUARD.) Even so, the national guards were still not a part of the national forces in peacetime. It was apparently this fact that caused congress to create a body of citizen soldiers that was not responsible to the governments of the states. The new organization was designated the reserve corps.

Complete alteration of the traditional status of militia in the U.S. was achieved in 1933 when the national guard became a reserve component of the national force. This alteration was attained by imparting a dual personality to the guard, a form that had no counterpart in Great Britain. Those portions of the national guard which passed inspections by officers of the regular army, and which observed the appropriate regulations of the war department, were designated as "the National Guard of the United States." These units received supplies and equipment, and the members' pay, as before, from the federal government. But now there was a different consideration. They were liable to be ordered into service as units when congress declared a national emergency.

Any units of the state guards which did not qualify, and were thus not recognized by the war department, received no federal aid. They might, however, function as state militia. Acts passed after 1933 stressed the role of the national guard of the U.S. as one of the vital components of the national reserve. One, in 1947, added the air national guard to the national reserve.

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MILK. Milk is the fluid secreted by the mammary glands of the mammalia as food for their young in the period immediately after birth. Milk and products derived from milk, such as butter and cheese, have been used as food for human beings of all ages throughout the time of recorded history. The unqualified term, milk, is considered to refer usually to cows' milk, since most milk destined for human consumption is from the cow. However, approximately half of the milk consumed in India is from the buffalo, and buffaloes of local types produce milk that is used for food in China, Egypt and the Philippine Islands. Goats' milk is produced in countries bordering the Mediterranean sea and in small quantities in many other parts of the world. The milk of the reindeer is used as food in northern Europe; sheep's milk is used in southern Europe in making cheese.

Cows' milk and its products have become important articles of commerce, most of the research on the chemistry, bacteriology and technology of milk being carried out in relation to it. Of

the principal milk products, butter, cheese and ice cream are discussed elsewhere; evaporated. condensed and dried milks are discussed in succeeding paragraphs. *(See* BUTTER; CHEESE; ICE CREAM.)

History. — The milk of animals was used as food by man much earlier than the beginning of recorded history. Soured milks, butterlike products. and cheese were probably common foods of the peoples roaming the grasslands of Asia with their sheep and cattle thousands of years ago Abel. son of Adam. was a "keeper of sheep" and probably consumed milk although the earliest mention of milk in the Bible is Jacob's prediction in 1700 B C that Judah's teeth shall be "uhite with milk." Canaan was "a land flowing with milk and honey" in *1*500 B.c., and cheese was mentioned by Job at about the same time. The Hindu Vedas, written prior to 1400 B.C. mention the use of butter as food. But, in all these instances, the mention of milk br its products is incidental and implies much earlier use.

The ancient Greeks, Romans and Scythians did not use butter as food, but applied it to skin injuries and to the hair, and the soot from burned butter to sore eyes Butter was used as oil for lamps in Scotland as recently as the 19th century.

Prior to the 17th century. whey was employed widely in Europe as a medicine for many real and imagined ills. Milk sugar (lactose) seems to have displaced whey as a panacea subsequent to its isolation from whey in *1628*. In the 20th century, the medicinal use of lactose has been limited to its function of aiding the growth of desirable bacteria in the intestinal tract. Little is known of the early history of ice cream (*q.v*)

Commercial processes for making concentrated and dried milks were developed subsequent to 1850, although it appears that the Tatars prepared concentrated milks in paste, and probably in dry, form as early as AD. 1200 and used them as food during their raids under the leadership of Jenghiz Khan. The original United States patent for evaporated milk was granted to Gail Borden in 1856, and the utility of canned concentrated milk was demonstrated by its use by soldiers in the Civil War a few years later. F S Grimwade's British patent for producing dried milk was issued in 185*j*, but large-scale production of dried milks did not begin until 50 years later.

Composition. — The same constituents are present in the milks of all mammals, but the proportions differ somewhat, both among species and within a species. The following typical analyses, which are from many sources, include the major components in the milks used as food for man.

Species	Water %	Protein %	Fat %	Milk	
Cow	87.0	3.5	3.9	4.9	0.7
Goat	87.9	3.5	4.3	4.3	0.9
Sheep.	82.0	5.8	6.5	4.8	0.9
Indian buffalo	82.7	3.6	7.4	5.5	0.8
Chinese buffalo.	76.8	6.0	12.6	3.7	0.9
Egyptian buffalo	82.1	4.2	8.0	4.9	0.8
Philippine carabao	78.5	5.9	10.4	4.3	0.9
Reindeer	63.3	10.3	22.5	2.5	1.4

Many factors influence the composition of milk, including breed, the genetic constitution of the individual cow and the interval between milkings. Since the last milk to be drawn at each milking is richer in fat than the rest, the completeness with which the mammary apparatus is emptied, influences the composition of the sample. The age of the cow, the stage of lactation and certain disease conditions are among other factors affecting composition. In general, the kind of feed has slight effect on the composition of milk. but feed of poor quality and insufficient quantity causes both a low yield and a low percentage of nonfat solids. *(See* DAIRY INDUSTRY.)

The milk of each species seems to be a complete food for its own young for a while after birth, but in the natural state small quantities of other foods are usually taken early in life. Milk protein is of high nutritional value, since it contains all the essential amino acids; *i.e* , those that man cannot synthesize in quantities sufficient for his needs. In the stomach of the young it is precipitated as a soft curd in which the globules of fat are enclosed. Digestion can thus proceed smoothly without the disturbance which the ingestion of fatty foods often causes. The mineral content includes calcium and phosphorus adequate for normal skeletal development, but little iron. Milk contains the fat-soluble vitamin A and carotene, its precursor, but the amount varies considerably with the food of the lactating animal. Since green food is the main source of this vitamin in the diet of cows, summer milk usually has more than winter milk. The fat-soluble vitamin D and the water-soluble B complex and C are also present. Because cows' milk contains proportionally more casein and less lactose than women's milk, it is usually recommended that, for babies' formulas. water be added to cows' milk to decrease the percentage of casein, and that lactose be added. Pediatricians often prescribe formulas based on evaporated or dried milk. and may suggest substituting the more rapidly assimilated glucose for lactose. It has been shown that one pint of English summer milk contributes to the daily requirements of a moderately active man about 90% of the calcium, 30%–40% of the riboflavin, 25%–30% of the protein. 10%–20% of the calories, vitamins A and B, and less than 10% of the iron and vitamin D. Although it would supply a higher proportion of the daily needs of a five-year-old child for calories, protein, vitamins A, B_1 and riboflavin, the contribution to the calcium needs would be reduced to about 70%.

In most countries in which milk is an article of commerce, standards of composition of milk for retail sale are established by law or local regulations. The minimal standard for fat is usually some value between *3.0%* and 3.5%, that for nonfat solids usually *8* 5%.

Sanitation. — Raw milk, which is milk that has not been heated, contains microorganisms that eventually cause it to become sour to the taste and to curdle. During the milking, handling and transportation, it may become contaminated with organisms that cause disease in man. In many countries, regulations specify requirements relating to the health and care of cows, the health and personal cleanliness of persons who handle milk, methods of cleaning and sterilizing pails and other equipment, construction and cleanliness of buildings in which milk is produced and stored, and the temperatures of milk in storage. The effectiveness of such regulations is usually insured by periodic inspection of farms and dairies and by bacteria counts made on milk delivered to dairies and on milk delivered to consumers. Cooling of milk to temperatures slightly above the freezing point markedly reduces the rate of multiplication of the bacteria, and the amount of chemical change they produce. and, consequently, increases the length of time milk continues to be palatable.

Pasteurization. — Even sanitary regulations are not considered in many countries to be adequate protection against transmission of disease by milk and, hence.. pasteurization of milk for retail. sale is a requirement in some areas, and pasteurization or boiling a recommendation in others. Pasteurization, properly carried out, kills all disease-producing organisms and a large proportion of those causing souring. If milk is pasteurized in closed containers and kept from contamination thereafter, it will continue to be a safe milk. It should be kept refrigerated to minimize the gronth of remaining harmless bacteria which can produce unpleasant flavours. Pasteurization has been defined by the United States public health service as "the process of heating every particle of milk to at least 145° F. and holding at such temperature for at least *30* minutes, or to at least 161° F. and holding at such temperature for at least 1*j* seconds." After pasteurization, milk should be cooled rapidly to refrigerator temperatures.

Homogenization. — Much of the milk sold for beverage purposes is homogenized. In this process, the milk is forced under very high pressure through small openings to break up the clusters of globules of milk fat and to reduce the size of the globules. The milk fat then remains evenly distributed throughout the milk rather than rising to form a layer of cream. Vitamin D, supplied in solution in oil, is incorporated in milk by homogenization. This process is employed also to prevent separation of milk fat from cream, evaporated milk and ice cream mix.

Separation of Cream. — If milk, which has not been homogenized, is allowed to stand undisturbed, the milk fat will rise grad-

ually to form a layer of cream. This was the only method known for producing cream until the cream separator was invented in the second half of the 19th century. This device is a high-speed centrifuge modified for the purpose. It can be adjusted to produce either 18% to 20% coffee cream, 30% medium cream or 36% to 40% whipping cream in one passage. By repeated passages, cream can be produced to contain as much as 80% fat, a product known as plastic cream.

Evaporated and Condensed Milk.—Of the concentrated milks on the market, the most important in volume is evaporated milk. This is whole milk that has been concentrated in a ratio of approximately 2.1 to 1.0, sealed in cans, and sterilized by heating at 240° F., for 15 to 20 minutes. It may contain added vitamin D and a fraction of a percent of stabilizing salts. It has a cooked flavour and a brownish colour. The evaporated milk produced in the United States is marketed at retail mostly in cans containing 14½ fluid ounces each, this quantity being equivalent in solids and food value to one quart of fluid milk. Other countries use containers of different sizes, usually based on the metric system. Minimal standards of composition are, for example, 25.9% total milk solids and 7.9% fat in the United States, and 31.0% total milk solids and 9.0% fat in Great Britain; the percentage of total milk solids includes in both instances the percentage of fat.

Plain condensed milk is a concentrated whole milk of a composition similar to that of evaporated milk, but not sterilized. It is sold to bakers and confectioners in bulk containers and must be used within a few days after manufacture to avoid spoilage. Plain condensed skim milk, containing at least 20% milk solids, is another product sold only in bulk for use in bakery products and ice cream.

Sweetened condensed milk is whole milk that has been concentrated in a ratio of 2.2 to 1.0, or greater, and contains more than 40% of sugar, which prevents bacterial spoilage. It is not sterilized and therefore does not have the brownish colour and cooked flavour associated with evaporated milk. For consumer use it is sealed in 14-oz. cans, or in baby-size 6-oz. cans. For use by food manufacturers, it is packed in 10-gal, milk cans or in barrels. The standards for sweetened condensed milk require at least 28.0% total milk solids and 8.5% fat in the United States, and 31.0% total milk solids and 9.5% fat in Great Britain. During World War II, an "Over-Standard" product containing approximately 9.5% fat, 33.5% total milk solids and 42% sugar was made for military use. It was put in 2-oz. cans and used as the milk and sugar component of a canteen cupful of coffee. Sweetened condensed skim milk, containing a minimum of 20% milk solids is marketed in bulk containers for use in bakery products and, especially, ice cream.

Other concentrated dairy products, not sold directly to consumers, but used in food and confectionery manufacture or for animal feed, are condensed buttermilk, concentrated sour skim milk, plain condensed whey and sweetened condensed whey.

Dried Milks.—The first commercially dried milk was malted milk powder. This product consists of approximately half milk solids and half solids from a mash prepared from barley malt and wheat flour. It usually contains about 8% milk fat. Dried whole milk, which contains at least 26.5% of fat and at least 95% of total milk solids, is produced principally for food manufacture, but is available in drug stores in the United States and in chemists' shops in Great Britain. Dried skim milk, or nonfat dried milk, as it is designated in the United States, is used extensively as a constituent of bread and other bakery products and of dry mixes for home baking. A rapidly soluble nonfat dried milk is available in food stores for reconstituting into beverage skim milk in the home. Dried ice cream mix, containing approximately 60% milk solids (of which half is milk fat) and 40% added sugar, is another available dried product. Others, made in relatively small quantities and in only a few countries, are dried cream, dried buttermilk and dried cheese whey. Butter oil, which is a dry butterfat, produced in quantity in Australia, New Zealand and Argentina, has, since World War II, been reconstituted with dried skim milk, mostly from the United States, to produce a whole milk in plants built for the purpose in areas of milk shortage, such as eastern Asia and the Pacific islands.

Other Milk Products.—Soured milks of several varieties, such as kefir, yoghurt and Bulgarian buttermilk, are made and consumed in countries near the eastern end of the Mediterranean sea. Cultured buttermilk and chocolate-flavoured milks are available in western Europe and North America. These products are usually made from skim milk or partially skimmed milk. Cultured buttermilk, acidophilus milk and Bulgarian buttermilk are skim milks that have been soured by lactic acid produced from milk sugar by bacteria. They differ in the bacteria used, the degree of sourness and in that acidophilus milk contains added milk sugar. (See BUTTERMILK.) Yoghurt or yogurt (*q.v.*), is a sharply sour, semisolid, fermented milk containing lactic acid and made from whole milk concentrated to two-thirds of its original volume. It is commercially available in western Europe and the United States. The fermenting culture contains bacteria of three species. Kefir is a self-carbonated, fermented milk containing both lactic acid and alcohol. Kefir grains, which are small lumps of milk protein carrying both bacteria and yeasts are the fermenting agents. Chocolate-flavoured milks contain sugar, cocoa or chocolate liquor and a stabilizer, such as gelatine. Chocolate-flavoured nonfat dry milk is available for reconstituting in the home.

Consumption.—Differences in the level of consumption of milk and its products are attributable to many factors, among these are economic level, food habits, knowledge of nutritional values, price and availability. In western Europe. Oceania and Canada, milk and milk products account for 25% to 30% of total food expenditures of wage-earners, but in the British West Indies and Japan for less than 10%. The distribution of consumption among dairy products differs considerably among countries, but, for Europe, North America and Oceania in 1950, about 39% of the total milk produced was consumed as fluid milk, about 35% as butter, 11% as cheese, 4% as concentrated and dried milks and 3% as ice cream and other products.

Marketing.—The marketing and distribution of fluid milk are complex and highly organized. Care has to be taken, not only of physical and hygienic aspects, but also of the great seasonal differences in volume of supply and day to day irregularities in demand. The so-called "flush" season of milk supply is in the months of May and June in the northern hemisphere and in the corresponding late spring months in the southern hemisphere. The winter months are those of shortest supply. Since fluid milk is perishable, it is necessary that the surplus of the spring months be converted into products that can be stored and placed on the market at a later time. Chiefly butter and, to a lesser extent, cheese are the dairy products that have served as a means of carry-over, but, since World War II, the skim milk that is a by-product of butter manufacture has been converted to nonfat dried milk and stored for later marketing. The heaviest demand for fluid milk in cities is during the week end. The midweek surpluses are converted into such products as cream for home consumption, cream for ice cream, cottage cheese and cultured buttermilk.

Since fluid milk is both highly perishable and very bulky for its content of solids, it is supplied to cities and villages from farms within a well-defined, close, surrounding area. It is transported from farms to dairy plants within the cities in 10-gal. cans or in tanks. After the milk is pasteurized and bottled or put in cardboard containers, it is delivered to the consumer. In countries in which homes do not generally have refrigerators. milk deliveries are made daily. In countries, such as the United States, in which nearly every home has a refrigerator, deliveries are usually made on alternate days or three times a week. An increasing proportion of fluid milk is being marketed in the United States through food stores having refrigerated cabinets.

The price paid to farmers for milk for fluid consumption is greater than that paid by manufacturers of milk products. In some areas of the English-speaking countries, the producer receives the market-milk price for a fixed quantity of milk throughout the year and the lower manufacturing-milk price for all milk delivered in excess of the fixed quantity. In other areas, a regional pooling arrangement is operated under which each producer receives a price related to the average price realized for sales in

both markets, irrespective of the purpose for which his own supply was used. Countries specializing in the production of milk for manufactured dairy products (*i.e.,* New Zealand and Denmark) also have highly organized marketing arrangements.

Producers who supply factories making cheese, concentrated milks, dried milks and casein (*q.v.*), deliver whole milk. Before the demand for dried skim milk began its remarkable increase, butter factories received mostly cream produced by the use of cream separators on the farms. Since before 1940 there has been an increasing tendency for whole milk to be delivered to butter factories in Australia, New Zealand, and the butter-producing areas of the United States. Payment is made for cream on the basis of its fat content. Payment for whole milk is on a weight basis, with additional payment for fat above a standard percentage.

Production and Trade.—Milk and its products are produced in the largest quantities in the United States, Australia, New Zealand, and the countries of western Europe, especially Denmark, the Netherlands, France and western Germany.

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MILKING MACHINE: *see* DAIRY INDUSTRY: *Dairy Machinery and Manufacturing Processes.*

MILK RIVER. The headwaters of Milk river are in the Blackfeet Indian reservation in the rolling foothills of the Rocky mountains in northwestern Montana, U.S. The north and south branches of the river flow northeastward through dry grassland and ranching country into Alberta, Can., where they join. The river flows east through southern Alberta and then bends southeastward into north-central Montana; it joins the Missouri river a few miles northeast of the Fort Peck dam and reservoir. In its total length of 625 mi., slightly more than 100 mi. are in Canada. Some water from its north branch is diverted into St. Mary river for use in irrigation. Milk river is entrenched about 100 ft. below the level of the flat, dry plains of southern Alberta. Winter pasture and feed grains are grown in the valley flats for the cattle-ranching industry. East of the town of Chinook, Mont., much of its water is used for irrigation farming; strips of irrigated green in the valley bottom contrast with the brown grasslands of the rolling hills above. The main line of the Great Northern railway follows the Milk river valley; it serves several towns, of which Malta and Glasgow are the largest. (J. L. R.)

MILK TREE: *see* COW TREE OR MILK TREE.

MILKWEED, or silkweed, the name given to plants of the genus *Asclepias,* of the milkweed family (Asclepiadaceae; *q.v.*), comprising about 100 species, natives mostly of the western hemisphere, about 33 of which are found in North America. Many species have a milky juice, and all have silky downy seeds. Well-known species of the eastern U.S. and Canada are the common milkweed, *A. syriaca,* often a troublesome weed; the swamp milkweed, *A. incarnata;* and *A. exaltata,* a tall perennial.

JOHN H. GERARD

RIPENED PODS OF A BUTTERFLY OR MILKWEED (ASCLEPIAS TUBEROSA)

The orange milkweed *A. tuberosa,* usually called butterfly weed or pleurisy root, common on sandy soils, has rough hairy foliage and contains a resinous juice. Some species, notably the desert milkweed, *A. subulata,* contain small quantities of rubber. *Asclepias* species contain variable amounts of resinoids and other substances of a toxic nature, which sometimes prove fatal to livestock. *A. galioides* and *A. verticillata* are especially dangerous in this regard. Earlier, the drug asclepias, derived from the resinous juice of *A. tuberosa,* served as a diaphoretic, diuretic and expectorant.

The seed floss of *A. syriaca* is very buoyant and has been used in life belts and vests. Noteworthy species of the western U.S. are the showy milkweed, *A. speciosa,* and the narrow-leaved milkweed, *A. mexicana.* Some species are cultivated for ornament, such as *A. curassavica,* but many are weeds, effectively controlled only by chemical spraying.

See also BUTTERFLY WEED. (N. TR.)

MILKWORT, the common name for plants of the genus *Polygala* (family Polygalaceae), a large genus of about 500 species, which are widely dispersed in temperate and tropical regions and represented by about 50 species in North America and a few species in Great Britain. The common species, P. *vulgaris,* is a small wiry perennial found on heaths and in meadows throughout the British Isles. The stems are two to ten inches long and bear narrow rather tough leaves and small, one-sixth to one-third inch long, white, pink, blue, lilac or purple flowers. The flowers are peculiar in form and arrangement of parts; they have five free sepals, the two inner of which are large petaloid and winglike, forming the most conspicuous part of the flower; the petals are united below with the sheath of the eight stamens forming a tube split at the base behind; their form recalls that of the pea family. The name *Polygala* is from the Greek *polys,* much, and *gala,* milk, the plant being supposed to increase the yield of milk in cows. Some species with showy flowers are known in cultivation as greenhouse or hardy annual or perennial herbs or shrubs. The root of *P. senega,* snakeroot, a North American species, is officinal. The fringed milkwort or flowering wintergreen (*P. paucifolia*) of the northeastern United States and adjacent Canada is a delicate woodland plant with handsome purple flowers. Sea milkwort is the common name for *Glaux maritima,* a small succulent herb found on northern ocean shores, and occurring on the Atlantic and Pacific coasts and locally in the interior of North America and also in the British Isles; it belongs to the primrose family (Primulaceae).

MILL, HUGH ROBERT (1861–1950), British geographer and meteorologist who exercised a great influence in the reform of geography teaching and on the development of meteorology, was born at Thurso, Scot., on May 28, 1861. He was educated at Edinburgh university, graduating in chemistry (1883) and specializing in the chemistry of sea water for his doctorate (1886). Love of the sea and of boats led to his famous pioneer survey, *The English Lakes* (1895). Indifferent health and physique—he became totally blind in later life—prevented his becoming an explorer, but from 1892 on (when he was appointed librarian of the Royal Geographical society and settled in London), he became an acknowledged world expert in oceanography and antarctic exploration. It was through *The Realm of Nature* (1891) that he influenced the reform of geography teaching. As director of the British Rainfall organization (1901–19), editor of *British Rainfall* and *Symons' Meteorological Magazine,* honorary secretary of the Royal Meteorological society from 1902 until 1907 when he became president, he had a profound influence on the development of meteorology which was recognized by the institution of a Hugh Robert Mill medal by the society, with Mill as first recipient. He served as vice-president of the Royal Geographical society from 1927 to 1931, but was compelled by ill-health to refuse the presidency in 1933. His autobiography was in proof when he died at Dormans park, East Grinstead, Susses, on April 5, 1950.

Mill's other publications include: *Hints . . . on the Choice of Geographical Books . . .* (1897); *New Lands* (1900); *The Siege of the South Pole* (1905); *The Life of Sir Ernest Shackleton* (1923); *Hugh Robert Mill: an Autobiography,* with introduction by L. Dudley Stamp (1951); he also edited *The International Geography* (1911) and was geographical editor for the 11th edition of *Encyclopedia Britannica* (1911). (L. D. S.)

MILL, JAMES (1773–1836), British historian, economist and philosopher, prominent as a representative of "philosophical radicalism," was born on April 6, 1773, at Northwater Bridge, in the parish of Logie-Pert, Forfarshire, the son of James Mill, a

shoemaker. His mother, Isabel Fenton, of a good family which had suffered from connection with the Stuart rising of 1745, sent him to the parish school, to the Montrose academy and then to the University of Edinburgh, where he distinguished himself as a Greek scholar. He was licensed as a preacher in Oct. 1798 but occupied himself with occasional teaching and with historical and philosophical studies. In 1802 he went to London in company with Sir John Stuart, M.P. for Kincardineshire, and devoted himself to journalism. In 1804 he wrote a pamphlet on the corn trade, arguing against a bounty on the exportation of grain. After his marriage (1805) with Harriet Burrow, he took a house in Pentonville, where his eldest son, John Stuart Mill (*q.v.*), was born in 1806. About the end of 1806 he began his *History of British India.*

Mill became acquainted with Jeremy Bentham in 1808 and was for many years his chief companion and ally. He adopted Bentham's principles in their entirety and did more to propagate them and to oppose the beginnings of romanticism than anyone else. He was a regular contributor (1806–18) to the *Anti-Jacobin Review,* the *British Review,* the *Eclectic Review* and the *Edinburgh Review* (1808–13). In 1811 he co-operated with William Allen (1770–1843) in a periodical called the *Philanthropist.* He contributed largely to every number—his principal topics being education, the freedom of the press and prison discipline (under which he expounded Bentham's "Panopticon"). He took part in the discussions which led to the foundation of London university in 1825.

In 1814 Mill undertook various articles—including, eventually, "Government," "Jurisprudence," "Liberty of the Press," "Prisons and Prison Discipline," "Colony," "Law of Nations" and "Education"—for the supplement to the 4th, 5th and 6th editions of the *Encyclopedia Britannica.* These were reprinted and enjoyed an extensive circulation. Although the article "Government" was the target of some very able articles by Thomas Babington Macaulay, it had a considerable influence on public opinion in the 1820s and did a good deal to prepare the ground for the passage of the first Reform bill in 1832. It provides perhaps the most succinct statement of the political theory of the philosophical radicals. It also had the merit of stimulating the production of such diverse political theories as those of John C. Calhoun and John Stuart Mill. (*Cf.* Sir Ernest Barker's introduction to the Cambridge reprint of 1937.)

The History of British India, 3 vol. (1817), appeared at the beginning of 1818; and in 1819, though his *History* contained drastic criticisms of British rule in India, Mill was appointed an official in the India house. He gradually rose till he was appointed, in 1830, head of the examiner's office. His *Elements of Political Economy* appeared in 1821 (3rd and revised ed., 1826).

From 1824 to 1826 Mill contributed to the *Westminster Review,* started as the organ of the philosophical radicals, articles attacking the *Edinburgh Review,* the *Quarterly Review* and ecclesiastical establishments. In 1829 appeared the *Analysis of the Phenomena of the Human Mind,* 2 vol. From 1831 to 1833 Mill was largely occupied, as the spokesman of the court of directors, in the defense of the East India company, during the controversy attending the renewal of its charter. His last published book was the *Fragment on Mackintosh* (1835). He died June 23, 1836.

Mill's greatest literary monument is *The History of British India.* The materials for the history of the conquest of India were put into shape for the first time; political theory was brought to bear on the delineation of the Hindu civilization; and the conduct of the successive stages of the conquest and administration of India was subjected to severe criticism. The work itself and the author's official connection with India for the last 17 years of his life effected a complete change in the system of governing that country.

Mill played a great part in English politics. His writings on government and his personal influence among the radical politicians of his time determined the change of view from the French Revolutionary theories of the rights of man and the absolute equality of men to the claiming of securities for good government through a wide extension of the franchise. His *Elements of Political Economy* shows all the author's precision and lucidity. Its interest is mainly historical, as a summary of the views of the philosophical radicals, based mainly on David Ricardo. Mill maintained: (1) that the chief problem of political reformers is to limit the increase of population, on the assumption that capital does not naturally increase at the same rate as population (ii, sec. 2, art. 3); (2) that the value of a thing depends entirely on the quantity of labour put into it; and (3) that what is now known as the "unearned increment" of land is a proper object for taxation. The enunciation of the second of these propositions is important in view of the use made of it by Karl Marx.

In his *Analysis of the Phenomena of the Human Mind* Mill developed the psychological side of Benthamism. It was a more systematic attempt than that already made by David Hartley to explain all mental phenomena by the association of ideas.

All the writings of James Mill—economic, political and psychological—should be regarded as contributions to the program of the philosophical radicals. Élie Halévy provides much the best account of that movement in his *Growth of Philosophical Radicalism* (Eng. trans., Faber and Faber Ltd., London, 1928; page 6): "Given a science of the mind and a science of society which exhibit the qualities both of the experimental and of the exact sciences analogous to the physics of Newton, should it not be possible to found on these new disciplines a moral and legal theory which would be scientific—the achievement of the universal practical science? Such is the problem which exercised thinking people in England throughout Bentham's century. What is known as Utilitarianism, or Philosophical Radicalism, can be defined as nothing but an attempt to apply the principles of Newton to the affairs of politics and of morals. In this moral Newtonianism the principle of the association of ideas and the principle of utility take the place of the principle of universal attraction."

MILL, JOHN STUART (1806–1873), British philosopher and economist, prominent as a publicist in the reforming age of the 19th century and of lasting interest as a logician and as an ethical theorist. The eldest son of James Mill (*q.v.*), he was born on May 20, 1806, in his father's house in Pentonville, London. He was educated exclusively by his father, who was a strict disciplinarian. By his eighth year he had read in the original Aesop's *Fables,* Xenophon's *Anabasis* and the whole of Herodotus and was acquainted with Lucian, Diogenes Laërtius, Isocrates and six dialogues of Plato. (*See* his *Autobiography.*) He had also read a great deal of history in English. A contemporary record of Mill's studies from 8 to 13, published in Alexander Bain's sketch of his life, shows that the *Autobiography* rather understates the amount of work done. At the age of eight he started Latin, Euclid and algebra and began to teach the younger children of the family. His main reading was still history, but he went through all the Latin and Greek authors commonly read in the schools and universities and, by the age of ten, could read Plato and Demosthenes with ease. About the age of 12, he began a thorough study of the scholastic logic, at the same time reading Aristotle's logical treatises in the original. In the following year he was introduced to political economy and studied Adam Smith and David Ricardo.

The training which the younger Mill received has aroused amazement and criticism. The important part of it was the close association with the strenuous character and vigorous intellect of his father. From his earliest days he spent much time in his father's study and habitually accompanied him on his walks. He thus inevitably acquired many of his father's speculative opinions and his father's way of defending them. But he did not receive the impress passively and mechanically. "One of the grand objects of education," according to the elder Mill, "should be to generate a constant and anxious concern about evidence." The duty of collecting and weighing evidence for himself was at every turn impressed upon the boy. His childhood was not unhappy, but there is no doubt that it was a strain on his constitution and that he suffered from the lack of natural unforced development.

From May 1820 till July 1821 Mill was in France in the family of Sir Samuel Bentham, brother of Jeremy Bentham. Copious extracts from a diary kept by him at this time are given by Bain;

they show how methodically he read and wrote, studied chemistry and botany, tackled advanced mathematical problems and made notes on the scenery and the people and customs of the country. He also gained a thorough acquaintance with the French language. On his return in 1821 he added to his work the study of psychology and that of Roman law, which he read with John Austin, his father having half decided on the bar as the best profession open to him. This intention, however, was abandoned; and in 1823, when he had just completed his 17th year, he entered the examiner's office of the India house. After a short probation he was promoted, in 1828, to assistant examiner. For 20 years, from 1836 (when his father died) to 1856, Mill had charge of the East India company's relations with the native states, and in 1856 he became chief of the examiner's office.

In 1822 Mill had read P. L. E. Dumont's exposition of Bentham's doctrines in the *Traitk de ldgislation,* which made a lasting impression upon him. The impression was confirmed by the study of the English psychologists and also of Condillac and Helvétius; and in 1822–23 he established among a few friends the "Utilitarian" society, taking the word, as he tells us, from John Galt's *Annals of the Parish.*

Two newspapers were open to him—the *Traveller,* edited by a friend of Bentham's and the *Morning Chronicle,* edited by his father's friend John Black. One of his first efforts was a solid 'argument for freedom of discussion, in a series of letters to the *Chronicle* on the prosecution of Richard Carlile. He seized every chance for exposing departures from sound principle in parliament and courts of justice. Another outlet was opened up for him (April 1824) by the starting of the *Westminster Review,* which was the organ of the philosophical radicals. In 1825 he began work on an edition of Bentham's *Rationale of Judicial Evidence,* 5 vol. (1827). He discussed eagerly with the many men of distinction who came to his father's house and engaged in set discussions at a reading society formed at George Grote's house in 1825 and in set debates at the Speculative society, formed in the same year.

The *Autobiography* tells how in 1826 Mill's enthusiasm was checked by a misgiving as to the value of the ends which he had set before him. At the Speculative debating society, where he first measured his strength in public conflict, he found himself looked upon with curiosity as a precocious phenomenon, a "made man," an intellectual machine set to grind certain tunes. The elder Mill, like Plato, would have put poets under ban as enemies of truth; he subordinated private to public affections; and Landor's maxims of "few acquaintances, fewer friends, no familiarities" had his cordial approval. These doctrines the younger Mill now felt himself forced in reason to abandon. Too much in awe of his father to make him a confidant, he wrestled with his doubts in gloomy solitude. He emerged from the struggle with a more catholic view of human happiness, a delight in poetry for its own sake, a more placable attitude in controversy, a hatred of sectarianism and an ambition no less noble and disinterested but moderated to practical possibilities. Gradually the debates in the Speculative society attracted men whose society was invigorating and inspiring, among others J. F. D. Maurice and John Sterling. Mill ceased to attend the society in 1829, but he carried away from it the conviction that a true system of political philosophy was "something much more complex and many-sided than he had previously had any idea of, and that its office was to supply, not a set of model institutions but principles from which the institutions suitable to any given circumstances might be deduced."

Mill's letters in the *Examiner* in the autumn of 1830 after a visit to Paris, where he made the acquaintance of the younger liberals, may be taken as marking his return to hopeful activity; and a series of articles on "The Spirit of the Age" (ed. with introduction by F. A. von Hayek, Chicago, 1942) appeared in the same paper in 1831. During the years 1832 and 1833 he contributed many essays to *Tait's Magazine,* the *Jurist* and the *Monthly Repository.* In 1835 Sir William Molesworth founded the *London Review,* with Mill as editor. It was amalgamated with the *Westminster* (as the *London and Westminster Review)* in 1836, and Mill continued editor (latterly proprietor also) till 1840. In and after 1840 he published several important articles in the *Edinburgh Review.* Some of the essays written for these journals were reprinted in the first two volumes (1859) of Mill's *Dissertations and Discussions* and give evidence of the increasing width of his interests. Among the more important are "Thoughts on Poetry and Its Varieties" (1833), "Writings of Alfred de Vigny" (1838), "Bentham" (1838), "Coleridge" (1840), "M. de Tocqueville on Democracy in America" (1840), "Michelet's History of France" (1844) and "Guizot's Essays and Lectures on History" (1845). The twin essays on Bentham and Coleridge (together reprinted with introduction by F. R. Leavis, London, 1950; New York, 1951) are perhaps the finest things that Mill ever wrote and indicate very clearly the new spirit that he tried to breathe into English radicalism.

During these years Mill also wrote his great systematic works on logic and on political economy. His reawakened enthusiasm for humanity had taken shape as an aspiration to supply an unimpeachable method of proof for conclusions in moral and social science: Auguste Comte had some influence here but the main inspiration undoubtedly came from Newton, whose physics had already been accepted as a model of scientific exposition by Locke, Hume, Bentham and James Mill. But he was determined that the new logic should stand in no antagonism to the old. In his *Westminster* review of Richard Whately's *Logic* of 1828 he was already defending the syllogism against the Scottish philosophers who had talked of superseding it by a supposed system of inductive logic. He required his inductive logic to "supplement and not supersede." For several years he searched in vain for the means of concatenation. Finally, in 1837, on reading William Whewell's *Philosophy of the Inductive Sciences* and rereading J. F. W. Herschel's *Preliminary Discourse on the Study of Natural Philosophy,* Mill at last saw his way clear both to formulating the methods of scientific investigation and to joining the new logic onto the old as a supplement. *The System of Logic,* 2 vol., was published in 1843 (3rd–8th editions, introducing many changes, 1851–72).

Mill distinguished three stages in his development as a political economist. In 1844 he published the *Essays on Some Unsettled Questions in Political Economy,* which he had written several years earlier; and four out of five of these essays are solutions of perplexing technical problems—the distribution of the gains of international commerce, the influence of consumption on production. the definition of productive and unproductive labour and the precise relations between profits and wages. Here for the most part Mill appears as the disciple of Ricardo, striving after more precise statements and reaching forward to further consequences. In his second stage originality and independence become more conspicuous as he struggles toward the standpoint from which he wrote his *Principles of Political Economy.* This was published in 1848 (2 vol.; 2nd and 3rd editions, with significant differences, 1849, 1852), and at about the same time Mill was advocating the creation of peasant-proprietorships as a remedy for the distresses and disorder in Ireland. Thereafter Mill made a more thorough study of socialist writers. He was convinced that the social question was as important as the political question. He declined to accept property devised originally to secure peace in a primitive society as necessarily sacred in its existing developments in a quite different stage of society. He separated questions of production and distribution and could not rest satisfied with the distribution which condemned the labouring classes to a cramped and wretched existence, in many cases to starvation. He did not come to a socialist solution, but he had the great merit of having considered afresh the foundations of society. This he called his third stage as a political economist; and he says that he was helped toward it by the lady, Mrs. Taylor (Harriet Hardy), who became his wife in 1851.

It is generally supposed that Mill writes with a lover's extravagance about this lady's powers. He expressly says, indeed, that he owed none of his technical doctrine to her, that she influenced only his ideals of life for the individual and for society and that the only work which was directly inspired by her is the essay on the "Enfranchisement of Women" *(Dissertations,* vol.

ii). Nevertheless Mill's relations with her have always been something of a puzzle. It is noticeable that in his *Autobiography* Mill first introduces her name in a passage in which he closes his account with Thomas Carlyle, and it is possible that the clue to their relationship lies here. "I felt," he says of Carlyle, "that he was a poet and that I mas not; that he was a man of intuition which I was not; and that as such he not only saw many things before me, but that it was highly probable he could see many things which were not visible to me even after they were pointed out. I knew that I could not see round him and could never be certain that I saw over him; and I never presumed to judge him with any definiteness until he was interpreted to me by one [that is, Mrs. Taylor] who was greatly the superior of us both—who was more a poet than he and more a thinker than I—whose own mind and nature included his and infinitely more."

It would appear from this passage that Mrs. Taylor played something like the same role in Mill's life as Carlyle had done; and we know that Carlyle took over this role from Sterling. Each of these three, Sterling, Carlyle and Mrs. Taylor, seemed to provide some nourishment for Mill's perpetual love of loving—"the need," as he defines it. "of a sympathising support or of objects of admiration and reverence"; and at the back of his mind there was always the terrible fear of the stiffed melancholy that had visited him in his early manhood. It was to Sterling that he made the pathetic confession that "there is now no human being (with whom I can associate on terms of equality) who acknowledges a common object with me"; and he was even more explicit to Carlyle a few years later. "You wonder," he writes. "at the boundless capacity man has of loving: but I also wonder, judging from myself, at the narrowness of that capacity in others. That seems to me the only really insuperable calamity in life—the only one which is not conquerable by the power of a strong will. It is hard to have no aspiration and no reverence but for an Ideal towards which striving is of no use." The fact is that there were two distinct strains in Mill: the sensitive temperament that craved for sympathetic support and responded so delicately to every trend of the age was balanced, or almost balanced, by a strong and thoroughly trained will which was never content simply to absorb influences but insisted on systematizing them. The latter trait drew him to his father, the former to his wife; and it was perhaps inevitable that the conflict was only resolved at the cost of a good deal of suffering for all concerned.

During the seven years of his marriage Mill became increasingly absorbed in the work of the East India company and in consequence published less than at any other period of his life. In 1856 he became head of the examiner's office in the India house; and for two years, till the dissolution of the company in 1858, his official work kept him fully occupied. It fell to him as head of the office to write the defense of the company's government of India when the transfer of its powers was proposed. Mill opposed the transfer, and the documents in which he defended the company's administration are models of trenchant and dignified pleading. On the dissolution of the company Mill was offered a seat in the new council, but declined it and retired with a pension of £1,500. His retirement from official life was followed almost immediately by his wife's death at Avignon. He spent most of the rest of his life at a villa at St. Véran, near Avignon, returning to his Blackheath house only for a short period in each year.

Mill sought relief by publishing a series of books on ethics and politics which he had meditated and partly written in collaboration with his wife. The essay *On Liberty* appeared in 1859 with a touching dedication to her and the *Thoughts on Parliamentary Reform* in the same year. In his *Considerations on Representative Government* (1861) he systematized opinions already put forward in many casual articles and essays. Lord Lindsay remarked how Mill combined enthusiasm for democratic government with pessimism as to what democracy was likely to do; practically every discussion in these books exemplifies this. *(See* further R. B. McCallum, introduction to his edition of *On Liberty* and *Considerations on Representative Government,* Oxford. 1946; New York, 1947.) His *Utilitarianism* (in Fraser's *Magazine*, 1861; separate publication, 1863; reprint with study of the English utilitarians by J. P. Plamenatz, Oxford, New York, 1949) was a closely reasoned attempt to answer objections to his ethical theory and to remove misconceptions about it. He was especially anxious to make it clear that he included in "utility" the pleasures of the imagination and the gratification of the higher emotions.

Mill also began to write again on the wider philosophical questions that had occupied him in the *Logic.* In 1865 he published both his *Examination of Sir William Hamilton's Philosophy* and his *Auguste Comte and Positivism;* but in both cases his motives for writing were largely political. "The practical reformer," he writes in his *Autobiography,* "has continually to demand that changes be made in things which are supported by powerful and widely-spread feelings, or to question the apparent necessity and indefeasibleness of established facts; and it is often an indispensable part of his argument to show how those powerful feelings had their origin, and how those facts came to seem necessary and indefeasible. There is therefore a natural hostility between him and a philosophy which discourages the explanation of feelings and moral facts by circumstances and association, and prefers to treat them as ultimate elements of human nature." It was because he regarded the writings and sayings of Sir William Hamilton as the great fortress of intuitional philosophy in Great Britain that Mill undertook to counter his pretensions. In dealing with Comte, Mill distinguished sharply between Comte's earlier philosophical doctrine of positivism and his later religion of humanity. The doctrine he commended (as he had frequently done previously) because he regarded it as a natural development of the outlook of Berkeley and Hume; the religion he attacked because he saw in it merely another attempt to foist a priestly hierarchy upon suffering humanity. It is noticeable that Mill's language in these books is much closer to the language of Bentham and James Mill than it had been since his boyhood; and it was as an act of piety that in 1869 he republished his father's *Analysis of the Phenomena of the Human Mind* with additional illustrations and explanatory notes.

While mainly engaged in these years with theoretical studies, Mill did not remit his interest in current politics. He supported the North in the American crisis of 1862, using all his strength to explain that the real issue at stake in the struggle was the abolition of slavery. In 1865 he stood as parliamentary candidate for Westminster, on conditions strictly in accordance with his principles. He would not canvass or pay agents to canvass for him, nor would he engage to attend to the local business of the constituency. He was with difficulty persuaded even to address a meeting of the electors, but was elected. He took an active part in the debates on the Reform bills of 1866–67 and helped to extort from the government several useful modifications of the bill for the prevention of corrupt practices. The reform of land tenure in Ireland *(cf.* his *England and Ireland,* 1868, and his *Chapters and Speeches on the Irish Land Question,* 1870), the representation of women *(see* below), the reduction of the national debt, the reform of London government and the abrogation of the declaration of Paris were among the topics on which he spoke. He took occasion more than once to enforce what he had often advocated, England's duty to intervene in foreign politics in support of the cause of freedom. As a speaker Mill was somewhat hesitating, but he showed great readiness in extemporaneous debate. Elected rector of St. Andrews university, he published his *Inaugural Address* in 1867.

Mill's subscription to the election expenses of Charles Bradlaugh and his attack on the conduct of Gov. E. J. Eyre in Jamaica were perhaps the main causes of his defeat in the general parliamentary election of 1868. But his studied advocacy of unfamiliar projects of reform had made him unpopular with "moderate Liberals." He retired with a sense of relief to Avignon. His villa was filled with books and newspapers; the country round it furnished him with a variety of walks; he read, wrote, discussed, walked, botanized. He was extremely fond of music and was himself a fair pianist. His stepdaughter, Helen Taylor (d. Jan. 1907), was his constant companion after his wife's death. Mill was an enthusiastic botanist all his life and a frequent contributor of notes and short papers to the *Pkytologist.* During his last journey to Avignon he was looking forward to seeing the spring flowers and

completing a flora of the locality.

Mill did not relax his laborious habits or his ardent outlook on human affairs. The essays in the fourth volume of his *Dissertations* (1876; vol. iii had appeared in 1867)—on endowments, on land, on labour and on metaphysical and psychological questions—were written for the *Fortnightly Review* at intervals after his short parliamentary career. In 1867 he had been one of the founders, with Mrs. P. A. Taylor, Miss Emily Davies and others, of the first women's suffrage society, which developed into the National Union of Women's Suffrage Societies; and in 1869 he published *The Subjection of Women* (written 1861), the classical theoretical statement of the case for women's suffrage. His last public activity was concerned with the starting of the Land Tenure Reform association, for which he wrote in the *Examiner* and made a public speech a few months before his death: the interception by the state of the unearned increment on land and the promotion of co-operative agriculture were the most striking features in his program, which he regarded as a timely compromise in view of the impending struggle between capital and labour in Europe. His *Autobiography* (see *Bibliography,* below) and *Three Essays on Religion* (1874) were published posthumously.

Mill died at Avignon on May 8, 1873. A bronze statue of him stands on the Thames embankment in London, and G. F. Watts's copy of his original portrait of Mill hangs in the National gallery there.

Influence and Significance.—Mill was a man of extreme simplicity in his mode of life. The influence which his works exercised upon contemporary English thought can scarcely be overestimated; nor can there be any doubt about the value of the liberal and inquiring spirit with which he handled the great questions of his time. Beyond that, however, there has been considerable difference of opinion about the enduring merits of his philosophy. At first sight he is the most lucid of philosophers. Many people have spoken of the marvelous intelligibility of his writing; some have even mentioned the intellectual ecstasy produced in them by the exact and ordered sequence of his reasoning. Usually, however, it is not long before doubts begin to creep in. Although the lucidity remains, its span is seen to be somewhat limited, and one sometimes has the uneasy feeling that he is being equally lucid on both sides of a question. Hence it has often been held, since W. S. Jevons first made the discovery, that Mill's mind was "essentially illogical" and that his philosophy was notable mainly for its "intricate sophistry."

Oddly enough, however, this judgment has not led to any neglect of Mill. Little attention is now paid to Hamilton or to Whewell; but Mill's name continually crops up in philosophical discussions. This is partly due to the fact that Mill offers a body of doctrine and a set of technical terms on many subjects (notably on induction) which have proved extremely useful in the classroom. But a more important reason is that he has come to be regarded as a sort of personification of certain tendencies in philosophy which it is regarded as continually necessary to expose. Thus he is, or says he is, a utilitarian; yet nothing, it is pointed out, could tell more strongly against utilitarianism than certain passages in his writings. Then again he is said to be an empiricist (although he says himself that he is not), and his theories of the syllogism and of mathematics are constantly used to demonstrate the fatal consequences of this way of thinking.

Now we are, of course, paying a considerable compliment to any man when me link his name in this way with some important doctrine, but at the same time we also run a considerable risk of misunderstanding him. It has been generally acknowledged in the case of more than one philosopher—Locke's is a particularly pertinent case here—that a traditional labci, applied as often as not in the interests of party politics, has resulted in a very distorted view of the philosopher's teaching; and this appears to be at least as true of Mill as of Locke.

Thus it has been pointed out that the theory of the syllogism usually associated with Mill's name is an empiricist theory, while the theory of induction is not. "The characteristic feature of the former is the assertion that we can never attain certainty in our reasonings, because we must always argue from particulars to particulars. The underlying assumption is that we can never establish any real connection between particulars by way of universals because universals are merely collections of particulars. The theme of the latter, on the contrary, is that we can obtain certainty by way of scientific experiment because the particulars we are dealing with there are merely collections of universals. It is on this assumption that the problem of induction is reduced by Mill to the formal one of determining what universals in one particular are connected with what universals in another; and it is this problem which he solves by means of his Canons of Induction" (R. P. Anschutz, *Philosophy of* J. *S. Mill,* The Clarendon Press, Oxford, 1953).

It is equally misleading to speak without qualification of Mill's utilitarianism. If we do, we immediately suggest that there is a degree of agreement between the ethical and political doctrines of Bentham and those of Mill which does not on the face of it exist. Nor is it sufficient to add that Mill modified the utilitarianism that he inherited from Bentham and from his father in one way and another, in order to meet the criticisms which it encountered in Victorian times. He does, it is true, sometimes give that impression (as in his essay on *Utilitarianism);* but elsewhere (as in his essay *On Liberty)* he scarcely attempts to conceal the fact that his premises are completely independent of Bentham's. Thus, contrary to the common belief, it appears to be very hazardous to characterize offhand the precise position of Mill on any major philosophical topic. All his theories, like Locke's, are extremely complex and unstable structures, prone to fall to pieces at the first inconvenient question. Nevertheless one or two points about Mill leap to the eye, and with their aid it is possible to unravel to some degree the tangled skein of his thought.

For one thing, Mill was not the paragon of the middle-class virtues that he is sometimes represented as being. As in the case of his marriage, he sometimes behaved with a reckless disregard of consequences more suitable to a romantic than to a utilitarian. He is thoroughly romantic, again, and thoroughly representative of his age in the eagerness with which he seeks out and endeavours to assimilate every last exotic line of thought which shows any signs of vitality. He himself claimed to be superior to most of his contemporaries in "ability and willingness to learn from everybody"; and indeed, for all his father's careful schooling, there was never anybody less buttoned up against alien influences than Mill. Somewhere or other in his writings you can discern traces of every wind that blew in the earlier part of the 19th century.

On the other hand there was another strain in Mill which was perpetually at war with this: he was an inveterate systematizer and, search as he might, he never succeeded in finding a system which had anything like the appeal of the one in which he had been brought up. Looking back upon the stormy period of his youth, Mill said: "I found the fabric of my old and taught opinions giving way in many fresh places and I never alloned it to fall to pieces but was incessantly occupied in weaving it anew"; and this is a description that never really ceased to be applicable to him.

BIBLIOGRAPHY.—The primary source for Mill's life is his *Autobiography,* ed by I-Ielen Taylor (London, 1873), of which two new editions appeared in 1924 one (London) with an appendix of previous!~ unpublished speeches, a preface by H Laski and a good index; the other, ed. by J J. Coss (New York), including passages omitted from the original edition. There are collections of his letters ed. by Hugh Elliott. *Letters of John Stuart Mill,* 2 vol. (London, 1910); by E. d'Eichthal, *Correspondance inédite de J. S. Mill avec Gustave d'Eichthal* (Paris, 1898); by L. Lévy-Bruhl, *Lettres inédites de J. S. drill à Auguste Comte* (Paris, 1899); and by F. A. von Hayek, *John Stuart Mill and Harriet Taylor: Their Friendship and Subsequent Marriage* (London, Chicago, 1951). *See* further the *Bibliography of the Published Writings of J. S. Mill,* ed. by N. MacMinn, J. R. Hainds and J. McCrimmon (Evanston, Ill., 1945).

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MILL, the term given to the apparatus used in grinding flour, and hence applied to similar mechanical devices for grinding or pulping other substances; *e.g.,* coffee mill, powder mill. "Mill" was first used of the building containing the apparatus. frequently with a word attached descriptive of the motive power; *e.g.,* windmill.]+-ater mill. It was not the early word used of the actual grinding mechanism. The old hand mill, for example, was known as a "quern."

The word mill in mining is applied to various machines used in breaking and crushing the ore *(see* ORE DRESSING). In manufacturing. milling machines constitute a very important class of machine tools, the characteristic of which is that rotary cutters are employed for shaping the metal *(see* TOOL). In coins the "milling" is the serrated edge formed to prevent clipping and filing. In the United States the term "milling" is applied to the raised edge on the face of the coin; this is known in the British mint as "marking" *(see* MINT). *See* also FLOUR.

MILLAIS, SIR JOHN EVERETT (1829–1896), English painter and illustrator, and a founder member of the Pre-Raphaelite brotherhood. was born at Southampton on June 8, 1829. of Jersey extraction. In 1838 he went to London, and on Sir Martin Archer Shee's advice entered first Henry Sass's school, Bloomsbury, then the Royal Academy schools in 1840. Extremely precocious. Millais won all the academy prizes, including a gold medal for "The Young Men of the Tribe of Benjamin Seizing Their Brides" (1847). His first academy picture "Pizarro Seizing the Inca of Peru" (1846. Victoria and Albert museum, London) was influenced by William Etty. In 1847 his painting "The Widow's Mite" (fragments at Christchurch priory, Hampshire) went unrewarded in the competition for decorating the houses of parliament. The next year, 1848, Millais joined with Holman Hunt and D. G. Rossetti to form the Pre-Raphaelite movement, and his "Isabella" (1849, Walker art gallery, Liverpool) from Keats's "Isabella; or the Pot of Basil," was a remarkable tour de force in the new manner. At the next year's academy, Charles Dickens led the violent attack on Millais's "Christ in the House of His Parents" (Tate gallery, London), which many considered blasphemous. The storm gradually abated. "The Return of the Dove to the Ark" (1851, Ashmolean museum, Oxford) was admired by both John Ruskin and Théophile Gautier; and "The Order of Release" (1853, Tate gallery), which included a portrait of his future wife Effie Gray (then married to Ruskin), was praised by Eugène Delacroix in 1855 and earned for its artist his associateship to the Royal Academy in 1853. Thus was set the seal of respectability upon a former rebel.

In 1863 Millais became full academician, and by this time his style had noticeably broadened and his subject matter considerably altered. "The Black Brunswicker" (1860, Lady Lever art gallery, Port Sunlight) marks the transition toward a more deliberately popular, less didactic approach, although he executed illustrations for George Dalziel's *Parables* (1864) and *E.* Moxon's edition of Tennyson's poems, and contributed to *Once a Week, Good Words* and other periodicals. Millais's later work is undoubtedly of poorer over-all quality—a deterioration of which he was fully aware. In 1871 appeared the first of his pure landscapes, "Chill October," which makes interesting comparison with the jewellike landscape background (a view of Winchelsea, Sussex) of "The Blind Girl" (1856, Birmingham art gallery), a painting whose tender sentiment contrasts sharply with the banality of "Bubbles" (Messrs. Pears). Many of these landscapes are of Perthshire, where Millais also shot and fished in the autumn. Among the better products of this period may be noted "A Yeoman of the Guard" (1877, Tate gallery), and "The North-West Passage" (1874, Tate gallery) the model for which was Edward Trelawney, a friend of Lord Byron. Many portraits belong to this date, including those of Gladstone, Tennyson, Cardinal Newman and Mrs. Bischoffsheim. Millais was created a baronet in 1885 and was elected president of the Royal Academy in 1896. He died on Aug. 13, 1896, and was buried in St. Paul's cathedral.

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MILLAR, ANDREW (1707–1768), British publisher, started business as a bookseller and publisher in the Strand, London, about 1729. His own judgment in literary matters was small, but he collected an excellent staff of literary advisers and paid what at the time were large prices for good material. "I respect Millar, sir," said Dr. Johnson in 1755, "he has raised the price of literature." He paid Thomson £105 for *The Seasons,* and Fielding £700 for *Tom Jones* and £1,000 for *Amelia.* He helped finance Johnson's *Dictionary* and published the histories of Robertson and Hume. He died at London on June 8. 1768.

MILLAY, EDNA ST. VINCENT (1892–1950), U.S. poet, immensely popular in her day, something of an unofficial feminine laureate, and a personification of the Byronic spirit of the 1920s, was born in Rockland, Me.. on Feb. 22, 1892. She graduated from Vassar in 1917 and supported herself in New York city by writing short stories under pseudonyms, and as an actress and playwright with the Provincetown Players. In 1923 she married Eugen Boissevain and spent the rest of her life. except for occasional travels, on a farm in the Berkshires. She died there on Oct. 19, 1950.

Miss Millay first attracted attention with a long poem. "Renascence," published in *The Lyric Year* anthology (1912) and written when she was only 19. This was incorporated in 1917 into *Renascence and Other Poems,* a volume full of the romantic and independent temper' of youth. *A Few Figs From Thistles* (1920) did not maintain the level of quality of her first work. but *Second April* (1921) marked a return to her earlier mood and craftsmanship. In 1921 she also published three plays: *Two Slatterns and a King, The Lamp and the Bell* and *Aria Da Capo. The Harp-Weaver and Other Poems* (1923) revealed a new maturity, the title poem having been awarded a Pulitzer prize for poetry in 1922. In 1925 she was commissioned by the directors of the Metropolitan Opera company to write the book for an opera, the music of which was to be composed by Deems Taylor; the result of their collaboration, *The King's Henchman,* first presented in 1927, was a greater success than any previous American opera. Works of succeeding years were: *The Buck in the Snow and Other Poems* (1928), introducing a more sombre tone to her poetry; *Fatal Interview* (1931), a highly acclaimed sonnet sequence; *Wine From These Grapes* (1934); *Conversation at Midnight* (1937), an unsuccessful attempt at an intellectual discourse involving masculine speakers; *Huntsman, What Quarry?* (1939), a return to personal lyricism; *Make Bright the Arrows* (1940); and *The Murder of Lidice* (1942); the latter two are verse commentaries on the current political upheaval.

Critical judgment of Miss Millay's work remains divided. Its frequent romantic extravagance and inflated rhetoric is undeniable; many of her shorter poems, however, particularly the early ones. are models of lyric beauty and emotional restraint. Her *Letters* were edited by A. R. Macdougall (1952).

See E Atkins, *Edna St. Vincent Millay and Her* ***Times*** (1936).

MILLBOARD: *see* CARDBOARD.

MILLENNIUM, literally a period of 1,000 years, a term especially used of the period of 1.000 years during which Christ, as has been believed, would return to govern the earth in person. Hence it is used to describe a vague time in the future when all flaws in human existence will have vanished, and perfect goodness and happiness will prevail.

Faith in the nearness of Christ's second advent and the establishing of his reign of glory on the earth was undoubtedly a strong point in the primitive Christian church. In the anticipations of the future prevalent among the early Christians *(c.* 50–150) it is necessary to distinguish a fixed and a fluctuating element. The former includes: (1) the notion that a last terrible battle with the enemies of God was impending; (2) the faith in the speedy return of Christ; (3) the conviction that Christ will judge all men; and (4) the conviction that He will set up a kingdom of glory on earth. To the latter belong views of the Antichrist, of the heathen world-power. of the place, extent, and duration of the earthly kingdom of Christ, etc. These remained in a state of

solution; they were modified from day to day, partly because of the changing circumstances of the present by which forecasts of the future were regulated, partly because the indications—real or supposed—of the ancient prophets always admitted of new combinations and constructions. But even here certain positions were agreed on in large sections of Christendom. Among these was the expectation that the future kingdom of Christ on earth should have a fixed duration—according to the most prevalent opinion, a duration of 1,000 years.

This idea that the Messianic kingdom of the future on earth should have a definite duration has—like the whole eschatology of the primitive church—its roots in the Jewish apocalyptic literature, where it appears at a comparatively late period. At first it was assumed that the Messianic kingdom in Palestine would last forever, and this seems always to have been the most widely accepted view. But from a comparison of prophetic passages of the Old Testament, learned apocalyptic writers came to the conclusion that a distinction must be drawn between the earthly appearance of the Messiah and the appearance of God Himself among His people and in the Gentile world for the final judgment.

Nowhere in the discourses of Jesus is there a hint of a limited duration of the Messianic kingdom, and the apostolic epistles are equally free from any trace of it. In Revelation, however. it occurs in the following shape (ch. xx): After Christ has appeared from heaven in the guise of a warrior, and vanquished the anti-Christian world-power, the wisdom of the world and the devil, those who have remained steadfast in the time of the last catastrophe, and have given up their lives for their faith, shall be raised up, and shall reign with Christ on this earth as a royal priesthood for 1,000 years. At the end of this time Satan is to be let loose again for a short season; he will prepare a new onslaught, but God will miraculously destroy him and his hosts. Then will follow the general resurrection of the dead, the last judgment and the creation of new heavens and a new earth. That all believers will have a share in the first resurrection and in the Messianic kingdom is an idea of which the author of Revelation knows nothing. The earthly kingdom of Christ is reserved for those who have endured the most terrible tribulation. who have uithstood the supreme effort of the world-power—that is, for those who are actually members of the church of the last days. The Jewish expectation is thus considerably curtailed, as it is also shorn of its sensual attractions.

Other ancient Christian authors were not so cautious. Accepting the Jewish apocalypses as sacred books of venerable antiquity, they read them eagerly and transferred their contents bodily to Christianity. Further, the Gentile Christians took possession of them, and just in proportion as they were neglected by the Jews—who, after the war of Bar-Cochba, became indifferent to the Messianic hope and hardened themselves in devotion to the law—they were naturalized in the Christian communities. The result was that these books became "Christian" documents; it is entirely to Christian, not to Jewish, tradition that we owe their preservation. The Jewish expectations are adopted, for example, by Papias, by the writer of the epistle of Barnabas, and also by Justin. That a philosopher like Justin, with a bias toward a Hellenic construction of the Christian religion, should nevertheless have accepted it's millennial elements is the strongest proof that these enthusiastic expectations were inseparably bound up with the Christian faith down to the middle of the 2nd century.

After the middle of the 2nd century these expectations were gradually thrust into the background. They would never have died out, however. had not circumstances altered and a new mental attitude been taken up. The spirit of philosophical and theological speculation and of ethical reflection. which began to spread through the churches, did not know what to make of the old hopes of the future. To a new generation they seemed paltry, earthly and fantastic, and farseeing men had good reason to regard them as a source of political danger. But more than this, these wild dreams about the glorious kingdom of Christ began to disturb the organization which the churches had seen fit to introduce. In the interests of self-preservation against the world, the state and the heretics, the Christian communities had formed themselves into compact societies with a definite creed and constitution, and they felt that their existence was threatened by the white heat of religious subjectivity. So early as the year 170, a church party in Asia Minor—the so-called Alogi—rejected the whole body of the apocalyptic writings and denounced the book of Revelation as a book of fables. All the more powerful was the reaction. In the so-called Montanistic controversy (c. 160–220) one of the principal issues involved was the continuance of the millennial expectations in the churches. The Montanists of Asia Minor defended them in their integrity, with one slight modification: they announced that Pepuza. the city of Montanus, would be the site of the New Jerusalem and the millennial kingdom.

After the Montanistic controversy millennial views were more and more discredited in the Greek church; they were, in fact, stigmatized as "Jewish" and therefore "heretical." Dionysius, bishop of Alexandria, succeeded in healing the schism and asserting the allegorical interpretation of the prophets as the only legitimate exegesis. During this controversy Dionysius became convinced that the victory of mystical theology over "Jewish" millenarianism would never be secure so long as the book of Revelation passed for an apostolic writing. He accordingly raised the question of its apostolic origin; and by reviving old difficulties, with ingenious new arguments, he carried his point. The Greek church kept Revelation out of its canon, and consequently millenarianism remained in its grave. It was considered a sufficient safeguard against the spiritualizing eschatology of Origen and his school to have rescued the main doctrines of the creed and the *regula fidei* (the visible advent of Christ; eternal misery and hell-fire for the wicked). Anything going beyond this was held to be Jewish. In the very conservative Semitic churches of the East (the Syrian, Arabian and Ethiopian), and in that of Armenia, the apocalyptic literature was preserved much longer than in the Greek church.

But the Western church was also more conservative than the Greek. Its theologians had. to begin with, little turn for mystical speculation; their tendency was rather to reduce the gospel to a system of morals. Now for the moralists millenarianism had a special significance as the one distinguishing feature of the gospel, and the only thing that gave a specifically Christian character to their system. This, however, holds good of the western theologians only after the middle of the 3rd century. The earlier fathers believed in millenarianism simply because it was a part of the tradition of the church and because Marcion and the Gnostics would have nothing to do with this conception. It is the same all through the 3rd and 4th centuries with those Latin theologians who escaped the influence of Greek speculation. As to the canonicity and the apostolic authorship of the Johannine Apocalypse no doubts were ever entertained in the west; indeed an Apocalypse of Peter was still retained in the canon in the 3rd century. That of Ezra, in its Latin translation, must have been all but a canonical book. These facts show how vigorously the early hopes of the future maintained themselves in the west. In the hands of moralistic theologians, like Lactantius, they certainly assume a somewhat grotesque form, but the fact that these men clung to them is the clearest evidence that in the west millenarianism was still a point of "orthodoxy" in the 4th century.

This state of matters, however, gradually disappeared after the end of the 4th century. The change was brought about by two causes—first, Greek theology, which reached the west chiefly through Jerome, Rufinus and Ambrose. and, second, the new idea of the church wrought out by Augustine on the basis of the altered political situation of the church. Augustine was the first who ventured to teach that the Catholic Church, in its empirical form, was the kingdom of Christ, that the millennial kingdom had commenced with the appearing of Christ, and was therefore an accomplished fact. By this doctrine of Augustine's, the old millenarianism, though not completely extirpated, was at least banished from the official theology. It still lived on, however, in the lower strata of Christian society; and in certain undercurrents of tradition it was transmitted from century to century. At various periods in the history of the middle ages we encounter sudden outbreaks of rnillenarianism, sometimes as the tenet of a small sect.

sometimes as a far-reaching movement. And, since it had been suppressed. not, as in the east. by mystical speculation, its mightiest antagonist, but by the political church of the hierarchy, we find that wherever millenarianism appears in the middle ages it makes common cause with all enemies of the secularized church. It strengthened the hands of church democracy; it formed an alliance with the pure souls who held up to the church the ideal of apostolic poverty; it united itself for a time even with mysticism in a common opposition to the supremacy of the church; indeed. it lent the strength of its convictions to the support of states and princes in their efforts to break the political power of the church. It is sufficient to recall the well-known names of Joachim of Floris, of all the numerous Franciscan spiritualists. of the leading sectaries from the 13th to the 1 jth century who assailed the papacy and the secularism of the church — above all. the name of Occam. In these men the millenarianism of the ancient church came to life again; and in the revolutionary movements of the 15th and 16th centuries — especially in the Anabaptist movements—it appears with all its old uncompromising energy. If the church, and not the state. was regarded as Babylon. and the pope declared to be the Antichrist, these were legitimate inferences from the ancient traditions and the actual position of the church.

The German and Swiss reformers also believed that the end of the world was near. but they had different aims in view from those of the Anabaptists. It was not from poverty and apocalypticism that they hoped for a reformation of the church. In contrast to the fanatics, after a brief hesitation they threw millenarianism overboard. and along with it all other *opiniones Judaicae.* They took up the same ground in this respect which the Roman Catholic Church had occupied since the time of Xugustine. How millenarianism nevertheless found its way, with the help of apocalyptic mysticism and Anabaptist influences into the churches of the Reformation. chiefly among the Reformed sects, but afterwards also in the Lutheran Church, how it became incorporated with Pietism, how in later times an exceedingly mild type of "academic" millenarianism was developed from a belief in the verbal inspiration of the Bible; how finally new sects are still springing up here and there with apocalyptic and millennia1 expectations — these are matters which cannot be fully entered upon here.

BIBLIOGRAPHY.—Corrodi, *Kritische Geschichte des Chiliasmus* **(1781)**; Bousset, *Religion des Judentums* (1926), and works there quoted; Lohmeyer, *Dze Offenbarung des Johannes* **(1926).** *See* also the Histories of Christian Doctrine and *cf* ESCHATOLOGY. (A HA.; X.)

MILLER, DAVID HUNTER (1875–1961), U S. international lawyer and expert on treaties. was born in Kew York city on Jan. 2, 1875. Graduating from New York Law school, he practised in New York, 1911–29. Between 1917 and 1919 he served on the Inquiry (a body of experts who collected data for the Paris peace conference) conducted by Col. Edward M House (*q.v.*), was legal adviser to the American commission to negotiate peace at Paris and collaborated in the drafting of the League covenant. Subsequently he published in limited edition *My Diary at the Conference of Paris, with Documents,* 21 vol. (1924–26). As an officer of the U.S. department of state, 1929–44, Miller headed the U.S. delegation to the 1930 Hague conference for the codification of international law and compiled *Treaties and Other International Acts of the United States of America,* 8 vol. (1931–48). Miller was the author of books and articles on the Versailles treaty, the League of Kations and other international and legal subjects. He died in Washington, D.C., on July 21, 1961. (G. B. N.)

MILLER, HENRY (JOHN) (1860–1926), U S. actor and theatrical manager. was born in London, Eng., Feb. 1. 1860, and moved to Canada at an early age, He made his New York acting debut in *Cymbeline* at Booth's theatre on April 26, 1880. During the next seven years he gathered acting experience in a variety of plays, including much Shakespeare. In 1887 he joined Charles Frohman's Empire Theatre stock company and for ten years was an important member of that troupe. In 1897 he played his first starring role in *Heurtsease,* and later was acclaimed in *The Devil's Disciple, The Importance* of *Being Earnest* and *Michael and His Lost Angel.*

In 1906 Miller took over management of the Princess theatre in New York city. and entered the most successful period of his career. His production in 1906 of William Vaughan Moody's The *Great Divide,* in which he starred opposite Margaret Anglin, is considered by many the beginning of modern American drama. His subsequent productions—*The Servant in the House* (1908) and *The Faith Healer* (1910)—were only slightly less successful. In 1918 he opened the Henry Miller theatre in New York. He died April 9, 1926.

His son GILBERT HERON MILLER (1884–), who also became a theatrical manager, produced a number of successful plays in New York and London. (S. W. H.)

MILLER, JOAQUIN (CINCINNATUS HINER [HEINE] MILLER) (1837–1913), U.S. poet who made a significant early attempt to celebrate the west. He was born near Liberty, Ind., on Sept. 8. 1837. He went west with his family and led a picaresque early life in California among miners, gamblers and Indians. He attended Columbia college (Eugene. Ore.) briefly in 1858–59 and was admitted to the bar in 1860 in Oregon. In 1862 he established a pony express; in 1863 he bought the *Eugene Democratic Register.* For it he wrote an article defending the Mexican brigand Joaquin Murietta, whose given name he later used as an author; he also presumably adopted the more "poetic" name "Heine" for the same purpose. He became a county judge in Canyon City, Ore., in 1866. His first volumes of poems, *Specimens* (1868) and *Joaquin et ul.* (1869). attracted little attention.

In 1870 he traveled to England, where his exotic manners and flamboyant western costume made him a great favourite with the literati. *Pacific Poems* (1871) was privately printed there. *Songs of the Sierrus* (1871), upon which his reputation mainly rests. was loudly acclaimed in England, while generally derided in the United States for its excessive romanticism. Productions of succeeding years included *Songs of the Sunlands* (1873), *The Ship in the Desert* (1875), *The Baroness of New York* (1877), *Songs of Italy* (1878), *Mernorie and Rime* (1884) and the *Complete Poetical Works* (1897). In 1886 he settled in Oakland, Calif., where he died Feb. 17, 1913.

Whitmanesque in temper, his work is frequently bombastic and artificial. Because of his fondness for Byronic posturings, his autobiographical writings are untrustworthy.

See M. S. Peterson, *Joaquin Miller, Literary Frontiersman* (1937); *M.* Marberry, *Splendid Poseur: Joaquin Miller, American Poet* (1953).

MILLER, JOE (JOSEPH or JOSIAS) (1684–1738), English actor, first appeared in the cast of Sir Robert Howard's *Committee* at Drury Lane in 1709 as Teague. Trinculo in *The Tempest,* the First Grave-digger in *Hamlet* and Marplot in The *Busybody* were among his many favourite parts. He died on Aug. 16, 1738. He is remembered chiefly for the association of his name with a book brought out after his death by John Mottley (1692–1750). Called *Joe Miller's Jests, or tlze Wit's Vade Mecum* (1739), it was a collection of contemporary and ancient coarse witticisms, only three of which were told of Miller. Any timeworn jest came, somewhat unjustly, to be called "a Joe Miller."

MILLER, SAMUEL FREEMAN (1816–1890), associate justice of the U.S. supreme court. was foremost in sustaining measures taken for the preservation of the union — notably in upholding the validity of the legal tender legislation. Born at Richmond, in central Kentucky, on April 5, 1816. after a common school education he studied medicine at Transylvania university at Lexington, and practised at Barbourville, near the Cumberland gap, in southern Kentucky.

While caring for patients he read law, and in 1847 was admitted to the bar of Knox county. When the movement for gradual emancipation of slaves was lost in the Kentucky constitutional convention of 1849, Miller decided to seek a home in free territory, and in 18jo moved with his family to Keokuk, Ia. He soon became a leader in the Iowa bar, and in the organization of the Republican party in that state. In 1862, with the very active support of the Iowa delegation in congress, he was appointed by President Lincoln to the supreme court. Throughout his 28 years of service he was assigned to the 8th circuit. extending from the Mississippi river to Colorado. His work in first instance, as he

coped mith the practical problems of this expanding circuit, was marked by a zeal for essential justice and an impatience with mere technicality.

Miller spoke for the majority of the court in the Slaughterhouse cases in which, in 1873, the court first construed the 14th amendment. To establish certain principles resulting from the Civil War, the amendment had been added to declare that no state shall abridge the privileges or immunities of citizens of the U.S., nor deprive any person of due process of law, nor deny equal protection of the laws. The amendment was first invoked to resist a monopoly on butchering granted by the carpetbag (*q.v.*) legislature of Louisiana. In holding that no federal right had been abridged by this malodorous legislation. Miller stressed what a distortion it would work in the federal system if the amendment were so read as to make the court "a perpetual censor upon all legislation of the States." Ever a believer in effective and responsible government, he was loath to see the court interpose even at moments when legislative power seemed lost to reason. His opinion in *Kilbourn* v. *Thompson,* in 1880, is, however, the classic rebuke to vagrant congressional investigation. He set himself. unavailingly, against a strong judicial movement to sustain public grants to railroad corporations, notwithstanding well founded contentions that the grant had been made in disregard of constitutional limitations.

A bold and self-confident magistrate who moved directly to the controlling issues, a statesman whose judgments were infused with a strong sense of public policy, Justice Miller remains one of the court's heroic figures.

He died in Washington, D.C., on Oct. 13, 1890.

See Charles Fairman, *Mr. Justice Miller and the Supreme Court, 1862–1890* (1939), which studies his judicial work and includes a collection of his letters. (C. Fn.)

MILLER, WILLIAM (1782–1849), U.S. religious enthusiast, leader of a movement called Millerism that sought to revive belief in the bodily, imminent Advent of Christ. was born Feb. 15. 1782, at Pittsfield, Mass. In 1786 his family moved to Low Hampton, N.Y. Miller was a farmer, but also held such offices as deputy sheriff and justice of the peace. In the War of 1812 he served as a captain of the 30th infantry. After years of Bible study he began to preach in 1831 that the present world would end "about the year 1843." He based this belief primarily on Dan. viii, 13, 14. He published a 64-page pamphlet in 1833, and a book of lectures in 1836, the first of many publications, Principal organs of the Millerite movement were the *Signs of the Times* (Boston) and the *Midnight Cry* (New York). Miller estimated that between 50,000 and 100,000 believed in his views. When 1843 passed, some of his associates set Oct. 22, 1844, as the date of the second coming. This date brought the movement to a sharp climax. There is no historical foundation for stories that the Millerites engaged in such fanatical excesses as ascending hills, housetops and trees in ascension robes. The last general conference met at Albany. N.Y.. April 1845. Belief in the imminence of the Advent was restated, but no date was set and no church organization created. Miller died at Low Hampton. Dec. 20, 1849.

There are two principal Adventist bodies today—the Advent Christian church, organized in 1861, and the much larger body of Seventh-day Adventists, organized in 1863—and several small Adventist bodies.

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MILLER, WILLIAM (1795–1861), British soldier, who took a prominent part in the South American wars of liberation, was born on Dec. 2, 1795, at Wingham, Kent. He entered the British artillery service in 1811, and till 1814 served with Wellington's army in the Peninsula. He afterward served in Korth America, then traveled for two years in Europe, and went to South America. The war which culminated in the expulsion of the Spaniards was just breaking out, and he took command in the Chilean artillery. As a major he commanded the marines on Cochrane's vessel, the "O'Higgins." In 1821 he landed in Peru, to assist General San Martin, and as general of brigade, rendered conspicuous services at Junin (Aug. 6, 1824) and at Ayacucho (Dec. 9, 1824). He subsequently filled various high military and political offices in Peru. In 1839 he was involved in the fall of Santa Cruz, and went into exile. For some years he filled the post of British consul-general of the Pacific coast. He died on board H.M.S. "Naiad" at Callao, on Oct. 31, 1861.

MILLERAND, ALEXANDRE (1859–1943), French lawyer, politician and president of the republic, was born in Paris on Feb. 10, 1859. He was educated for the bar, and made his reputation by his defense of the instigators of the strike at Decazeville in 1883. He was elected to the chamber of deputies for the *département* of the Seine in 1885 as a Socialist. He became chief of the Socialist left, when then mustered 60 members, and edited until 1896 their organ in the press, *La Petite République*. When in June 1899 he entered Waldeck-Rousseau's cabinet of "republican defense" as minister of commerce he limited himself to practical reforms, devoting his attention to the improvement of the mercantile marine, to the development of trade, of technical education, of the postal system and to the amelioration of the conditions of labour. He was bitterly denounced by many Socialists as a traitor, for agreeing to participate in a nonsocialist government along with men hated by the workers.

He was a fierce opponent of the Combes ministry, which succeeded that of Waldeck-Rousseau, for he objected to its narrow anticlericalism. In July 1909 he became minister of public works in Briand's first cabinet, his principal achievement being the reorganization of the state railways. Together with Briand he took strong measures to suppress the railway strike of Oct. 1910. In Jan. 1912 he was appointed minister of war under Raymond Poincaré. He reorganized the higher command, and gave a definite status to military aeronautics for the first time. On Aug. 25, 1914, he was invited by Viviani to become minister of war. Accused, however, of being too slow in providing the necessary heavy artillery, he resigned with the other members of the Viviani cabinet at the end of Oct. 1915. In 1918 he was elected a member of the Acadkmie des Sciences Morales et Politiques.

A few months after the conclusion of hostilities, on March 21, 1919, Millerand was appointed commissioner general for Alsace-Lorraine, and filled this post with complete success. In a speech delivered in Paris on Nov. 15, 1919, on the eve of the elections, he outlined the policy of the coalition which, under the name of the *bloc national,* was returned to power.

On the resignation of Clemenceau, Jan. 18, 1920, Millerand was chosen to form a cabinet, and became both prime minister and minister for foreign affairs. His main activities were in regard to the application of the Treaty of Versailles. He was present at the inter-Allied conferences at San Remo and Spa, in April and July 1920. In May 1920 he frustrated various attempts, especially by the railwaymen, to organize revolutionary strikes. He did much to supply matériel to Poland during the Polish-Soviet war.

In Sept. 1920 Deschanel, president of the republic, was forced by ill-health to resign. Millerand was elected as his successor, and out of 892 votes cast 695 were given in his favour. During his candidature he made it known that, if he were elected, he intended to exert a more powerful influence on the policy of the government than his predecessors had done, and made no secret of his wish to strengthen the power of the president by a revision of the constitution. Millerand's conception of the role of president of the republic brought him into collision with the Radical and Socialist majority, which, under the name of the *cartel des gauches,* was successful in the elections of May 11, 1924. He was violently attacked by the Radical and Socialist press, which accused him of having exceeded his powers by intervening in the party struggle, and called for his resignation. Herriot, the leader of the *cartel des gauches,* when asked by Millerand to succeed Poincaré as premier, announced that he would do so only on Millerand's resignation.

Millerand therefore invited the senator François-Marsal, who had been his minister of finance in 1920, to form a cabinet. His government, however, was immediately defeated; and Millerand tendered his resignation.

In Jan. 1927, at the senatorial elections in the *département* of

the Seine. Millerand was defeated. Several months later he stood for a by-election in the *département* of the Orne. in Normandy. He was elected and resumed his place in the senate. He remained a controversial figure in French politics, too independent in mind to please any party. Among his published works are *Le Socialisme réformiste* (1903) and *Pour la défense nationale* (1913). He died at Versailles, France, April 7, 1943.

See R. Persil, *A. Millerand* (1949). (D. TN.)

MILLERITE, a mineral consisting of nickel sulfide. NiS, is a minor ore of nickel. Millerite crystals belong to the rhombohedral system and have the form of slender needles arranged in divergent groups or of delicate fibres loosely matted together ("hair-pyrites"). The colour is brass yellow and the lustre metallic. Typical specimens of millerite (so named in 1845 in honour of mineralogist W. H. Miller) are found in the coal measures in the neighbourhood of Merthyr Tydfil. Glamorgan, Wales, where the delicate needles and fibres occur with crystals of quartz and pearl spar in the fissures of septarian nodules of clay ironstone (siderite). It is found in various localities in Germany and in Canada, and in the United States in New Tork and Pennsylvania and at Keokuk, Ia., St. Louis, Mo., and Milwaukee, Wis.

MILLER'S THUMB, a small fish, abundant in all rivers and lakes of northern and central Europe with clear water and gravelly bottom. up to 7,000 feet. It has a broad, flat head, rounded and scaleless body, large pectoral and narrow ventral fins, with two dorsal fins; the gill cover is armed with a spine. The numerous species of this family are confined to the north temperate zone, the majority being marine and called "bullheads." The miller's thumb is confined to fresh water; one other fresh-water species is found in Europe, others occur in the fresh waters of northern Asia and North America. The miller's thumb *(Cottus gobio)* is common in all suitable localities in Great Britain. but rare in Ireland. Its usual length is from 3 to j inches. Its prey consists of small aquatic animals, upon which it pounces from some refuge. The female deposits her eggs in a cavity under a stone, and the male watches and defends them until the young are hatched. The common American bullhead is the sculpin (a name sometimes applied to all the new world members of the family), *Myoxocephalus octodecim-spinosus,* which is marine.

MILLES, CARL (originally VILHELM CARL EMIL ANDERSON) (1875–19jj). Swedish-U.S. sculptor, designer of decorative fountains and memorial monuments in Sweden and the United States, was born in Cppsala, Swed.. June 23. 1875.

In 1902, during student years in Paris. Milles won recognition through the competition for the Sten Sture monument at Uppsala (completed 1925). His style, at first impressionistic under Auguste Rodin's influence, became more abrupt and formal under successive influences of medieval art and early Greek art, and later showed more fluent patterns within individual figures and among the parts of his elaborate compositions. Milles worked in clay (for casting into bronze), stone and wood. His first maior fountain, "Europa" in Halmstad, Swed. (1926), has the elements of spacious design, subtle water effects and inventive figure types (such as the fusion of classical triton or faun with Nordic goblin or troll) which also characterize his "Orpheus" fountain in Stockholm (1936) and the "Meeting of the Waters." in St. Louis, Mo. (1940). Milles' reputation spread with exhibitions at the Tate gallery, London (1926–27), and the City Art museum, St. Louis (1931). In 1931 he became head of the department of sculpture at Cranbrook Academy of Art, Bloomfield Hills, Mich. He became a U.S. citizen in 1945.

Milles' works were collected at Cranbrook, his home for 20 years, and at the Milles villa, now a museum, in Lidingö, near Stockholm. Stockholm has over 20 Milles monuments, and notable examples of his work are in Detroit, Mich., Chicago, Ill., St. Paul, Minn., Harrisburg, Pa., Falls Church, Va., Wilmington, Del., and New York city. His "Aganippe" fountain was set up in the New Tork Metropolitan Museum of Art shortly after his death at Lidingö on Sept. 19, 1955.

See Meyric *R.* Rogers, Carl *Milles,* an *Appreciation of His Work* (1940). (JS. W. F.)

MILLET, FRANCIS DAVIS (1846–1912), U.S. painter, illustrator and writer, was born at Mattapoisett, Mass., on Nov. 3, 1846. He was a drummer boy with the Union forces in the Civil War. graduated from Harvard college in 1869, and in 1871 entered the Royal Academy of Fine Arts, Antwerp. During the Russo-Turkish War of 1877–78 he was a correspondent for several newspapers, and was decorated twice by the Russian government. On his return he was made a member from the United States of the international art jury at the Paris exposition of 1878. He was director of decorations at the Columbian exposition, Chicago, 1893, and in 1898 went to Manila as war correspondent. blillet was a passenger on the "Titanic" when it sank on April 15, 1912; he was last seen urging women and children into lifeboats.

In 1880 Millet became a member of the Society of American Artists, and in 1885 was elected to the National Academy of Design, New York. He was a trustee of the Metropolitan Museum of Art, secretary of the American academy at Rome and vice-chairman of the Fine Arts committee. His work as a decorative artist may be seen at Trinity church, Boston; the Bank of Pittsburgh; and the capitol at St. Paul, Minn. His pictures are in many public collections. among them being "A Cosy Comer" in the Metropolitan Museum of Art. New York, and "Between Two Fires" in the Tate gallery. London. Millet also wrote essays and short stories, and an English version of Tolstoi's *Sebastopol* (1887). Among his publications are *The Danube* (1891), *Capillary Crime and Other Stories* (1892) and *Expedition to the Philippines* (1899).

MILLET, JEAN FRANÇOIS (c. 1642–1679), commonly called FRANCISQUE, was born at Antwerp about 1642. He is generally classed among the painters of Flanders because of the accident of his birth, but his father was a Frenchman, who, while on service with the prince of Condé in Antwerp, apprenticed his son to a painter named Laurent. With Laurent, Francisque left Antwerp for Paris, and there settled in 1660 after marrying his master's daughter. He was received a member of the Academy of Painting at Paris in 1673, and after gaining consideration as an imitator of the Poussins he died in 1679, bequeathing his art and some of his talents to one of his sons.

Francisque's paintings of Italian and Arcadian scenery were graceful and effective, although, as he had not traveled, his impressions of them were gained at secondhand. Twelve of his most important landscapes in the Tuileries were destroyed by fire; and though many of his pieces may still be found catalogued. a great number remain unknown and unacknowledged.

MILLET, JEAN FRANÇOIS (1814–187j), the French peasant nho became a celebrated Barbizon painter and etcher. was born at Gruchy, near Gréville (La Manche) on Oct. 4, 1813. He spent his youth working on the land, but by the age of 19 he was studying under Mouchel (real name Bon Dumoucel), a former pupil of J. L. David. These studies were interrupted by the death of his father in 1835, but in the spring of 1836 Millet was again

EWING GALLOWAY

"THE GLEANERS– BY JEAN FRANÇOIS MILLET. IN THE LOUVRE. PARIS

at Cherbourg, studying now with J. C. Langlois (a pupil of A. J. Gros), who at the end of the year persuaded the authorities to finance Millet's further studies. In Jan. 1837, Millet arrived in Paris with an allowance of 1,000 francs and eventually enrolled in the studio of Paul Delaroche, where he seems to have remained until 1839. It was here that Millet came into contact with P. de Marolle, who introduced him to the works of La Fontaine and J. B. L. Gresset, which provided subjects for "Le Lutrin Vivant" and "Vert-Vert."

After the rejection of one of his entries for the Salon of 1840, Millet returned to Cherbourg where he remained during most of 1841. Here he painted a number of portraits including those of M. and Mme. Feuardent and that of his first wife, Pauline Virginie, whom he married in Nov. 1841. Rejected at the Salon of 1842. Millet achieved his first success in 1844 with "The Milkmaid" and a large pastel. "The Riding Lesson." The pastel shows the type of work which was to occupy a large part of his production during the 1840s, and which has a sensual character somewhat reminiscent of N. V. Diaz. J. H. Fragonard and Correggio. The "Offering to Pan" (1845) and "Oedipus Taken From the Tree" (1847) are important examples of this type. With the death of his first wife in April 1844, Millet again returned to Cherbourg, remaining in that area until 1845. Among portraits painted at this time are the "Antoinette Hébert" and the "Officer of Marine." The technical variety of his work up to this time indicates the range of Millet's interests and enthusiasms—Italian primitives. Michelangelo, Poussin, Ribera, Titian and Rembrandt. From 1845 dates Millet's union with Catherine Lemaire, a union which was legalized in 1853.

The peasant subjects, which from the early 1850s were to be Millet's principal concern, made their first important appearance at the Salon of 1848 with "The Winnower," The first version, later destroyed by fire, was purchased by A. A. Ledru-Rollin, who also secured for Millet a state commission for which the artist painted "The Haymakers at Rest" (1848–49, Louvre). After the Salon of 1849 ("The Seated Peasant Girl," Boston), Millet left Paris for Barbizon, a small hamlet in the forest of Fontainebleau. Barbizon was to become Millet's home for the remainder of his life; it was here that he died on Jan. 20, 1875. The Salon of 1850 included "The Sower" and "The Binders" and it was these paintings which first roused hostile critics to accuse Millet of being a socialist. This charge Millet refuted, but in a letter of Feb. 1851, he admits, "at the risk of appearing even more socialist. that it is the human, the frankly human side which moves me most in art." The same letter indicates a wish to have done with the "Nudes and Mythologies" for which he had acquired a reputation, but during the course of 1851 such works, if not produced, were still being offered for sale by Millet's friend and biographer, A. Sensier. The Salon of 1853 included "The Reapers" (now at Boston) which is probably identical with a "Ruth and Boaz," mentioned by Millet in a letter of 1851. This doubt concerning the real subject of the work may be indicative of Millet's idealistic attitude toward his subjects and his desire "to make the trivial serve to express the sublime." Major works of the following years, conceived in much the same spirit, are "A Peasant Grafting a Tree" (1855), "The Gleaners" (1857), "The Angelus" and "Death and the Woodcutter" (1858–59), "Sheep Shearing" (1860), "Sheepfold by Moonlight" (1861), "The Potato Planters" (1862) and "The Man With a Hoe" (1863). This last painting again raised the accusation that Millet was a socialist, and letters of the period defending Millet's position underline the fundamentally classical nature of his approach to painting.

In 1860, Millet entered into contract with two picture dealers, Arthur Stevens and Ennemond Blanc. The agreement. which was to provide him with a fixed income for three years, did not work out very satisfactorily. It did, however, ensure a regular showing of those works which had come into the possession of Blanc. By the middle of the 1860s, Millet's work was beginning to be in demand; official recognition came in 1868, after nine important paintings had been shown at the Exposition of the previous year. Important collections of Millet's pictures are to be found in the Museum of Fine Arts, Boston (68 pastels and paintings) and in the Louvre (23 pictures).

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(R. A. DY.)

MILLET is the name applied to various small-seeded grasses which were probably first cultivated in Asia or Africa. All are annual, warm-season plants with small edible seeds. Important millets are pearl or cattail millet, called bajri in India (Pennisetum glaucum), foxtail millet [*Setaria* (*Chaetochla*) *italica*], proso, common or broomcorn millet (*Panicum* miliaceum), and finger, or coracan millet, also called ragi, (Eleusine coracana). Others include Japanese millet (*Echinochloa crus-galli* var. frumentacea), koda or ditch millet (*Paspalum* scrobiculatum), browntop (*Panicum* ramosum) and little millet (Panicum *miliare*). The finger, koda and little millets are not grown in North America. Sorghum (*q.v.*) is erroneously called millet.

J. HORACE MCFARLAND CO.

FOXTAIL MILLET (SETARIA ITALICA)

With the exception of pearl millet, plants range from one to four feet in height. The heads of pearl and foxtail millets are rather dense cylindrical spikes; those of finger and koda are racemes; and the other millets bear panicles. The flowers are largely cross-pollinated. All seeds except pearl millet remain enclosed in hulls after threshing. Hulled seeds are mostly creamy white.

Pearl millet, a popular food crop in India and Africa, is well suited to soils of low fertility and limited moisture. Its stalks are five to ten feet tall and up to one inch or more in thickness. It provides abundant pasture and hay in the U.S. southeast.

Proso, grown chiefly in Soviet Russia, Manchuria and China, has hairy stems and compact to loose panicles. The hulls on the seeds are red, light to very dark brown. gray. greenish-gray, yellow or white. The leading U.S. varieties are Yellow Manitoba, Turghai and Early Fortune. Proso ripens 60 to 80 days after sowing. The grain is used in birdseed and chick feed mixtures and as livestock feed in the United States, and as food in Asia and eastern Europe.

Foxtail varieties, including German or Golden. Common, Hungarian, Siberian, White Wonder and Kursk, have yellow, orange, green or gray hulls. Foxtail millets are grown for hay in North America and western Europe, but the small pointed seeds are important foods in China and other Asiatic countries.

Finger is an important food grain in southern Asia and parts of Africa. Japanese millet is grown chiefly for hay in Japan, the United States and some other countries. The little millet is grown for food chiefly in India. Browntop is grown in the southeastern United States for hay, pasture er feed for game birds.

Millets are sown in drills or cultivated rows in late spring or early summer after the weather is warm. The grain is harvested by the same methods used for wheat, barley or rice. Hulled millet grains, either whole or cracked, are cooked into porridge called kasha in Russia and Poland. Some grain is ground and made into unleavened breads. The composition of millet grain is similar to that of wheat, maize or rice.

About 26,000,000 tons of millet are produced annually, chiefly in China, India, Manchuria, U.S.S.R., French West Africa and Korea. In these countries the millets are used chiefly as food grains, but in western Europe and the United States millets are grown mostly for hay and pasture.

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U.S. Dept. Agri. Misc. Pub. **zoo** (1950); **E.** Anderson and J. H. Martin, *World Production and Consumption of Millet and Sorghum*, Economic Botany 3(3) (1949). (J. **H.** MN.; X.)

MILLIKAN, ROBERT ANDREWS (1868–1953), U.S. physicist, recipient of the 1923 Nobel prize in physics for his study of the elementary electrical charge and the photoelectric effect, was born at Morrison, Ill. on March 22, 1868. He graduated from Oberlin college (1891) and obtained his doctorate at Columbia university in 1895; later he was in residence at the universities of Berlin and Gottingen. In 1896, he was appointed by A. **A.** Michelson (*q.v.*) to an assistantship in physics at The University of Chicago, where he became a full professor in 1910.

Millikan's earliest outstanding investigation was an accurate determination of the charge, ϵ, carried by an electron, followed by a proof that this charge was not merely a "statistical mean" but a definite constant. In this investigation he improved upon the method of "the falling cloud" (already employed, in several forms, at the Cavendish laboratory) by substituting for the indefinite cloud a single falling drop whose motion in the gravitational field could be easily measured and whose motion in the electrical field could be controlled. This work was first fully reported in the *Philosophical Magazine,* Feb. 1910. The complete story of this work is told in his highly interesting volume, The *Electron,* 2nd ed., 1924. For this beautiful piece of work, Millikan was awarded the Comstock prize by the National Academy of Sciences in 1913; and, in 1915, he was elected to membership in this academy. During the year 1916 he took up with the same skill the experimental verification of Einstein's well-known photoelectric equation, $\frac{1}{2}\ mv^2 = V\epsilon = \mathrm{h}\nu - p$, and the evaluation of Planck's constant, *h*. The result was a thorough confirmation of Einstein's equation and a value of 6.57×10^{-27} for Planck's constant. (*Phys. Rev.,* 7:355–388, 1916).

In 1921, he resigned his chair at Chicago in order to accept the directorship of the Norman Bridge Laboratory of Physics of the California Institute of Technology, at Pasadena, Calif., and became chairman of the executive council of the institute, a post which he held with marked success until his retirement in 1945. He represented the United States for ten years (1922–32) on the League of Nations committee for intellectual co-operation and served as chairman of the board of directors of the Huntington library and art gallery, San Marino, Calif.

Millikan's research at the California Institute of Technology was mainly in cosmic rays. The complete story of this investigation, which covered 360° of longitude, 60° or 70° of latitude, north and south, and altitudes ranging from the stratosphere to the bottom of deep melted-snow lakes, was told in his small volume *Cosmic Rays* (1939).

Among the many honours — degrees, prizes, medals — which came to hirn during half a century of professional life, possibly the most significant was the Nobel prize in 1923. Millikan died Dec. 19, 1953, in San Marino, Calif.

The professional reader will find most of Millikan's papers in the *Physical Review.* The following is intended for the general reader: *The Electron,* 2nd ed. (1924); *A First Course in Physics for Colleges* (with *H.* G. Gale and C. W. Edwards) (1928); *Evolution in Science and Religion* (1927); *Time, Matter, and Values* (1932); *Cosmic Rays* (1939); *Autobiography* (1950).

(H. Cw.; X.)

MILLING: *see* FLOUR.

MILLING MACHINES are highly important machine tools (*q.v.*) which will perform almost all the operations necessary in metal-cutting, by means of revolving cutters past which the work is fed. Milling was first done in the lathe, the cutter being rotated between the centres, while the slide traversed the piece of metal across and beneath it.

There are still many milling machines, termed Lincoln millers, in which the resemblance to the lathe is evident, and which were developed at an early period to mill parts of small arms and sewing machines, when the interchangeable system of manufacture began.

The great advantage of the milling machine is that cutters can be made for all sorts of shapes, to mill corresponding profiles, which they will do on tens of thousands of pieces alike. Hand production by files is thus eliminated and great accuracy ensured. Cutters can also be multiplied, several being used on one spindle, so that a complicated surface or a number of duplicate pieces may be milled at one pass. Machines with multiple spindles, each carrying a cutter or a set will surface off very complex shapes of castings, *e.g.,* castings for parts of engines and machinery, etc., thereby saving a lot of piecemeal cutting which would otherwise be necessary to finish the outlines. There is a system termed *profile milling,* by means of which a cutter will produce curves and flats, the work being coerced during the traverse by a copy of like shape. The constantly-changing curves of cams are also milled by a similar device. Screw-threads and worms are cut by a milling cutter of suitable shape, revolved and fed laterally while the screw rotates.

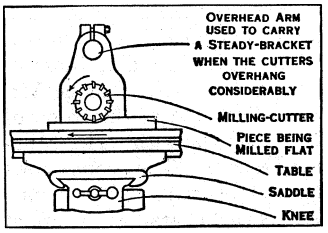


DIAGRAM SHOWING THE ELEMENTS OF A MILLING MACHINE

The Lincoln machine mentioned is built in small and in large sizes for what is termed *manufacturing,* that is the milling of large numbers of similar shapes for small arms, machine guns, sewing machines, cycles, parts of cars, etc. Its constructional features are relatively simple, and the pieces of work are either gripped in a vice, or in a special clamping unit, termed a fixture, which automatically gives the correct attitude in relation to the cutter. Often several articles are clamped in line for the cutter to mill them in succession, so that at one traverse of the table three or four or more receive treatment.

When a varied range of milling has to be performed, this model is not sufficiently adaptable, and what is termed a plain or a universal machine is chosen. This has a column near the top of which a horizontal spindle is driven by belt or motor, and usually a change-speed gearing to obtain the various speeds. **A** triangular-shaped knee is adjustable up and down, slideways on the face of the column, and across the flat face at the top of the knee a saddle is adjustable. This saddle, in turn, carries the long sliding table for the objects to be milled. The operator has thus the choice of three adjustments with which he can bring all sorts of castings and forgings into correct position for milling, and then feed them by hand or automatically. Some cutters, termed end mills, cut mainly by their ends and effect surfacing and the milling of slots and grooves. By putting a pair of index centres, *i* e., a couple of heads with point centres between which work can be swung, on the table circular dividing may be effected. This action enables flats, squares, hexagons, etc., to be finished, or slots cut around a cylinder or disc. Gearwheel teeth are also made in the same manner. The difference between a plain and a universal miller is that the latter has a swivel-mounting for the table, so that it may be slewed at a suitable angle, and spiral grooves be cut, or the helically set teeth of milling-cutters or gears be produced, as well as screws and worms that may be required.

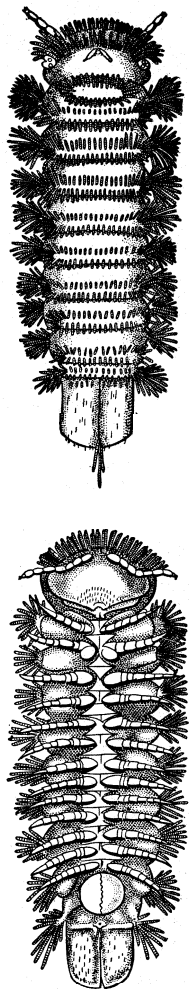
(F. H.)

MILLIPEDE. The millipedes, composing a group of many-legged, air-breathing arthropods having cylindrical segmented bodies, are now recognized as a distinct class, Diplopoda. They were formerly placed as an order or subclass under Myriapoda (*q.v.*) until accumulated evidence made it impossible to regard the latter as a homogeneous or wholly natural assemblage. Millipedes, many of which are brightly coloured, are world-wide in distribution, their numbers, species and sizes being greatest in the tropics and decreasing notably toward the polar regions. Geologically they were among the most ancient of land animals. Millipedes, or forms closely related to them, occurred in the swamps of Carboniferous times, some of them one foot in length and probably amphibious. Fossils of other forms have been found in rocks of Silurian age.

The head segment is as distinct as it is in insects, whereas the remaining segments follow each other, in rather monotonous succession, to form a continuous trunk or body. The name Diplopoda is derived from the fact that most of the apparent segments of the

body bear two pairs of legs resulting from a complete or partial fusing of the primary segments in couples, each couple having a single dorsal plate (tergite) while retaining two sterna. One or two of the posterior (caudal) segments and usually four of the most anterior segments remain single. Of these four, three bear only a single pair of legs, while the, other—usually the first—remains legless. In some forms the number of segments in the body is invariable. Thus in the large order Polydesmida hundreds of species invariably have 20 segments, though in some this number holds only for the female, the male having 19. In millipedes consisting of more than 32 segments the number is variable not only from group to group and from species to species but also to a certain extent within a species itself. The number of segments approaches zoo. Millipedes vary in length from about 2 mm. to almost 300 mm.; the width ranges up to jo mm., as in some of the family Sphaerotheridae.

The often cylindrical body of millipedes may be modified to hemicylindrical or may even appear more flattened through a lateral extension of the segments. Millipedes, when disturbed, generally curve the body into a spiral or, in the broader forms. into a ball. Although in rare cases (*e.g.*, Polyxenus) the body is soft. in most species it is covered by a crustaceous shell or armour, the skin (integument) consisting of a strong base of chitin stiffened by a rich deposit of lime salts. Millipedes, like many other arthropods, grow between molts; as each old integument is discarded the new soft one is exposed. Since the animal is particularly vulnerable at this time it usually retires to a concealed nest or retreat.



FROM 'ERHOEFF, "DIPLOPODA"

FIG. 1.—POLYXENUS LAGURUS, BACK AND VENTRAL VIEWS

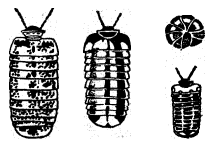
With the exception of the crustaceous integument, stink glands comprise the only protection of most millipedes. These glands discharge their product through pores located along the sides of the body. The secretion is sometimes exuded as a gas, but more frequently as a liquid which may be colourless or may range from white to yellow, brown or red. In composition it varies considerably from group to group but in many common forms has been found to contain prussic acid, iodine and quinone. It has a pungent odour and is toxic enough to kill certain insects. An aqueous or alcoholic solution injected into mice or other small mammals proves fatal. Injury to the human skin may result from accidental contact. as when the animals find their nay into bedding or clothing. The secretion is extruded when the millipede is disturbed, especially when it is in the process of rolling up, at which time the secretion may be squirted a considerable distance.

FROM H. DE SAUSSURE "ESSAI D'UNE FAUNE DES MYRIAPODES DU MEXIQUE

FIG. 2.—GLOMERIDESMUS MEXICANUS

In contrast with the centipedes, which are carnivorous, the millipedes are inoffensive creatures living primarily upon decaying vegetable—or, rarely, animal—matter A few forms feed upon the rootlets or other delicate tissues of living plants. sometimes damaging vegetable crops. They live in damp localities under decaying logs and leaves, and in dry seasons may be found at considerable depths in the soil where they have followed the retreating moisture In comparison with other ground-dwelling animals such as beetles and spiders, millipedes occur only sparsely in a given area. Occasionally, however, they appear suddenly and in great numbers—for some reason not fully understood—often migrating in swarms. entering houses and even becoming a nuisance (because of their crushed bodies) on roads and railroad tracks As a general rule, however, millipedes are very much subject to factors of isolation; as a result they are among the most useful animals in studies of geographical distribution.

The head of millipedes bears a pair of relatively short antennae, each composed of seven or eight sections of which the terminal one bears four or more sensory cones. The eyes in most forms are composed of one or many simple ocelli on each side but they may be absent, as in the large order Polydesmida A pair of mandibles are present. These are typically fitted for biting or chewing and have a terminal lobe which bears combs used in scraping off the soft portion of food tissues. Only one pair of maxillae are developed, the first pair in adults being absent or represented merely by rudiments. The second pair of maxillae form a large, complicated plate termed the gnathochilarium. nhich varies much in detail in different groups. This plate is generally accepted as homologous with the labium of insects. but is rnore highly evolved. Poison jaws, so characteristic of centipedes, are never present.

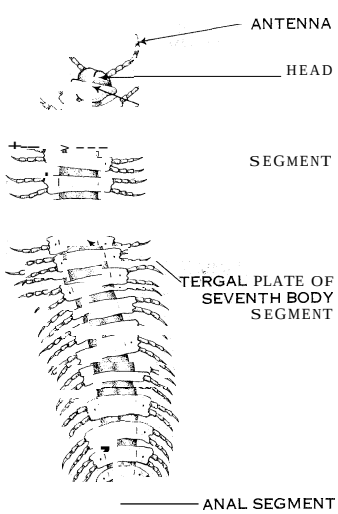


FROM BRONN 'KLASSEN UND ORDNUNGEN DES THIERREICHS'

FIG 3.—GLOMERIS (THE PILL MILLIPEDE)

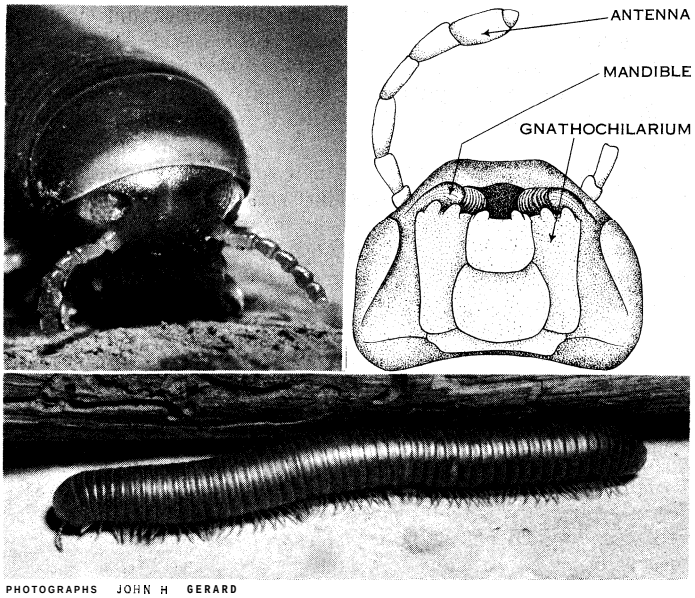
hlillipedes breathe by means of tracheae, one pair on each segment bearing one pair of legs, and two pairs on each fused double segment. The opening (stigma) of each trachea lies in the corresponding sternum. Each stigma opens into a pocket from which branches proceed. Each tracheal system is independent and shows no fusion (anastomosis), in this respect contrasting with the systems of insects and centipedes. The alimentary canal is a short, almost straight tube, which at most shows only an S-shaped (sigmoidal) flexure posteriorly. The canal has three divisions: a narrow foregut (esophagus), a thicker midgut and a narrow hindgut into uhich open tno or four hlalpighian tubules. Salivary glands open into the mouth. The heart is a tube running lengthwise above the alimentary canal The lateral openings into the heart (ostia) occur in double pairs in each double segment. The nervous system consists of a ventral nerve cord which has ganglionic swellings in each segment—two pairs of them in each double segment. In the head the nerve cord is joined by a ring with the small brain lying above the esophagus. The paired reproductive organs lie between the intestine and the ventral nerve cord. their ducts opening through the coxae of either the second legs or those directly behind.

The eggs of millipedes are most commonly laid below the surface of the ground in clumps of from 25 to 50, the clumps being enclosed in an earthy capsule or sometimes, as in *Polydesmus,* in a capsule made of pellets of excrement. The female often remains nith the eggs until the young hatch out. In the course of development the embryo usually leaves the egg in a quiescent, pupoidal form. Soon emerges a larva resembling a wingless insect with three pairs of legs, behind which lie four footless segments. Following this first stage new segments are added in groups of one. two, three or more double segments. The development is thus anamorphic. The attainment of each new stage is preceded by a pause or rest period. The animal occupies a retreat or nest while undergoing the molting process as mentioned earlier. More rarely the first free larva possesses four (*e.g.,* Polyzonium)



FROM ... POCOCK ZOOLOGISCHE ERGEB ... (E. J. BRILL)

FIG 4.—PLATYRHACUS MIRANDUS A SUMATRAN SPECIES OF POLYDESMIDAE SHOWING THE FORM CHARACTERISTIC OF THE ORDER POLYDESMOIDA



PHOTOGRAPHS JOHN H GERARD

FIG. 5.— (TOP LEFT) CLOSE-UP OF HEAD OF NARCEUS SHOWING SIMPLE EYES PRESENT IN SMALL AGGREGATES; (TOP RIGHT) HEAD OF JULUS FROM BELOW; (BOTTOM) NARCEUS MILLIPEDE AT APPROXIMATELY ACTUAL SIZE

or even more pairs of legs. The new segments are invariably produced (intercalated) between the last leg-bearing segment and the final, or anal. segment.

Rlillipedes which breed and lay their eggs in the autumn commonly die out by early winter, the males disappearing first. In these types a new generation emerges from the eggs in early spring. the life cycle being completed within a year's time. Other millipedes may live two years and some are estimated to live as long as seven years.

The class Diplopoda embraces two subclasses: the Pselaphognatha, and the Chilognatha.

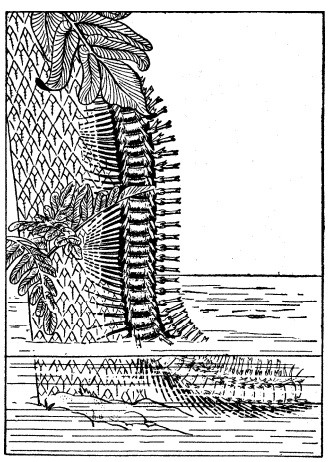
I. The Pselaphognatha include small, soft-bodied forms which bear bristles (setae) of several kinds arranged in rows and bundles (fascicles). Copulatory organs (gonopods) are lacking and the gnathochilarium is abortive or poorly developed (*e.g.,* Polyxenidae).

II. The Chilognatha include the great majority of millipedes. In these the integument forms a hard shell which bears setae only singly, never grouped in fascicles, and the gonopods are always well developed. The major subdivisions of this subclass may be listed as follows:

1. Superorder Pentazonia (Opisthandria) : the gonopods are at the tail-end of the body, being modified from the last two pairs of legs; tracheae two-branched. (*E.g.,* orders Glomerida and Glomeridesmida.)

2. Superorder Colobognatha : first legs of seventh segment of males not modified; eight pairs of legs in front of the gonopods; head small, mandibles usually much reduced; labrum without teeth; tracheae unbranched. (*E.g.,* orders Platydesmida and Polyzoniida.)

3. Superorder Helminthomorpha: first legs of seventh segment of male always modified; seven pairs of legs in front of the gonopods; head not reduced, mouthparts of normal size; labrum usually with three teeth; tracheae unbranched. (*E.g.,* orders Polydesmida, Chordeumida, Julida, Spirobolida, Cambalida and Spirostreptida.)

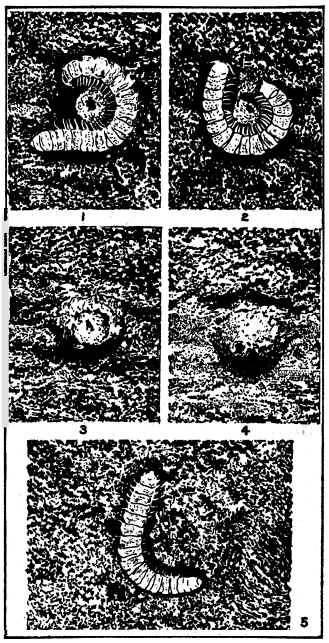


AFTER SCUDDER, MEM BOSTON SOC. NAT. HIST.

FIG. 6.—ACANTHERPESTES MAJOR, MILLIPEDE (SUPPOSEDLY AMPHIBIOUS) OF COAL MEASURE TIMES

In contrast with the Pentazonia (Opisthandria), the second and third superorders are often placed as the Proterandria, because of their agreement in having the copulatory organs on the seventh segment and in not having the tracheae branched.

BIBLIOGRAPHY.—The best accounts of the Diplopoda as a whole are in German a d French. To be mentioned specially are the following: Carl Graf Attems' treatment in Kükenthal and Krumbach's *Handbuch der Zoologie,* vol. iv (1926); Karl W. Verhoeff in Bronn's *Klassen und Ordnungen des Tierreichs,* vol. v (1910–1914, 1926); H. W. Brolemann, "Myriapodes Diplopodes," in *Faune de France,* 29 (1936 seq.). Many excellent papers and monographs on particular regions and groups have appeared by these and other authors. For the diplopods of North America a complete bibliography is given in R. V. Chamberlin and R. L. Hoffman. "Checklist of the Millipeds of North America," *Bull. U.S. Nat. Mus.,* 212 (1958). (R. V. C.)



BY COURTESY OF HUGH MAIN

FIG. 7.— NEST-BUILDING OF A MILLIPEDE. SHOWING SUCCESSIVE STAGES BY WHICH THE FEMALE MILLIPEDE POLYDESMUS MAKES THE NEST TO PROTECT ITS EGGS

MILLOM, a coastal town in Cumberland, Eng., at its southern point on the west coast of the Duddon estuary, 69 mi. S S W. of Carlisle by road. Pop. (1951) 7,116. The castle was held by the lords of Millom from the 13th century until 1774; it was fortified by Sir John Huddlestone in the 14th century, attacked by Oliver Cromwell in the Civil War, and is now in ruins. Holy Trinity church is early Norman with a piscine window and a massive roodstone in the churchyard.

Henry III granted the town a market charter in 1200, but markets are no longer held, and Millom was deurbanized in 1934. Its industries are iron mining, with blast furnaces and foundry, chrome leather tanning and nylon yarn knitting.

MILLS, CLARK (1810–1883), U.S. sculptor, was born in Onondaga county. New Tork. Dec. 13. 1810. In 1848 he began an equestrian statue of Andrew Jackson. casting it himself because there were then no U.S. foundries that could handle the work. The figure is located in Washington, D.C., directly across from the White House. Mills cast the "Statue of Freedom" which tops the U.S. capitol dome. He died in Washington, Jan. 12, 1883.

MILLS, ROBERT (1781–1855), the first strictly professional architect of U.S. birth, was born on Aug. 12, 1781, in Charleston, S.C. Mills generally followed the principle, enunciated by Thomas Jefferson, that classical architectural forms best befitted a reincarnation of ancient republics. *i.e.,* the new United States; but he used those forms with originality, both in plan (*e.g.,* his auditorium type of evangelical church) and structure (*e.g.,* his ideas about fireproofing and acoustics). Mills's more than 50 major works included colleges, prisons, hospitals, houses, canals, bridges and breakwaters. His most famous buildings, however, were public—the Treasury (1836–42) and Patent office (1839) in Washington, D.C., the wings of Independence hall in Philadelphia (1807) and, best known of all, the monuments to George Washington in Baltimore (1814) and Washington, D.C. (designed 1836, completed 1884).

Mills died on March 3, 1855, at Washington, D.C.

See H. M. Pierce Gallagher, *Robert* **Mills** (1935); T. F. Hamlin, *Greek* **Revival** *Architecture in America* (1944). (AN. G.)

MILLS, ROGER QUARLES (1832–1911), U.S. legislator, was born in Todd county. Ky., on March 30. 1832.

He went to Texas in 1839, studied lam, and was admitted to the bar. He entered the Confederate army in 1861. took part as a private in the battle of Wilson's Creek, and as colonel at Arkansas Post, Chickamauga, Missionary Ridge and Atlanta. He served in the national house of representatives as a Democrat

in 1873–92, and in the senate 1892–99. He made the tariff his special study and was long recognized as a leading authority in congress. As chairman of the ways and means committee he reported in April 1888 the "Mills bill," which provided for a reduction of the duties on sugar. earthenware. glassware. plate glass, woolen goods and other articles, the. substitution of ad valorem for specific duties in many cases, and the placing of lumber, hemp, wool, flax, borax. tin plates. salt and other articles on the free list. This bill was passed by the Democratic house on July 21 and was then so amended by a Republican senate as to be unacceptable to the house. The tariff thus became the chief issue in the presidential campaign of 1888.

During the free silver controversy Mills adhered to the Cleveland section of the Democratic party, and failed to be re-elected when his term in the senate expired in 1899. He then engaged in business and the practice of law in Corsicana, Tex., where he died on Sept. 2, 1911.

MILMAN, HENRY HART (1791–1868), English historian and ecclesiastic, was born in London on Feb. 10, 1791. Educated at Eton and at Brasenose college, Oxford, he was ordained in 1816. Milman's early work included tragedies, epic poems, hymns and translations from the classics. In 1821 he was elected professor of poetry at Oxford. Turning to another field, Milman published in 1829 his *History of the Jews,* which is memorable as the first book by an English clergyman which treated the Jews as an oriental tribe. recognized sheikhs and amirs in the Old Testament, sifted and classified documentary evidence and evaded or minimized the miraculous. In 1835 Sir Robert Peel made him rector of St. Margaret's, Westminster, and canon of Westminster, and in 1839 he became dean of St. Paul's. Milman died on Sept. 24, 1868. His works include *History of Chi-istiunity to tlze Abolition of Paganism in the Roman Empire* (1840), *History of Latin Christianity* (1855) and *Life of Gibbon* (1839). In 1838 he edited Gibbon's *Decline and Fall of the Roman Empire.*

MILNE, EDWARD ARTHUR (1896–1950), English mathematician. astrophysicist and cosmologist, best known in his later years for his original researches in relativity and cosmology, was born at Hull on Feb. 14. 1896. He was educated at Hymers college. Hull, and at Trinity college. Cambridge, where he was elected to a prize fellowship in 1919. In 1920, he became assistant director of the Solar Physics observatory. Four years later, he was elected professor of applied mathematics at Manchester university.

In 1928, Milne was appointed first Rouse Ball professor of mathematics at Oxford. He became a fellow of the Royal society at the age of 30, and was awarded a Royal medal in 1941. He died suddenly in Dublin on Sept. 21, 1950.

Milne first became internationally known for his pioneer work on the theory of stellar atmospheres. He showed, in collaboration with R. H. Fowler, that the pressures of the levels of stellar atmospheres where absorption lines are formed are considerably lower than previously imagined. He also found that atoms can be ejected from the sun at about 1.000 mi. per second. In 1929, Milne turned his attention to problems of stellar constitution and became an acute critic of A. S. Eddington's hypothesis that the interior of a star obeys the perfect gas law throughout. He did much work on the highly dense white dwarf stars which afterward stimulated S. Chandrasekhar to develop the now generally accepted theory.

Milne's theory of the expanding universe was easier to visualize physically than that based on Einstein's theory of general relativity. In place of expanding curved space, Milne considered a cloud of particles expanding into a vacuum in flat space. In studying such a system. he was led to develop a new form of relativity, called kinematic relativity, based on a deep analysis of time measurement.

Milne's works include *Thermodynamics of the Stars* (1930); *The White Dwarf Stars* (1932); *Relativity, Gravitation and World-Structure* (1935); *Kinematic Relativity* (1938).

(G. J. Ww.)

MILNE, GEORGE FRANCIS MILNE, 1st BARON (1866–1948), British soldier, born Nov. j, 1566, joined the Royal artillery in 1885. He served in the Nile expedition of 1898 and the South African War (1899–1902). In 1913 he became commander of the artillery of the 4th division, with which he went to France in 1914. He was given, in July 1915, command of the 27th division, which he took to the Salonika theatre. At the end of the year he was placed in charge of an army corps. In May 1916 Milne was advanced to the command of the British forces in Macedonia, and he occupied this responsible position under the orders of three successive French commanders in chief until the end of the struggle. He filled a difficult position with unfailing tact and sound judgment; after the final victory in 1918, he remained in charge of the British forces in the near east until 1920. He was chief of the imperial general staff from 1926 to 1933, when he was created a baron. He was gazetted field marshal in 1928.

Milne died on March 23, 1948, in London.

MILNE, JOHN (1850–1913), British seismologist and mining engineer, was born at Liverpool on Dec. 30, 1850, and educated at King's college. London, and the Royal School of Mines. He worked as mining engineer in Newfoundland and Labrador, and in 1874 went as geologist with Dr. Beke's expedition to northwestern Arabia. In 1875 he was appointed professor of geology and mining in the Imperial Engineering college at Tokyo, where he remained for 20 years. Milne was recognized as a leading authority on seismology. He traveled widely in the east, and about 1880 established the seismic survey of Japan. with 968 stations. He invented various forms of the seismograph. In 1894 he returned to England and established a private observation station near Newport, Isle of Wight. As secretary of the seismological committee of the British association he was largely responsible for the establishment of seismological stations throughout the world.

Milne died on July 30, 1913.

He published two standard works, ***Earthquakes*** (1883) and ***Seismology*** (1898), besides many books on scientific mining and crystallography and papers in scientific journals.

MILNE-EDWARDS, HENRI (1800–1885), Belgian zoologist prominent in comparative anatomy, comparative physiology and general zoology, was born at Bruges on Oct. 23, 1800, the son of British parents settled in Belgium. He studied in Belgium and then in Paris where he took a medical diploma in 1823. He soon gave up medicine. however, and taught natural history at the *lycée* Henri IV. where in 1827 he introduced the theory of the division of physiological labour. In 1838 he was elected a member of the Académie des Sciences, Paris, in succession to Georges Cuvier. Subsequently he was appointed professor of entomology at the Jardin des Plantes and in 1844 professor of zoology and comparative physiology at the Muséum d'Histoire Naturelle, Paris. He took a very active part in organizing courses in natural history and was a member of several government commissions. He was a prolific writer and keenly interested in the popularization of natural history. Milne-Edwards also made important contributions on the littoral fauna of France and Sicily, especially on the ,anatomy, physiology, classification and habits of Crustacea and Coelenterata. He was the author of various textbooks, the most important being *Leçons sur la physiologie et l'anatomie comparée de l'homme et des animaux,* 14 vol. (1857–81). He was one of the most outstanding of those zoologists who refused to accept Darwin's evolution theory, and explained zoological distribution as a result of special creation in different centres. He died in Paris on July 28, 1885. (ED. HE.)

MILNER, ALFRED MILNER, VISCOUNT (1854–1925), British statesman and colonial administrator, was born at Bonn on March 23, 1854. Alfred Milner was educated first at Tiibingen, where his father was reader in English of the university, then at King's college. London, and under Jowett as a scholar of Balliol college, Oxford. from 1872 to 1876. He graduated in 1877, with a first class in classics, having won the Hertford, Craven, Eldon and Derby scholarships, and was elected to a fellowship of New college. At Oxford he formed a close friendship with Arnold Toynbee, and was associated with his schemes of social work; and subsequently he wrote a tribute to his friend, *Arnold Toyn-*

bee: a Reminiscence (1895). In 1881 he was called to the bar at the Inner Temple and joined the staff of the Pall Mall Gazette under John Morley, becoming assistant editor under W. T. Stead. In 1885 he was Liberal candidate for the Harrow division of Middlesex at the general election, but was defeated. He acted as private secretary to Mr. (afterward Lord) Goschen, and in 1887, when Goschen became chancellor of the exchequer, was appointed his principal private secretary. It was by Goschen's influence that in 1889 he was made under-secretary of finance in Egypt. He remained in Egypt four years, his period of office coinciding with the first great reforms, after the danger of bankruptcy had been avoided. Milner returned to England in 1892, and was appointed chairman of the board of inland revenue, being made C.B. in 1894 and K.C.B. in 1895. Shortly after his return to England he published his England in Egypt, which at once became the authoritative account of the work done since the British occupation.

Sir Alfred Milner remained at the board of inland revenue until 1897. In April of that year Lord Rosmead resigned his posts of high commissioner for South Africa and governor of Cape Colony. The situation resulting from the Jameson raid (see TRANSVAAL and SOUTH AFRICA) was one of the greatest delicacy and difficulty, and Mr. Chamberlain, now colonial secretary, selected Milner as Lord Rosmead's successor.

Milner reached the Cape in May 1897, and between Aug. 1897 and May 1898 he travelled through Cape Colony, the Bechuanaland Protectorate, Rhodesia and Basutoland, and also during this period learned both Dutch and the South African "Taal." He came to the conclusion that there could be no hope of peace and progress in South Africa while there remained the "permanent subjection of British to Dutch in one of the Republics." He also realized—as was shown by the triumphant re-election of Kruger to the presidency of the Transvaal in Feb. 1898—that the Pretoria government would never on its own initiative redress the grievances of the "Uitlanders." That Milner had good grounds for his view of the situation is shown in a letter written (March 11) by J. X. Merriman to President Steyn of the Free State: "The greatest danger," wrote Merriman, "lies in the attitude of President Kruger and his vain hope of building up a State on a foundation of a narrow unenlightened minority." Though this was recognized by the more far-seeing of the Bond leaders, they were ready to support Kruger. whether or not he granted reforms, and they sought to make Milner's position impossible. At the general election in Cape Colony the Bond obtained a majority, and in accordance with constitutional practice were invoked to form a ministry. In November he visited England, and the next February (1899) returned, assured of support, to find the situation more critical. On May 4 Milner penned a memorable despatch to the colonial office, in which he insisted that the remedy for the unrest in the Transvaal was to strike at the root of the evil—the political impotence of the injured. "It may seem a paradox," he wrote, "but it is true that the only way for protecting our subjects is to help them to cease to be our subjects." The policy of leaving things alone only led from bad to worse, and "the case for intervention is overwhelming." Milner felt that only the enfranchisement of the Citlanders in the Transvaal would give stability to the South African situation. He realized keenly that the spectacle of thousands of British subjects in the Transvaal in the condition of "helots" (as he expressed it) was undermining the prestige of Great Britain throughout South Africa. This despatch mas kept private for a time by the home government but its tenor was known to the leading politicians at the Cape, and at the instance of J. H. Hofmeyr a conference was held (May 31–June 5) at Bloemfontein between the high commissioner and the president of the Transvaal. Milner then made the enactment by the Transvaal of a franchise law which would at once give the Johannesburgers a share in the government of the country his main, and practically his only, demand. The conference ended without any agreement being reached, and war broke out in Oct. 1899.

In Feb. 1901 he was called upon to undertake the administration of the two Boer states, both now annexed to the British empire, though the war was still in progress. He thereupon resigned the governorship of Cape Colony, while retaining the post of high commissioner. The work of reconstructing the civil administration in the Transvaal and Orange River Colony could only be carried on to a limited extent while operations continued in the field. Milner therefore returned to England for a holiday; on his arrival he was raised to the peerage with the title of Baron Milner of St. James's and Capetown. Meannhile the diplomacy of 1899 and the conduct of the war had caused a great change in the attitude of the Liberal party in England toward Lord Milner, A violent agitation for his recall, in which Sir Henry Campbell-Bannerman joined, was organized, but uithout success, and in August he returned to South Africa, where he plunged into the herculean task of remodelling the administration. In the negotiations for peace he was associated with Lord Kitchener, and the terms of surrender, signed at Pretoria on May 31, 1902, were drafted by him. On July 1j he was made a viscount.

Immediately following the conclusion of peace Milner published (June 21) the Letters Patent establishing the system of crown colony government in the Transvaal and Orange River colonies, and exchanging his title of administrator to that of governor. The reconstructive work necessary after the ravages of the war was enormous. He provided a steady revenue by the levying of a tax of 10% on the annual net produce of the gold mines, and devoted special attention to the repatriation of the Boers, land settlement by British colonists, education, justice, the constabulary, and the development of railways. During a visit to Europe he was offered the post of secretary of state for the colonies, but refused, returning to South Africa, where economic depression was becoming pronounced. He was back in Johannesburg in Dec. 1903, and had to consider the crisis in the gold-mining industry caused by the shortage of native labour. Reluctantly he agreed, with the assent of the home government, to the proposal of the mineowners to import Chinese coolies on a three years' contract.

In the latter part of 1904 and the early months of 1905 Lord Milner was engaged on the elaboration of a scheme to provide the Transvaal with a system of "representative" government, a half-way house between crown colony administration and that of self-government. Letters Patent providing for representative government were issued on March 31, 1905. Owing to the advent of a Liberal ministry in England, in Dec. 1905, this scheme remained inoperative. (See TRANSVAAL: History.) For some time he had suffered in health from the incessant strain of work, and he determined to retire. He left Pretoria on April 2, and sailed for Europe on the following day.

Milner occupied himself mainly, after his return from South Africa, with business interests in the City of London. He was active on behalf of causes which appealed to him from the imperial side, and he made several speeches on behalf of tariff reform and colonial preference. He was roused, however, by Lloyd George's budget of 1909, and he advised the House of Lords to reject the Finance Bill, and, as he said at Glasgow, to "damn the consequences." He made several speeches in the next 12 months in defense of the lords' position; and when the Parliament bill came up to the house of lords in 1911, he was a leading spirit among the "Diehards" who advised resistance to the end.

Lloyd George, when he formed his first war ministry in Dec. 1915, at once turned to Milner, the only British administrator who before 1914 had directed a war from the civil side. and constituted him one of his principal colleagues in his war cabinet of four. From this time to the cessation of hostilities their relations were close, and, after Lloyd George, Milner took the largest share in the civilian conduct of World War I. In Feb. 1917 he attended, on behalf of the British government, a conference of the Allies in St. Petersburg (Leningrad).

He devoted himself to his duties in the war cabinet, seldom appearing in the house of lords except to explain and defend the government's food policy. The acceptance by the government of the principle of imperial preference, and of the conservation of the raw materials of the empire, owed much to his influence and support. He worked heartily for inter-Allied co-operation in

the conduct of the war. and he was in France as the representative of the British cabinet at the time of the victorious German advance in March 1918; it was largely owing to his influence that General Foch was appointed generalissimo of the Allied forces in France on March 26. Lord Milner was made secretary for war on April 19, and presided over the army council during the succeeding months of the year uhich ended with victory.

After the general election, Lord Milner became colonial secretary. In that capacity he attended the Paris Peace conference. and was a signatory to the Treaty of Versailles; he subsequently helped to deal with a number of difficult questions arising under the treaty out of the disposal of the German colonies conquered in war. His financial authority mas invoked to defend ministerial finance in the house of lords; when a serious revolutionary outbreak took place in Egypt in 1919, he was sent there in December, at the head of a special mission. The mission remained until March and subsequently conferred with Zaghlul Pasha, the Nationalist leader in London. In November they recommended the recognition of Egyptian independence. Great Britain was to guarantee the integrity of Egypt against aggression; she would have a privileged position in Egypt and would maintain a garrison in the canal zone The capitulations were to be abolished, and the veto on legislation affecting foreigners mould be vested in the high commissioner. Lord Milner resigned. Feb. 1921, and was given the Order of the Garter.

After this, though he took an active part in the work of the Rhodes Trust, and also published his views *(Questions of the Hour,* 1923), Milner only once showed any disposition to resume public work. When Baldnin, in the autumn of 1923, appealed to the country for a mandate to introduce protection, Milner accepted the chairmanship of a committee to advise the government as to the proposed tariff. As the electorate rejected protection, the committee proved abortive. Soon after returning from a visit to South Africa he was attacked by sleeping sickness and died on May 13. 1925. at Sturry Court, near Canterbury. There was found among his papers, and published shortly after his death, an impressive document containing his *Credo* (1925).

See also E B Iwan-Muller, Lord Milner and South Africa (1902); W B *Worsfold. Lord Milner's Work in South Afrira* (1906); W *T. Stead, "Sir Alfred Milner," in The Review of Reviews, vol* xx *(1899); The Nation and the Empire, collected speeches* (1913); *and the bibliography to* SOUTH AFRICA, UNION OF

MILNER, JOHN (1752–1826), English antiquary and Roman Catholic controversialist. had great influence in the campaign to obtain the parliamentary relief of Catholics from legal disabilities. Born in London on Oct. 14, 1752, and educated first at Sedgeley Park school, near Wolverhampton, and later at the English college at Douai, in France, Milner was ordained priest in 1777 and returned to pastoral work in England, chiefly at Winchester. His *The History, Civil and Ecclesiastical, and Survey of the Antiquities of Winchester,* 2 vol (Winchester. n.d. [1798–1801]), was very well received and achieved a third edition in 1839. Even more famous was his *The End of Religious Controversy,* published in 1818.

In 1803 Milner became titular bishop of Castabala and vicar-apostolic of the Midland district, in which offices he died at Wolverhampton on April 19, 1826.

Milner's chief political success was to prevent parliament's granting relief to Catholics from the penal laws of an earlier age on terms unduly restrictive of papal power. In this he was unsuccessfully opposed by influential Catholic laymen and even bishops who mere prepared to take oaths incompatible with Catholicism and to grant the English government a power of veto over the appointment of Catholic bishops. Milner's resistance was sustained in numerous published writings marred, however, by a too great asperity of style.

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(E. McD.)

MILNGAVIE (locally pronounced "Milguy"), a small burgh of Dumbartonshire, Scot., 6 mi. N N.W of Glasgow. Pop. (1951) 7,885. Industries include the making of paper, cardboard boxes, bedding, scientific instruments, spectacle frames and light engineering; but the town is largely a residential quarter for Glasgow. Two reservoirs store water from Loch Katrine. Mugdock castle. 1¾ mi N. of Milngavie, is an old stronghold of the Grahams; in Baldernock parish, about 2 mi. E., a megalith called the "Auld \fives' Lift" stands on a hill 400 ft. high.

MILO (MILON), of Crotona. Greek athlete, lived about the end of the 6th century B C. He was six times crowned at the Olympic games and six times at the Pythian for wrestling, and was famous throughout the civilized world for his feats of strength—such as carrying an ox on his shoulders through the stadium at Olympia. In his native city he was much honoured, and he commanded the army which defeated the people of Sybaris in 511.

The traditional account of his death is often used to point a moral: he found a tree which some woodcutters had partially split with a wedge, and attempted to rend it asunder; but the wedge fell out. and the tree closed on his hand. imprisoning him till wolves came and devoured him. His name became proverbial for personal strength.

MILO, TITUS ANNIUS, Roman politician, was the son of C. Papius Celsus. but was adopted by his mother's father, T. Annius Luscus. He joined the Pompeian party and organized bands of mercenaries and gladiators to support the cause by public violence in opposition to P. Clodius, who gave similar support to the democratic cause. Milo was tribune of the plebs in 57 B C. He took a prominent part in bringing about the recall of Cicero from exile, in spite of the opposition of Clodius. In 53, when Milo was candidate for the consulship and Clodius for the praetorship, the two leaders met by accident on the Appian Way at Bovillae and Clodius was murdered (January 52). Milo was impeached; his guilt was clear, and his enemies took every means of intimidating his supporters and his judges. Cicero was afraid to speak, and the extant *Pro Milone* is an expanded form of the unspoken defense. Milo went into exile at Massilia, and his property was sold by auction. He was the only man excepted from Caesar's general amnesty. He joined M. Caelius Rufus in 48 in his rising against Caesar, but was slain near Thurii in Lucania. His wife was Fausta, daughter of the dictator Sulla.

MILO OF GLOUCESTER, lord of Brecknock and earl of Hereford (d. 1143), was the son of Walter of Gloucester, who appears as sheriff of that county between 1104 and 1121, when he was succeeded by his son who later combined this office with that of local justiciar for Gloucestershire. After the death of Henry I he declared for Stephen, at whose court he appeared as constable in 1136. But in 1139, when the empress Matilda appeared in England, he declared for her and placed the city of Gloucester at her disposal. He sacked the royalist city of Worcester and reduced the county of Hereford. In 1141, at Matilda's coronation, he was rewarded with the earldom of Hereford. He remained loyal to the empress after her defeat at Winchester.

See B. Thorpe (ed), Continuation of Florence of Worcester (1848–49); *the* Cartulary of *Gloucester Abbey ("Rolls Series");* *and J. H. Round, Geoffrey de Mandeville (1892).*

MILORADOVICH, MICHAEL ANDRIJEVICH, COUNT (1770–1825), Russian general. saw service under Suvarov in the wars against Turkey and Poland, and in the campaign of Italy and Switzerland (1799) earned much distinction as a commander of advanced troops. In 1805, having attained the rank of lieutenant general, he served under Kutusov in the campaign of Austerlitz. In the Turkish War he distinguished himself at Guirgevo (1807). Promoted general of infantry in 1810, he commanded a corps at Borodino, and subsequently inflicted the defeat of Tarutino (or Winkovo) on Murat, king of Naples (Oct. 18, 1812). His corps was one of those most active in the pursuit of Napoleon's *Grande Armée,* and in 1813 he led the rear guard of the Allies after their earlier defeats. He led a Russian-Prussian corps at Leipzig and in the campaign of 1814. From 1818 to the time of his death he was military governor of St. Petersburg. He died in the popular outbreak in the capital, on Dec. 26, 1825.

MILOŠ OBRENOVIĆ I (1780–1860), prince of Serbia, founder of the Obrenovii: dynasty, was born in 1780 of poor Serbian peasants, and began life as a cattle drover. Appointed

voivode by Karageorge (*q.v.*) in 1807, Milo5 distinguished himself both as military leader and administrator, and early became one of the leaders of the Russophil opposition to Karageorge, with whom he had a personal feud, believing him to have poisoned his half-brother. He was one of the few Serb leaders who remained behind when Karageorge and his followers fled in 1813 (see SERBIA) and obtained from the Turks the post of voivode of Rudnik, in central Serbia, in return for his co-operation in restoring order. His attitude, when a fresh Serbian revolt broke out against the cruelties of the returning Turks, was at first most equivocal; but at last he decided to join the rebels, and on Palm Sunday 1815 proclaimed the new revolt in the church of Takovo. By diplomatic astuteness and bribery, but chiefly by representing himself to the Turks as alone capable of restraining the extreme Serbian patriots, Milo5 persuaded them to raise no active opposition to his election in 1817 as supreme prince of Serbia; shortly before he had almost certainly had his old chief and rival Karageorge murdered in his sleep. The Turkish regime was gradually relaxed, although the new position remained undefined, until the Hatti-sherif of 1830 recognized Miloš as hereditary prince, besides granting the Serbs other concessions.

While preserving the appearance of loyalty to the Porte, Miloš actually furthered his own ambitions. He did much for the organization of his country, but more for himself, and so tyrannical were the methods by which he enriched himself as to evoke a rebellion in 1824. His general enemies were assassinated; his officials forced to dust his boots; and he secured to himself the monopoly of the export of swine to Austria, Serbia's most lucrative trade. At last his exasperated people forced him in 1835 to grant a democratic constitution which in turn brought on him the disfavour both of the Porte and of Russia. Russia's intrigues with the Serb opposition at last forced Milo5 to abdicate (1839). His sons Milan and Michael III. (*q.v.*) ruled Serbia; Miloš lived on his estates in Rumania, or in Vienna. He was recalled to the throne in 1859, on the deposition of Prince Alexander Karageorgevid, but had only just time to show that his ideas remained unchanged. He died on Sept. 27, 1860, in Belgrade.

MILOVANOVIĆ, MILOVÁN (1863–1912), Serbian statesman and diplomatist, was born at Belgrade on March 2, 1863, and was educated there and in Paris, where he was the first Serb to take his degree as doctor of law and was awarded a gold medal for his thesis. On returning home he was appointed professor of international law at Belgrade university and soon acquired the position of one of Serbia's leading jurists. He was mainly responsible for drafting the new Serbian Constitution of 1888; and, becoming secretary of the central committee of the Radical party, he entered politics and held successively the portfolios of justice, commerce and finance during the closing decade of last century. In 1901 he went to Rome as minister, and retained his post after the revolution of 1903. In 1907 he represented Serbia at the Second Hague Conference, and was appointed a member of the international court of arbitration. In July 1908 he was made foreign minister in the Vetimirović cabinet, and thus had to guide Serbian policy through the difficult period of the Bosnian annexation crisis.

In 1911 he succeeded Păsić as premier. In foreign politics he showed signal moderation, and though a confirmed Russophil, initiated negotiations for a commercial treaty with Austria-Hungary and actively favoured good relations with Turkey. He was one of the chief founders of the Balkan League, the decisive step towards the creation of which was taken at a meeting between Milovanović and the Bulgarian premier, Gueschov, on Oct. 11, 1911. Secret negotiations continued throughout the winter and led to the conclusion of the Serbo-Bulgarian treaty of March 13, 1912 (see SERBIA). Discussions were still pending between the various Balkan capitals for a more precise and comprehensive project of alliance when, on July 1, 1912 at Belgrade, Dr. Milovanović died suddenly of heart failure. His removal at so critical a juncture was a grave blow to the cause of peace and moderation, and also deprived Serbia of her ablest statesman since the death of Prince Michael.

MILREIS. The reis was the monetary unit of Portugal, and was naturally adopted in its South American colonies. With its depreciation in bygone days. it became too small to be convenient, and was replaced by the milreis, or thousand reis. When Brazil won its independence, it retained the milreis as its monetary unit, and as Portugal now calls the milreis the escudo (*q.v.*), the milreis became the monetary unit of Brazil. A thousand milreis were known as a conto. Though nominally a gold coin, the milreis always consisted of inconvertible currency notes.

Effective Nov. 1, 1942, the milreis was replaced by the cruzeiro as the monetary unit, equal to the old milreis and divided into 100 centavos.

MILTIADES, the name of two Athenian statesmen and generals of a family (the Philaidae) of Aeginetan origin, which claimed descent from Aeacus.

1. MILTIADES (6th century B.C.), the son of Cypselus, a prominent opponent of Peisistratus. He founded an Athenian colony in the Thracian Chersonese at the request of the Doloncians (Herod. vi. 36). He became "tyrant" of the Chersonese which he fortified by a wall across the isthmus from Cardia to Pactya. He was captured by the people of Lampsacus, but released on the intercession of Croesus of Lydia. He was succeeded by Stesagoras, son of his half-brother, Cimon.

2. MILTIADES (died c. 488 B.C.), the victor of Marathon (*q.v.*), was another son of Cimon. On the death of Stesagoras, he was sent to the Chersonese (? about 518–516) by Hippias—no doubt to support Hegesistratus at Sigeum (see PEISISTRATUS). He entrapped and imprisoned the chief men of the Chersonese, which was then in a turbulent condition, and married Hegesipyle, daughter of the Thracian prince Olorus (Herod. vi. 39). He led a contingent in the Scythian expedition of Darius Hystaspes, but Herodotus' story of the subsequent event is improbable (see SCYTHIA) and is probably derived from Alcmaeonid tradition, hostile to Miltiades. According to Herodotus, he advised the destruction of the Danube bridge, which would have cut off Darius' retreat, and was subsequently driven out by Scythian invaders, being restored by the Doloncians; he then fled to Athens on the arrival of the Persian expedition under Datis and Artophernes (492 B.C.), and was at once impeached for tyranny.

On the approach of the Persians Miltiades was made one of the ten Athenian generals, and it was on his advice that the polemarch Callimachus decided to give battle at Marathon (*q.v.*). Subsequently he obtained a fleet of 70 ships from the Athenians, with a commission, according to Cornelius Nepos, to regain control over the Aegean. Herodotus says that, having besieged Paros vainly for nearly a month, he made a secret visit to Timo, a priestess of Demeter in Paros, with a view to the betrayal of the island, and being compelled to flee wounded himself severely in attempting to leap a fence (but *see* Ephorus in *Fragm. hist. gr.* 107). In any case, the siege was raised for some reason, and the Alcmaeonidae had him impeached on some charge on his return. All that is known is that he died of his wound (489–488), without paying the fine, which was paid subsequently by his son Cimon (*q.v.*). He appears to have been a man of strong determination and great personal courage, of a type characteristic of the pre-Cleisthenic constitution. His absence in the Chersonese during the first years of the new democracy (508–493?) and his patrician lineage account naturally for the difference which existed between him and the popular leaders—Themistocles and Aristides.

See Herodotus, vi., and Cornelius Nepos, *Miltiades,* and histories of Greece. On the Parian expedition and the trial, R. W. Macan, *Herodotus iv.–vi.*, vol. 2. appendix xi.; on the foreign policy of Miltiades *see* THEMISTOCLES.

MILTON, JOHN (1608–1674), who ranks next to Shakespeare among English poets. was born in London, in Bread street, Cheapside, on Dec. 9, 1608.

Family.—&ilton's grandfather, an Oxfordshire yeoman, had been a staunch Roman Catholic who disinherited his son. the poet's father, for turning Protestant. John Milton senior. going to London. made his way to prominence and a comfortable fortune as a scrivener or notary and through the collateral business of private banking or moneylending. Possibly the poet inherited a disposition toward religious independence; certainly he was given

the best education, then six years of leisure and finally a continental tour. Milton paid repeated tributes. in verse and prose, to his father's generous concern. Another debt was in the way of music. The father was a composer, not of the first rank but still of enough repute to be a contributor to Thomas Morley's famous collection, The Triumphs of *Oriana* (1601); the poet's lifelong devotion to music is attested by the warmth of his own allusions and by his early biographers. Of his mother (d. 1637) Milton said only that she was well esteemed and knoan for her charities. He had an older sister Anne who married in 1623, and a younger brother Christopher who became a lawyer and, though a royalist, continued on good terms with him.

Education and Early Poems.—The conventional date given for Milton's admission to St. Paul's school, 1620, has no authority; it may have been as early as 1615. In addition to his regular schoolwork in Latin, Greek and—later—Hebrew, the boy had instruction at home, perhaps partly in modern languages, from private tutors; to one of these, the Scottish Thomas Young, he later wrote two letters and the Latin Elegy IV (1627), in nhich he gratefully recalled Young's introducing him to Latin poetry. Milton was irom childhood a voracious student; he traced the initial cause of his blindness to his having, from his 12th year, rarely quitted his books before midnight.

Along with a couple of Latin exercises that have survived, his earliest attempts at verse, made nhen he was 15, were rhymed paraphrases of Psalms 114 and 136. Milton's closest friend, at school and later. was Charles Diodati. the son of a prominent physician of Italian origin, who went from St. Paul's to Oxford; a less intimate friendship, which also lasted beyond school, was with Alexander Gill. the son of the headmaster.

On April 9. 162j, Milton matriculated at Christ's college, Cambridge; he received his B.A. degree in March 1629, his M.A. in July 1632. Young men of future distinction whose Cambridge careers more or less overlapped Milton's were Roger Williams, Thomas Fuller, Thomas Randolph and Jeremy Taylor and. at Christ's. John Cleveland and Henry More. Milton's experience at Cambridge can be partly gathered from his abundant Latin verse and his seven Latin prolusions (these were public speeches expected to display the speaker's learning and rhetorical and argumentative powers). The occasion of his first Latin elegy, addressed to Diodati, was his rustication, after a clash with his tutor, apparently in March 1626; at home in London, he compared his exile to that of his beloved Ovid and rejoiced in the opportunity to read the books (here classical plays) "that are my life" and to see beautiful girls while strolling. Evidently the college authorities did not find serious fault, since on his return he was assigned to another tutor and graduated in the normal time.

The nickname Milton acknowledged, "the Lady," no doubt referred to his handsome and delicate features and to a purity of mind and behaviour that disdained the diversions of his coarser fellows. During his seven years at Cambridge he seems to have moved from some unpopularity to general respect and, among dons and cultivated students, high esteem. He did not love the scholastic logic -which largely dominated the university curriculum and which, in prolusions and later in Of *Education,* he denounced as barren. In his last prolusion (1631–32?) he proclaimed the fervent creed and dream of a young Renaissance humanist who was at once a Christian, a Platonist and—whether or not he had yet read Francis Bacon—a Baconian: it was in man's power to master all fruitful knowledge, to become an oracle of nations, a godlike ruler of nature.

Meanwhile Milton had been learning his art and sometimes revealing his inner self in writing Latin verse. Neo-Latin poets, such as George Buchanan or the contemporary Hugo Grotius (whom Milton later met in Paris. and nhom posterity remembers as a jurist). enjoyed European fame; and college students commonly celebrated academic and national events in what was the normal language of the university world.

Milton's Latin poetry. with all its conventional rhetoric, sometimes attained higher levels than that of any other English practitioner. His small anti-Catholic epic of 1626, "In Quintum Novembris" (*i.e.,* on Guy Fawkes day), gives a vigorous if crude sketch of Satan and hell, and even formal obituaries on bishops inspire the Miltonic vision of heaven. Elegy V (1629), a picture of awakening spring, is aflame with the sexual imagery of an intense though innocent paganism. In Elegy VII (1627–28?) Milton presents himself as a confident foe of Cupid who is overcome by the beauty of a girl he encounters. The young poet's sensuous instincts mere further displayed, along with his mastery of Italian, in six Italian sonnets (1630?), with which may be linked his first English sonnet. "O Nightingale."

"On the Morning of Christ's Nativity."—Early in 1628 Milton wrote the earliest of his extant English poems (apart from the two psalms), "On the Death of a Fair Infant," an elegy. in the Elizabethan vein, on his baby niece, Anne Phillips. In part of an academic prolusion in English couplets ("At a Vacation Exercise," July 1628) he declared his devotion to his native language, a style free from eccentricity, and exalted themes concerning nature and man. And in the Latin Elegy VI, addressed to Diodati in the festive Christmas season of 1629–30, he praised the light verse kindled by wine and love but turned from that to celebrate the ascetic purity of the heroic poet. The elegy ended with a reference to a poem he had just written, his first great poem in English. "On the Morning of Christ's Nativity." Such a poem, composed shortly after his 21st birthday. may be taken as a kind of announcement of his poetical coming of age and future direction. both in its religious theme and in its mastery of conception and form and image and rhythm. A short prelude enunciates, in terms of light, the supreme paradox of the Incarnation and leaps over time and space to link the poet's humble ode with the gifts of the three wise men. Then the hymn unfolds itself in three movements: the universal peace of the Roman world and all nature's awareness of its defects on the eve of its Creator's birth; the angelic song which. in symbolizing the new bond between heaven and earth. recalls the celestial music that attended creation and anticipates the trump of doom and the bliss of eternity: and, finally, the overthrow and flight of the pagan gods with the earthly advent of the true God. The last lines quietly reaffirm the central theme of divine order and harmony.

"L'Allegro," etc.—Probably in the long vacation of 1631 Milton wrote the companion poems. "L'Allegro" and "Il Penseroso." Less ambitious in theme than the "Nativity." they have their own complexity, concealed beneath a unique grace and charm. These celebrations of mirth and melancholy (really contemplation) transcend the traditions they belong to, the traditions of the encomium, the emblem, the prose "character" and the pastoral. The representative of mirth observes people, in pastoral sunshine or bright and crowded interiors; the contemplative solitary communes with himself and nature in tnilight and with books through the night. But the "man" in each case is only a thread for the varied scenes and times and seasons that evoke or reflect the quality of the experience. and the descriptions are quite rightly generalized. The twin poems are related through abundant parallel and contrast; and the couplets. in trochaic and iambic lines of seven or eight syllables, trip and flow and pause with expressive ease. If the imagery and tone of the "Nativity" partake in some degree of the Italianate and Spenserian manner. these poems may be said to embody—and excel—the urbane, civilized decorum of Jonson's lyrical and reflective pieces—a quality already manifested in the tiny ceremonial "Song. On May Morning" (1629–30?) and the "Epitaph on the Marchioness of Winchester" (1631). In "L'Allegro" the learned Jonson is joined with "sweetest Shakespeare" the unlearned author of outdoor comedies (the plays that would appeal to the mirthful man). Milton had lately (1630) nritten the lines "On Shakespeare" which had the honour—the circumstances are not known—to be printed in the Shakespearian Second Folio (1632). The two elegies on Hobson the Cambridge carrier—whose death (1631) occasioned much student wit—were on a different level, of jocose punning.

Milton's scholarly and literary gifts had from childhood marked him out in the minds of his family and teachers for the ministry; in his later prose he said he had refused to "subscribe slave" in a church governed by prelacy, but the date of his negative decision is not knonn. As his academic career approached its end, the

problem of an occupation would come up, and the poem "Ad Patrem" — though some scholars link it with Comus (1634) — may well have been written in 1631–32. In this piece, with a mixture of filial gratitude, firmness and confidence in poetry and himself, Milton assumes or urges that he would not be pushed into some basely lucrative profession by a father who has fostered his literary pursuits and is himself a devotee of the muses.

Horton Period (1632–38).—On taking his M.A. in July 1632, Milton retired to his father's house — perhaps first at Hammersmith, then the country estate at Horton, near Windsor, Berkshire — and proceeded to give himself the liberal education Cambridge had not provided. It was in these years that he laid the foundation or set the direction of his liberal thinking. With the humanistic zeal that had fired the seventh prolusion, he sought to digest the mass of history, literature and philosophy ancient and modern, to gain the "insight into all seemly and generous arts and affairs" needed by the citizen-poet who would be, no less than the cleric, a leader and teacher. At times he suspended his labours to visit London in quest of books or something new in mathematics or music.

An important landmark in Milton's early development is the sober sonnet, "How soon hath Time," written on his 24th birthday, Dec. 9, 1632. During recent years he had become a figure in the small university world; now he writes this sonnet while his contemporaries are forging ahead and he has had six months of studious and outwardly unfruitful obscurity at home. But any uneasiness about his present and future is quieted in the earnest dedication of his life to his great Taskmaster's will. What might be called the first pledges toward the fulfillment of this self-consecration were two short religious poems, "On Time" and "At a Solemn Music" (1632–33). They have the form of a madrigal, a stanza of a *canzone,* and the irregular lines are powerfully modulated, so that every word has weight. The poems are early renderings of the beatific vision that always kindled Milton's imagination. Both, in different sequence, contrast the grossness of temporal life, the jarring discord of sin, with the eternity and harmony of heaven and good.

Cornus. — The same contrast is sounded in the opening lines and carried through the whole of the masque known as Comus. During 1630–33, perhaps in 1632, Milton had, at the invitation probably of the musician Henry Lawes, written Arcades, a miniature masque of Jonsonian courtliness designed as a tribute to the dowager countess of Derby. Arcades presumably led to a request from Lawes for another masque. Comus was presented on Sept. 29, 1634, before the earl of Bridgewater at Ludlow castle in Shropshire, in honour of his becoming lord president of Wales. Lawes, the producer, acted the role of the Attendant Spirit; the parts of the Lady and the two Brothers were taken by the earl's children, of whom the eldest, Lady Alice Egerton, was only 15. The acting version, though somewhat shorter than the text familiar to readers, in length and elevated seriousness went far beyond the limits of the usual court masque, which emphasized lavish costumes, spectacle, music and dancing. Milton did provide such elements in some degree, and also, in Comus' rout of monsters, the "antimasque" often used as a grotesque contrast to ordered beauty, but his aim was not merely decorative. Comus was his first dramatizing of his great theme, the conflict of good and evil.

The Homeric and Ovidian Circe, whose power of changing men to beasts had long been allegorized as sensuality, becomes Comus ("revelry"), the son of Circe and Bacchus. Many sources have been suggested as contributing to Milton's mythological and pastoral fable — George Peele's Old Wives' Tale, Spenser's Faerie Queene, John Fletcher's Faithful Shepherdess, Jonson's Pleasure Reconciled to Virtue, William Browne's Inner Temple *Masque,* Erycius Puteanus' Comus, Tasso's *Aminta,* Italian musical dramas. But, from the first lines of the Attendant Spirit (who is a fusion of Neoplatonic daemon and Christian angel) to the incantatory epilogue, the conception and the poetry bear the clear impress of the author; they embody the crystal purity of his vision of perfection. The chastity the Lady represents is not mere abstinence; it is the positive love of the good that is both Christian and Platonic. Comus, who is projected with a dramatic irony that anticipates the treatment of Satan, puts forth specious naturalistic arguments which the Lady answers first on the rational level; then, with a conscious change of tone, she rises to an impassioned religious affirmation of "the Sun-clad power of chastity," and the epilogue celebrates the love of virtue which alone brings freedom and joy and the help of heaven. The best commentary on Comus is the personal passage in Milton's antiprelatical tract, An Apology for *Smectymnuus* (1642). where he tells how early reading had nourished his faith in chastity: he had loved and imitated the erotic poetry of Ovid and his fellows, but, while continuing to cherish their art, he had turned away from their sensuality to the idealism of Dante and Petrarch; then came the romances of knighthood (doubtless these included "our sage and serious poet Spenser"); and finally "the divine volumes of Plato" taught the true love of the good; and prior to and beyond all were "those chaste and high mysteries" glorified by St. Paul and the book of Revelation.

"Lycidas."—If *Comus* was in a way a song of innocence, "Lycidas" (written in Nov. 1637) was a song of experience, Milton's first attempt to justify the ways of God to himself and to men. His former fellow collegian, Edward King, was drowned in a shipwreck in the Irish sea in Aug. 1637, and Milton was asked to contribute to a volume of elegies; "Lycidas," signed "J. M.," appeared at the end of an undistinguished collection of pieces in Latin, Greek and English (1638). The pastoral convention had, from its Greek beginnings, proved its value as a dramatic vehicle or mask for almost anything, public or private, that a poet wished to say, and Milton, working as usual within a venerable tradition, as usual re-created it. The pastoral devices — the lament of nature, the procession of mourners and so on — were accommodated to the Italian *canzone,* with its paragraphs and lines of irregular length and irregular rhyme. Dr. Johnson, in complaining of the absence of grief and the presence of pastoral artifice and a mixture of Christian and pagan allusion, missed the point entirely. Milton had no reason to feel deep personal sorrow, for King had not apparently been an intimate friend; but the drowning of a virtuous and promising young man, on the threshold of service in God's church, brought home the whole enigma of life and death, of the rightness of things in a world where such events could happen. What if his own talents — which during his years of study at Horton he has been nurturing under his great Taskmaster's eye — should be cut off? Thus the "digressions" on fame and hireling clergy are not digressions but quite central in the emotional dialectic. In the end, God's justice and providence and the conditions of earthly life are vindicated, not by reason, but by the beatific vision of Lycidas' soul received into heaven. A few bald sentences, however, cannot approach the complexities and depths of the poem, its reverberating solidity of reference, its rich variety of pace and tone, the artistic control that dominates turbulent emotions and ends with the high serenity of victory won. "Lycidas" may be the greatest short poem in the language.

Italian Tour (1638–39).—In May 1638, a year after his mother's death, Milton set off — with one servant — on a visit to Italy. He sojourned chiefly in Florence, Rome and Naples. Milton and some of his early poems — not those in English — were cordially welcomed among men of letters and patrons and their academies. The experience, which he described at length in the Second Defence of the English People (1654) and alluded to elsewhere, warmed his heart and nourished his self-confidence. (It may be remembered that at home he had very little literary acquaintance and, outside a small circle, no poetic reputation; his only writings in print were "On Shakespeare." *Comus*—published anonymously by Lawes in 1637 — and "Lycidas," which was buried in the volume on King.) To his distinguished host in Naples, Baptista Manso, marquis of Villa, who had been the patron of Tasso and Marino, Milton wrote a bread-and-butter epistle, "Mansus" (1638–39), which is one of his best Latin poems, a graceful apologia for English culture and a no less graceful statement of his own poetic standing and hopes. He wrote also an epistle to a Roman poet. Salzilli, and several epigrams in praise of the singing of the famous Leonora Baroni. Though he mingled happily with Catholics, and was a guest at a grand entertainment given by Cardinal Barberini, the stout Protestant did not remain

silent on matters of religion. He made a call—recorded in *Areopagitica*—on Galileo in his semicaptivity. Milton felt obliged to forgo a visit to Sicily and Greece because of news of mounting tensions in England, although. as he says, he lingered some time longer in Italy.

Epitaphium Damonis.—In Aug. 1638 Milton's friend Diodati (who had become a physician) died. Milton no doubt learned of his loss while in Italy; on his way homeward he stopped to see Diodati's uncle, John Diodati, professor of theology at Geneva. He returned to England in July 1639, and proceeded to settle in a house in London and prepare to take in pupils; the first ones were Edward and John Phillips, the sons of his sister Anne. His elaborate pastoral elegy on Diodati, Epitaphium *Damonis,* was written apparently late in 1640 and privately printed. This has commonly been ranked at the head of Milton's Latin poetry, though dissenters may ask if the fact of its commemorating his dearly loved friend has not heightened its intrinsic merits. There are expressions of heartfelt loneliness which are especially moving from a man often regarded as proudly self-sufficient; but in the poem as a whole Milton seems unable. perhaps because of the reality of his grief, to unify and re-create his pastoral material as he had done so powerfully in "Lycidas."

Prose Works.—In his denunciation of hireling clergy in "Lycidas," Milton had virtually declared his Puritan allegiance, and the years 1641–60 he gave almost wholly to pamphleteering in the cause of religious and civil liberty. He had returned to England with anxiety about that cause, and also with plans for an Arthurian epic (plans set forth briefly in "Mansus" and Epitaphium *Damonis*); like other ambitious poets of the Renaissance, he hoped to write the great modern heroic poem. As he shows in the important personal passage in his fourth tract, the Reason of Church-Government *Urged* against Prelaty (1642), it was a heavy sacrifice to put aside his craving for poetic immortality and his cherished studies to "embark in a troubled sea of noises and hoarse disputes," but he could not be deaf to God's summons. And, as his work went on, he was sustained by the conviction that in his many and varied defenses of liberty he was, in another way, fulfilling his epic and patriotic aspirations.

The large bulk of Milton's prose—which fills four times as many volumes as his poetry—is read only by scholars, but much of it is important for several reasons. In an age of great prose, Milton's, at its best, has a very individual if often undisciplined greatness, and Areopagitica at least is a classic document and possession of the race. Then, even if he had never written any poetry, his prose works, though they had small influence in their own time, would remain a valuable interpretation of the Puritan revolution, and they have their place in modern histories of political thought. Finally, as the record of Milton's growth (a leftward growth, in religion and politics) and of his dreams and disillusionments, they are the essential introduction to Paradise Lost, Paradise Regained and Santson Agonistes, the bridge between the radiant idealism of youth and the much-tried faith and fortitude of age.

Antiprelatical Tracts.—In Nov. 1640 what was to be the Long parliament met and began its reform of abuses; it was soon confronted with a popular agitation against the bishops. During 1641–42 Milton contributed five pamphlets to the attack on prelacy made by the "Smectymnuus" group of Presbyterian divines (the uord was composed of their initials, ty being Thomas Young, Milton's old tutor). The main issue was what had been the main issue since the emergence of Puritanism early in Elizabeth's reign: that the Church of England with its episcopal hierarchy and Prayer Book and ritual was a compromise with Rome (as it had been). and that the Reformation must be completed with a drastic purge of Romanism and a return to the democratic simplicity and purity of the apostolic church. Milton has all the Puritan emphasis on the inward spirit of biblical faith in contrast with outuard show and spurious tradition; thus in the opening of his first tract, Of Reformation *Touching Church-Discipline* in England (1641), the Anglican service, so beautifully described in "Il Penseroso." has become "the new-vomited paganism of sensual idolatry." The tract ends with a vehement and magnificent prayer which proclaims Milton's glowing vision of a new and grand Reformation; he touches on his own role as the poet-singer of God's mercies and judgments, and his share in the millenarian dreams of his time appears in the apostrophe to "the eternal and shortly-expected King" who will reward his champions. All the main points come up in this pamphlet, though the Reason of *Church-*Government (1642) is a more ordered argument. It contains the memorable passage in which, with characteristically sublime naïveté. Milton explains his religious conception of poetry and the deferment of his projected epic because of public duty. The fifth and last tract, known under its abbreviated title. An Apology for *Smectymnuus* (1642), lives chiefly in the passage cited above in connection with Comus, a self-defense that rises far above the refuting of opponents' charges of immorality.

Tracts on Divorce; Marriage.—Milton's first real notoriety came with his Docfrine and Discipline of Divorce (Aug. 1643; enlarged edition, Feb. 1644), which was buttressed by three more tracts. *The* Judgment of *Martin* Bucer, concerning Divorce (Aug. 1644) and Tetrachordon and Colasterion (March 1645). Marriage—a prime concern of men in all ages—had been a signal concern of Reformation thought and one that Milton had reflected on in the Horton period (as entries in his Commonplace Book indicate). His discussion was presumably hastened by his own marital disaster. About May 29, 1642, several months before the outbreak of the Great Rebellion, Milton had married Mary Powell, the daughter of a royalist squire of Oxfordshire who owed money to his father. Success could hardly be predicted for the marriage of a scholar and poet of 33 and an uneducated girl of half his age from a large, easygoing household. The young wife, visiting her family a little later, declined—doubtless with their backing—to return. The shock of the experience must have been especially severe for a man who—as one may infer from the anguished cries that recur in the Doctrine—had approached marriage not only with high hopes (and an unblemished past) but with earnest prayers; and there was no release from such a tragic mistake. In the tracts, Milton argued that the sole cause admitted for divorce, adultery, might be less valid than incompatibility, that the forced yoke of a loveless marriage was a crime against human dignity. Both religious and philosophic tradition and the way of the world (including the usually meagre education given to girls) kept woman inferior to man; Milton. without denying that view, upheld a personal and Puritan ideal of marriage as an active bond of mutual love and mental companionship, an ideal that exalted women and wives far above the level they occupied. say, in Cavalier poetry. He was, however, assailed as a new libertine by royalists and Presbyterians alike. In 1645 friends brought about a reunion between Milton and his wife; and in 1646, when the Powells had been ruined by the war, he took into his house, for nearly a year, the whole noisy family of ten. Three daughters, Anne, Mary and Deborah, were born in 1646, 1648 and 1652 (a son died in infancy); Mrs. Milton died a few days after Deborah's birth.

Of Education and *Areopagitica.*—In 1644 Milton published what are for modern readers his best-known pamphlets, Of Education (June) and Areopagitica (November). The former, written at the request of Samuel Hartlib, a man active on many progressive fronts, was one of the last in the long line of European expositions of Renaissance humanism. Milton's aim was the traditional aim, the molding of boys into enlightened, cultivated, responsible citizens and leaders. His proposed academy, which would take the place of both secondary school and college, was to be the model for many others. The main material was the ancient classics, in due subordination to the Bible and Christian teaching. The traditional role of physical and martial exercise was perhaps heightened by Milton's concern over the war in progress. Several points suggest some affinity with the especially Puritan movement toward practical education. While Milton could not share its illiberal hostility to the classics, he did want less gerund-grinding; also, objecting to a premature excess of logic, he planned a graduated advance from sense experience to abstract ideas; and, most conspicuously, he gave a large place to all kinds of science. If his program now seems unduly strenuous it must be compared,

not with modern schools and colleges, but with contemporary practice and with the programs of earlier humanists, such as Rabelais.

Areopagitica (1644) is of course one of those tracts for the times that transcend their occasion. In 1637 the Star Chamber, reinforcing traditional censorship, put control of the press virtually in the hands of Archbishop Laud and the bishop of London. While the Long parliament abolished the hated Star Chamber, it was disturbed in its turn by the rising flood of unlicensed books, and, in order to maintain or regain its authority, it issued a new ordinance on licensing (June 14. 1643). In Aug. 1644 the Stationers' company (the guild of master printers) demanded stricter enforcement of this ordinance, naming Milton among transgressors. He had written his antiprelatical tracts as a Presbyterian, but in *Areopagitica* he saw the new censorship as only an exchange of episcopal for Presbyterian tyranny. Notwithstanding this disillusionment. he expresses a boundless faith in the Englishmen whom God has chosen to complete the Reformation Wycliffe had begun. With a still larger vision, Milton writes as a scholar and poet and lover of books, above all as a resolute believer in the power of truth to win its way through free inquiry and discussion. (While this grand plea deserves its classic status, it is not the plea for complete freedom that modern libertarians sometimes make it: in vehemently denouncing censorship before publication Milton freely admits censorship afterward, since for him as for other liberals there must be safeguards for religion and morality.) Themes so near Milton's heart inspire soaring, richly figurative eloquence and also homely, richly figurative satire. In the whole work, cast in the form of a classical oration and addressed to parliament (as if to the Athenian assembly) with more than Milton's usual tact. the organization of topics and sentences alike has more deliberate order and clarity than his hurried prose commonly achieved. *Areopagitica* seems to have had very little effect in its own time — partly, perhaps, because the main theme of pamphlet controversy in 1644–45 was the problem of religious toleration raised by a group of Independent divines who sought congregational freedom from Presbyterian uniformity.

Political Tracts and Secretaryship. — *In* the next few years Milton may have been working chiefly on his *History of Britain* and his large treatise on Christian doctrine. By Feb. 13, 1649, two weeks after King Charles's execution, appeared his first political tract, *The Tenure of Kings and Magistrates.* In his first tract of 1641, Milton had written as a good monarchist, intent only on freeing the crown from the incubus of prelacy. By 1649 he has moved far enough to the left to expound the more or less democratic doctrine of Renaissance liberals, that power resides always in the people, who delegate it to a sovereign but may, if it is abused, resume it and depose or even execute the tyrant. Milton obviously rejected the Stuart claim of divine right; and his view of that abstract theorem, the social contract, was directly opposed to the view of such absolutists as Thomas Hobbes, who held that the people surrendered all rights. In the *Second Defence of the English People* (1654), surveying his earlier writings on liberty, Milton said that he wrote the *Tenure* to reconcile the public mind to Charles's execution, though the terms of his reference suggest the possibility that his own mind was not entirely at ease.

In March 1649, a month after the appearance of the *Tenure,* Milton was invited to become secretary for foreign languages to Cromwell's council of state. Hitherto a detached observer, Milton, in spite of his private studies, was doubtless eager to have a hand in the workings of government (his official experience has often been thought to have contributed to the realism of the fallen angels' debate). He was not on the policy-making level, but he had the easy command of Latin needed for foreign correspondence. Also, as a publicist of demonstrated sympathy with the revolution, he was expected to continue his defense of the cause against the multiplying attacks on the Commonwealth regicides.

Milton's first effort in this line was *Eikonoklastes* (Oct. 1649), one of a number of answers to *Eikon Basilike,* a book edited from the king's papers by his chaplain, John Gauden; this ostensible self-portrait of the royal saint and martyr, catching the public in its first shock of horror over the execution, was one of the most potent pieces of propaganda in English history, and not even Milton could prevail against it.

During 1651 Milton was censor and supervisory editor of the chief Commonwealth newspaper, *Mercurius Politicus,* edited by Marchamont Needham. In this year he became an actor on the European stage, with the publication of his Latin *Defence of the English People.* Charles II, in exile, had engaged Claudius Salmasius (Claude Saumaise), the most eminent of classical scholars, to arraign the regicides *(Defensio Regia pro Carolo I,* 1649). Milton was less effective in legal argument than in discrediting Salmasius by personal abuse; like some other crusaders, he tended to see opponents as monstrous enemies of a sacred cause who must be destroyed by any means. If he was, then and later, uplifted by the vanquishing of a renowned antagonist, he was inevitably and profoundly depressed by the loss of his eyesight; it had been failing for years and blindness became complete in the winter of 1651–52. Milton was only 43, and the great poem was still unwritten. Blindness reduced his strictly secretarial duties, though he continued through 1659 as a translator of state letters.

The *Second Defence of the English People* (1654) — also in Latin, since it also was addressed to Europe at large — was much more worthy of its subject and its author. It was a reply to an anonymous attack, *Regii Sanguinis Clamor ad Coelum adversus Parricidas Anglicanos* (1652), which Milton insisted on ascribing to Alexander More, though it was written by Peter Du Moulin (More had had a share in the business). Milton celebrated the achievements of the Commonwealth leaders in the heroic mood of his sonnets on some of them (Fairfax, Cromwell, Vane) — though he was bold enough to warn Cromwell against one-man rule; and, replying to the charge that he had brought on his blindness by immorality, he linked himself with the blind poet-seers of ancient myth in a passage that approaches the invocation to light in *Paradise Lost.* In *Pro Se Defensio* (1655), answering More's self-exculpatory attack, Milton tacitly accepted his denial of authorship but piled up evidence for his general responsibility and personal depravity.

Two tracts on church and state were published in 1659. In *A Treatise of Civil Power in Ecclesiastical Causes* (February), Milton argued that "it is not lawful for any power on earth to compel in matters of religion"; from such large toleration Roman Catholics were exempted, since Catholicism had shown itself a danger to national security. *Considerations touching the Likeliest Means to Remove Hirelings out of the Church* (August) reasserted, against an establishment and its tithes, the ideal of a clergy of apostolic simplicity of life. Much later, in *Of True Religion, Heresy, Schism, Toleration, and... the Growth of Popery* (1673), Milton pleaded for Protestant harmony and unity in place of needless division.

His last political pamphlet, *The Ready and Easy Way to Establish a Free Commonwealth,* was published in March 1660 and again, enlarged, in April. It was an act no less courageous than futile, since machinery was patently moving to bring back Charles II (he made his triumphal entry on May 29). Though Milton's outline of a republican constitution has historical interest, the modem reader's chief reaction is emotional. The tract is a cry of incredulity and despair from the last champion of "the good Old Cause." The glories of the Commonwealth, to which he himself had given 20 years and his eyesight, are being swept away by a nation of slaves "now choosing them a captain back for Egypt" — the "noble and puissant nation" whose faith and love of freedom he had so celebrated in his early pamphlets. The Restoration was the last and heaviest of Milton's many disillusionments.

Many things might be said of his religio-political thinking (and of its effects on later times), but only two can be here. The dynamic centre of his creed was "Christian liberty," a Reformation doctrine which he deepened and widened beyond its common limits. The superseding of the Covenant of Works by the Covenant of Grace is expounded in the *Christian Doctrine* (I, xxvii) and in a grand passage at the end of *Paradise Lost* (xii, 285–306). *In* brief, the Mosaic law was a primitive moral and ceremonial discipline imposed from above upon an untutored people; it is

abrogated for the Christian, who, with the illumination of grace, is a self-governing agent. "freed from the yoke of human judgments, much more of civil decrees and penalties in religious matters." The revolutionary implications of such a creed are obvious —though one must not forget Milton's constant stress on inward discipline. A second point is that the revolutionary radical was not a democrat in the modern sense. He was a classical or "aristocratic" republican in whose ideal vision Platonic philosopher-kings coalesced with the Puritan "saints," and who found historical approximations in ancient Athens and Rome and some modern counterparts.

De Doctrina Christians.-Milton's very large treatise, *On Christian Doctrine,* though now read only by students, held a central place in his thoughts and labours. He seems to have finished it by c. 1658–60. It mas first printed and translated by Charles Sumner in 1825. But Milton apparently hoped that it might, in his own time, provide a solid basis of strictly biblical doctrine on which all Protestants could unite. For such a compendium he had special models in the work of Johannes Wollebius and William Ames. Granted his premises (which of course long ago lost their validity), Milton's treatise contains much acute argument; its modern importance is that it spells out with clear precision the theology that operates in *Paradise Lost.* Viewed in a large perspective, most of Milton's essential beliefs are those of traditional Christianity, but—always on authority he finds in the Bible —he departs from orthodoxy on some notable points (not to mention polygamy): God created the world, not out of nothing, but out of his own substance; God the Father, the Son and the Holy Ghost are not a coequal Trinity but a descending order; man's soul dies with his body. until revived at the resurrection (this "mortalist" heresy, which is put into the mouth of the despairing Adam. had other adherents in Milton's England). The significance of the first point is that, in *Paradise Lost* (v, 469 ff.) as well as in the treatise (I, vii), Milton expounds a monistic and "optimistic" metaphysics, a sort of Christian materialism: since the one first matter of God's own substance is good, since all creation proceeds from God and, if not depraved from good, returns to him. matter is not essentially different from spirit but is forever in the process of becoming spirit. Milton's conception of the Trinity, which in itself and its background is too complex for summary. is apparent to alert readers of *Paradise Lost,* though the poem did not disturb generations of the orthodox. More basic for the poem is Milton's denial of Calvinistic predestination (which of course is not a heresy). Brought up, like most Anglicans of his time. as a Calvinist, he regarded himself as one at least until 1644. but his final belief was in the Arminian doctrine—the salvation, not of a predestined few, but of all believers, who constitute the true "elect." As one would expect of a man who had absorbed classical and especially Platonic ethics, Milton insisted on man's rational freedom and responsible power of choice (a main premise and theme of *Areopagitica).* His conception of "Christian liberty" was noticed in the preceding section. While the *Christian Doctrine* is an invaluable gloss on the epic, Milton the poet was well aware of the gulf between biblical truth and imaginative illustration; in the treatise Satan and the war in heaven received only a few lines.

Sonnets and Other Poems (1642–58).—Milton's early poems, English. Latin. Greek and Italian, were published at the beginning of 1646 (dated 1645). The loss of a gift copy on its way to the Bodleian library. Oxford, prompted an urbane Latin poem (1647) to John Rous, the librarian, a wartime meditation on poetry and culture that is somewhat akin to the sonnet of Nov. 1642, "Captain or Colonel." During the 20 years given to public affairs Milton was mostly cut off from poetry, but he wrote 17 occasional sonnets, versified a number of psalms and began the composition of *Paradise Lost.* Some of the sonnets on public men and events—for which Tasso had set an example—have been mentioned already; these, although so different in form, have the heroic tone of Horace's loftier odes (in Milton's hands, as Wordsworth said, the sonnet became a trumpet), and the leaders he salutes are invested with the large dignity of ancient heroes. "On the Late Massacre in Piemont" (1655) is a tremendous imprecation that suggests the Hebrew prophets. Milton is sometimes consciously Horatian in the urbane geniality of addresses to young friends like Edward Lawrence and Cyriack Skinner; and the sonnets to Lady Margaret Ley and Henry Lawes further attest his genius for friendship. Several sonnets, on the Presbyterian reception of his divorce tracts and on Presbyterian rigidity, are roughly colloquial journalism. At the opposite pole are the deeply personal sonnets, two on his blindness (1651?–55) and one on the death in 1658, some months after childbirth, of Milton's second wife, Katherine Woodcock, whom he had married in 1656. The major sonnets have much poetical as well as autobiographical interest, and as a group they illustrate (with "Lycidas") both in texture and rhythm the beginnings of the grand style which Milton may have learned partly from Della Casa and Tasso and which was to have full scope in the epic. One is less conscious of the sonnet structure and of rhymes than of a single massive unit which approaches a paragraph of Milton's blank verse.

Later Life (1660–74).—The Restoration government executed Sir Henry Vane and exhumed and hanged at Tyburn the bodies of Cromwell, Ireton and Bradshaw—acts of revenge apparently recalled in lines 693–696 of *Samson Agonistes.* Milton himself, as the noted defender of the regicides, was in real danger. In the summer of 1660, when a warrant was out for his arrest, he was kept in hiding by friends; and, though not excepted for punishment in the Act of Oblivion (August), he was later taken into custody (and released on Dec. 15). According to different early stories, his life was spared through the intercession of the poet Andrew Marvell, who in 1657 had become a fellow secretary and was now a member of parliament, or of the royalist playwright Sir William Davenant. whose life Milton had earlier been the means of saving. It may have been thought that the blind writer was now harmless and that nominal proceedings against him were enough; he was even said to have been offered a Latin secretaryship under Charles II. Milton's 14 remaining years were on the whole outwardly and in part inwardly peaceful, although, along with sombre or uplifting thoughts of past and present, there were concrete troubles: a frugal domestic economy necessitated by greatly diminished resources; blindness, and what was sometimes a more severe affliction, the pains of gout; and a degree of friction with his daughters, due probably to faults on both sides. Apart from the publication of books, the chief events of these years were Milton's marriage (1663) to a third wife, a young and amiable Elizabeth Minshull, who survived him, and the removal, during the plague of 1665, to a house at Chalfont St. Giles, Buckinghamshire (now a Milton museum). One cannot catalogue the 11 houses, including temporary lodgings, that Milton occupied in London.

Early biographers give pictures of a quiet daily routine. Milton got up at 4 A.M. and had the Hebrew Bible read to him. Meditation, reading and dictation filled the time till midday dinner. Milton's late and long poems were of course composed in his head, especially at night, as famous allusions in *Paradise Lost* indicate (according to his nephew, Edward Phillips, his vein flowed happily only from the autumnal to the vernal equinox); when he was ready "to be milked," he would dictate, often with one leg flung over the arm of his chair. The taking of dictation, the correcting of copy, and reading aloud in various languages were services performed by paid amanuenses, his two nephews, his daughter Deborah and friends and disciples. After dinner, says John Aubrey, "he used to walk 3 or 4 hours at a time (he always had a garden where he lived)." In the evening there was reading of poetry and he went to bed about 9, after a pipe and a glass of water. One refreshment was music, playing on the organ or viol and singing; "he would be cheerful even in his gout fits, and sing" (Aubrey). And there were many, sometimes too many, callers—foreigners (who came to see the conqueror of Salmasius, not the poet) and English friends. old and young, such as men already mentioned and the young Quaker, Thomas Elwood, whom Milton helped with his Latin. He was, Aubrey reports, "Extreme pleasant in his conversation, and at dinner. supper, etc.: but satirical"; "He pronounced the letter R *(littera canina)* very hard ('A certain sign of a satirical wit'—from John Dryden)." In religion Milton

had moved from the low-church Anglicanism of his parents to Presbyterianism to Independency to independence. In the latter part of his life, said John Toland, "he was not a professed member of any particular sect among Christians. he frequented none of their assemblies, nor made use of their peculiar rites in his family." But, as Dr. Johnson observed, suspending his Anglican hostility, "his studies and meditations were an habitual prayer." Milton died on Nov. 8, 1674. "of the gout struck in" (Aubrey), a month short of his 66th birthday. His burial in St. Giles's. Cripplegate, was attended by "All his learned and great friends in London, not without a friendly concourse of the vulgar" (Toland).

The publications of Milton's late years were: *Paradise Lost* (1667), for which he received £10; textbooks of simplified Latin grammar (1669) and logic (1672); the *History of Britain* (1670); *Paradise Regained* and *Samson Agonistes* (1671); the second, enlarged edition of the *Poems* of 1645 (1673); the second, revised edition of *Paradise Lost* (1674); and *Epistolae Familiares* with the *Prolusiones Oratoriae* (1674). *A Brief History of Moscovia* appeared in 1682. A Latin dictionary on which Milton had long worked was completed by others and published in 1693. Eduard Phillips translated *Letters of State, written by Mr. John Milton* (1694). with a life.

Paradise Lost.—Milton gave up the idea of a British epic described in "Mansus" and *Epitaphium Damonis*. Among nearly 100 biblical and historical subjects for dramas that he set down *c.* 1640, he chose the most momentous event. next to the life and death of Christ, in the world's history. He outlined dramatic treatments of this theme in four short drafts which suggest Italian allegorical representations of biblical story, such as G. Andreini's *L'Adamo* (1613). Edward Phillips recorded that part of Satan's address to the sun *(Paradise Lost,* iv, 32–41) was written early as the opening speech of a drama. In shifting to the epic Milton may have been impelled by the supreme place that form held in Renaissance theory and by his own need for larger scope. It is not known when actual composition began; guesses have centred on 1655–58. Clearly the lines on the poet's having fallen on evil days, in the prelude to book vii, were composed after the Restoration, and presumably the whole mas done pretty much in the order in which it stands. It was finished by 1665. The first edition of 1667 was in ten books; this was reissued in 1668 and 1669, and in one of the 1668 issues Milton added the prefatory note on his use of blank verse and the arguments. In the second edition (1674), along with some small revisions, books vii and x were each split into two; and the arguments, formerly grouped together, were placed at the head of the respective books.

The fall of man had for many centuries received copious theological commentary and innumerable imaginative treatments, narrative and dramatic, so that the simple tale in Genesis and the more shadowy role of Satan in heaven, earth and hell had acquired a good deal of interpretative and concrete embellishment. One late, long and popular example which Milton had known in boyhood is the crudely vigorous poem on the creation and the fall by the Huguenot Guillaume Du Bartas, which, translated by Josuah Sylvester as *The Divine Weeks and Works* (1605), held sway in England until superseded by *Paradise Lost* (line 373 in book iii is identical with a line in Sylvester). And Milton would surely have read Grotius' drama, *Adamus Exul* (1601). His knowledge of both the theological and the literary tradition was probably extensive but can seldom be pinned down; from time to time this or that work has been claimed as his "source," yet the inevitable family resemblance among the numerous poetic versions negates or discounts most such claims. The general fact is that the main motives and events of *Paradise Lost* had more or less precedent, though they were handled with powerful originality; Milton, like a Greek dramatist, was reworking a story familiar in outline to his audience. His story, moreover, was one of unique truth, sacredness and universal and eternal import, and it gave the poet the advantage of immemorial belief and association in the minds of his earlier readers, an advantage that no longer operates in the same way—although, for modern readers, the fable possesses the immemorial and universal import of archetypal myth.

Notwithstanding the accumulated embellishments, and the anthropomorphic nature of the nonhuman personages, the story had little of the solidity and variety of character and action of the classical epics, and Milton the classicist naturally took over much in the way of form and style and epic convention. While he was said to have known the Homeric poems by heart, and often echoed them, the great neoclassical model was the *Aeneid,* with which *Paradise Lost* has some inner as well as surface affinities. As Virgil, with his partly abstract theme, re-created what he imitated from the concrete Homer, so Milton, with his far more abstract theme—the assertion of Eternal Providence, the justification of God's ways to men—re-created what he borrowed from both. Thus invocations of the muse. which in Milton mark new stages in the story or changes of scene, become addresses to the heavenly muse, Urania, and prayers for the aid of the creative spirit of God. As artist, he links himself, both proudly and humbly, with the ancients, especially Homer and the blind bards of Greek myth, but he regularly ranks his Christian theme above the themes of the pagan poets. As he had said long before, in explaining why he must postpone his epic, it was a work not "to be obtained by the invocation of Dame Memory and her Siren daughters, but by devout prayer to that eternal Spirit who can enrich with all utterance and knowledge, and sends out his seraphim, with the hallowed fire of his altar, to touch and purify the lips of whom he pleases."

Some other large features of the classical and especially Virgilian pattern must be mentioned. Milton makes daring use of the prescribed plunge *in medias res,* since he gives the magnificent first two books to his "villain." Virgil has a roll call of the Italian chiefs who gather to oppose the heaven-sent Aeneas; Milton's roll call of the leaders of the fallen angels, in making them individuals, also becomes a survey of the spread of heathen idolatry over the eastern world. The realistic power of the debate in hell dwarfs all other epic councils. Epic accounts of Hades and of funeral games are combined, in Milton's pictures of hell, with Christian lore, but the lurid and dismal scenes and the physical and mental diversions of the fallen angels symbolize their spiritual death and futile striving. The wars of gods and Titans and giants supply details for the war in heaven, which is a large metaphor for the anarchy of sin. The story of events that preceded the opening of the poem, which Odysseus recapitulated at the court of Alcinous and Aeneas at the court of Dido, becomes the archangel Raphael's account of Satan's revolt and war and the Son's creation of the world; and the great object lesson for Adam is underlined by a discourse on astronomical uncertainties which contrasts humble righteousness with the prideful quest of external knowledge. Finally. while a prophetic picture of human history might figure in stories of the fall, Michael's revelation to Adam (books xi–xii) recalls Anchises' revelation to Aeneas; but whereas Aeneas learns of the divinely destined Roman *imperium,* Adam is shown supernal grace contending with the sinfulness of men and the eventual triumph of love with the advent of man's Redeemer—though he is shown too how the gospel of salvation becomes corrupted.

The prime example of this kind, though it goes far beyond classical parallel and contrast, is the characterization of Satan, who is one of the supreme figures in world literature. Satan has, on a superhuman scale, the strength and courage and capacity for leadership that belong to the ancient epic hero, but these qualities are all perverted in being devoted to evil and self-aggrandizement. Satan's character is presented partly through narrative bnd comment and heroic or—later—animal simile (and many of our most vivid visual memories of the poem are of Satan in his various postures and settings). But there is also the full dramatic self-revelation familiar from Shakespeare's villains, and Satan's speeches at moments remind the reader of Richard III, of Iago and Edmund, of Macbeth. Thus in his first grand speech to his lieutenant Beelzebub, Satan's defiance of God manifests in every phrase his egoistic pride and passion, his false conception of freedom. his alienation from all good; and his other public harangues reinforce and amplify our sense of power that is religiously and morally corrupt and blind. Against the background of hell. Satan maintains (up to the final, wholesale metamorphosis that

follows his return from earth) the false magnificence of his "heroic" stature; outside of hell he loses even that. In his soliloquy addressed to the sun he reveals, like Dr. Faustus or Macbeth, his despairing consciousness of his own evil and damnation, a consciousness that gives him potentially tragic dimensions, though he is not allowed to become, like Macbeth, a truly tragic figure. Thus Satan (in his usual public role) and his fellows are enveloped in dramatic irony. because—though the corruption of man is achieved—they fight and scheme in ignorance of the issues at stake, in ignorance of the unshakable power of God and goodness.

Adam and Eve are enveloped in a partly parallel kind of irony. The picture of Eden is a symbolic rendering of Milton's vision of perfection, but it is presented when the reader accompanies Satan into the garden, so that idyllic innocence and happiness are seen only under the shadow of evil. Though the pair have had warnings, Eve is beguiled by an appeal to her vanity and ambition, by the hubristic dream of attaining godlike knowledge and power; and Adam. whose stronger reason is aware of the issues, allows his love for Eve to oversway his love for God. Both, far from attaining godlike knowledge, succumb to animal lust; yet, when grace and penitence begin to work in them, they have a strength beyond the reach of Satan. On the other hand, though there is promised redemption for the faithful, and though the poem is, logically, a divine comedy with a happy ending, Milton's panorama of human history gives little ground for hope on earth. Irony, profoundly compassionate irony, pervades the simple, complex and moving last lines which describe Adam and Eve as they depart from Eden—not now the majestic lords of creation but two frail human beings beginning life anew in the world of sin and sorrow and death, though "with Providence their guide" and the hope of achieving a "paradise within."

The more one reads *Paradise Lost* the more one recognizes Milton's powers of imagination and organization. Everywhere, on the largest or the smallest scale, in abstract idea or concrete act, theme and material are closely knit through parallel and contrast. The central conflict and contrast between good and evil are reflected and intensified in the contrasts between heaven and hell, light and darkness, order and chaos, love and hate, humility and pride. reason and passion. In the council in hell, Satan alone volunteers for the perilous journey to earth to bring about the fall of man; in the council in heaven, the Son alone volunteers to suffer on earth for man's salvation. Satan and Sin and Death, at the gates of hell, constitute a monstrous and abhorrent parody of the Trinity; when Sin and Death build a bridge from hell to earth, their new domain, they hover upon the waters, like the spirit of God at the creation. Satan unlooses the destructive anarchy of war; the Son creates the world. Eve and Adam reenact the sin and fall of Satan. The boundless scene of *Paradise Lost* is indeed only a backdrop or magnified reflection of the drama that goes on in the hearts of the human protagonists; and when they fall, the ideal world of eternal spring and eternal life becomes the world we live in.

To speak of the setting in more literal terms. Milton's imagination fills space so immense that the created universe—the Ptolemaic one—hangs from heaven like one of the smallest stars close by the moon. Milton showed his awareness of the Copernican universe but the Ptolemaic had the advantages of traditional familiarity and of keeping earth and man at the focal centre. In his handling of vast space Milton's imagination and language work with a suggestive vagueness (mixed with the substantial and concrete) that is very different from the minute particularity of Dante's world. He is excited by the starry dance of the cosmic order, and likewise by the fecundity of Eden; and the account of creation is alive with the sense of movement and growth. The poem is rich in its appeal to the eye—and other senses—as well as to the ear.

Milton's preface stressed the novelty and rightness of blank verse for a heroic poem, and his manipulation of rhythm and sound is of course one of his supreme achievements. The continuous flow of his long sentences and paragraphs is naturally unlike the dramatic blank verse of Shakespearian dialogue, and it builds up a continuous onward pressure. Some main elements of Milton's technique had been conspicuous in his sonnets, in spite of their pattern of rhyme. While the iambic pentameter line remains in one's ear as the norm, there may be extra syllables, and there is endless variety in the number, weight and position of stresses. At the same time there is a secondary and still more fluid system of rhythmic units, which flow from the caesura in one line to the caesura in the next. The principle stated thus baldly means, in practice, an infinity of permutations and combinations. As a modern master of rhythm, T. S. Eliot, has said, Milton's blank verse is never monotonous. And the pattern of sound is so wedded to the pattern of sense that each is essential to the other.

Milton's frequently Latinete syntax and diction have sometimes been censured, especially by modern poets and critics for whom colloquial speech and rhythm are the only acceptable medium (though this is in fact no less "artificial" than the grand style). Milton had both ancient and modem (especially Italian) tradition on his side; Homer and Virgil were, in their different ways, thoroughly stylized, and such moderns as Tasso had practised and critically expounded the various ways of achieving the elevation required by a lofty theme. Miltonic elevation is rarely inflation; and it is intermixed with pure simplicity. Latinate syntax or structure, freedom in the placing of phrases and clauses, does not obscure the sense and greatly enlarges and enriches the poet's range of emphasis, the means of economy, contrast, suspension, all the devices of forceful utterance—devices often really colloquial. Many other and likewise functional elements of the grand style could be noted: periphrasis, epic similes, geographical, historical and mythological allusions, etc.

Paradise Regained.—In *Paradise Lost* (ix) Milton spoke of "patience and heroic martyrdom" as themes unsung, though nobler than martial prowess, and this "better fortitude" was celebrated in *Paradise Regained* and *Samson Agonistes* (1671). Presumably both works were composed after *Paradise Lost*. In the *Reason of Church-Government (1642)* Milton had named the Book of Job as a model for a brief epic, and its influence is clear in both. *Paradise Regained* is a logical sequel to the long poem since Christ, the second Adam, wins back for man what the first Adam lost. But Milton did not, as his title and theological tradition might suggest, deal with the Crucifixion; instead he showed Christ in the wilderness overcoming Satan the tempter, thereby proving (by God's design) his fitness for his ultimate trial and, in his human role, proving what man in general might achieve through strong integrity and humble obedience to the divine will. Milton follo ed Luke's version. The first temptation, to change stones into bread, would imply distrust of Providence. The second temptation. that of the kingdoms of the world. Milton extended into a series—a gorgeous banquet, wealth, glory, the delivery of Israel from the Roman yoke, alliance with Parthia or Rome, the imperial throne and. finally, the wisdom of Greece. Christ is proof against all of these. "To the utmost of mere man both wise and good." Dramatic tension has been built up by Satan's tormenting doubts of his antagonist's identity and mission, and also by Christ's own deepening knowledge of both and by our mounting sense of his isolation. The third temptation, that of standing on the pinnacle of the temple, is a challenge which, with dramatic suddenness, reveals Christ's divinity to both Satan and himself. This poem, less of an epic than a drama with elaborate stage directions. is cast in a style of almost gospel simplicity. The mass of readers and critics seem to have found it cold, though it has all the fire of Milton's religious and moral passion, his reverence for true heroism. Many, too, have been upset by Christ's repudiation of the Greek culture which Satan praises in language that seems to come, and does come, from the poet's own heart; but Milton had always, like other Christian humanists, ranked the literature and natural wisdom of antiquity below the Bible and Christian faith. There is a scale of values.

Samson **Agonistes.**—That Christ's rejection of Greece is relative, not absolute, is shown by the fact that *Samson,* in the same volume with *Paradise Regained,* is in the pattern of Greek tragedy,

which (along with Italian) Milton extols in his preface. Samson, by far the greatest English drama on the Greek model—and. for some readers, the most powerful and completely satisfying of Milton's major works—has affinities with all three of the Greek masters because the poet did not "get up" the technique for the occasion; he wrote out of lifelong saturation and as the Christian peer of the ancients. But the drama recalls especially Aeschylus' Prontetheus Bound and Sophocles' Oedipus at *Colonus*. Always a strict observer of "decorum," Milton admits no specifically Christian idea. attitude or allusion; his hero, to be sure, is not at all the brawny barbarian of the book of Judges, but he remains Hebraic—with touches, toward the end, of a calm reasonableness that reminds one of Socrates in prison. The action up to the reported catastrophe, is wholly psychological; it is the process by which Samson. "Eyeless in Gaza at the mill with slaves." moves from preoccupation uith his misery and disgrace to selfless humility and renewed spiritual strength, so that he can once more feel himself God's chosen champion. Still more clearly than the Christ of Paradise Regained, Samson is isolated; not even his father or the chorus perceives the true inwardness of his experience. The whole drama is charged uith more than Sophoclean irony. Every scene has an effect different from that expected by the interlocutor; and countless details, from the title and the first line onward, are potently ambiguous. Though the subject had long been in Milton's mind, the drama must owe a good deal of its power to his sense of kinship with his hero; he has been eyeless in London among a nation of slaves. But nowhere does the classical impersonality and restraint of Milton's art show itself so strongly; there is nothing in the drama that does not belong to the story of Samson. And Milton's classical style appears in a new phase, in a rugged, sinewy, colloquial texture and in irregular rhythms of new expressiveness. Altogether, if Samson was his last work, it was a grand testament. Like Samson, Milton was able to conquer despair, or to sublimate it in his last three poems. These expressed, not his earlier revolutionary faith in men and movements. but a purified faith in God and the regenerative strength of the individual soul.

Miltonic Criticism.—Much of the older criticism, down into the 20th century, is mainly of historical interest and may give modern readers less insight into the poet than into the critic and his cultural climate; but Milton's fame and influence are part of the history of English literature and culture (and libertarian thought). Since criticism in the modern sense was only being created by his young contemporary, Dryden, there is little early testimony: Sir Henry Wotton's praise of *Comus* (in the letter prefixed to the Poems of 1645). Marvell's commendatory lines on Paradise Lost (1674), Dryden's epigram linking Milton with Homer and Vergil and his more restrained comments in prose, and a few anecdotes. Of special interest is Dryden's report (preface to the Fables): "Milton has acknowledged to me that Spenser was his original"—*i.e.*, general model. But Milton's growing eminence is attested by the series of early biographies (Early Lives of *Milton*, ed. by H. Darbishire, 1932): the anonymous manuscript first printed in 1902 (assigned by Miss Darbishire to Milton's nephew, John Phillips, but claimed by W. R. Parker for Cyriack Skinner); the notes, printed in 1813, of the lively and careful John Aubrey; and the lives by Anthony à Wood (1691), who has next to no original value, Edward Phillips (1694), John Toland (1698) and Jonathan Richardson (1734).

Patrick Hume's annotated edition of Paradise Lost (1695)—one of Jacob Tonson's five editions of 1688–98—mas the first scholarly edition of any English poet. Richard Bentley's edition (1732) was the disastrous attempt of a great classical scholar to emend a supposedly corrupt text. Better evidence of Milton's classical standing was Bishop Newton's variorum edition of the poems (1749–52) and Thomas Warton's edition of the early poems (1785; rev. 1791). Criticism proper began with Addison's papers on Paradise Lost in The Spectator (1712) in which, accepting Milton as the peer of the ancients. he applied neoclassical theory. noted classical parallels and praised "beauties." Addison was a prime agent in extending Milton's fame on the continent. Dr. Johnson's treatment (Lives of the Poets, 1779) suffered from his political and religious prejudice and from some critical failures of understanding. but it retains the value of its author's massive honesty and genuine if limited insight. Milton's enormous influence on 18th-century verse is traced by R. D. Havens, *The Influence* of *Milton* on English Poetry (1922).

The 19th century opened with H. J. Todd's variorum edition of the complete poems (1801; rev. 1809; 5th ed., 1852), which is still useful. and may be said to have closed with David Masson's important edition (1890). Masson's Life (6 vol., 1859–80, with revised editions of the first 3 vol. and an Index, 1881–96) is subject to correction on many things, but it was a great achievement and remains of much value for Milton's life and times.

Nineteenth-century criticism includes many notable names, such as Hazlitt, Coleridge, Keats, Landor, Macaulay, Emerson, Bagehot. Arnold, up through the larger and more professional studies of Mark Pattison (1879) and Sir Walter Raleigh (1900). A brief summary may divide criticism of the 19th arid the early 20th century into two main streams. First, the revolutionary romantics, Blake and Shelley, launched the "Satanist" misinterpretation of Paradise Lost and its author which is summed up in Blake's saying that Milton was of the Devil's party uithout knowing it; that is, Milton—as a rebel like Blake and Shelley—projected himself into Satan, his real hero. The other main attitude, also focused on the epic, was also a product of 19th-century liberalism; its exponents threw Milton's beliefs and ideas overboard as long-dead fundamentalism and listened only to the organ voice.

Milton's influence, which had worked from about 1650 up through the romantic poets, largely waned in the Victorian age. In the 20th century the new poetry and criticism inaugurated by Ezra Pound and T. S. Eliot was strongly anti-Miltonic and pro-Donnian. but in the 1940s and 1950s critical activity shifted markedly from Donne back to Milton. Scholarship. going its own way, had already discovered "the new Milton." The movement in scholarship and scholarly criticism which began about 1920 and which (in the late 1950s) showed no sign of exhaustion, produced a vast and varied array of general and special studies; these placed the thinker, the publicist and the poet firmly and significantly in the history of ideas, exterminated the romantic notions touched on above. and brought a new refinement of perception and analysis to the aesthetic study of the poetry (though a poet steeped in the classics may have fared better, in that area, with the older critics). A conspectus is provided in James Thorpe, Milton Criticism: *Selections* From Four Centuries (1950).

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(D BH)

MILTON, a town of Norfolk county, Mass., U.S., located on the Neponset river 7 mi. S. of Boston on hilly terrain that falls gently down to the river from the Blue hills in the south. Settled in 1636 as a part of Dorchester and known by the Indian name of Unquity-quisset, the town of Milton was incorporated in 1662. It soon grew into a mill town and in the 18th century was an important small industrial centre. Industrial activity decreased during the 19th century with the important exception of stone cutting. Stone for the Bunker Hill monument was quarried in Quincy, cut in Milton and transported by the Granite railway, the first railroad chartered in the U.S.; motive power was furnished by horses and oxen.

In the late 19th century Milton became a wealthy suburb of Boston. The large estates were gradually broken up after 1930 and Milton became a suburban community with a small amount of manufacturing. Milton academy (boys) and Milton Academy Girls' school are located there. Blue Hill observatory was established in 1885. For comparative population figures *see* table in MASSACHUSETTS: *Population.*

(L. G. BA.)

MILWAUKEE, the largest city of Wisconsin, U.S., is located on the west shore of Lake Michigan, 85 mi. N. of Chicago; a port of entry and seat of Milwaukee county. Population (1960) city 741.324; standard metropolitan statistical area (Milwaukee and Waukesha counties) 1,194,290. (For comparative population figures see table in WISCONSIN: Population.)

The city proper is entirely within Milwaukee county and almost wholly hemmed in by incorporated suburbs, including Wauwatosa and West Allis (*qq.v.*). The altitude of 580 ft. at lake level rises 75 to 125 ft. to the west. Three rivers cut the city into natural divisions: the Milwaukee river, entering from the north, is joined half a mile from its mouth by the Menomonee flowing from the west, and nearer the lake by the Kinnickinnic from the south; it empties into Milwaukee bay, about 6 mi. wide. Commercial and industrial property lines the banks of these streams in their navigable, downtown sections. A large part of the lake front was reclaimed or redeveloped for parks and municipally owned outer harbour facilities, including Lincoln Memorial drive. The Court of Honor, a broad park space dedicated to participants in U.S. wars, extends for three blocks on Wisconsin avenue, past the public library and museum. In the heart of the city lies the City centre, a municipal redevelopment area dominated on the west by the massive neoclassical courthouse, made of Indiana limestone, and extending to lake-front Juneau park. Side by side on its north are the municipal auditorium and arena, whose halls can seat 24.500 persons and provide 140,000 sq.ft. for exhibits; on the south the city hall (1894) suggests a Flemish Renaissance town hall. The county's parks and river parkways cover more than 9,100 ac. and provide for all the popular games and recreations, including an extensive zoological garden, botanical gardens and golf courses. County stadium (capacity 43,110) is the home of the Milwaukee Braves, baseball team of the National league.

History.—In 1673 Jacques Marquette and Louis Jolliet skirted the west shore of Lake Michigan in their canoes, and Milwaukee bay is distinctly marked on a map attributed to Marquette. La Salle and his party probably stopped there on their way south in 1679 and the name (spelled Melleoki) first appears in missionary records of that year. Occasional French fur traders may have visited there in the late 17th century. By the time of the American Revolution, British traders also were stopping. Jacques Vieau used the Milwaukee post annually for the North West Fur company (British) from 1795 to 1818, when he was superseded by his French-Canadian son-in-law Solomon Juneau (1793–1856), representing Astor's American Fur company. The settlement, sporadically occupied by Indians, was on the route from Fort Dearborn (Chicago) to Green Bay, and as soon as Indian titles in southeastern Wisconsin were extinguished by treaties with the Menominees and others, 1831–33, land-seekers appeared. In 1833 Morgan L. Martin (1805–87), a Green Bay land speculator of New York birth, visited Milwaukee, mapped the harbour, and conceived of townsite speculation. In association with Michael Dousman he entered into an agreement with Juneau for a half interest in the latter's pre-emptive claim to the east side. The next year Connecticut-born Byron Kilbourn (1801–70) and a Virginian, George H. Walker (1811–66), planned a similar promotion of the west and south sides. Platting of the townsite occurred in 1835. with completion of the survey and opening of the land to public sale. Two of the villages, officially Milwaukee East Side and Milwaukee West Side, were popularly known as Juneautown and Kilbourntown; rivalry between them, especially over bridges, streets and finances, survived their union as two wards of the town of Milwaukee in 1839 and the addition of Walker's Point (to the south) in 1845. In 1846 the three wards, which up to that time had each retained complete financial and administrative autonomy of its own affairs, were incorporated as the City of Milwaukee, with Juneau the first mayor.

The first newspaper, the Milwaukee Advertiser, began publication on July 14. 1836. In the same year a public school district was formed but a free school system awaited incorporation of the city. In 1839 George Smith and Alexander Mitchell established the Wisconsin Marine and Fire Insurance company, which, despite its name, served as one of the strongest banking houses west of the Alleghenies for over 40 years. The first brewery was built in 1840. Harbour development, advocated as early as 1834, soon permitted Milwaukee's emergence as a major grain and flour port, draining the wheat-raising hinterlands to the Mississippi by plank road and rail. Commerce dominated the city's early decades, but in post-Civil War years industry developed, especially meat packing, tanning, brewing and iron and steel making.

Population Characteristics.— About 1840 the Yankee village received the first German migration; by 1900, 72% of the population had Germanic origins which marked the city's society and culture. Modest Irish and Scandinavian migrations dwindled late in the 19th century before a Polish influx, which impressed the city's south side as much as the Germans on the north. Additional east and south European elements joined a Negro migration from the south in swelling the city's population in the 20th century. An 1850 population of 20.061 swelled to 285,315 by 1900 and 578,249 by 1930, after which growth was slight.

Government.— The city operates under an 1874 charter, providing for a "weak" mayor and a "strong" board of aldermen, representing 20 wards, elected every four years. A charter convention of 1908 failed to bring reform but a home rule amend-

ment to the state constitution in 1924 permitted revision by simple council ordinance. Frank P. Zeidler served as mayor from 1948 to 1960, the third member of the Socialist party to become the city's chief executive (Emil Seidel 1910–12, Daniel W. Hoan 1916–40). Henry W Maier became mayor in 1960.

Two pumping stations of the municipal water works provide a daily average of 142,000,000 gal. from Lake Michigan to city and some suburban consumers. The policy of financing expansion from earnings mas necessarily abandoned as new consumption demands mounted rapidly. In 1925 a sewage disposal system based on the activated sludge process was completed at a cost of $10,000,000 nith a daily capacity of 85,000,000 gal. Additions permitting treatment of 115,000,000 gal. were placed in operation in 1935 and 1951. Co-ordination of city sewage disposal with that of the suburbs has been provided since 1921 by a metropolitan sewerage commission. Water purity is guarded by a $5,100,000 filtration plant put into operation in 1939.

A Progressive era reform movement brought Milnaukee a reputation for clean and efficient government. Nonpartisan elections (1914), law enforcement free from politics, long tenure for able career administrators and a civic conscience supporting expanded government services on a pay-as-you-go basis characterized the city. But in the 1960s tension with the 18 suburbs in the county—eight neuly incorporated and several sparsely settled—had replaced housekeeping functions as the city's major concern. Programs for an expanded uater supply, expressways, public housing. renewal and redevelopment of the city's core, downtown parking and cultural and recreational facilities not only represented municipal maturity but also entailed new relationships to suburban, county, state and federal governments.

Commerce, Industry and **Transportation.**—Milwaukee is the commercial metropolis of the state and a major industrial centre of the United States in the value of its manufactured products. Its fine harbour, open during most of the year and accessible to the largest ships using the Great Lakes-St. Lawrence seaway, is the most important gateway to the northwest for traffic across Lake Michigan. Water-borne commerce in the second half of the 20th century amounted to 7,500,000 to 9.000.000 tons annually. For more than a century Milwaukee has been one of the great grain ports of the Great Lakes. A small but increasing portion of its port tonnage is overseas. Wholesale trade covers the upper Mississippi valley; retail trade suffers from nearness to Chicago.

The leading manufactured products are electrical machinery. construction and mining machinery, castings and forgings, general industrial machinery and autos and auto parts. Dependence on such capital goods somewhat obscures important consumer products—small gasoline engines, batteries, locks, motorcycles, outboard motors, beers, shoes and meats. The largest firms do not dominate the local economy nor is military buying so important as in other heavy industry centres. Local and in many instances family ownership of substantial concerns has persisted longer than nas usual in other places. The labour force is highly skilled and well paid.

Several federal highways enter and pass through Milwaukee. Railways connect the city with Chicago and with the "Twin Cities" of Minneapolis and St. Paul, Minn., and with the west; some eastern rail traffic goes by car ferry across Lake Michigan. Milwaukee county's General Mitchell air terminal on the south is a regular stop for commercial airlines; it handles both passengers and freight. The Lawrence J. Timmerman airport to the northnest is for feeder use. Numerous motor coach, truck and lake steamship lines serve the community. Electric and gas buses have superseded trolley cars within the city, while expressnays violate a checkerboard street pattern to facilitate auto flow from central city to suburbs.

Education and Welfare.— The public school system includes elementary and junior, senior and technical high schools and a vocational school, founded in 1912, which offers apprenticeship, continuation, adult vocational and recreational. and accredited high school and junior college programs. There are also Roman Catholic and Lutheran elementary and high schools. The central library services a number of neighbourhood branches and some of the suburbs. The museum of natural and human history has a special collection of prehistoric American Indian materials. Its typewriter collection appropriately reflects the Milwaukee invention of the first practical instrument in 1869 by C. Latham Sholes. The Milwaukee Art centre, housed in the War memorial on the lake front, combines collections of the former Milwaukee Art institute and Layton Art gallery. The Layton School of Art became a degree-granting institution in 1951, the Wisconsin Conservatory in 1930. Marquette university, a Roman Catholic coeducational institution founded in 1881, provides liberal arts. business, engineering. dental, medical, law and journalism curricula. The University of Wisconsin-Milwaukee combines the former facilities of the Milwaukee State (Teachers) college and the University of Wisconsin's Milwaukee extension division, merged in 1956 as an autonomous unit under a provost responsible to the president and regents of the university. It awards degrees in education, letters and science, commerce and engineering. Milnaukee-Downer college, a private college formed in 1895 by consolidation of Milwaukee college and Downer college of Fox Lake, instructs women in liberal arts, home economics and occupational therapy. Alverno (1887), Cardinal Stritch (1934) and Mount Mary (1872) are Roman Catholic colleges for women; St. Francis seminary (1856) prepares Catholic priests; and Concordia college (1881) offers a Lutheran preseminary two-year course. Milwaukee School of Engineering (1903) is internationally known for electrical and mechanical training. In suburban Wauwatosa, county welfare institutions care for the aged, dependent, diseased and insane, while at Wood there is a U.S. veterans administration hospital on the site of one of the nation's three original post-Civil War soldiers homes. Civic programs for public health, traffic safety and fire and crime prevention have brought many records and awards since the 1920s.

The *Milwaukee* Sentinel (morning; founded 1837; daily since 1844) and the *Milwaukee* Journal (evening; founded 1882) are augmented by a German and a Polish daily, the survivors of a once thriving foreign language press, and by numerous church, suburban and foreign language weeklies. Several television stations. one of them an educational outlet of the vocational school, and several radio stations transmit local and network programs to the area. (F. I. O.)

MILYUKOV, PAUL NIKOLAYEVICH (1859–1943), Russian politician and historian, was born near St. Petersburg (Leningrad) on Jan. 27, 1859. He studied history and humanities at the University of Moscow, and received the degree of master in history for a learned work on the State *Economics* of *Russia* in the First *Quarter* of the 18th *Century.* His liberal opinions brought conflict with the educational authorities, and he was dismissed in 1895 after a university "riot." After the meetings of the zemstvos (1905) he became political editor of Retch, helping to found the Constitutional Democratic party (Kadets). He became the leader of that party, although he was not elected a member of the first or second *duma.* When the tsar dissolved the first *duma* he helped draft the "Viborg manifesto," in which members of the duma declared themselves ready to follow the people in resisting arbitrary rule. Milyukov did not sign, as he was not a member of the duma, and escaped the persecution accompanying the Stolypin reaction. He nas elected to the third and the fourth *duma,* and was a leader of the opposition.

When World War I broke out he stood for national union and co-operation with the entente, but the maladministration of the nar office increased his hostility. Milyukov took office in Prince Lvov's provisional government as minister of foreign affairs. When the Bolsheviks seized power he escaped to Kiev, then occupied by the Germans. and gave up the cause of the Allies as lost. After the Armistice, Milyukov went to London, then to Paris, where in 1921 he directed a journal (Last News), advocating an alliance with patriotic Socialists. He died March 31, 1943.

His works include a *History of the Second Russian Revolution,* 3 vol. (1921–23) and *Russia's Catastrophe,* 2 vol (1927).

MIME, an ancient Greek dramatic form in which the players portrayed events of everyday life, with the help of elaborate ges-

tures; the name came to be applied also to the actors themselves. As literature. the mime developed in Sicily and southern Italy (jth century B.C.) through the prose of Sophron and Epicharmus. and later (3rd century B.C.) through the metric compositions of Herondas. The *mimus* found its way into Roman literature (1st century B.c.) through D. Labienus, Publius Syrus and others. For later growth and development *see* DRAMA; PANTOMIME.

MIMETITE, a mineral consisting of lead chloroarsenate and closely resembling the lead chlorophosphate pyromorphite (*q.v.*) in appearance and general characters. The arsenic in mimetite is usually partly replaced by equivalent amounts of phosphorus; thus, there may be a gradual passage from mimetite to the isomorphous pyromorphite. The two species can, as a rule, only be distinguished by chemical analysis and because of their close resemblance, the less frequently occurring chloroarsenate was named mimetite or mimetesite, from the Greek word for imitator. Like pyromorphite, mimetite is found in the upper parts of veins of lead ore. where it has been formed by the oxidation of galena and mispickel. When found in large amount it is important as an ore of lead. Its composition can be represented by the formula $Pb_5(AsO_4)_3Cl$ and it crystallizes in the hexagonal system. Crystals of pyromorphite though usually optically uniaxial are sometimes biaxial, but in mimetite this anomalous character is almost always present; a cross-section of a hexagonal prism of mimetite shows a division into six optically biaxial sectors or a complex lamellated structure. In colour mimetite is usually yellow or brown, rarely white or colourless; the lustre is resinous to adamantine. The hardness is 3.5; the specific gravity. 7.0–7.2j. The best crystallized specimens are those from Johanngeorgenstadt in Saxony, Wheal Unity in Cornwall, and Tsumeb in southwest Africa. In the United States mimetite has been found in Pennsylvania and in Arizona. California. Nevada and Utah. It was formerly found in considerable amount at Drygill, Cumberland, as six-sided barrel-shaped crystals of a brownish-red or orange-yellow colour; this variety has been called campylite from a Greek word meaning curved, because of the remarkable curvature of the faces of the crystals.

MIMICRY. The word "mimicry" is applied by naturalists to certain advantageous resemblances between animals, and in some instances between plants. The resemblance of the common dead-nettle to the stinging nettle, with which it is commonly associated, is a good example of plant mimicry. These resemblances are independent of affinity, viz., they may exist between species of very different degrees of relationship, generally distant but sometimes near; they are such as appeal to the senses of enemies, especially to the sense of sight, not uncommonly to hearing, occasionally to smell and touch. They differ from the much larger class of Protective Resemblances in that these bring about concealment by a likeness to some object of no interest to enemies, whereas the true mimic resembles a conspicuous "model" feared or disliked by its enemies, and thus becomes conspicuous itself. Other differences have been suggested — that the mimic resembles an animal model and not the vegetable or mineral surroundings; that it resembles a moving and not a stationary object. These distinctions, although generally true, do not always hold. The resemblance of external parasites to the hair, feathers or skin of their host, and of many insects to the excrement of birds, snails or of other insects, and to empty snail-shells, is not mimicry but protective resemblance, which would also include those caterpillars whose curious swaying movements suggest a swinging fragment of twig, or butterflies and moths which float to the ground like a falling leaf or allow themselves to be driven like a leaf before the wind. Mimics are also commonly adapted to resemble their models in the position of rest as well as in flight.

Mimetic resemblances also differ from those which are an incidental result of similar functions, such as the general likeness in form between the racehorse and the greyhound or between the mole-like species with mole-like habits of life in the insectivores, rodents and marsupials; also from the incidental likeness between species which resemble the same part of their surroundings — sand, bark, leaves, etc. Mimetic resemblances differ from these in that they have been developed for the sake of the resemblance because of some advantage conferred in the struggle for existence. The term "mimicry," implying in its ordinary use conscious imitation, has been a source of confusion; it has now, however, a technical scientific meaning.

Other views as to the origin of these resemblances are: — that they are due (1) to the direct influence of the environment acting similarly on different species; (2) to a physiological response to constant mental experience such as colour sensation; (3) to sexual selection, modified by the presence of other types of colour. This last suggestion, due to Fritz Müller, is not supported by the fact that female butterflies are far more commonly mimetic than males.

Although mimetic resemblance is believed to exist in mammals, birds and fishes the number of examples is small and their interpretation often doubtful. Among reptiles poisonous snakes are mimicked by harmless species. Even the English grass-snake will often, when cornered, poise itself and strike like an adder. But for the study of the subject the insects are supreme, the small percentage of survival and swift succession of generations rendering natural selection peculiarly searching in its operation and rapid in its results.

DANAINE BUTTERFLIES

The striking similarity of one animal to another illustrates that mimicry is an advantageous resemblance and has been developed for its own sake — facts which are meaningless on any suggested interpretation except one based on selection. The butterflies most generally mimicked by species of other groups and by day-flying moths belong to a few dominant tropical sub-families, the Danainae and Acraeinae of the Old World, and, in the New, the Ithomiinae, allied to the first, and the Heliconinae allied to the second, together with very few Danainae and many Acraeinae. Now, however widely the types of pattern vary within each of these sub-families, they are still mimicked by butterflies of other groups and often by moths. The South American Acraeas have very different patterns from those of the African Acraeas, yet both are extensively mimicked. The most striking evidence is, however, supplied by the divergent colours and patterns of the Danaine models.

The Oriental *Hestia* and its allies are large, black-and-white butterflies with thin papery wings. A characteristic example is *Hestza leuconoe* from the Philippine islands and its swallowtail mimic *(Papilio idaeoides),* family Papilionidae, from the same locality. In this and the following pair it must be borne in mind that the mimic is but a single example selected to represent many butterflies of different groups, and also day-flying moths. which mimic the same type of pattern in various parts of the Oriental region. The male of *Euploea midamus,* an example of a far more dominant and widespread Danaine type, that of the blue *Euploeas,* has a blue swallowtail mimic *(Papilio paradoxus).* These two species are endemic in the same part of the Malayan peninsula. In Africa the Danaines are much less numerous but still supply the chief models for mimicry. The majority of the species belong to the genus *Amauris,* black butterflies with white or yellowish markings, very unlike the Oriental Danainae.

An entirely different type of Danaine pattern is borne by a series of nearly related species in the Oriental region, which must be regarded as the original home. This pattern is of especial interest for the present argurnent, because one species bearing it has migrated westward and become the chief model for mimicry in Africa. while two others have travelled eastward and become the ancestors of American species mimicked by species of indigenous American butterflies.

The best-known invader, the monarch butterfly *(Danaus plexippus),* together with its mimic, the viceroy *(Basilarchia archippus),* are particularly well-known examples in North America The viceroy (of the family Nymphalidae) is related to the British white admiral and itself so recently descended from a North American white admiral that the two will interbreed and produce hybrid offspring In all the earlier stages of its life-history the mimic remains a white admiral, the mimetic resemblance being restricted to the final colour and pattern. If, as some have supposed, mimetic likeness is the result of local influences, we should expect that the invader would have come to resemble the native rather than that

the native should mimic the invader.

The above facts point directly to the conclusion that there is some advantage in mimicking Danaine butterflies, and, if space permitted, similar evidence could be brought forward to show that the widespread mimicry of the other great tropical groups is also advantageous. The proof becomes especially convincing in certain butterflies with many forms of female. Thus, three Uganda females of the African swallowtail *Papilio dardanus* mimic respectively three very different Danaine patterns, and the fourth an Acraeine; and in other parts of Africa where the Danaine patterns alter, and one of them or the Acraeine model is absent, we find that the corresponding female is similarly modified or wanting. In another African swallowtail. *Papilio cynorta,* the females mimic an Acraeine. changing geographically with the changes of the model. But in Abyssinia, where there is no appropriate model of this group, the female mimics a Danaine.

From these and many other examples it is evident that in butterflies the female is more commonly mimetic than the male. Furthermore when both sexes mimic, the female's likeness to a model is often the more complete.

Returning to a consideration of the advantages secured by mimicking the great tropical groups we find that their species possess conspicuous patterns made up of contrasted tints, the pattern of the under-surface of the wings being generally similar to that on the upper, so that when these butterflies fly with their characteristic flapping or sailing flight, or rest with wings closed, the colours and patterns, once learned, are easily recognized. Many of the species when disturbed emit an unpleasant odour which in some species is known to be secreted by special glands. When offered to insect-eating animals they are rejected except under the stress of hunger, and they have been seen to be attacked and rejected by enemies in the wild state. Their tissues are soft and flexible so that they can often recover from the injuries of experimental tasting. Just as these groups of butterflies are foremost in providing models for mimicry so are they conspicuous in the possession and in the advertisement of qualities which protect against attack.

Mimicry of the advertisement suggests possession of the qualities. That young insect enemies do learn to associate the advertisement with the qualities has been proved by the interesting experiments of Lloyd Morgan. It must be remembered that the qualities are of the most varied kinds. Thus C. F. M. Swynnerton has shown that large African butterflies *Charaxes,* although palatable, are rejected because of their toughness, thus accounting for the mimetic likeness to them borne by smaller and less tough species of the genus; also for the resemblance of larger species to one another.

It is interesting to note the diverse occurrence of mimicry. Species of the great tropical groups are not only mimicked by other butterflies but they also mimic each other. Thus several African Acraeines mimic Danaines, while in both groups the species of one genus sometimes mimic those of another; the same is true of the Oriental Danaines.

In tropical America the few Danaines and many of the Heliconines mimic species of the dominant group, the Ithomiines. This last mimetic association has been a fruitful source of confusion, for the superficial resemblance between the Ithomiines and an important section of the Heliconines is so strong that both groups were united under the Heliconidae by the older naturalists. But in the meantime naturalists have recognized the true distinction, placing the two sections far apart, the Ithomiinae being placed next to the Danainae, and the Heliconinae next to the Acraeinae.

Now in the numerous mimetic associations between the two groups, the Ithomiinae, with hardly an exception, are the models and the Heliconinae the mimics.

BATESIAN AND MÜLLERIAN MIMICRY

It is obvious that this resemblance between the butterflies of distasteful groups is, as Bates recognized, a different thing from the mimicry he sought to explain by his hypothesis — the likeness of a harmless or palatable species to a formidable or nauseous one which advertises its qualities by warning characters, especially colours, but often by movement, attitude or sound. The mimic gains advantage by the display of false warning characters. This is called "Batesian Mimicry" after its discoverer. The resemblance between the distasteful species themselves was later explained by Fritz Müller as an adaptation which economizes life by facilitating the education of enemies.

If two distasteful species are alike they will share between them the lives which must be sacrificed before the enemies have learned to associate the warning characters with their special means of defence. If they are unlike, the lives must be contributed by each of them independently. These resemblances, which are a form of common or combined warning, are called "Mullerian mimicry." A Batesian mimic may be compared to an unscrupulous tradesman who copies the advertisement of a successful firm; Miillerian mimicry to a combination between firms to adopt a common advertisement and share the expense.

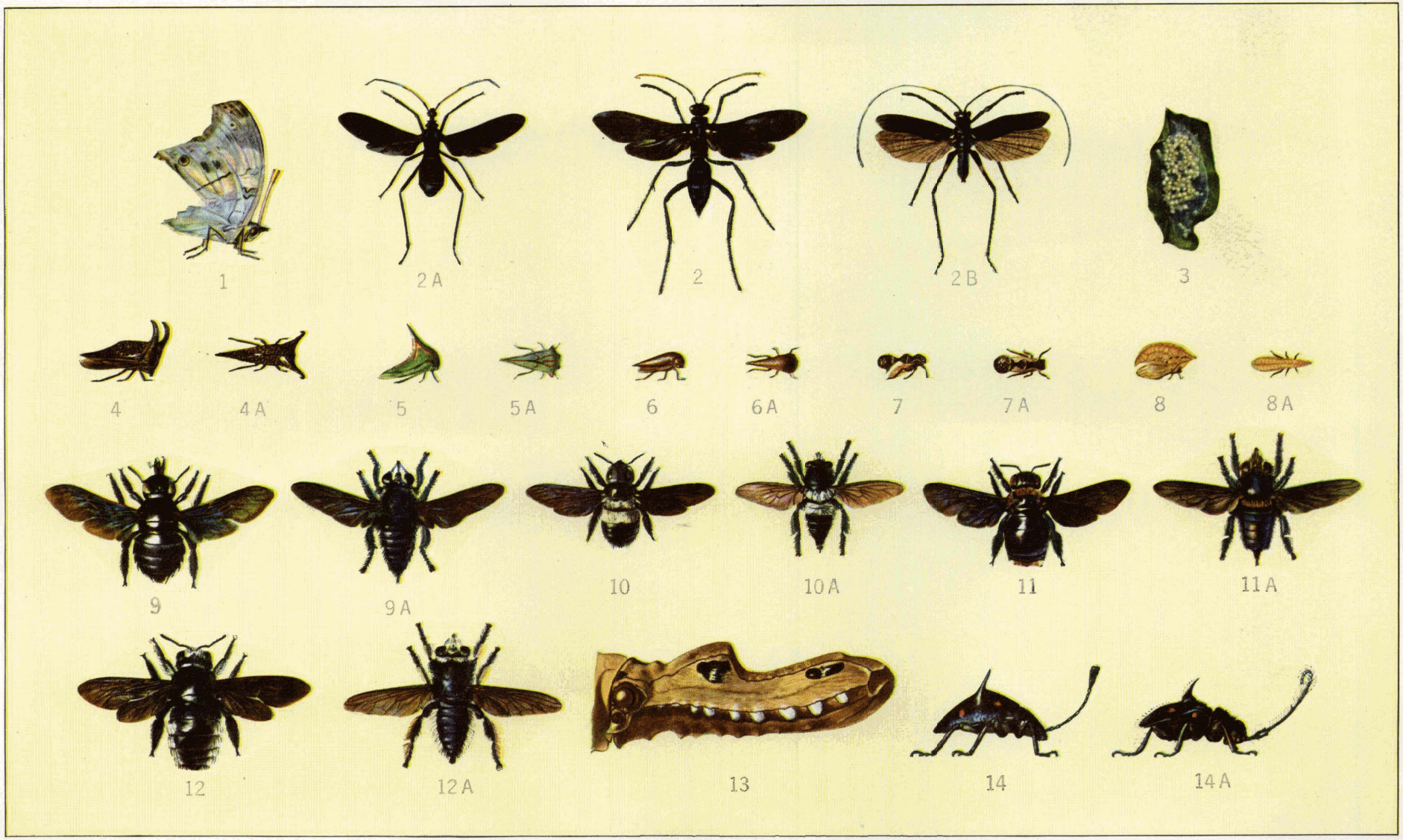
While Batesian mimicry is never an advantage and may be a disadvantage to its model, Miillerian mimicry is never a disadvantage but generally (theoretically always) an advantage. Although this criterion is in itself simple, it is extremely difficult, with our present imperfect knowledge of mimics and their enemies in life. to apply. The decision therefore rests on indirect evidence, which makes a different appeal to different minds, so that opinions differ widely as to the relative importance of the two kinds of mimicry.

It will be generally agreed that the resemblance of a Batesian mimic to its model is closely related to protective resemblance. In fact Bates originally included both resemblances under mimicry. A. R. Wallace and nearly all later writers on the subject have differed from him in this because, although the two classes are so near akin, the species in one are conspicuous, in the other well-concealed. They may, however, be conveniently grouped together under deceptive (or apatetic) resemblance. Both classes include palatable species, much sought after by the enemies of the group to which they belong.

Any evidence supporting the conclusion that a mimic has been developed from a species with concealing colours would be evidence that it is a Batesian and not a Mullerian mimic. Such evidence may generally be obtained by comparison with its closest non-mimetic allies, and in butterflies often by comparing a mimetic female with its non-mimetic male, paying special attention to the under-surface, upon which concealing colours are specially developed. In the tropical American butterfly *Protogonius,* conspicuously mimetic on the upper surface and dead-leaf-like on the under. it has been observed that the latter appearance is so transparent that when the insect is sailing with expanded wings above the observer, he can only see the colours of the upper side.

If, on the other hand, the above comparisons lead to the conclusion that a mimic belongs to a group with warning colours, especially one which supplies models for mimicry, — we should, in the opinion of the present writer, be justified in considering it as Müllerian. Special evidence is offered by some mimics which retain warning characters independent of the mimetic appearance, and by others which, themselves resembling a central model, nevertheless act as models for still more outlying members of an association. Still stronger evidence may sometimes be found in reciprocal relationship between the species of two groups or between the groups themselves, *A* usually supplying models and B their mimics, but *B* also including models mimicked by species in *A.* In any case it is often difficult to draw the line between Batesian and Miillerian mimicry.

It is not always necessary, as has been generally assumed, that a mimetic pattern should be beneficial to the species. Certain butterflies which have developed such patterns in the presence of Danaine or Acraeine models are equally abundant, but non-mimetic, in other areas where the models are absent. It is clear that, in these species, the variations which promote the resemblance have been selected, but it is equally clear that the average number of survivors in each generation was not thereby increased. It is the proportion of survivors with and without the mimetic pattern that has been changed, not the total number of surviving



DRAWN FOR THE ENCYCLOPÆDIA BRITANNICA BY MISS O. F. TASSART FROM SPECIMENS IN THE HOPE DEPARTMENT, OXFORD UNIVERSITY MUSEUM AND BRITISH MUSEUM (NATURAL HISTORY)

MIMETIC RESEMBLANCES AMONG INSECTS

1. A butterfly with a damaged wing which is evidence of bird attack; this common injury was seen to be caused by a bird
2. Brazilian fossorial wasp with (2a) its mimic bug and (2b) its long-horned grasshopper mimic
3. Cocoon of African moth covered with sham parasitic cocoons which were produced by a caterpillar

4 to 8. Tropical American membracid bugs shown from above and side, emphasizing the resemblance of the covering shield of the insect's body to (4) a hooked seed, (5) a thorn, (6) a smooth seed, (7) an ant, (8) a cocoon of a nauseous moth

9. Indian carpenter bee and (9a) its fly mimic
10. African carpenter bee and (10a) its fly mimic
11. Second African carpenter bee and (11a) its fly mimic
12. Third African carpenter bee and (12a) its fly mimic
13. Front of head of South American fulgorid, resembling the head of an alligator
14. Bornean nauseous beetle and (14a) its longhorn mimic, with a pencil of hairs imitating the spine of the model

individuals of the species. For this process, J. S. Huxley has suggested the term intra-specific selection.

One of the chief objections urged against the interpretation of mimicry as a resemblance perfected by selection is the belief that birds rarely attack butterflies. Some naturalists of great experience state that they have never witnessed such an attack. Nevertheless those who have paid special attention to this aspect of the subject have recorded numbers of instances from their own observation. Fig. 1 on the Plate represents an injury seen by F. Muir to be inflicted by a bird upon a butterfly at Durban. The insect was at rest and the bird. attacking it from the rear, has shorn through both hind-wings symmetrically. Now this is a common type of injury and it is reasonable to suppose that it is generally if not always caused in the manner observed by Muir and others. Again Swynnerton in Rhodesia and Lamborn in Nyasaland have found the impress of a beak upon the wings which they have picked up after seeing them torn off by a bird. And such beak-marks are often found on specimens by those who look for them.

The remaining figures on the Plate illustrate mimicry in other insects, especially the species resembling the most formidable of all models, the bees and wasps, among which, it must be added, Miillerian combinations are especially prevalent. Striking examples of the carpenter bees (Xylocopidae) and their fly mimics are represented in figures 9–12A, fig. g being a black Indian species *(Xylocopa tenuiscapa)* mimicked by the fly *(Hyperechia xylocopiformis)* shown in fig. 9A. The following three examples are African, fig. 10 the white-banded bee *X. inconstans* and 10A its fly mimic *H. bifasciata*; fig. 11, the reddish-brown banded *X. flavorufa,* with 11A *H. marshalli,* the model and mimic here represented having been taken within a few yards of each other at Mt. Mlanje, Nyasaland; fig. 12, the white-marked *X. nigrita,* with 12A, H. *consimilis.* It has been proved in recent years that the larvae of these flies burrow into the tunnels made by the larvae of their models and devour the occupants. It might appear at first sight that the object of the mimetic resemblance is to enable the flies to approach the nest and lay their eggs near or within the opening, but no such aid is necessary, for the mimics are more powerful fliers and more alert than their models. They are also more formidable and sometimes have been known to prey upon the bees themselves although generally upon other insects; but with all their other powers they have not the dreaded sting and are therefore protected by resembling the much commoner bees among which they live.

Wasps and bees are also mimicked by many other insects of varied groups. Fig. 2 represents a Brazilian sand-wasp *(Pepsis)* the model of 2A, a bug *(Spiniger),* and 2B a long-horned grasshopper *(Scaphura).* The movements in life of these two mimics—both members of unwasp-like groups—are known to promote the resemblance. The wasp's yellow-tipped antennae are seen to be short and thick as compared with those of its mimics but in both the section near the base is thickened and that beyond of hair-like fineness so as to be invisible except on close inspection. The end of the thick section is yellow in the grasshopper like the tip of the wasp's antennae. Similarly in certain beetles which mimic others with shorter knobbed antennae, a thickening at the corresponding distance from the base, or in some species the appearance of a thickening produced by a tuft of hairs, brings about a superficial likeness to the model. The close resemblance to a powerful curved spine on the wing-cases of the model, a distasteful Bornean beetle (an Endomychid), fig. 14, is similarly brought about by a curved pencil of hairs on its Longicorn mimic *(Zelota)* shown in 14A. Examples such as these afford strong evidence that the likeness has been achieved by the selection of any variation which led in the right direction, and as a result some feature in the mimic which seems to the eye to be similar to that of the model is often in its essential structure entirely different.

A good example of a mimetic resemblance attained in many ways is to be seen in the large tropical American association of diverse butterflies and day-flying moths which have developed transparent areas on their wings in mimicry of dominant Ithomiine models. Transparency has been attained by the following different methods in different mimetic species or groups of species:—(I) the scales of the wing may be so reduced in size that the light passes between them; (2) remaining the same size they may become much fewer; (3) they may stand up on edge; (4) remaining in the usual overlapping position they may become themselves transparent. Furthermore in the models themselves, the scales of the transparent parts have become minute vestiges, reduced to a much greater extent in one of the two genera to which the species belong. It may be added that the wings of many moths which mimic bees are, on emergence from the chrysalis, covered with loosely attached scales which blow off during the first flight. Such different methods of attaining the same end are to be expected if the development has been brought about by natural selection, for it is unreasonable to believe that similar variations would appear in very different species with very different natures.

The most convincing evidence of the development of mimicry and protective resemblance by natural selection is to be found in the Homoptera which, in addition to the cicadas, aphides, etc. also include the Membracidae, a family of small insects found nearly all over the world but most commonly in tropical America. These insects have, on the body-ring behind the head, a projection which grows backwards and expands into a shield covering every part except the head, wings and legs. The form of the concealed body is much like that of the allied greenfly and other aphids of our gardens. Five tropical American rnembracids are represented in figs. 4–8A. *Hemikyptha,* like a hooked seed, seen from above in 4A, from the side in fig. 4; the thornlike *Umbonia* in figs. 5, 5A; the smooth-seedlike *Hebetica* in 6, 6A; the ant-like *Heteronotus* in 7, 7A; finally *Oeda,* resembling the orange-coloured, freely exposed cocoon of a distasteful moth, in 8, 8A. Thus in the Membracidae the concealing or the mimetic appearance is developed on the covering shield, and not, as in so many other insects, on the body. Mimicry is only developed where it can be seen. The value of the ant-mimicry in figs. 7, 7A has been questioned because the Membracidae, like the allied froghoppers (Cercopidae), can escape by jumping, but this is only one of the numerous examples in which different methods are adopted by a species so that if the first fails there is still a chance of success by the second. It has also been objected that ants have many enemies and are therefore dangerous models. Haase is the only naturalist who has thought it necessary to assume that the special protection of models confers absolute immunity, even believing that it is efficient against the insect-enemies of insects. We know, however, that the species which are most distasteful to the higher insect-eating animals are especially liable to be attacked by parasitic and predaceous insects. Admitting the existence of numerous enemies, ants nevertheless possess qualities which render them the most successful insects in the world. Analogous reasoning would attempt to show that the form, colour and pattern of grass-feeding caterpillars are valueless because so many animals feed upon grass!

The mimicry of ants is a vast subject which cannot be treated even superficially here. They are models not only for insects of many diverse kinds but also, in movement as well as appearance, by numerous spiders. Certain species of the carnivorous mantises and also of long-horned grasshoppers mimic ants when small but in their later stages become flower- or leaf-like. Some idea of the advantage which may be conferred by resembling these models is suggested by a study of their guests. Since 1891 H. Donisthorpe has discovered in British ants' nests 150 species of insects, spiders and mites new to the country, including 70 new to science. Of these guests 28 species are mimics of ants and thus would be protected outside the nest or in a disturbed nest against enemies which fear the ants. In addition to these British ants are mimicked by 34 species living independently, and by 15 species possibly guests, possibly independent.

BOGEYS

A very different kind of mimicry is adopted by another tropical American homopterous insect, one of the large lantern flies (Fulgoridae). The front part of the head of this insect, *Laternaria lucifera,* projects forward as a hollow mask which resembles in remarkable detail the head of an alligator as may be seen from the side view represented in fig. 13. The true eye of the insect is

shown behind the last of the apparent teeth, the alligator's eye and nostril are represented on humps in their characteristic position. The rows of long sharp teeth, not hidden by lips as in other animals: form the most terrifying feature of the alligator's head, and these are convincingly suggested by a series of brilliantly white elevations. The mask of this lantern-fly in fact reproduces the appearance of the reptile's head not only in colour but in form, as it would be reproduced by a sculptor. Alligators are excessively abundant in tropical America and a terrible menace to animals which come to the riverside to drink, among them the arboreal monkeys which are probably some of the chief enemies of the lantern-fly. It is not supposed that the insect is mistaken for the reptile—but that an appearance. even on a very small scale, associated with a near escape from death, causes such a shock to an intelligent animal that the lantern-fly is given the chance of flight. This remarkable example is only one of many in which reptiles are mimicked by insects, especially snakes by caterpillars. Experiments have proved that the deceptive appearance is effective in terrifying insectivorous monkeys, birds and lizards.

Another remarkable form of mimetic resemblance is illustrated in fig. 3, representing the cocoon of a west African moth *Deilemera,* covered with the apparent cocoons of a hymenopterous parasite. Such cocoons are woven by larvae which have hatched from eggs laid in the body of a caterpillar, lived and fed without injuring any vital part until the host is full-grown, then devoured the whole of it or its chrysalis, and bored their way out. The nutriment is then divided up and enclosed in numbers of tough cases, each containing very little and very difficult to open. It is therefore an advantage for a caterpillar to mimic the appearance of such an attack, and Lamborn has shown how this is achieved. The caterpillar while spinning produces from the end of its body a number of pale yellowish frothy spheres, each encircled by a silken girdle, dragged off and fixed to the cocoon by a few strands of silk. Other examples of the kind are known and probably numbers will be found now that Lamborn's discovery has directed attention to this kind of mimicry.

It has been impossible to describe more than a very small proportion of the recorded examples of mimicry. It is believed, however, that those which have been selected will serve to illustrate the chief aspects of the subject.

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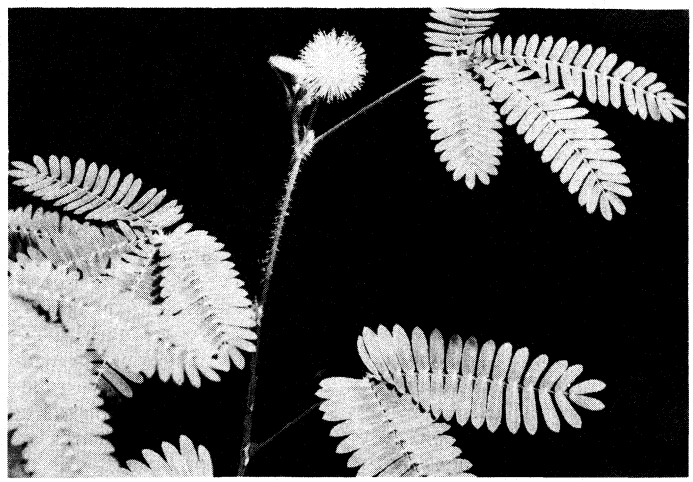
MIMNERMUS of Colophon (fl. c. 630–600 B.C.), Greek elegiac poet. One of his extant fragments refers to the struggle of the Ionians against Lydia. His most important poems were a set of elegies addressed to a flute player named Nanno. Mimnermus was the first to make the elegiac verse the vehicle for love poetry. He set his own poems to the music of the flute, and the poet Hipponax says that he used the melancholy *nomus kradies,* a melody peculiar to the Thargelia festival, to the accompaniment of which two human purificatory victims were led out of Athens to be sacrificed (Hesychius, *s.v.*).

Edition of fragments in T. Bergk, *Poetae lyrici Graeci;* see also G. Vanzolini, *Mimnermo* (1883), a study of the poet, with notes and a metrical version of the fragments.

MIMOSA, so named from the movements of the leaves in many species which "mimic" animal sensibility, a genus of 400 species of the family Leguminosae, which gives its name to the large subfamily Mimosoideae (characterized by usually small regular flowers with valvate corolla), to which belongs the nearly allied genus *Acacia.* They are distributed throughout almost all tropical and subtropical regions, the acacias preponderating in



BY COURTESY OF GENERAL BIOLOGICAL SUPPLY HOUSE, INC., CHICAGO, ILL.

SENSITIVE PLANT (MIMOSA PUDICA)

Australia and the true mimosas in America. The acacias are of considerable importance as sources of timber, gum and tannin, but the mimosas are of much less economic vaiue. though a fen, like the falh (M. *ferruginea*) of Arabia and central Africa, are important trees. Most are herbs or undershrubs, but some South American species are tall woody climbers. They are often prickly. The roots of some Brazilian species are poisonous, and those of M. *pudica* have irritating properties. The mimosas, however, owe their interest and their extensive cultivation partly to the beauty of their usually bipinnate foliage. but still more to the remarkable development in some species of the sleep movements manifested to some extent by most of the pinnate Leguminosae, as well as many other (especially seedling) plants.

In the so-called "sensitive plants" these movements not only take place under the influence of light and darkness, but can be easily excited by mechanical and other stimuli *(see* TROPISM; PLANTS AND PLANT SCIENCE: *Plant Movements).* When stimulated—say. at the axis of one of the secondary petioles—the leaflets move upward on each side until they meet, the movement being propagated centripetally. It may then be communicated to the leaflets of the other secondary petioles, which close (the petioles, too, converging'). and thence to the main petiole, which sinks rapidly downward toward the stem, the bending taking place at the pulvinus (saollen base of the leafstalk). When shaken in any way, the leaves close and droop simultaneously, but if the agitation be continued they soon cease to respond to the shock. The common sensitive plant of hothouses is *M. pudica,* a native of tropical America, now naturalized in corresponding latitudes of Asia and Africa. but the hardly distinguishable M. *sensitiva* and others are also cultivated Species of the closely allied genus *Sclzrankia* are known as sensitive brier in the southern United States.

MIMULUS, a genus (family Scrophulariaceae) comprising about 115 species of showy, hardy or half-hardy. herbaceous, rarely shrubby plants, natives of the extratropical or mountainous parts of both old and new worlds excepting Europe. but most numerous in western North America, 45 species occurring in California.

The plants have opposite, undivided leaves, and axillary, generally solitary flowers with a two-lipped. gaping corolla. The herbaceous species thrive best in damp situations; the shrubby species, of which *M. aurantiacus,* bush-monkey flouer, is best known, are adapted for pot culture in the greenhouse. *M. guttatus* (common monkey flower). widespread in western North America, has become naturalized by riversides in many parts of Britain. *M rnoschatus* (musk plant), a native of northwestern America, with small, nearly regular, yellow flowers, diffuse hairy stem and hairy scented leaves. is a well known and favourite perennial for pot culture and outside borders. Several other species are cultivated for their attractive flowers.

MINANGKABAU: *see* MENANGKABAU.

MINARDI, TOMMASO (1787–1871), Italian artist, was

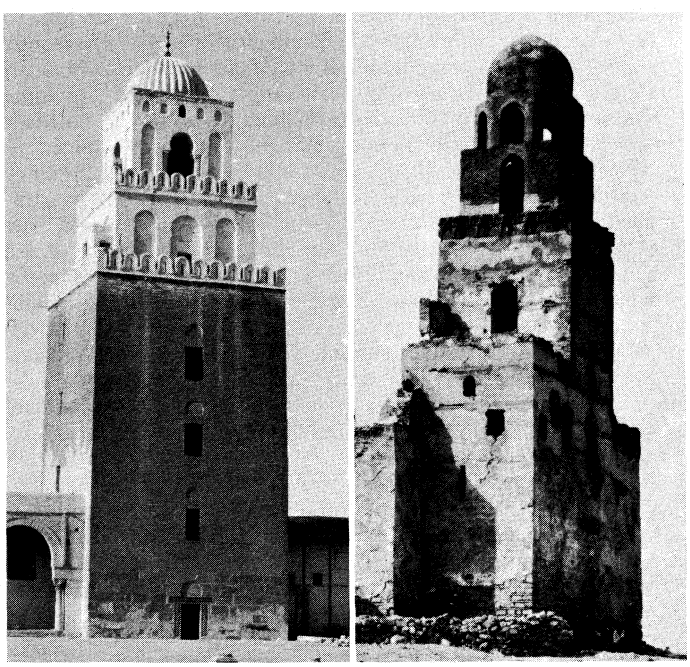
born in Faenza, Dec. 4, 1787. He is generally considered the leader of the purist movement in Italy and exerted much influence as a teacher. At 15 he obtained a pension from the Institute of St. Gregory at Faenza and went to Rome to study art. He entered a competition in Rome which he won, and as a result was commissioned to make a drawing of the "Last Judgment" of Michelangelo by the engraver Longhi.

Minardi is distinguished as an artist through his drawings. which comprise many volumes. His paintings are comparatively few and weak in colour. He died on Jan. 13, 1871.

MINARET, the tower from which the call to prayer is given for Moslems five times a day. In the time of Mohammed no such thing as a minaret was known; when he and his followers first came to Medina they prayed without any preliminary call to prayer. But. having heard that the Jews used a horn and the Christians a *naqus* or clapper, they nanted an equivalent. Mohammed therefore ordered Bilal to give the call to prayer from the highest roof near the mosque.

The first minarets in Islam were the four square towers at the corners of the *temenos* or sacred enclosure of the pagan god (perhaps Haddad), who was worshipped at Damascus. This *temenos* was the enclosure nhick is now the Great Omayyad mosque. Ibn al-Faqih (903) refers to these towers. saying, "the minarets which are in the Damascus Mosque were originally watch towers in the Greek days." Mas'udi (943) says, "then came Christianity and it [the *temenos]* became a church. then came Islam and it became a mosque . . . and the *Sawami'* [the four corner towers] were not changed; they serve for the call to prayer at the present day." A square tower became the Syrian type of minaret and remained so until after 1200.

In north Africa the oldest minaret, that of Kairouan (Qairwān), is likewise a square tower with a small second story set back upon



BY COURTESY OF KEPPEL CRESWELL

(LEFT) MINARET OF THE MOSQUE AT KAIROUAN. TUNISIA: (RIGHT) MINARET OF THE MOSQUE OF AL-GUYŪSHĪ (1085), CAIRO. EGYPT

it; the third story is later. This became the regular type in north Africa and Spain; *e.g.,* at Cordova. in the mosque of Hassan at Rabat, the Koutoubiya at Marrakesh and the Giralda at Seville, the last three dating from the end of the 12th century.

In Iran and central Asia, the earliest minarets preserved date from the end of the 11th century. They are all tall, cylindrical, tapering shafts with a gallery near the top. and are often decorated with geometrical patterns in the brickwork, or with faience *(see* A. U. Pope, *Survey* of *Persian Art,* plates 358–364). They are sometimes built in pairs, generally flanking a monumental entrance, or placed at opposite ends of the main façade; *e.g.,* at Tabriz. Turkish minarets are derived from this type, but they generally have two or even three galleries, and terminate in a tall tapering lead-covered cone. Turkish mosques usually have at least two, sometimes four and, in one case, six minarets (Sultan Ahmad, 1615).

Of existing Egyptian minarets, the earliest are those of the mosque of al-Hakim (1013), of which one is a tall. cylindrical stone shaft on a nearly cubical base; the other minaret is a tall, square shaft surmounted by a series of receding octagonal storys. In both cases, the original top part has gone. The minaret of al-Guyūshī (1085) consists of a square shaft of brick with a stalactite cornice. surmounted by a little cube, an octagonal drum and a dome.

In subsequent minarets, this upper part was elaborately decorated, and elongated at the expense of the square shaft, until a type is evolved consisting of a square shaft surmounted by an octagonal and a circular story; examples are those of Sangar al-Gawli (1303) and Kusun (1336). After Kusun, the square shaft suddenly shortens so much that only its beveled-off top corners show above the roof of the mosque, and the visible part consists of a tall octagonal shaft, which has two galleries and terminates in an open domed pavilion; *e.g.,* Shaikhun (1355), Sarghitmish (1356) and Sultan Hasan (1362). *See* also INDIAN ARCHITECTURE; ISLAMIC ARCHITECTURE; MOSQUE.

See K. A. C. Creswell in *Burlington* Magazine (May 1926).

(K. A. C. C.)

MINAS, capital of the department of Lavalleja in southwest Uruguay, was founded in 1783 and named for the surrounding mines (Spanish *minas*). In the second part of the 20th century Minas became increasingly attractive to tourists. since it is only 75 mi. from Montevideo and offers hills and forests, both unusual in Uruguay. Its bottled mineral waters long have been distributed throughout the country. A brewery also uses Minas' famous water. Neighbouring mines and quarries, administration, trade and some industry provide the city's principal occupations. Minas is on a national highway and railroad line. Its population (1934 est.) was 36,700. (M. I. V.)

MINAS GERAIS (*i.e.,* "general mines"), an inland state in Brazil. Area 224,701 sq.mi. Pop. (1950) 7,717,792. Among the Brazilian states it is exceeded in population only by São Paulo. Minas Gerais, formerly spelled Geraes, is bordered by the state of Rio de Janeiro on the southeast, by the state of São Paulo on the south and west. by Goiás on the northwest, by Bahia on the north and by Espirito Santo on the east. An area of 3,914 sq.mi. along its eastern border is claimed by both Minas Gerais and Espirito Santo. The state capital is Belo Horizonte (*q.v.*).

Physical **Geography.**—Minas Gerais lies almost wholly within the geologically ancient uplands known as the Brazilian highlands. Only small parts of the southern and eastern parts of the state are within the zone of the Great Escarpment. In the southwest, along the border of São Paulo, is the commanding range of mountains known as the Serra da Mantiqueira (*q.v.*), n-hose highest summit. Itatiaia peak (Xgulhas Negras), reaches 9,144 ft. This range ends near the easternmost border of São Paulo. The other principal mountain range in Minas Gerais is the Serra do Espinhaço, which begins a little south of Belo Horizonte and extends northward into Bahia. It forms the divide between the rivers draining to the São Francisco (*q.v.*) and those draining eastward directly to the Atlantic (Doce, Macurí, Jequitinhonha). The greater part of the state consists of a much dissected hilly upland, with hilltops reaching an elevation of about 2,600 ft. above sea level. In the west, on the border of Goiás, Minas Gerais includes a part of the ancient erosion surface still untouched by stream erosion over wide areas. and standing about 4.000 ft. above sea level. The stream divides, often erroneously described as mountain ranges, are in fact the undissected remnants of an ancient erosion surface. Minas Gerais is drained to the east and south of the Serra do Espinhaço by the smaller streams named above and by tributaries of the Paraiba river. In the southnest it is drained by the Rio Grande, one of the major headwaters of the Paraná river which reaches the sea at Buenos Aires, Arg. The whole

northwest part of the state is drained by the great São Francisco, which flows northward through a rift valley to the west of the Serra do Espinhaqo. Along the west border of the state there is a triangular projection (Triângulo Mineiro) lying between the Rio Grande on the south (border of São Paulo) and the Paranaiba river (border of Goiás).

The climate is characteristic of an upland region in the low latitudes. Temperatures are not so high as they are along the coast. At Belo Horizonte (2,800 ft. above sea level) the average of the warmest month (February) is 72.1° F.; and the average of the coldest month (July) is 62.2°. The rainfall throughout most parts of the state averages between 40 and 60 in., but is concentrated in a rainy season between November and March. The period between May and September is very dry, and lack of moisture is a major factor in agriculture along the stream divides. Reflecting these climatic conditions, the southern and eastern part of the state was originally covered with a dense tropical forest, consisting of many species of trees that retained their leaves throughout the year, but with a few that shed their leaves in the dry season. This semideciduous type of forest was called mata da *primeira classe* ("first-class forest") by Brazilians. On the upper slopes of the Serra da Mantiqueira and of the Serra do Espinhaço the forest gives way to upland meadows or to a scrubby growth of deciduous woodland. All of southwestern and western Minas Gerais is covered by a woodland savanna, consisting of stretches of grassland mingled in complex fashion with stands of woodland. The latter (*campo cerrado*, literally "closed grassland") is made up of low broadleaf trees with gnarled trunks. The woodland species lose their leaves in the dry season. Even in the midst of the woodland savanna, however, semideciduous forests extend along the deeply cut river valleys.

Agriculture.— The agricultural area of Minas Gerais is almost exclusively a region once occupied by the semideciduous forest. This forest has been largely cleared by centuries of "land rotation." In this system of agriculture, a tenant farmer clears the forest by cutting and burning it at the end of the dry season. He then plants maize, rice, beans and cassava in the newly cleared land, and fair harvests are gained for a period of two or three years before the essential infertility of the soil becomes apparent. He then plants pasture grass, chiefly for cattle grazing, and moves to a new part of the forest. This area is the chief source of beef for Rio de Janeiro, São Paulo and other cities. Dairy farming is important in southern Minas Gerais. In only a few spots is the land used for sugar cane or coffee, which were formerly of greater importance. On the hillsides, which today are used only for poor pasture, the marks of former coffee trees can be seen.

Minerals.— Minas Gerais has long been known for its wealth of minerals and for its mining activities (as its name suggests). It supplies half the mineral production of Brazil. Gold was discovered by explorers from São Paulo in 1698. At first the many prospectors who rushed into Minas Gerais only looked for gold in the stream gravels, and today there are many marks of abandoned placer mines at the valley bottoms and on hillsides. The gold was found in the streams draining away from the Serra do Espinhaco. In 1729 diamonds were discovered, also in stream gravels, near Tijuco (now called Diamantina). These precious commodities created great wealth in the 18th century, and Ouro Preto (*q.v.*), the administrative centre of Minas Gerais, became a city of great splendour, with numerous beautifully decorated churches. But after 1800 the richest gold sources had been used up, and the miners turned their attention elsewhere. It is interesting, however, that at Nova Lima, a few miles south of Belo Horizonte, a British mining company has been mining gold continuously since 1834. This mine is now one of the world's deepest. In modern times Minas Gerais is also widely known for its semiprecious gems: such as aquamarine, amethyst, tourmaline and topaz. From the high country in the western part of the state come the large quartz crystals that are used in radios:

Of greater importance in the modern world, however, are the vast deposits of high-grade iron ore and manganese. In the southern part of the Serra do Espinhaço is one of the world's largest stores of iron ore, in which impurities are few and which is so disposed that it can be mined by steam shovels without expensive shafts or tunnels. A huge ore deposit exists at Itabira on the headwaters of the Doce river, and ore from this source is now exported in small quantities through the port of Vitória (*q.v.*). Another huge deposit near Lafaiete, at the southern end of the Espinhaco, is used to supply the new steel plant at Volta Redonda in the Paraiba valley. Also mined near Lafaiete are the manganese supplies needed for Volta Redonda; and limestone for the new steel plant is supplied from quarries in western Minas Gerais. There are also a number of small, charcod-burning steel plants, notably at Sabará, Caité, Barão de Cocais, Monlevade and Itabira. In addition to the iron and manganese, the industrial diamonds and the gem stones, Minas Gerais supplies bauxite, zirconium, iron pyrite, rutile, graphite, chromite, molybdenum, nickel, tungsten, titanium, beryl and mica.

Tourism.——Another aspect of the economy of Minas Gerais is tourism. In the Serra da Mantiqueira and in the southwestern uplands of the state to the north of these mountains are a number of resort towns, most of them possessing various hot and curative baths. The mineral uaters are bottled and widely dispensed in Brazil. The more important centres are Araxá, Caxambu. Lambarí, Poços de Caldas and São Lourenço. Health resorts have also been established at the higher elevations.

Transportation.—Minas Gerais is served by railroads, all-weather highways, airports, and by river steamers that descend the São Francisco from Pirapora to Juazeiro in Bahia. The main railroad, Central do Brasil, runs from Rio de Janeiro to Belo Horizonte, with a narrow-gauge extension to Pirapora. To the west of this line is the narrow-gauge Oeste de Minas; east of it is the Leopoldina, also narrow gauge. A railroad also ascends the valley of the Doce river from Vitória to Itabira. It connects with a branch of the Central do Brasil which crosses the Serra do Espinhaqo to Belo Horizonte. In the period since World War II, all-weather motor highways have been built to connect Rio de Janeiro with Belo Horizonte, and also São Paulo city with Belo Horizonte. Another road runs through east Minas Gerais to Bahia. Most of these roads parallel the earlier railroads rather than providing feeder service. Away from the main highways and the railroads the roads are passable for motor traffic only in dry weather.

History.— illinas Gerais was established as a separate captaincy general in 1720, shortly after the discovery of gold. It has traditionally played an important role in Brazilian politics, in part because of its central position, but also because of the dense population in its southwest. In 1824 Minas Gerais became a province in the Brazilian empire, and in 1889 a state in the federal republic. In 1897 the old colonial capital of Ouro Preto was deprived of its administrative function The new capital was placed at Belo Horizonte, where a new city, laid out on previously almost unoccupied land, was planned and built. Ouro Preto is a national monument, while Belo Horizonte has become a city with a population (1950) of 338,585.

The second city of the state is Juiz de Fora in the south, noted for its textiles. There is a dense rural population in the south and east, but the whole northern and western part of the state is still very thinly occupied. (P. E. J.)

MINBU, a town and district in the Magwe division of Burma. The district has an area of 3,j94 sq mi. and a population (1941) of 302,373. It consists of low plainland toward the Irrawaddy and of undulating country inland rising toward the Arakan hills. There are considerable fisheries along the Irrawaddy and on the Paunglin lake, a lagoon fed from the Irrawaddy. Oil occurs near the mud volcanoes of Minbu, and oil fields have been developed in the anticline of Peguan rocks which runs through Minbu town.

There is a large area of reserved forest in the district. The chief crops are rice, gram, millet, beans, peas, sesamum and tobacco. Minbu, the district headquarters, stands on the Irrawaddy. The town had a population of 9,096 in 1953.

MINDANAO, second largest island of the Philippines, located in the southern part of the archipelago and comprising Agusan, Bukidnon. Cotabato. Davao, Zamboanga del Norte, Zamboanga del Sur, Misamis Occidental, Misamis Oriental, Surigao, Lanao del Norte and Lanao del Sur provinces. Area, including several

small neighbouring islands, 36,537 sq.mi. The rapidly growing population was estimated at 3,310,720 in 1959. The island measures 300 mi. north to south and about the same from east to west; it is marked by the long, irregular Zamboanga peninsula on the west. Rugged faulted mountains and volcanoes occur in many areas, particularly paralleling the east coast, along the southwest coast, in the north central part of the island and at the backbone of Zamboanga peninsula. Mt. Apo, 9,610 ft., on the Davao-Cotabato border, is the highest peak in the Philippines. Rolling plateaus characterize central Bukidnon. Broad plains and extensive swamps are found in the valleys of the Mindanao river in Cotabato and of the Agusan river. Narrow coastal plains almost surround the island and broaden considerably near Davao and Pagadian. In the low-lands temperatures average 73° to 83° F. Rainfall varies from 208 to 38 in., averaging about 80 in, a year. Shortly after the advent of U.S. rule Mindanao became the Philippine pioneer frontier. Migration to the island was slow at first, expanded somewhat in the late 1920s and grew rapidly from 1939; following World War II migration from Cebu, the Ilocos provinces, Panay, Negros, Bohol and Manila was resumed. Major crops are corn, rice: abaci and coconuts, with cotton, ramie. coffee and cacao as secondary products. Timber production is high, especially in Agusan and the Zamboanga provinces. Lateritic iron ore reserves in Surigao are large. ***See*** also PHILIPPINES, REPUBLIC OF THE; and articles on various Mindanaoan provinces. (R. E. HE.)

MINDANAO DEEP is a submarine depression in the Philippine sea section of the North Pacific ocean and one of the deepest areas on the earth's surface. The sounding made by the Danish ship "Galathea" in 1951 recorded a depth of 34,583 ft. It is also known as the Mindanao trench, Philippine trench or Philippine deep. ***See*** PHILIPPINE SEA.

MINDEN, a town of Germany, in the *Land* of North Rhine-Westphalia, 44 mi. W.S.W. of Hanover by rail, on the left bank of the Weser. Pop. (1910) 41,527. Minden (Mindun, Mindo), apparently a trading place of some importance in the time of Charlemagne, was made the seat of a bishop by that monarch, and subsequently joined the Hanseatic league. In the 13th century it was surrounded with walls. In 1648 the bishopric mas converted into a secular principality under the elector of Brandenburg. From 1807 to 1814 Minden was included in the kingdom of Westphalia, and in the latter year it passed to Prussia. Industries include brewing, shipbuilding and the manufacture of tobacco, glass, soap, chocolate, leather, shoddy, cement and chemicals.

The Battle of **Minden** was fought Aug. 1. 1759, between the Anglo-Allied army commanded by Duke Ferdinand of Brunswick and the French under Marshal Contades. The most brilliant episode of the battle mas the defeat of the French cavalry by British infantry. ***See*** SEVEN YEARS' WAR.

MINDORO, seventh largest island in the Philippine archipelago. Area 3,759 sq.mi. Pop. (1959 est.) 205,450. It lies across Verde Island passage from Batangas province. Luzon, and contains a mountainous core surrounded by a discontinuous plain widest along the eastern shore. Lake Naujan, on this eastern plain, is the third largest lake in the Philippines. The rugged interior is peopled in part by Negritos, in part by other primitive groups. *i.e.,* Hanuóo, that practise a shifting slash-and-burn agriculture (*kaingin*). The coastal areas are settled principally by Christian Tagalogs, but Visayans have migrated to the southern part of the island. The timaroo, a large native mammal, is found only in interior Mindoro.

The island is divided into two provinces, Mindoro Oriental and Mindoro Occidental. The former is the more populous and, since it faces Luzon, is the more progressive and has more commercial activity. The capital and principal town is Calapan (pop. [1959 est.] 27,368). A provincial highway extends from Calapan southward along the east coast to Eongabong and east along the north coast to Puerto Galera, where the University of the Philippines maintains a small marine biological station. The principal products are lumber, rice of both upland and paddy varieties, corn, coconuts, bananas and sweet potatoes.

Mindoro Occidental, fronting on the China sea, is mainly upland. Its principal towns are Mamburao (pop. [1959 est.] 6,825), the provincial capital, in the northwest and San Jose (Panduracan), on a small plain at the southern end of the island. Principal crops are rice: corn, coconuts and sugar cane. ***See*** also PHILIPPINES, REPUBLIC OF THE. (AN. C.)

MIND READING: ***see*** PARAPSYCHOLOGY; PSYCHICAL RESEARCH.

MINE, LAND. The land mine, an important weapon of World War II, was an encased explosive charge, sometimes laid on the surface of the ground but usually buried just below the surface. According to the type of fuze, it was fired by the weight of vehicles or men, by the passage of time or by remote control. The case was generally circular or square, made of metal or, to combat the magnetic detector, of wood, cardboard, glass or plastics. There were two types of mines. the antitank, to immobilize tanks and other vehicles, and the antipersonnel, to maim or kill soldiers.

History. — The ancestor of the antitank mine was the artillery shell buried by the Germans late in World War I to stop British tanks. The true antitank mine and the first antipersonnel mine appeared early in World War II. An economical way of stopping an enemy or restricting his movements, the mine field. composed of both types, was soon widely used by all major belligerents. Land mines were sown by the millions in the tank battles which took place in the north African desert and on the Russian front, and by 1943 had come to be considered almost a new arm of warfare. A postwar study of 10,000 tank casualties showed that 20% had been caused by mines. In the Korean war both the North Korean and the United Nations armies employed land mines extensively. Nuclear mines were not used but it was assumed that they were under development.

Antitank Mines. — The antitank mines developed in Great Britain, the Soviet Union and the United States between 1919 and 1939 contained only five or six pounds of TNT. They could stop a light tank, but had to be used in twos or threes against anything heavier. The Germans in 1939 had a mine that was twice as powerful. Their Teller mine (so named because it was plate shaped) had a profound influence on antitank mine history, for it led the Allies to manufacture similar heavy mines. As the Teller type was more likely to immobilize a tank by damaging its track than to destroy it, the emphasis in postwar research was on explosives that would penetrate the hull of a heavy tank and on fuzes that did not depend on pressure.

A standard postwar U.S. army antitank mine contained 12 lb. of TNT and weighed about 20 lb. in all. it required a weight of about 300 lb. to set it off.

In World War II the British and Americans also developed a very light antitank mine consisting of a flat quart can filled with tetrytol. Infantrymen could carry them in their pockets and use them in stacks against tanks or singly against other vehicles. Later this so-called "hasty" mine was given a secondary fuze that would function under the weight of a man; it thus became a combination antitank and antipersonnel mine.

Antipersonnel Mines. — The antipersonnel mine. generally containing less than one pound of explosive, could blow off a man's hand or foot or kill him with flying fragments. There mere two types, the bounding mine that threw a shell a few feet into the air before it exploded, and the fixed mine that exploded in place. The bounding mine n-as developed by the Germans before 1939. Called the "S" (spring mine or jumping mine), it was copied by most belligerents and employed with a fragmentation or high explosive shell. The fixed mine was a specialty of the Russians, who organized special battalion-size mine units. The Soviet army used more than 50 models of mines during World War II, but they consisted of three main types: (1) a seven-ounce block of explosive in an oblong wooden box with a hinged lid, which was adopted by Germany and Italy and became known to Allied troops as the dreaded "Schü" (Schiitzenmine or "rifleman's mine"); (2) a grooved. cast-iron shell on a wooden stake, which was copied by the Germans in concrete and used in large numbers in Europe; and (3) a cardboard "scatter" mine about the size of a shoe-polish can, resembling in size the very small U.S. plastic mine used by the United Nations in Korea. ***See*** also FORTIFICATION: *Field Fortification* in *World*

War II and the Korean War; AMMUNITION, ARTILLERY.

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MINE, NAVAL. A naval mine is an underwater weapon used in naval warfare. It may be used defensively, to protect a harbour or naval anchorage against enemy attack; offensively, as in the case of the British mining of the Danube river in World War II; or strategically, as in the U.S. blockade of Japanese shipping lanes which effectively cut off that nation's imports of raw materials. Mines may be laid by surface ships, submarines or aircraft, but all fit a basic description: an explosive charge fitted with a device which will cause it to explode when a target presents itself.

Mines are the only weapons which are not directed against a specific target, in contrast with guided missiles or projectiles such as rockets, torpedoes, bombs, shells and depth charges. These highly mobile weapons have their effective life only during the seconds it takes them to travel from point of discharge to point of impact, while the mine, handicapped by its immobility! can sink only those objects that come to it, but its design enables it to wait days or even years for that event. This points out another difference between mines and other weapons: the result of gunfire or bombing, whether. hit or miss, is usually plainly and immediately evident, but because of the indirect nature of mine warfare there is no such immediate evidence on which to estimate the effectiveness of mine laying. In fact, mines used with proper strategy can cause great loss even though they are never exploded.

Mines are cheap weapons to construct, but on a weight basis are the most destructive of all naval weapons because they explode under a ship where the surrounding water concentrates practically all of the explosive forces upward against the relatively unprotected bottom. This factor, combined with the long effective life, makes the mine a favourite weapon of attrition for use against a strong naval power by a weaker naval power; an effective weapon against the merchant marine of a nation dependent on extensive imports; and a logical weapon to be employed by a self-contained continental power which has little to lose and everything to gain by unrestricted mine warfare.

Early History and Development. — Sir William Monson, an admiral in Britain's Royal Navy during the reign of Queen Elizabeth I, first realized that the most vulnerable part of a ship was that beneath the water line. Monson planned to fire cannons into the underwater bodies of enemy ships from the hold of an attacking ship alongside, but there is no record that he ever tried this plan, which undoubtedly would have resulted in more damage to attacker than to attacked. The first use of a self-contained explosive agent against a ship occurred during the siege of Antwerp in 1585, when the Dutch used small boats filled with gunpowder and exploded by a clockwork device to dispose of several hundred Spaniards. Charles I of England later ordered his master of the ordnance to construct "divers watermines, water-petards and boats to go under water," and such devices were used by the duke of Buckingham, then lord high admiral, during the expedition for the relief of La Rochelle, France, in 1628, although without much success. In neither of these cases was the presence of an enemy ship necessary to set off the explosion, which did not take place under water. A "ship destroying engine!' was invented by the marquess of Worcester in 1658. He adopted the Dutch idea of clockwork to explode the mine, but depended on a diver to fasten it to the target, which may have accounted for its nonuse.

Technically, these early devices were delayed-action floating bombs, which could damage the sides of a ship only at or above the water line, in contrast to the true mine which is designed to hit a ship under water. It should be noted that a torpedo is designed for the same purpose, and for many years the two names were used interchangeably. Robert Fulton applied the term torpedo to one of his mines, possibly because it had the power to stun or make one torpid. Until about 1870 any device which could be exploded under water was called a torpedo. Later, a torpedo was defined as a missile with self-contained propulsion and steering devices. *(See* TORPEDOES.)

American inventiveness was turned to the problems of underwater attack during the Revolutionary War, and David Bushnell, the "father of the submarine," also became the originator of mine warfare. Bushnell used his submarine, the "Turtle." to carry a mine containing 150 lb. of explosive which was attached to a ship by a screw; the act of releasing the mine from the submarine started a timing mechanism which caused the mine to explode after a predetermined interval. Such a system required both skill and bravery on the part of the crew, who in the person of a sergeant, Ezra Lee, made a one-man attack on the British fleet in the Hudson river. Lee selected the 64-gun frigate "Eagle" as the target for the world's first combined submarine and mine attack, but that ship's copper bottom foiled his efforts with the screw and he was forced to drop his mine and withdraw. Bushnell then devised a form of contact mine, which greatly improved the efficiency of the weapon by eliminating the human factor; this was a keg filled with gunpowder and supported by floats, which was fired by a gunlock actuated when it struck the target ship. Here was the direct ancestor of all modern mines; it would not explode until the target set it off. One of these "trigger mines" was used with great effect in 1777, when Bushnell launched it against the British frigate "Cerberus" in the Connecticut river; the mine missed that ship but completely demolished a schooner anchored nearby. The next year, on Jan. 7, 1778, Bushnell made another attack on the British fleet in the Delaware river near Philadelphia, Pa., but his kegs were hampered by ice and blew up only one small boat, although they created no little panic among the British. This incident is sometimes referred to as the "battle of the kegs."

The next step in developing underwater warfare was made about 20 years later by another American. Robert Fulton, better known for his success with the steamship "Clermont." Fulton had invented a form of mine which he termed an explosive carcass, and a submarine, the "Nautilus," to carry it. (It was this vessel on which Jules Verne later based *Twenty Thousand Leagues Under the Sea.)* The French Revolution gave Fulton a chance to test his ideas in 1797, when French ports were blockaded by the British. While Napoleon became interested in Fulton's devices, to the extent of providing a schooner mhich the inventor managed to blow to bits in a test, his interest waned when Fulton failed to actually damage any British ships; besides, there was a general feeling among French naval officers that this new form of underwater attack was not in keeping with the traditions of chivalry. (There was some agreement. even after World Wars I and II, that the use of mines is like an unexpected stab in the back, but probably the principal objection to mine warfare, as to atomic, biological and iadiological warfare, lies in the fear of retaliation in kind by the enemy. On the other hand, an able tactician will endeavour to surprise an enemy by striking the first blow, and the element of surprise contained in a well-placed mine is not to be overlooked.) Rejected by the French, Fulton went to the British, who. possibly considering the advantages of opportunity over chivalry, decided to use his inventicns against the French. The British fleet made an attack on the French off Boulogne in 1804, using Fulton's catamarans, each carrying 40 bbl. of gunpowder, with exploding devices operated by clockuork. Although no damage was inflicted, the French thought even less of the British use of mine warfare than they had of their own.

All early developments in mines were of the noncontrolled or independent type. The first example of a controlled mine, representing the other major classification of mine types, was introduced in 1843 by Samuel Colt, who is better remembered for the revolver bearing his name. Colt experimented with mines fired by electric current supplied from the shore through underwater cables and was finally able to blow up a ship five miles at sea from the control station. Shortly after this, in 1848, a form of controlled mine resulting from German experiments at Kiel university was used during the Schleswig-Holstein war of emancipation to protect Kiel from the Danish fleet. This was the first use of mines as weapons of defense.

Mines nere again used defensively during the Crimean War, when the Russians employed contact mines to protect Sevastopol, Sveaborg and Kronstadt. The fuzes for these mines, designed

probably by Alfred Bernhard Nobel, consisted of glass tubes of sulfuric acid which, when broken by a ship's hull, allowed the acid to mix with chlorate of potassium and sugar, generating sufficient heat and flame to set off the main charge of gunpowder.

Both sides employed mines (called torpedoes) in the U S. Civil War. Perhaps the most dramatic incident of this mine warfare occurred when Adm. David Glasgow Farragut's squadron was steaming into Mobile bay, in column, under gunfire from Ft. Morgan and the Confederate vessels inside. A new monitor leading the Union line struck a mine and sank instantly. Other ships stopped and massed together blanketing their own gunfire. Admiral Farragut ordered all to go ahead. Lookouts called out "Torpedoes!" Farragut replied, "Damn the torpedoes! Full speed ahead!"

Between the end of the Civil War and the start of World War I. the most important development was the perfection by the German mine defense committee of a highly improved method of firing independent mines, the Herz horn. This was a refinement of the heat-generating fuze credited to Nobel, producing sufficient electrical current to fire a detonator which set off the charge Britain came up with an automatic mine-laying system nhich greatly speeded the process of laying a mine field, at the same time offering better depth control The automatic depth-taking mine nas fitted with a hydrostatic device preset to operate at the depth at nhich the mine was intended to float; mine and sinker were launched together and sank to the bottom, where either a soluble plug or timing device released the mine after a safety period which allowed the mine layer to get clear. The mine then rose toward the surface on a cable unreeled from the sinker or anchor, carrying with it a hydrostat on a pilot wire attached to the cable reel. When the mine reached the proper level, reduced water pressure caused the hydrostat to operate, thus setting up a pull on the pilot wire which applied a brake on the cable drum and stopped the mine's ascent.

Mines were used on both sides in the Spanish-American War, with no casualties, but the war between Russia and Japan, commencing in 1904, resulted in liberal use of mines by both poners, nith effective results. In particular, the use of mine fields laid in the open sea as a means of Influencing the movements of an enemy fleet was the first step in a new phase of mine warfare to be greatly exploited in World War I. The Russian fleet, concentrated in Port Arthur, was protected by a series of controlled mines Early in April 1904 the Japanese laid a mine field of their own off the harbour entrance, attempting to screen this operation by a diversionary torpedo attack which failed to prevent the Russians from observing and plotting the action. The following day a squadron of Japanese cruisers moved into the mouth of the harbour to tempt the Russians out across the mine field, while the main Japanese fleet remained at sea just over the horizon. Adm. Stepan Osipovich Makaroff accepted the challenge and gave chase, but when the full strength of the Japanese forces became apparent he declined action, in the meantime having been maneuvered by Japanese tactics into such a position that a return to harbour would probably involve crossing the mine field. Either the Russians forgot, or else discounted, the mine-laying operations of the day before, because they did attempt to go through the mine field, with the result that the 11,000-ton flagship "Petropavlovsk" mas sunk with 600 casualties, while the 13,000-ton "Pobieda" nas badly damaged.

Two months later the Russians turned the tables on the Japanese, nhen the mine layer "Amur," after careful observations of the movements of the blockading Japanese warships, laid a mine field in the patrol area. The battleships "Hatsuse," 15,000 tons, and "Yashima," 12,000 tons, both hit mines in this field, the former sank and the latter was abandoned en route to Japan. The Japanese then tried to sweep the area clear of mines. but before the task nas completed three of their cruisers were also mined—possibly because Japanese buoys marking safe areas had been moved to more doubtful locations by the Russians.

The value of accurate knowledge of the location of mine fields, whether ones oan or the enemy's, was again demonstrated nhen the Japanese mine layer "Yenisei" was blown up in one of her own fields. This was not the last incident to emphasize that independent mines, once laid, lose all sense of nationality: in World War II, Japan alone lost 21 merchant ships in its own mine fields. Before the Russo-Japanese War terminated, Russia had lost a battleship, a cruiser, two destroyers and two smaller craft, while Japan lost two battleships, four cruisers, two destroyers, a torpedo boat and a mine layer, all to mines.

World War I.—Mines were used on a vast scale during World War I, with belligerents and neutrals together laying about 240,000 of various types in all parts of the world. Germany was the first to lay mines outside its own territorial limits, planting a mine field at sea off Lowestoft. Eng., the night of Aug. 4, 1914; in fact, the mine layer "Konigin Luise" responsible for this operation was en route when war was declared. By the end of 1914 Britain had established extensive mine fields in the English channel to ensure free communications with the continent. and had declared the entire North sea a military area in which designated safety lanes were presumably protected by mine fields. Russia mined the gulfs of Finland and Riga in the Baltic sea as protection against German U-boats in that area while Turkey mined the southern approaches to the Suez canal and the Dardanelles, making effective use of drifting mines in the latter area where the current always moved out into the Aegean sea. As soon as Turkey entered the war Russia also mined the entrance to the Bosporus.

By 1915 Germany had proclaimed a war zone to exist in the waters surrounding the British Isles and commenced wide use of mines. It also enlarged existing mine fields off Heligoland; during the battle of Dogger bank in January of that pear Adm. Franz von Hipper probably planned to maneuver the British into these mine fields, but was unsuccessful.

On March 18. 1915, British and French forces operating in the Dardanelles encountered the Turkish floating mines; the "Bouvet," "Irresistible" and "Ocean" mere sunk and the "Inflexible" damaged. Britain by this time had discovered that Germany was using mine-laying submarines and converted two of its own submersibles, the E-24 and E-41, to this purpose. Four more British submarines nere converted for mine laying in 1916, and the E-24 laid the first British submarine mine field in history off Heligoland bight on March 7. Germany continued laying mine fields from U-boats, and German mines destroyed the British battleships "King Edward VII" and "Russell" and the cruisers "Arethusa" and "Hampshire," the latter with Lord Kitchener on board. Italy lost the battleship "Regina Margherita" in the Mediterranean in Dec. 1916

By 1917 Britain had more than 1,000 mine sweepers engaged in methodical clearance of German mines in its coastal waters; more than 4,600 were swept up that year It also tightened its own mine blockade of German waters. The U.S had assumed an active part in developing mine warfare, planning a mine barrage which would completely stop up the North sea and prevent German U-boats from entering the Atlantic on their shipping raids. The U.S. navy's bureau of ordnance designed a new type of mine for this purpose, and more than 100,000 of these were manufactured The great North sea barrage nas laid in 1918 by four British and ten U S. mine layers, commencing on June 8 and finishing on Oct. 26. It consisted of 70.263 mines, of nhich 56,611 were U.S. made and laid, in a belt 25 mi. wide from the Orkney Islands off Scotland to the coast of Norway, a distance of 230 mi. Seventeen U-boats nere either sunk or damaged in this barrage before the war ended.

Germany made only a small effort to lay mines in U.S. naters. At various times between April and Nov. 1918, a total of six U-boats laid mines off U.S. east coast ports. One of these was responsible for sinking the cruiser "San Diego" off Fire Island, N.Y.

During the four war years. Allied mines accounted for approximately 1 jo warships and auxiliaries of the central powers. including an estimated 35 U-boats plus a large number of merchant ships. Britain lost 40 warships, 225 auxiliaries including a great number of mine sweepers and 260 merchant ships to German mines. Total Allied loss of merchant ships amounted to j86. totaling 1,000,000 tons

World War 11.—Aerial mine laying. considered at the close of World War I, was not actively practised until 1939. By 1943 the British were using Lancaster bombers to drop mines with

great accuracy from altitudes of 15,000 ft. In the seven weeks preceding the Allied landings in Normandy in 1944, the British bomber command laid 4,000 mines in enemy waters, accounting for the loss of approximately 100 ships. British bombers also laid mines in the Kiel and Konigsberg canals, a feat which involved extremely low-level flying. Although this operation caused the Germans no shipping losses, it resulted in untold losses in delayed cargo movement before the mines could be cleared.

Wellington and Liberator bombers of the Mediterranean Allied air forces also systematically mined the Danube river for a six-month period commencing in May 1944; more than 1,200 mines were laid, resulting in 200 ships sunk or damaged.

In all British mine-laying operations involving aircraft, nearly 55,000 mines were dropped in 21,000 sorties, with the loss of 500 planes.

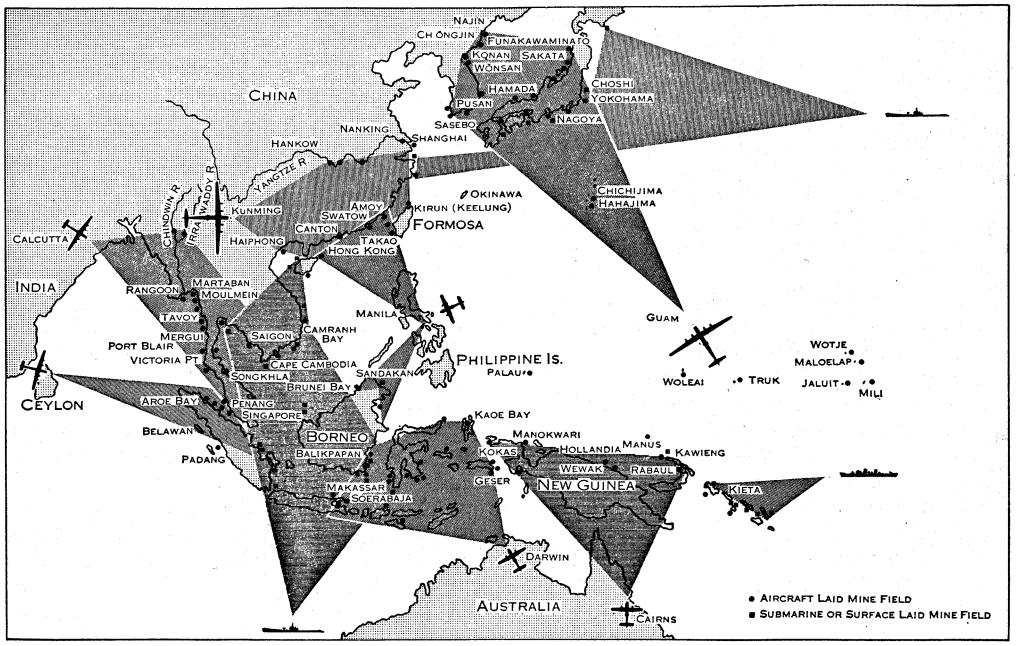


FIG. 1.—MAP OF OFFENSIVE MINE-LAYING CAMPAIGN AGAINST JAPAN, OCT. 1942 TO AUG. 1945

In the Pacific, aerial mine laying was carried out by the U.S. army air force, the Royal Air Force and the Royal Australian air force. The first mine-laying mission by U.S. B-29 bombers, and also the longest combat mission of any kind during the war, took place on Aug. 10, 1944, when Superforts based in Ceylon flew 3,800 mi. round-trip to Palembang in Sumatra, where 16 mines dropped sank three Japanese ships and damaged four more.

The first mining of a harbour by planes flying from aircraft carriers was conducted in April 1944 when U.S. carrier forces raided Palau in the Caroline Islands. In order to prevent ships in the harbour from escaping it was necessary to mine the channels after the raid commenced. In broad daylight and under anti-aircraft fire, planes from the "Lexington," "Bunker Hill" and "Hornet" laid 78 mines, as a result of nhich, according to Japanese reports, "for 20 days all channels were closed to navigation."

Only a few mines had been laid in Japanese waters until the last few months of the war. In late 1944 and early 1945 the capture of air bases within practical bomber range of Japan gave every prospect of success for an aerial mine-laying campaign designed to cut Japanese lifelines to the Asian mainland and the Indies. Submarine attacks on Japanese shipping had already forced most ocean-going traffic into a few crowded, mineable channels opening into the Inland sea.

On March 27, 1945, army B-29s dropped 900 mines in the approaches to Shimonoseki strait, which at that time handled 40% of all Japanese marine traffic. Before the war ended 'ten weeks later more than 12,000 mines had been laid from the air, effecting a blockade that took a staggering toll of shipping and almost completely cut off raw materials desperately needed by Japan. Magnetic, acoustic and pressure-type mines were laid, some nith ship-counting devices which allowed a specified number of ships to pass before they exploded, thus foiling too-eager mine sweepers. In laying this blockade, the army air force flew a total of 1,529 sorties to drop 12,135 mines, with a loss of only 15 aircraft. The effectiveness of this operation is shown in figures for Japanese shipping losses credited to mines after March 27, 1945: April, 16 ships; May, 65 ships; June, 58 ships; July, 65 ships; August (9 days) 16 ships. Japanese losses from mines laid by U.S. planes for the entire war totaled 257 ships, with a combined tonnage of 580,360.

Submarine Mine Laying.—To a large degree, aircraft replaced submarines as mine layers during World War II, but submarines were used by both Allied and Axis powers. During the early months of the war, U.S. submarines concentrated their efforts on the hunting down and torpedoing of Japanese naval and merchant vessels, and it was not until a shortage of torpedoes developed that the submarines had space to carry mines. It should be noted that as a U.S. submarine lays mines from its torpedo tubes, its load of torpedoes is reduced or eliminated completely by mine-laying activities and its combat potential is restricted accordingly. The first U.S. submarines to mine enemy waters, in Oct. and Nov. 1942, laid mines from the Gulf of Siam to Kii Suido at the eastern entrance to Japan's Inland sea. These early mining expeditions, aside from actual destruction of Japanese shipping, provided valuable pointers for later mine planting, among them the conclusion that mine fields laid in shallow coastal areas mere valuable even though they sank no ships, because they forced shipping out into deeper water where the submarines could do the sinking.

Many more mine fields were laid in the Pacific by U.S. submarines operating out of Hawaii and Australia. The British submarines "Porpoise" and "Rorqual" and the Royal Netherlands submarine O-19 also laid mines in the Pacific.

Japanese *Mine* Warfare.—Japan made extensive use of mines. One vast mine field was laid from Formosa to Kyushu to keep U.S. submarines out of the East China sea, and another concentration of mines plugged the Strait of Formosa. The principal gates to the Sea of Japan, the straits of Tsushima, La Perouse and Tsugaru, were mined, as were many other navigable channels in the Philippines, the Netherlands East Indies and the Sulu archipelago.

The Japanese placed great faith in their type 93 mine, a moored contact mine fired by chemical horns, which could be used in water as deep as 550 fathoms. These mines conformed to requirements of international law in that they disarmed themselves if their mooring cables broke and they went adrift. The Japanese also used type 92, a moored controlled mine, in defensive fields for harbours. The type 92 carried 1,100 lb. of explosive and was fitted with hydrophones and magnetic detectors intended to warn the shore control station when a submarine approached. A third type of mine used was a moored contact mine laid in fields in the open sea. U.S. submarines managed to keep clear of the controlled mine fields during the entire war, although three were lost to contact-type mines.

Japan lost 21 merchant ships in its own mine fields. The small bag of submarines taken by Japanese mines is accounted for partly by the fact that sonar enabled U.S. submarines to keep clear of mines, and partly because Japanese notices of mine fields, issued to warn their own ships of such dangers, sometimes were recovered by Allied personnel, with the result that these submarines often knew as much about Japanese mine fields as the Japanese did.

Mine *Warfare* in the *U.S.*—German U-boats laid a total of 11

mine fields off east coast ports in 1942 and 1943. These ventures cost Germany at least tno submarines sunk by aircraft almost as soon as they laid their mines, and resulted in several sunken or damaged ships. Not all the mine fields laid were effective; four of them, including one off Boston. Mass., and one off Charleston, S.C., were either badly laid or consisted of defective mines and were not discovered until the war was over; their location was disclosed by German records. A field of 15 mines laid by the U-701 in the Chesapeake capes ship channel was the most effective, sinking the S.S. "Robert C. Tuttle," the British trawler "Kingston Ceylonite" and a coal barge. The steamer was later salvaged. The tug "J R. Williams" was sunk by another field off Delaware. Mines forced the closing of the port of New Work for two days, but no ships were lost in that area. Five German mine fields were discovered and cleared before they caused any damage.

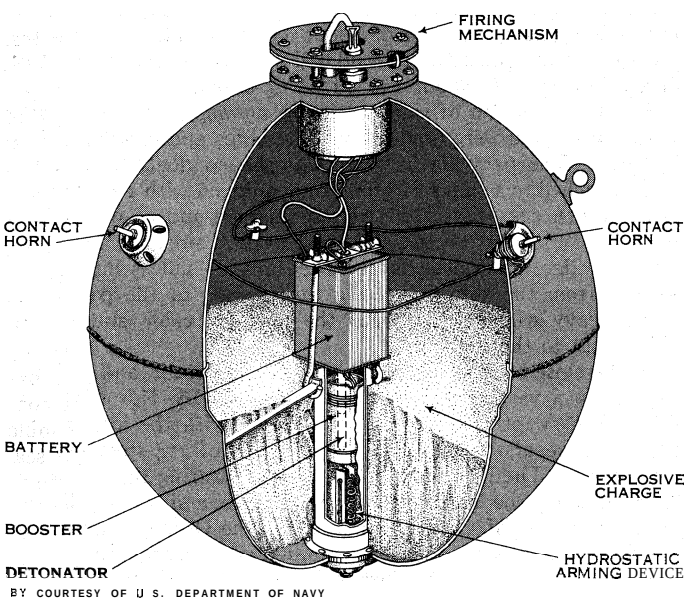
Summary.—It is estimated that British, dominion and Allied ships, including mine layers, destroyers. submarines. motor torpedo boats and motor launches. laid 206.969 mines in enemy waters during World War II, while aircraft laid another 53,552 mines. Germany laid about 120,000 mines around northnest Europe and no small number in the Mediterranean, where Italy assisted in the operation. The U.S. laid about 25,000 mines in the Pacific, ahile Japan may possibly have laid three times that many.

Admiralty figures on Axis naval and merchant losses as the result of British mine laying indicated that a total of 1,050 such ships were sunk and another 540 damaged. Britain lost 281 naval vessels of all types to Axis mines, in addition to 296 merchant vessels. The total of merchant ships lost by the other Allies reached 521. The U.S. navy lost six destroyers and destroyer escorts, three submarines, nine large mine sweepers and mine layers, two auxiliary craft and some small unnamed craft to mines. Japan lost 19 naval vessels and 247 merchant ships for a total of 266, out of which British mines claimed 10, Netherlands mines 2 and Australian mines 9.

At the close of 1947 it was estimated that a total of 251 ships of all nations had been mined in various parts of the world since the war ended, either by drifting or unswept contact mines.

Korean War.—The Korean war demonstrated the classic use of mines by a land power to hamper operations of a strong sea power. By extensive use of mines the North Korean forces achieved an initial surprise, sank or damaged several U.S. and South Korean ships, successfully interfered with U.S fleet movements and tied up much Allied effort in mine sweeping. Mines laid from sampans took their toll first in Sept. 1950, sinking the U S. mine sweeper "Magpie" and damaging destroyers "Brush" and "Mansfield" and the Republic of Korea mine sweeper YMS 504.

Mines used were Russian-made moored and ground magnetic-influence types. Extensive mine fields off the east coast port of Wonsan, where U.S. mine sweepers began clearing a channel on Oct. 10, 1950, actually delayed an amphibious landing there for one week; the 250-ship armada could not land its 50,000 troops, even though the city was in friendly hands, until about 2,500 mines uere cleared out. The U S. mine sweepers "Pirate" and "Pledge" and the ROK mine sweeper YMS 516 were sunk in this operation; the "Partridge" was later mined in Korean waters. Attempts were made to "countermine" these mines by carrier aircraft dropping bombs in the water, but with no success. During this war helicopters proved valuable in locating mine fields.



BY COURTESY OF U S. DEPARTMENT OF NAVY

FIG. 2.— CUTAWAYDIAGRAM OF CONTACT MINE SHOWING PRINCIPAL INTERNAL COMPONENTS

An "unarmed" mine is put into a ready-to-fire condition when the hydrostatic arming device reacts to a predetermined water depth. If a ship strikes a contact horn, an electrical current activates the firing mechanism. This in turn switches on the battery, which sends a strong current through the detonator, firing the booster and exploding the charge

TYPES OF MINES

All naval mines are of two general types, controlled or independent. Controlled mines can be made safe or dangerous as needed; their dependence on shore control and observation stations, plus the need for extensive underwater power and control cable systems, restrict their use to harbour defense areas where their laying or removal, while complicated, does not present the problems encountered in open seas or in enemy naters.

The greater percentage of mines used in modern warfare have been independent mines of tno general classes. moored and ground mines the latter resting on the sea bottom. Moored mines may be either contact (fired when hit by a ship) or influence mines; ground mines are, for obvious reasons. always influence mines.

Magnetic Mines.—These nere used by the British as early as 1917, although it was not until the Germans commenced using aircraft to lay them in British harbour entrances during Sept 1939 that they became a major threat. The operation of the magnetic mine depends on the fact that a steel ship acquires both permanent and induced magnetism; the firing mechanism of this mine is designed to be actuated by a ship's magnetic field. The unit for measuring magnetic induction is the gauss. Protection against magnetic mines is obtained by degaussing ships, or reducing their magnetic fields. This was achieved by passing an electrical current through a permanent coil, or degaussing girdle, which was build around the hull in a horizontal plane. Eventually, two simpler methods of degaussing were developed. "Flashing" involved placing a huge temporary coil around the ship and reversing the polarity of the permanent magnetic field. However, the process was expensive and each treatment lasted only a few months. "Wiping" consisted of simply moving a single cable, uith about a 3,000-amp. load, up the ship's side, section by section, with the same results as from flashing. Another process, called deperming, referred to all steps taken to reduce the ship's permanent magnetic field, after which degaussing reduced the induced magnetic field almost to a zero condition.

Sweeping magnetzc *mines* required that the mine sweeper produce a magnetic field strong enough to detonate the mines, at a safe distance from itself. Eventually a type of buoyant cable nas developed through which an electric current could be pulsed; each mine saeeper towed two of these cables, one several times longer than the other, with an electrode at the end of each, and a current pulsed through the cables set up a field strong enough to detonate any mine in an area between the ends of the two cables and for some distance on either side. Two mine sweepers steaming abreast of each other could thus clear a much wider path, and by timing the pulse intervals in accordance nith their speed it was possible to make the fields overlap each other and produce a continuous sweep.

Pressure Mines.—This type of mine, simple in operation, involves a principle long known to canal engineers: beneath every ship in motion in shallow water there is an area of reduced pressure, and this reduction in pressure depends on the ship's draft and speed. The pressure mine contains a chamber divided into two parts by a diaphragm, with one side of the chamber open to the

sea. The diaphragm is so constructed that any decrease in pressure on the sea side causes it to bend toward that side sufficiently to close a firing circuit and explode the mine. A small leak hole between the open and closed sides of the diaphragm serves to equalize pressure on both sides and to take care of slow changes such as those caused by tides, but it cannot absorb a sudden decrease in pressure quickly enough to prevent the diaphragm from closing the firing circuit. A ship passing over the mine will reduce the pressure too fast for the leak hole to equalize and will thus fire the mine. The pressure mine's outstanding advantage is that it reacts only to a low-pressure change equal to that produced by a ship or an object the size of a ship, thus making it practically impossible to sweep. Pressure mines, first used by the Germans in 1944, were developed by both Britain and Germany, but as neirher nation had found an effective countermeasure, they were reluctant to use them and give opposing forces a chance to turn such a weapon against them. Allied ships were informed of safe speed limits to use in sailing over pressure mines in order to avoid setting up the critical low-pressure effect, but this procedure could be used only by smaller ships.

Sweeping *Pressure* Mines.—Since pressure mines are fired by the reduced water pressure produced by a ship passing over them, the best method of sweeping them is to simulate the passage of a ship by towing a large, expendable target over them; a slow and sometimes costly procedure, as the exploding mine is likely to damage the target to the point where it must be laid up for repairs. Too, there is alnays the chance that heavy swells might temporarily inactivate the mine at the exact moment of sweeping. The Japanese had some success in sweeping these mines with bottom trawl nets and also used divers in some cases, but this was usually in the ratio of one diver to one mine. The U.S. used "guinea pig" ships in Japanese waters after World War II: they were damaged cargo ships, operated by volunteer crews at remote-control stations on the upper decks, which made high-speed runs through swept areas to see if all mines had been swept.

Because heavy seas sometimes actuate these mines—strong gales off the Normandy beaches in particular saved Allied mine sweepers the work of sweeping some German pressure mines—it was U.S. practice to combine pressure mines with magnetic or acoustic mechanisms. In heavy swells, mine sweepers had only to set up magnetic or acoustic influences to sweep the mines. In general, pressure mines retain a high nuisance value in comparison with other types.

Acoustic Mines.—These mines depend on a simple microphone which picks up and amplifies the sound of a ship's propellers or engine. As drifting mud or silt and accumulating marine growth foul the mine, it requires an increasingly higher sound level to fire it. In addition, the continuous drain on the battery will eventually sterilize the mine. Acoustic mines are swept by mine sneepers using mechanical noisemakers, such as' an air hammer beating on a steel plate. British sweepers used both built-in and towed-type "hammer boxes" in sweeping German acoustic mines. U.S. sweepers used the towed type of noisemaker exclusively. So far as is known, the Japanese laid no acoustic mines in the Pacific, but the U.S. used two different types, each responsive to different frequency bands of noise.

MINE SWEEPERS

Mine sweeping is the term applied to the process of clearing an area of mines; the vessel which performs this task is a mine sweeper by employment if not by design. The mine sweeper's place in naval warfare is well described in "The End of an Empire," vol. iv of Battle Report: "It is always the minesweeps that spearhead an invasion; it is always the minesaeeps that open up the vital gap through which the amphibious forces pour their massed weight. And it is almost always a minesweep that gets sunk first" (Capt. Walter Karig, Lieut. Comdr. Russell L. Harris and Lieut. Comdr. Frank A. Manson, Rinehart & Co., Inc., 1948).

Sweeping mines laid by an enemy is only part of the mine sweeper's task; equally important and every bit as hazardous is the business of sneeping up one's own mines in order to render sea lanes safe for maritime commerce. The earliest sweeping system, devised to clear anchored contact mines, consisted of two ships steaming across a mine field towing a wire rope between them. The wire was kept at the necessary depth by otters, a sort of underwater kite, and mooring lines of mines were cut by saw-like projections on the sweep wire or by cutting jaws. When the released mine floated to the surface it was destroyed by gunfire.

Fishing boats were first used by the British for mine sweeping during World War I, but they were too slow for operations with the fleet. Special mine-sweeping vessels were designed, followed by high-speed mine sweepers which could sweep at speeds up to 25 knots. At the same time the British developed the Oropesa sweep, named for the first ship to experiment with it, which provided a means of protection for all the mine sweepers in a sweeping operation except the leader. The Oropesa sweep was a long cable, supported at the outer end by a float and maintained at the proper depth by otters, which swept a path to one side of the

BY COURTESY OF U.S. DEPARTMENT OF NAVY

FIG. 3.— U.S.S."CONQUEST." AN OCEAN-GOING. NONMAGNETIC COASTAL MINE SWEEPER. 172 FT. IN LENGTH, 630-TON DISPLACEMENT. SPEED OF 15 KNOTS

course followed by the mine sweeper. Each following sweeper thus sailed in a swept channel. With the introduction of high-speed destroyer-type mine sweepers using an Oropesa sweep on each side at once, a spread of about 450 yd. could be cleared at low speeds; the sweeps were modified so that increased speed reduced the spread to about 150 yd. at 25 knots.

For the protection of ships at sea in unswept areas, paravanes were devised and were used by both warships and merchant ships by 1917. The paravane is a torpedo-shaped float, towed by a cable attached to a ship's forefoot and equipped with a rudder and planes which cause it to tow well submerged and to one side of the ship. With a paravane streamed to each side, the tow wires form a wedge which deflects anchored mines—unless hit bow on—away from the ship and along the towline to the paravanes, where heavy wire cutters shear the mooring cable and let the mines float to the surface.

At the close of World War I, both Great Britain and the U.S. engaged in a vast mine-sweeping campaign. By Nov. 1919 the British had swept more than 23,000 mines, with the loss of only six mine sweepers, as compared with the loss of 214 sweepers during the war. The U.S. took on the task of clearing the North sea barrage; about 90 ships swept 56,033 U.S. and 15,093 British mines in an area of 5,000 sq.mi. between the Orkney Islands and the Norwegian coast. The impossibility of obtaining 100% success in clearing all such mines was demonstrated in July 1947 when a World War I type mine was found off Cape May, N.J.

With the build-up of naval strength commencing in 1938, the U.S. added large numbers of mine sweepers to the fleet, which at that time depended for such service on the "Bird" class mine sweepers left over from World War I. Some high-speed mine sweepers were converted from World War I-type destroyers;

others were converted, during the war, from "Bristol" class destroyers. About 70 of the "Raven" class mine sweepers. nith speeds of 18 knots, nere commissioned; another 130 "Admiral" class sweepers and about 70 "Accentor" class coastal mine sweepers also joined the fleet. Other mine sweepers were converted from trawlers, purse seiners and tuna clippers (all types of commercial fishing boats). Smallest sweepers were the zoo-ton motor mine sweepers, of which more than 450 were in service.

The extensive use of magnetic mines by Communist forces during the Korean war led to U.S. development of new types of wooden-hulled, nonmagnetic sweepers to replace most steel-hulled World War II types. Identified as MSO's, they displaced from *600* to *800* tons and were less than *200* ft. in length.

MSO's had plywood hulls, stainless steel alloy engines and metal fittings of aluminum, brass or magnesium. Approximately 100 steel-hulled sweepers of the World War II type remained in service. Another addition to the U.S. mine-sweeping force was the mine-sweeping boat (MSB) that was only 57 ft. long and displaced about 44 tons. These vessels were completely nonmagnetic, were equipped to sweep contact, magnetic or acoustic mines and were operated by a crew of six enlisted men. The U.S. navy also developed helicopter mine sweepers; the powerful, slow-moving "whirly birds" can hover safely above the sea while towing mine-sweeping gear which explodes magnetic or acoustic mines.

During World War II U.S. mine sweepers took part in every combined landing assault and many fleet operations. Before the Normandy landings, 255 mine sweepers were assembled in England. On the opposite side of the world, when the U.S. fleet moved into Leyte gulf in Dec. 1944, 65 mine sweepers were in the van. From the time sweeping started until the war ended U.S. mine sweepers cleared about 10,000 mines; it was estimated that there remained in the Pacific alone 100,000 mines which had to be swept before sale navigation could be ensured. British, Australian and Dutch mine sweepers took over the task of clearing the Asian coast off Formosa and the islands south of the Philippine Islands, while U.S. mine sweepers cleared fields off the Philippine Islands, East Hainan strait, the Palaus, Marshall and Gilbert Islands, Truk, the Bonins and Japan. At the peak of these operations, which mere completed in March 1946, about 300 Japanese-manned mine sweepers were assisting 374 U.S. mine sweepers.

Mine Watching.—During World War II, Allied and Axis nations in Europe, and the Japanese, during the last months of the war, used mine watchers to detect night-flying, mine-laying aircraft and to mark exact locations of dropped mines, thus expediting their removal. Great Britain maintained mine watchers after the war and organized the Royal Navy mine-watching service in 1951. A uniformed civilian organization affiliated with and administered by the admiralty, it included shore-based watching posts with necessary plotting instruments and communications equipment and floating watching posts for all major ports and waterways consisting of a mother ship and several smaller watching craft. A port mine-watching service officer was stationed at each major port. Members of the service, frequently with prior military service, were recruited, furnished distinctive uniforms and trained in essential duties

In the European theatre, from Sept. 3, 1939, to June 13, 1945, British and other Allied mine sweepers cleared 20,429 mines, exclusive of U.S. operations. A total of 1,533 ships were used in this operation, of which 263 were lost. During the next three years, an international organization initiated by the British admiralty cleared 125.000 mi. of sea lanes. About 1,900 mine sweepers of many nations engaged in this project, destroying 12,000 mines.

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MINEHEAD, a market and seaside town and urban district *(1894)* in the Bridgwater parliamentary division of Somerset, Eng., on the Bristol channel, 24 mi. N.W. of Taunton. Pop. *(1951) 7,401.*

Minehead owes its origin and growth to its good harbour, and there is still in existence a record of the port dues charged in 1380, although it was not until 1558 that the town was granted a charter of incorporation by Elizabeth I. This was revoked by James I, but until the Reform act of 1832 Minehead continued to send two members to parliament. A weekly market and annual fair were held from the 15th century, and since the reign of Edward IV the iair has been held on the Wednesday in Whitsun week. Buildings of interest include St. Michael's church (1450); Quirke's almshouses (1630); the Old Manor office; and the 17th-century cottages at the Quay and Church steps. The present harbour was built in 1616. During the 17th century Minehead mas a thriving port conducting a considerable trade with the West Indics and other colonies, but today only coasting vessels use the harbour. Minehead's main industry is catering, although light industry, notaoly shoemaking and the manufacture of electrical components, has been established in the town.

MINEOLA, a village on Long Island, New York, U.S., the seat of Nassau county, lies midway across the county at the junction of the main line and the Oyster Bay branch of the Long Island railroad. In the 17th century both the Dutch and English, who crossed Long Island sound from Connecticut, made settlements on Long Island *(q.v.).* Both started farming what was called Hempstead plains. Mineola, then called Hempstead Branch, was a part of the Hempstead plains. In 1858 the name was changed to Mineola. When Nassau county was created in 1898 by dividing Queens county. Mineola was made the county seat; in *1906* it became an incorporated village. Near Mineola are Roosevelt field (closed to flying in 1951; the site of a shopping centre), where many of the great names in flying made early aviation history, and Mitchel air force base. For comparative population figures *see* table in NEW YORK: *Population.* (D. L. D.)

MINE PROSPECTING AND DEVELOPMENT. The search for economic mineral deposits is called prospecting. Prior to the 20th century. mineral deposits were found by prospectors roving the surface of the earth looking for visible evidence of mineralization. Valuable minerals were recognized by their various distinctive physical properties. Gold occurs in nature as a heavy, malleable, yellow metal. The most important mineral of lead, galena, is dark gray, heavy and lustrous. The first ores of iron to be mined were deposits of magnetite, a black, heavy mineral capable of attracting a piece of iron metal. All three of these minerals are eye catching. (See also METALLURGY: *History.*)

Geologic Methods.—As the deposits of minerals that cropped out at the surface of the earth were mined, the search for additional supplies of minerals took a more sophisticated turn. The science of geology was used to explain the occurrence of ore deposits. It was discovered that certain types of mineral deposits are associated with certain types of rock and geologic land forms and structures. *(See* GEOLOGY: *Physical Geology: Economic Geology).*

Minerals of the common metals, copper. lead and zinc, generally form in igneous rock, which is formed by the cooling of masses of molten minerals at or near the surface of the earth. Wherever igneous rock came into contact with a bed of sedimentary rock a favourable location for the concentration of metallic minerals resulted *(see* ORE DEPOSITS). By mapping the rocks that. crop out at the surface of the earth, geologists can sometimes infer such locations even though the contact between the sedimentary rock and the igneous rock does not appear at the surface. Drilling holes for samples of rock at depth will then confirm or disprove the existence of a mineral deposit at such a location. *(See* also MINERALOGY: *Geologic Occurrence and Origin.*)

Geophysical Methods.—As the science of physics progressed in the methods of measuring the properties of matter, these methods of measurement were adopted by prospectors to help find deposits of minerals that possess some detectable property not discernible to the naked eye. Probably the first use of a geophysical instrument to aid in the discovery of minerals was the use of a compass to locate bodies of magnetic iron ore. Prospectors found that a dip needle, a compass held in a vertical plane, could be used to find magnetic bodies that could not be seen at the surface. An instrument known as a magnetometer, which can detect very small forces of magnetism, was developed and is used extensively in the search for completely buried mineral deposits.

Of ten the mineral possessing the magnetic property, magnetite, is associated with more valuable minerals of copper, lead and zinc, and the magnetometer can be used to prospect for this type of deposit also. This instrument has been developed to the point where it can be used effectively from an airplane.

Another property that minerals possess is density. Some min-

erals are much heavier or much more dense than others and this difference in density can sometimes be detected with an instrument known as a gravimeter. Gravimetric methods were used to locate deposits of chromite, a heavy mineral of the metal chromium. in Cuba during World War II.

Some deposits of sulfide ores possess characteristic electrical properties. Acting like giant batteries, these deposits can cause the flow of electric currents in the ground surrounding completely buried deposits of these materials. These currents can be detected at the surface by sensitive voltmeters.

Metallic ores are generally much better conductors of electricity than the surrounding barren rock. A more sensitive and selective electrical method of prospecting involves the injection of an electric current into the ground by means of a generator and ground electrodes. The flow of this manufactured electricity will be concentrated in the best conductors. By means of an instrument known as a galvanometer, the path of flow of this electric current can be traced, and if a metallic ore is present beneath an overburden of soil and rock it can be detected.

The principle of electromagnetic induction can also be used to locate mineral deposits. These methods utilize the physical principle that an artificially created electromagnetic field will induce a flow of current in an electrical conductor. The flow of current in the conductor, a conducting ore body in the case of mineral exploration, will in turn induce a secondary electromagnetic field which can be detected at the surface of a buried deposit. As well as being used to find deposits, these electrical methods are often used to help determine the size and depth of known ore deposits.

Seismic methods of prospecting employ knowledge gained in the study of earthquakes. Different types of rocks will transmit earthquake waves with different velocities. An artificial earthquake can be created by exploding a charge of dynamite in a hole drilled into the surface of the earth. The exact time of the explosion is recorded and the time of arrival of seismic waves at a number of stations is also recorded. The seismic waves also travel down into the rocks of the earth and are reflected like sound waves from the boundaries between layers of different kinds of rock. The time it takes for these echoes to arrive at the recording station is carefully determined and the velocity of the seismic wave can be computed. From the velocity of the wave, the type of rock through which the wave passed can be determined. Geologic structures can also be defined by use of this method, and favourable locations for the formation of oil reservoirs can be recognized. The seismic method is the most important geophysical prospecting method used in the search for new oil fields (see PETROLEUM).

Ores of uranium and thorium emit radiation that can be detected with an instrument known as the Geiger counter. A more sensitive instrument used in the detection of nuclear radiation is the scintillation detector. Uranium and thorium ores exposed at the surface can be easily found with this instrument. When uranium ores are covered by an overburden of loosely consolidated material they may still be detected. In the radioactive decay process a gas, radon, is formed which can migrate away from the ore deposit of uranium. This gas can work its way toward the surface, where it decays and forms elements which are also radioactive. This radioactivity can be detected by a scintillation detector or Geiger counter carried over the ore deposit.

For detailed discussion of geophysical methods and their application see GEOPHYSICAL PROSPECTING.

Geochemical Methods.—Geochemical prospecting methods involve chemical analysis for traces of metals in soils: vegetation and stream water or silt. The weathering of metal-bearing ores at the earth's surface results in a residual soil containing a higher than normal amount of the metal. Traces of this metal also find their way into the vegetation growing over the metal deposit and into water and sediment of streams flowing away from the deposit. Although to the unaided eye such metal-rich soils, vegetation and water are identical to normal materials, they can be distinguished by the chemical tests for the metals they contain. These simple tests, though extremely sensitive, are inexpensive and well fitted to the pocketbook of the independent prospector.

Prospecting Fields.—Prospecting is carried on most intensively in areas where chances are best for the discovery of large-tonnage but relatively low-grade deposits that can be worked profitably by modern mining methods. An area is generally considered promising if some valuable deposits have been found there in the past and if there is reason to believe that other similar deposits remain to be found by the application of modern exploration techniques. To this should be added the requirement that political conditions be favourable for a heavily capitalized industrial operation. These conditions are met, for example, in the following areas:

1. The Pre-Cambrian shield of central Canada, where major deposits of nickel and uranium have been found.
2. Southern Arizona, where two very large copper deposits are being developed.
3. An area including southern Peru and northern Chile, where several major copper deposits are being developed.
4. Central Africa, where extensions of the fabulously rich Rhodesian copper belt are being sought.

Mention should also be made of the flurry of uranium prospecting in the Colorado plateau following World War II, that led eventually to the discovery of the major uranium deposits of the Ambrosia lake district in New Mexico. (See also NATURAL RESOURCES.)

Exploration.—After a mineral deposit is found by the prospector, its size and richness must be determined. Various geophysical methods can be used to some extent. in this operation, known as exploration. Most commonly, a drill is used. Rotary drills capable of drilling holes 20.000 ft. into the earth are commonly used to explore metal deposits. The churn drill is simply a heavy steel chisel suspended on a steel cable. The steel chisel is raised and dropped on the ground, crushing the rock and forming a hole. Water is placed in the hole to hold the crushed rock in suspension during the drilling process. Periodically, the crushed rock is bailed from the hole and this material is sampled and analyzed for its mineral content.

The diamond drill has a hollow, cylindrical, diamond-studded bit which can cut a cylinder from the rock through which it passes. This rock cylinder is recovered and its mineral content is determined. While the churn drill can drill only vertical holes, the diamond drill can drill holes in any direction. Holes are drilled at measured distances across the ore deposit and the size and richness of the deposit can be estimated. (See also DRILLING MACHINERY.)

A profitable mine demands an economic balance between size and grade of the deposit. ease of transportation, availability of a market, availability of competent labour and political stability of the controlling government. Thus, a very low-grade but large copper deposit in the U.S. can be mined economically using skilled labour and mechanization while a much richer deposit in a remote area of the world may be uneconomic to mine.

Development.— If the main body of an ore deposit is near the surface, it can be mined as an open-pit mine and its development would entail the removal of the overburden. If the deposit is to be mined by underground methods, development entails the sinking of shafts, the installation of hoisting equipment and the driving of openings or tunnels through the ore body. Additional information on the shape and size of the ore body and the physical character of the ore and the surrounding rock is obtained during the development stage and many other factors, such as the type of artificial support required by the tunnels, the amount of water that has to be pumped from the underground workings and the ventilation that will be required, are determined.

Mine Surveying.—Once exploration is started, surveying assumes great importance in mining. The position and depth of all the exploration drill holes are accurately determined with surveying instruments. From these data, maps, which are blueprints for the mining engineer and geologist, are prepared which picture the ore deposit in three dimensions. The locations of all tunnels, shafts and veins of ore are carefully recorded on these maps. Because the surveying is done in very close quarters and often in

very wet or very dusty atmospheric conditions, special instruments are used for mine surveying.

For mining methods and production see MINING, METAL. See also COAL AND COAL MINING; COPPER; DIAMOND; LEAD; SALT DOME, etc.

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MINERAL DEPOSITS: see ORE DEPOSITS.

MINERALOGY, one of the geological sciences, is concerned with the study of minerals—the naturally formed and generally inorganic solid substances composing the crust of the earth, meteorites and other planetary bodies. The domain of mineralogy includes discovery, identification, description and classification of the different mineral species; study of their geological occurrences; explanation of their nature and properties; explanation of their origins; and consideration of their practical uses. In referring to minerals it should be borne in mind that popular usage of terms frequently differs from scientific usage. In everyday speech, the term mineral is likely to cover a great variety of inorganic matter, even that in foodstuffs. For scientific purposes, the term is reserved for substances having essentially the following characteristics: natural occurrence, homogeneity, definite chemical composition or ranges in composition, regular internal structure, and inorganic nature (with but few exceptions). However, as is the case for most natural substances, there exist many intermediate varieties between materials clearly covered by any simple definition and those that are not. The following examples illustrate some of the boundaries of the term. Coal is not a mineral because it is inhomogeneous, is composed chiefly of organic substances and is wholly to largely noncrystalline. On the other hand, two liquids, at ordinary temperatures and pressures (the usual reference conditions of man), are included as minerals—water and native mercury. A few natural crystalline organic compounds are also included as minerals (*e.g.,* whewellite, hydrous calcium oxylate, $CaC_2O_4.H_2O$).

This article presents a general survey of and introduction to the science of mineralogy and its more significant problems, directions, implications and applications, with special attention to developments in the second half of the 20th century. In addition to the cross references given in the various sections of this article further discussion of theories, concepts and techniques referred to will be found in the articles GEOCHEMISTRY; CRYSTALLOGRAPHY; GEOLOGY; PETROLOGY; METAMORPHISM; SEDIMENTARY ROCKS. *See* also separate articles on individual species and groups of .minerals, as: FELDSPAR; HALITE; QUARTZ; etc.

Following are the main divisions:

I. History
II. Nature of Minerals
III. Classification and Nomenclature
IV. Descriptive and Determinative Properties
V. Geologic Occurrence and Origin
VI. Experimental Mineralogy

I. HISTORY

The planet earth is a great ball of minerals. Not only do the minerals largely determine man's physical environment, but they provide also the ultimate source of a vast number of raw materials and much of the energy essential to him. Minerals are. therefore, of great interest from many points of view and have been intimately associated with the material and intellectual development of mankind. Earliest man used stones, clay, colourful or shiny mineral pieces and crystals, and rarely occurring native metal for implements, building materials, pigments. charms and ornaments almost as furnished by nature. Later, metals a-ere extracted from ore minerals; building blocks and bricks were worked from stone and clay; and pottery and glass were manufactured from clay minerals, feldspar and quartz. In modern times: an ever-growing host of chemicals, metals, other useful products and energy are obtained directly and indirectly from mineralogic sources (see NATURAL RESOURCES: *Minerals*).

Although man has speculated on the "nature of things" since prehistoric times, scientific study of minerals scarcely began much before the 19th century. Moreover, the study was largely descriptive until well into the 20th century by virtue of the extremely complex nature, properties and occurrences of minerals. This complexity has required that mineralogy utilize an extensive application of other sciences such as geology, crystallography; mathematics, many branches of chemistry and physics, metallurgy and ceramics. The development of mineralogy has depended, therefore, upon a co-ordinate development of these other sciences.

The earliest surviving work on minerals is that of Theophrastus, On Stones (*c.* 315 B.C.). It appears to have been part of a much larger treatise that has been lost. The most important mineralogical writings of classical times are the last five "books" (chapters) of *Natural* History by Pliny (C. A.D. 77). The books summarize the knowledge (correct and incorrect) about the mineral kingdom held by the classical authorities up to that time. The modern aspect of mineralogy began with Georgius Agricola ("father of mineralogy") and the publication of his De natura *fossilium* (1546) in which he classified minerals on the basis of physical properties and presented an extended description of the different varieties, many of them new. After Agricola, the attempts to develop the ideal classification polarized into: (1) the natural history method (*e.g.,* C. Linnaeus. 1735; F. Mohs, 1820). based on external characters; and (2) the chemical method (*e.g.,* A. F. Cronstedt, 1758; J. J. Berzelius. 1814). However. some mineralogists, notably A. G. Werner (1774), compromised with mixed systems.

Reliable quantitative chemical analysis of minerals was begun about 1800 by M. H. Klaproth and was widely and successfully applied by K. W. Scheele and Berzelius. During the same period, J. B. L. Romé de Lisle (1772) and especially R. J. Haüy (1801) laid the foundations of crystallography. W. H. Wollaston's invention (1809) of the reflecting goniometer (*q.v.*) made possible precise and rapid measurement of the angles of crystals. It then became apparent that chemical composition and crystallographic characters are the fundamental properties of minerals. E. Mitscherlich's explanation (1819) of the puzzling phenomenon of isomorphism, that is, the similarity of crystalline form in substances that are chemically related. laid the beginnings of the modern crystallochemical approach to mineralogy. The improvement of the polarizing microscope by H. C. Sorby. his use of it (1849) to study extremely thin slices of rock (thin sections). and the determination and compilation of mineral optical data by A. des Cloizeaux (1867) and others inaugurated the third and final major approach of classical mineralogy.

The more recent direction of mineralogy was stimulated by Max von Laue's brilliant suggestion (1912) that crystals could diffract X-rays. Shortly thereafter, W. H. Bragg, W. L. Bragg and others began the development of X-ray diffraction techniques and employed them in the study of mineral construction. Soon after, V. M. Goldschmidt and his co-workers laid the foundations of crystal chemistry. In an equally important development. N. L. Bowen and his co-workers began a comprehensive program of investigating experimentally the complex conditions under which minerals form.

II. NATURE OF MINERALS

The obvious properties of minerals. such as size, shape. colour and markings, are not essential or particularly informative ones. In fact, they tend to obscure those that are. Accordingly, minerals must be investigated by means of the less obvious properties and special techniques must be devised to measure and interpret them. Crystal morphology, diffraction of X-rays, crystallophysical behaviour (*e.g.,* optics) and chemical composition are the most informative. They are also of great value in determining the identity of mineral species and varieties. The nonessential properties are of interest chiefly as supplemental descriptive properties; they may aid in mineral identification in certain cases.

Morphological Crystallography.—The first information about the nature of minerals came from the study of the angular

relationships and schemes of arrangement of crystal faces and cleavages (crystal morphology). Such study, which began with and was long restricted to minerals, developed eventually into the independent science of crystallography. The most informative regularities in behaviour discovered were what are now known as the law of constancy of interfacial angle, the law of rational intercepts and the principle of symmetry. They indicate that minerals have characteristic internal structures made up of periodic arrays of submicroscopic "building blocks" (unit cells). Crystal morphology provides information about the shapes and relative dimensions (axial angles and ratios) of the building blocks but not their absolute dimensions or contents. An extended account of the subject is given in the article CRYSTALLOGRAPHY.

Structural Crystallography.—The development of X-ray diffraction in 1912 opened up a completely new avenue of approach to crystallography and to the nature of minerals (see CRYSTALLOGRAPHY: *Crystal-Structure Analysis;* X-RAYS). It now became possible to determine the detailed internal symmetries (space groups). absolute dimensions and atomic contents of the building blocks (unit cells). and thus the crystal structures of minerals. The first substances investigated by the new technique were mostly minerals, and within a few years a large number of crystal structures had been worked out, especially by the Braggs (father and son) and their co-workers.

More recently. electron diffraction, infrared spectroscopy. neutron diffraction, and nuclear and electron spin resonance also have become valuable tools of structural crystallography. These newer methods confirm and add a large volume of significant detail to the results of X-ray diffraction.

Structural crystallography established as fact the deduction of classical morphological crystallography that each mineral species is characterized by its chemical constituents and their ordered arrangement. It further established that the solid state is essentially the crystalline state. Most of those minerals once thought to be amorphous (noncrystalline) are. in actuality. extremely fine crystalline (cryptocrystalline) aggregates. However, no clear cut discontinuity exists between the crystalline and the rarely occurring amorphous state.

Chemical Composition.—Accurate determination of mineral composition is more difficult than would appear. Not only are many compositions extremely complex but most minerals exhibit appreciable ranges (solid solution) and many exhibit great ranges in composition. Moreover, most minerals occur intimately intermixed with one or more others, and some minerals. notahly the common rock-forming and ore minerals, may be intergrown on such a fine scale that the inhomogeneity can be observed only by methods such as optical and electron microscopy. or X-ray and electron diffraction. Thus, much difficulty has been experienced in understanding the true chemical nature of minerals. In a large part. progress in this direction has followed the co-ordinate development of crystallographic technique and theory.

Although almost all of the 90 or so natural elements play some part in mineral composition, by far the most important ones are oxygen (60.5%), silicon (20.4%), aluminum (6.2%), hydrogen (2.8%), sodium (2.5%), calcium (1.9%), iron (1.9%), magnesium (1.84; j. potassium (1.4%) and titanium (0.2%), which compose 99.6 atomic per cent (relative numbers of atoms) of the earth's crust. Important subsidiary elements are carbon (0.06%), phosphorus (0.05%), manganese (0.04%), sulfur (0.03%) and fluorine (0.03%). The remaining elements are extremely rare and are contained in abundance only in minerals other than the rock-forming ones. These minerals compose an almost infinitesimal fraction of the crust. Many of the rare elements also are widely dispersed as traces in solid solution in the rock-forming minerals. In addition to the common metallic and nonmetallic elements, hydrogen is a significant constituent in many minerals and one that was commonly overlooked even as recently as the 1930's. It occurs in water molecules in crystal hydrates, in adsorbed water molecules. in hydroxyl (OH) ions, and less commonly as cations (giving rise to hydrogen bonds).

Crystal Chemistry.—Modern mineralogy makes extensive use of crystal or solid state chemistry which combines crystallography and chemistry into a powerful unified approach. Much of the development of this field was based upon the study of minerals, and its early history is largely a part of the history of mineralogy.

Crystal chemistry considers the forces bonding atoms together, the gross and detailed features of crystal structures, the chemical-structural behaviour of the elements, and the explanation of the nature and properties of minerals and other crystalline matter. The great bulk of minerals, including the halides, most oxides and oxysalts (*e.g.,* carbonates. silicates) may be considered as ionic crystals (see SOLID STATE PHYSICS). They consist of positively. charged cations (metallic elements) and negatively charged anions (nonmetallic elements) bonded together by electrostatic attraction. Native nonmetallic elements and many sulfides. on the other hand. are predominantly covalently bonded. Metallic bonding occurs in the native metals and some sulfides. Some minerals—*e.g.,* brucite. $Mg(OH)_2$, molybdenite. MoS_2, goethite. $HFeO_2$—are held together by weak Van der Waals or by hydrogen bonding (*see* VALENCE: *The* Hydrogen *Bond*) as well as by ionic or by covalent bonding.

Many properties such as crystal optics. habit, cleavage, the greasy feel of talc and graphite. conductivity and adsorption depend at least in part upon the bonding present.

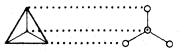
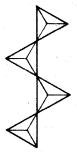
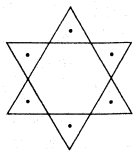
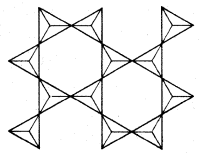
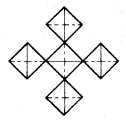
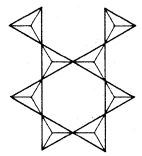
The crystal structures of minerals range from the simple (halite) to the complex (feldspars. tourmaline). Consideration of many structural features is simplified by the use of the geometric conception of co-ordination. Co-ordination refers to the array of immediate neighbour atoms (or ions) around a given kind of atom ior ion). Crystal structures can be readily described and analyzed in terms of different combinations of linked co-ordination groups. The reiated concept of close-packing is also of extremely useful application because in a great many minerals the nonmetallic atoms (notably oxygen and sulfur) not only occupy most of the volume hut are in (or close to) a close-packed arrangement. The structures of such minerals, therefore, are based upon a close-packed arrangement of nonmetals with the metal atoms occurring in the interstices.

There exist two crystallographic kinds of close-packing—hexagonal and cubic. Both have two sets of interstitial voids; each void of one set is surrounded by six nonmetal atoms (sixfold or octahedral co-ordination): and each of the other set by four (fourfold or tetrahedral co-ordination). Thus, the crystal structure of halite (NaCl) is described by stating that the chlorine anions are cubic close-packed and the sodium cations occupy the octahedrally (sixiold) co-ordinated sites. In sphalerite βZnS, the sulfur atoms also are cubic close-packed, but the zinc atoms occupy the tetrahedral (fourfold) position. In wurtzite αZnS, on the other hand, the zinc atoms again occupy tetrahedral sites. but the sulfur atoms occur in hexagonal close-packing. In the more complex structure of olivine Mg_2SiO_4, the oxygens are approximately hexagonal close-packed and the metals occupy both types of sites, the silicons occurring in tetrahedral interstices and magnesiums in octahedral ones. (*See* also INTERMETALLIC COMPOUNDS.)

A notable early triumph of crystal chemistry was the explanation of the structure and properties of the complex silicate minerals. Their fundamental constructional unit is the silicate tetrahedron $[SiO_4]$, a co-ordination group of four oxygens around each silicon atom. These tetrahedral groups occur in different schemes of iinkage so as to form different silicate anion radical types whose structures and formulas are illustrated in Table I. The structure of each silicate species is built with units of a particular kind of anion group bonded to one another by cations in theinterstices between them. Many mineral properties such as crystal habit, cleavage. optics, viscosity in the molten state. adsorptivity, reactivity and geologic occurrence are controlled or influenced by the kind of silicate radical present. Because of this close connection of crystal structure with mineral properties it is common practice to write the chemical formulas as structural formulas. Thus, the formula $KAl_2(Si_3AlO_{10})(OH)_2$ for muscovite indicates that two structural species of aluminum atoms are present; one-third of the aluminum atoms are tetrahedrally co-ordinated ("tetrahedral aluminum") and two-thirds are octahedrally co-ordinated ("octahedral aluminum"). The tetrahedral aluminum is structur-

ally similar to silicon and the two species together form alumino-silicate sheets (having the characteristic ratio of tetrahedral atoms to oxygen of 2:5).

Many different minerals (*e.g.*, halite, NaCl, periclase, MgO, and galena, PbS; barite, $BaSO_4$, celestite, $SrSO_4$ and crocoite, $PbCrO_4$) have the same kind of crystal structure, a property termed isostructuralism. On the other hand, some substances with the same chemical composition have different structures, the property of polymorphism (*q.v.*). The structural differences can be of any degree. Some polymorphs (different forms having the same composition) have distinctly different atomic arrangements and are clearly different crystal or mineral species (*e.g.*, calcite and aragonite, $CaCO_3$; pyrite and marcasite, FeS_2; andalusite, sillimanite and kyanite, Al_2SiO_5). Others, such as the temperature modifications of certain minerals (*e.g.*, high- and low-temperature quartz, high- and low-temperature albite), differ so slightly that they are simply structural variants of a mineral species. Many of the minor polymorphic differences are caused by differences in kind and degree of structural order. Thus, microcline and sanidine, $(K,Na)Si_3AlO_8$, differ from one another in the positional order (sequence) of the aluminum and silicon atoms in the tetrahedral sites in the alumino-silicate framework (*see* FELDSPAR). Moreover, certain minerals (*e.g.*, wurtzite, clays and micas) have subtle variants (polytypes) due to different schemes of order in the stacking of their constituent layers (*see* MICA). The silica minerals (quartz, tridymite, cristobalite and coesite, SiO_2) provide an especially notable illustration of variety in kind and number of different arrangements of the same atomic constituents (*see* SILICA). The particular polymorph present in a mineral system depends upon many factors, such as the temperature, pressure and composition of the environment during formation, the mechanism and rate of crystal growth, and the later thermal and mechanical history of the system.

TETRAHEDRAL GROUPING	DESCRIPTIVE NAME	RELATIVE NUMBERS OF ATOMS	ELECTRIC CHARGES +	ELECTRIC CHARGES −	FORMULA OF GROUP (LOWEST MULTIPLE)	REPRESENTATIVE MINERAL
	SEPARATE TETRAHEDRONS	1 Si 4 4 0 8 SiO_4		4−	$(SiO_4)^{4-}$	OLIVINE $(Mg,Fe)_2SiO_4$
	DOUBLE TETRAHEDRONS	2 Si 8 7 0 14 Si_2O_7		6−	$(Si_2O_7)^{6-}$	THORTVEITITE $Sc_2Si_2O_7$
	CHAIN	1 Si 4 2+2/2 0 6 SiO_3		2−	$(SiO_3)^{2-}$	PYROXENE $(Mg,Fe)SiO_3$
	THREE-MEMBERED RING	3 Si 12 9 0 18 Si_3O_9		6−	$(SiO_3)_3^{6-}$	BENITOITE $BaTiSi_3O_9$
	SIX-MEMBERED RING	6 Si 24 18 0 36 Si_6O_{18}		12−	$(SiO_3)_6^{12-}$	BERYL $Be_3Al_2Si_6O_{18}$
	SHEET	1 Si 4 1+3/2 0 5 $SiO_{5/2}$		1−	$(Si_2O_5)^{2-}$	TALC $Mg_3Si_4O_{10}(OH)_2$
	FRAMEWORK	1 Si 4 4/2 0 4 SiO_2		0	$(SiO_2)^0$	QUARTZ SiO_2
	DOUBLE CHAIN OR BAND	2 Si 8 4+3/2 0 11 $Si_2O_{11/2}$		3−	$(Si_4O_{11})^{6-}$	AMPHIBOLE $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$

FROM "JOURNAL OF GEOLOGICAL EDUCATION"

STRUCTURES AND COMPOSITIONS OF SILICATE RADICAL TYPES

Many mineral properties arise from the fact that real crystals are imperfect in terms of the ideal model of classical crystallography. The imperfections include various types of atomic thermal motion, vacant sites, interstitial atoms, impurity atoms, site disorder, dislocations and mosaic or domain structures. The colours, for example, of certain varieties of normally colourless minerals (*e.g.*, quartz, fluorite, halite) are attributed to colour centres, a type of imperfection in which electrons are trapped in vacant anion sites. Fluorescence and other varieties of luminescence result from the promotion of extra energy levels by certain impurity atoms.

Solid Solution.—The occurrence of ranges in chemical composition is an especially characteristic property of minerals. The phenomenon is termed solid solution and is caused by such mechanisms as simple proxy, cluster proxy, omission, interstitial "stuffing" and mixed-crystals. In simple proxy, chemically different species of atoms are structurally equivalent (*e.g.*, magnesium and ferrous iron; aluminum and silicon; fluorine, hydroxyl and oxygen) and occur in different proportions to one another in the same kind of sites. For example, magnesium, ferrous iron and manganese occur in octahedrally co-ordinated sites between the independent silicate tetrahedrons in olivine $(Mg,Fe,Mn)_2SiO_4$. All ranges between occupancy entirely by magnesium or by iron can occur, whereas only a relatively small proportion of the sites can be occupied by manganese. That is, solid solution is complete with respect to magnesium and iron but limited for manganese. Where solid solution involves atoms of unlike valence (*e.g.*, Al and Si), electric neutrality is maintained by complementary proxy that compensates for the charge difference. Cluster proxy occurs in a few minerals whereby atomic clusters such as Cl_2, CO_3 or SO_4 substitute for one another. Such proxy is restricted mainly to minerals having large voids as in the framework types of silicates (*e.g.*, feldspathoids, scapolites).

Compositional variations involving departures from the low stoichiometric ratios (simple combining proportions) of classical chemistry are common among the sulfide and related minerals. Atomic omission (by metals, nonmetals or even both) is the most common cause. In pyrrhotite, for example, as many as one-fifth of the metal sites may be vacant (symbolically: $Fe_{1-x}S$, with x between 0 and 0.2), and in skutterudite (formerly termed smaltite) as many as one-sixth of the nonmetal sites may be vacant—$(Co,Ni)As_{3-x}$, with x between 0 and 0.5.

Much solid solution commonly attributed to simple proxy is due more probably to mixed crystals. They consist of extremely minute (at or near the atomic scale of magnitude) domains having similar or closely related structures but different pure or nearly

pure end-member compositions. The domains are arranged to form single crystals, as far as ordinary methods of observation are concerned. All gradations probably can occur between a random sequence of solid solution constituents in simple proxy to the more ordered domains composing mixed crystals.

The extent of solid solution, whatever its mechanism, is controlled by the structural similarity and availability of the atoms involved, the nature of the host structure. and the temperature, pressure and composition of the environment of crystal growth. Structural similarity is related particularly to atomic size and bonding behaviour. High temperature promotes solid solution whereas low temperature inhibits it. Many minerals, notably feldspars and ore minerals, were formed originally at high temperatures with considerable solid solution and have exsolved or unmixed to separate phases of "purer" crystals upon later cooling. Much mineralogical research is devoted to the relationship of the solid solution compositions of co-existing minerals nith temperature and to the application of this relationship to geologic thermometry.

III. CLASSIFICATION AND NOMENCLATURE

In principle, a mineral species is defined by its chemical composition and crystal structure. In practice, however, the principle often is difficult to apply and the differentiation of many species must be made somewhat arbitrarily. For example, complete solid solution can exist between gold and silver but the series is, by convention, split into the two species native gold (Au,Ag) and native silver (Ag,Au). The boundary is set at the solid solution composition of equal numbers of gold and silver atoms. The complete solid solution series between magnesium and iron orthosilicate, on the other hand: is accepted as a single species, olivine $(Mg,Fe)_2SiO_4$. Many structural differences also are gradational so that species distinctions based on them must in many cases be arbitrary. Generally, individual polytypes, that is, different forms of a single species (*e.g.,* those of wurtzite), are not recognized as different mineral species, although species status has been given (partly on historical grounds) to certain clay and micalike minerals whose chief differences are attributable to polytypism. The total number of recognized mineral species; therefore. depends upon the criteria applied and differs with the authority. Something on the order of 1,500 species are accepted by modern criteria. although more than 8.000 different names, most of them based on trivial differences, have been applied.

Modern classifications are based on chemical composition and crystal structure. The chief divisions are chemical classes based on the nonmetal or anion radical present. The most important classes are: elements: sulfides (and the related arsenides, tellurides, sulfosalts), oxides (and hydrous oxides). halides, carbonates, borates. phosphates, sulfates', tungstates and silicates. The classes are further divided into chemical types and these into isostructural groups of the individual species. The silicate class is a particularly important one. It contains one-quarter of all the mineral species, a score of which make up more than 90% of the earth's crust. The silicates are subclassified into structural divisions essentially along the lines shown in Table I. (See also SILICON: *The* Silicates.)

Most mineral names, in modern practice, are characterized by a terminal "ite," a custom begun by the Greeks and Romans in naming stones. Mineral nomenclature is essentially the same throughout the English-speaking world since American and ,British mineralogists agreed on a uniform system around 1936. German and French nomenclature is essentially similar to it. Nonetheless, variation exists in the method of naming varieties of solid solution series. Although a scheme utilizing compositional modifiers (*e.g.,* magnesian olivine. manganoan calcite) along the lines proposed by W. T. Schaller, or one indicating symbolically a composition more quantitatively (*e.g.,* olivine Fo_{78}, plagioclase $An_{31}Ab_{66}Or_3$) would be desirable. a large number of individual varietal names are still widely used (oligoclase for plagioclase An_{10-35}, freibergite for argentian tetrahedrite, ankerite for ferroan dolomite).

IV. DESCRIPTIVE AND DETERMINATIVE PROPERTIES

Crystal properties fall into two classes — scalar, which have magnitude only (density, chemical composition), and vectorial,' which depend also upon direction (crystal faces: cleavage, refractive indices).

Chemical Properties. — In ordinary determinative work chemical properties are utilized mainly for confirmatory partial qualitative tests. Among the methods devised to deal with the extraordinary variety of chemical combinations occurring in the natural compounds. blowpipe methods, flame colorations. fused bead colorations and certain wet tests of ordinary qualitative analysis are much used. Such tests are described in the textbooks of mineralogy listed in the Bibliography. However. macrochemical tests commonly are inadequate, especially for the ores, because minerals are almost always intimately intergrown. Accurate identification of the opaque minerals commonly requires selection of minute samples under the reflecting microscope (see METALLOGRAPHY) and the use of microchemical tests.

Increasing use is made of partial quantitative analytical methods such as colorimetric tests, flame photometry, optical spectrography, and X-ray fluorescent spectrography for the determination of solid solution composition (because of its significance in connection with the environmental conditions during mineral evolution).

Density. — Density (mass of a unit volume of a substance) depends upon the number, atomic weights, and compactness of arrangement of the constituents and is a characteristic property of a mineral species. Solid solution series exhibit ranges in density dependent upon the composition; in fact, the composition of certain minerals (*e.g.,* gold. sphalerite) can be determined with fair precision from density measurement. Densities generally are measured as specific gravity (ratio of the density of a substance to that of water at 4° C. and 1 atm.) by means of the Jolly balance (for samples of a few grams), Berman balance (for milligram samples), pycnometer (for granules and powder), and various heavy liquids.

Heavy liquids (*e.g.,* mixtures of acetone and acetylene tetrabromide ranging up to s specific gravity of 2.9) are much used in the "sink-float" separation of mineral powders for chemical analysis and other purposes. (See also PETROLOGY: *Methods* of *Investigation.*j

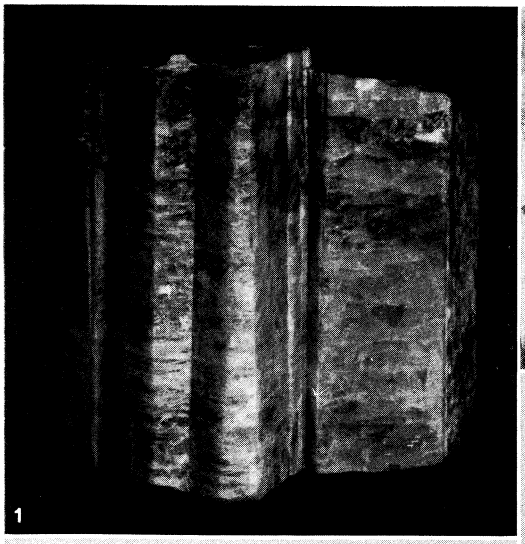
Crystal **Morphology.**—Minerals occurring in euhedral (completely bounded by faces) or subhedral (partly bounded by faces) crystals are identifiable. in principle, by their interfacial angles and symmetry, accurate determination of which requires use of the optical goniometer ("angle ineasurer"). Goniometry was formerly an important method of identification but has been largely supplanted by more powerful straightforward methods. Simple observation of crystal habit. nonetheless, is useful in the recognition of many minerals. It may be made megascopically or by optical and electron microscopy.

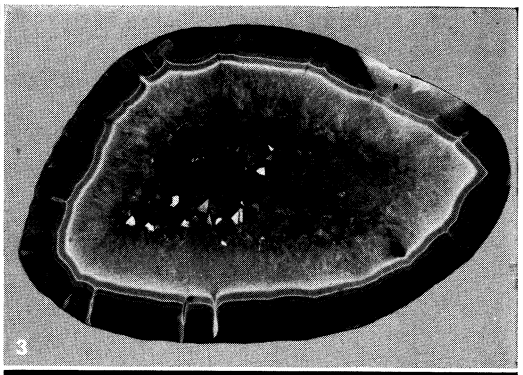
X-ray Diffraction. — X-ray diffraction effects in minerals are observed by several different techniques (see X-RAYS). Most extensively used is the powder (Hull-Debpe-Scherrer) method in which the diffraction pattern produced by a minute sample of fine powder is recorded as a series of curved lines on a strip of film. Each crystalline species is characterized by a particular set of lines having certain spacings and intensities.

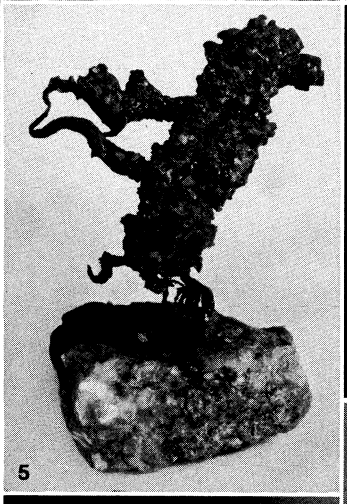
The method provides not only an extremeiy effective "finger print" for identification, but also yields information about homogeneity, composition, symmetry, unit cell, crystallinity and grain size. The powder and the related recording diffractometer methods are essential for the investigation of fine-grained minerals such as serpentines and clays.

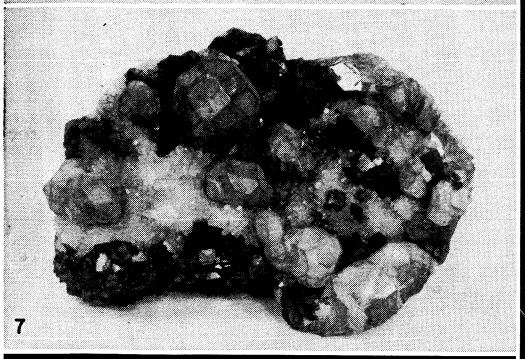
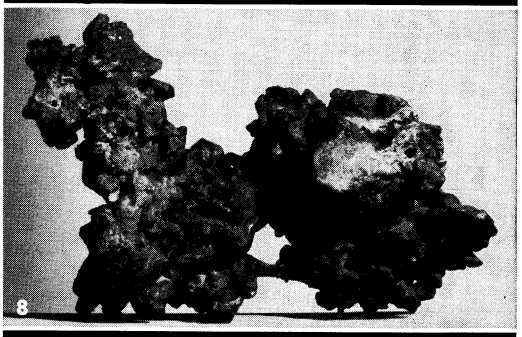
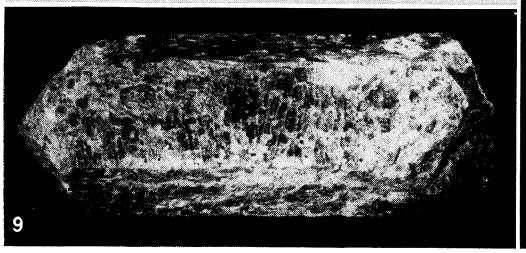
The single crystal techniques (oscillation. rotation, Weissenberg and precession methods) are used chiefly for the determination of unit-cell dimensions and shape, space group, special twin laws, crystal structure determinations and various structural details.

Optics. — The interaction of light. that is, electromagnetic radiation in the visible region (4,000 to 7,500 Å.), with crystalline matter provides another important class of properties. Minerals in which the bonds have significant metallic character absorb some and reflect the rest of the incident light; they are opaque and have a metallic lustre. Minerals whose bonds do not have appreciable metallic character can transmit light and are characterized







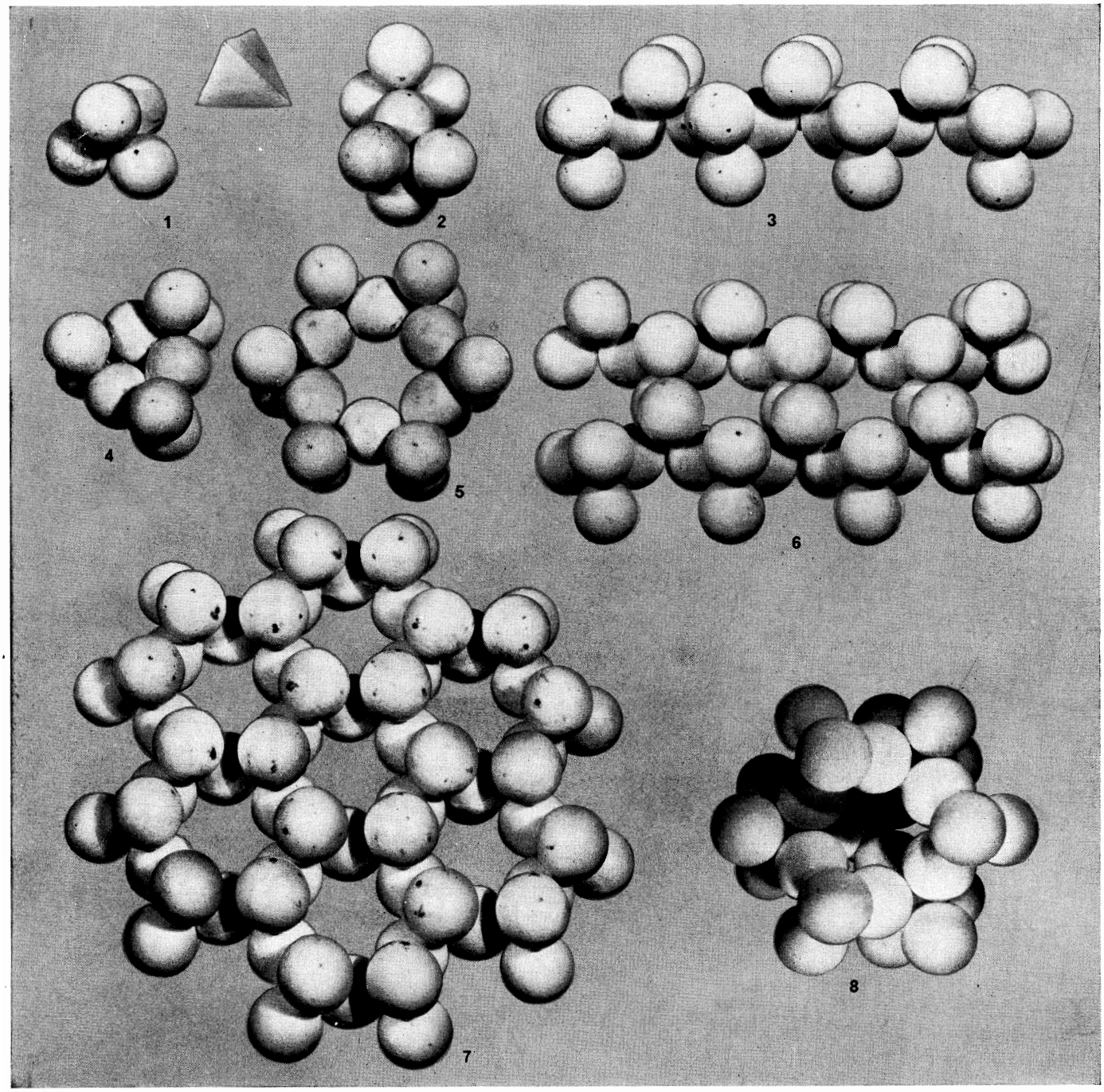




BY COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY

EXAMPLES OF IMPORTANT MINERALS

1. Beryl, a beryllium and aluminum silicate. Specimen from Portland, Conn.
2. Large crystals of feldspar (silicate). From Altodo Giz, Brazil
3. An agate geode lined with quartz crystals
4. Malachite, a green-coloured copper are. From southwest Africa
5. Silver. Kongsberg, Norway
6. Garnet crystals (a silicate)
7. Galena with siderite and quartz vein lining. Harz, Germany
8. Native crystallized copper. Upper Peninsula, Mich.
9. Large crystal of apatite, a phosphate-bearing mineral
10. Serpentine asbestos, hydrous magnesium silicate. Grand Canyon. Arir.
11. Barite. a mineral composed of barium sulfate. Cumberland, Eng.

MINERALOGY

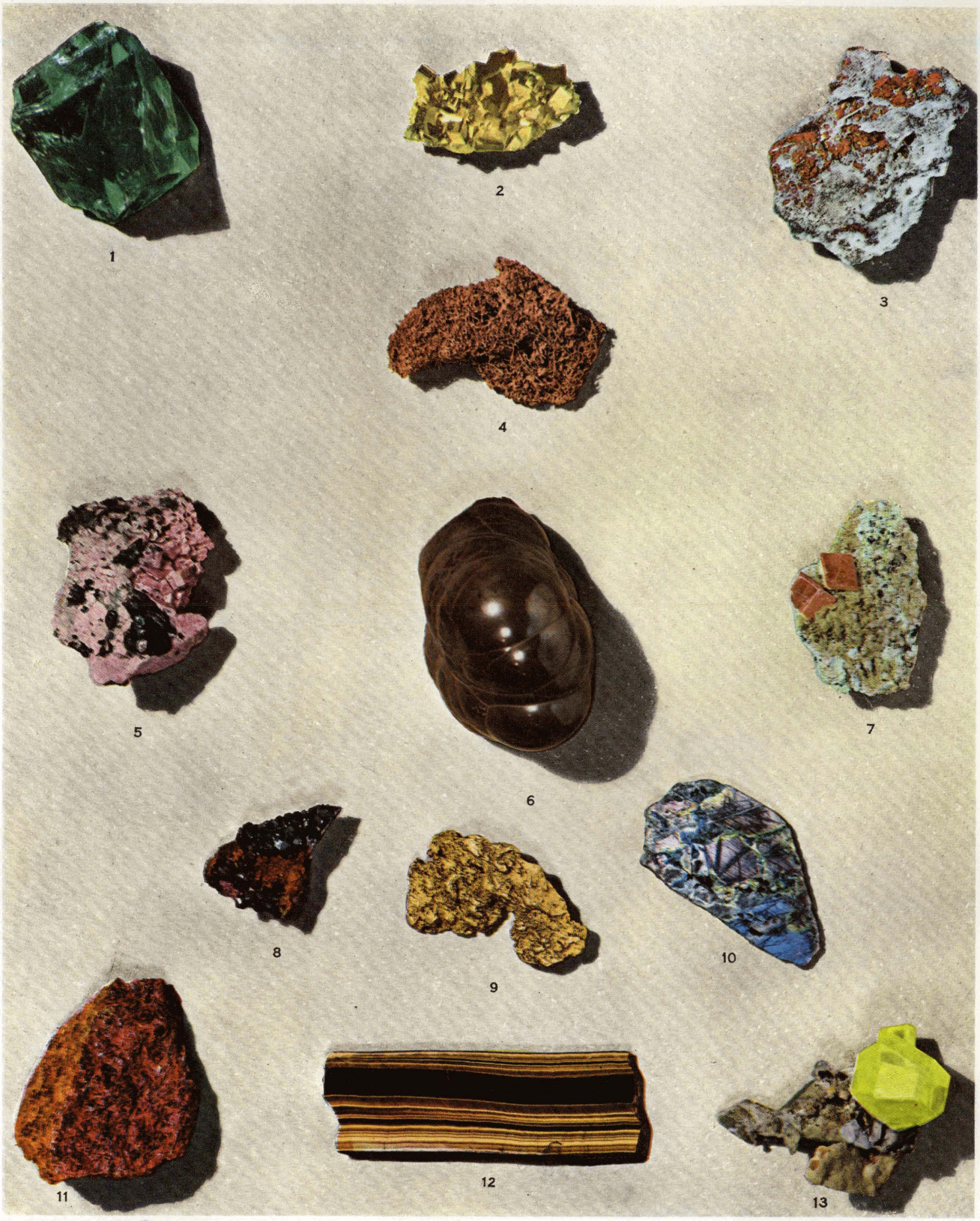


BY COURTESY OF D. M. HENDERSON

FUNDAMENTAL STRUCTURAL UNITS IN SILICATE MINERALS

The models illustrate the kinds of silicate radical groups controlling the structures and properties of mineral silicates. The white balls represent oxygen atoms 2.7 Angstom units in diameter (approximately one hundred millionth of an inch). Silicon (and frequently aluminum) atoms occupy the small voids within the tetrahedra of oxygen and bond them together; they are too small to be visible in these models.

1. Separate or independent tetrahedron, $[SiO_4]^{4-}$ the essential structural element in olivine. A geometric tetrahedron is shown for comparison
2. Double tetrahedral group, $[Si_2O_7]^{6-}$, occurring in thortveitite
3. Part of a tetrahedral chain, $[SiO_3]^{2-}$, occurring in pyroxene
4. Three-fold ring, $[SiO_3]_3^{6-}$, occurring in benitoite
5. Six-fold ring, $[SiO_3]_6^{12-}$, occurring in beryl
6. Part of a double chain or band. $[Si_4O_{11}]^{6-}$, characteristic of the amphiboles
7. Part of a sheet, $[Si_2O_5]^{2-}$, occurring in micas and clays
8. Part of a tetrahedral framework, $[SiO_2]^0$, occurring in cristobalite and, with modifications, in quartz, feldspars and zeolites



BY COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY

VALUABLE AND BEAUTIFUL MINERALS FROM MANY LANDS

1. Fluorite, or Fluor Spar, from Westmoreland, New Hampshire
2. Pyrite, "fool's gold," from Central City, Colorado
3. Cinnabar, native vermilion, from Felsobanya, Hungary
4. Copper, man's first useful metal, from Cornwall, England
5. Rhodonite, manganese ore, from Franklin Furnace, New Jersey
6. Hematite, iron ore, from Cumberland, England
7. Rhodochrosite, manganese ore, from Leadville, Colorado
8. Cassiterite, tin-stone, from St. Agnes, Cornwall, England
9. Gold nugget, from the Klondike, Northwestern Canada
10. Labradorite, with rainbow colours, from Labrador
11. Realgar, arsenic sulphide, from Manhattan, Nevada
12. Crocidolite, "tiger's eye," from Griqualand, South Africa
13. Sulphur, from Cianciana, Sicily

by a nonmetallic lustre. A few minerals, however, have intermediate character and submetallic lustres. The optical properties of minerals with metallic lustre have to do mainly with the behaviour of reflected light. The colour of smooth fresh surfaces of such minerals depends largely on the principal constituents and is, therefore, a useful determinative property. However, the true colour of many surfaces is camouflaged by tarnish (notably bornite), an extremely thin film of alteration product. The optical properties of opaque minerals are best observed on polished surfaces by means of the polarizing reflecting microscope.

The optical properties of the nonmetallic minerals depend mainly upon the behaviour of the transmitted light. However, the most obvious such property, colour, is much more variable than is the case for the metallic minerals. Although many nonmetallic minerals do have an intrinsic colour (sulfur, rhodonite, azurite) most do not (quartz, fluorite, celestite), and their colours, if any, depend on finely dispersed impurities, intergrown phases, state of aggregation, imperfections such as colour centres, fracture and cleavage, and nature of the surface. The colours, and even lustres, of many minerals having extensive solid solution (amphibole, olivine, wolframite) commonly show considerable range and can be of value in indicating approximate composition. The optical properties of crystals are vectorial, that is, depend upon direction. The repetitive arrays of atoms set up fields which polarize the transmitted visible electromagnetic radiation (see LIGHT): The fields in minerals having isometric symmetry cause isotropic behaviour of light (same in every direction). For all others the fields cause anisotropic behaviour, the optical symmetry being controlled by the atomic structure. Optical behaviour is observed and measured by the polarizing or petrographic microscope. Even colour is vectorial and except for isotropic minerals, any colour absorption present varies with direction (pleochroism). The most fundamental optical properties are refractive indices (relative velocity of light in the substance to that in air—strictly speaking, to that in a vacuum), optic symmetry and orientation. For a given direction of light vibration the refractive index varies with the wave length (and slightly with temperature). The difference in refractive index for light of different specified wave lengths (*e.g.*, that of the hydrogen C, 6563 Å., and hydrogen F, 4861 Å., lines) is termed the dispersion and is a fundamental property of the substance. In ordinary work refractive indices are measured with respect to white light, which gives values approximating those for the sodium D line (5893 Å.).

Isotropic minerals are characterized by a single refractive index (with respect to a particular wave length or to white light) and a particular dispersion. Anisotropic minerals are of two kinds: uniaxial crystals (tetragonal and hexagonal) characterized by two, and biaxial crystals (orthorhombic, monoclinic and triclinic) characterized by three principal refractive indices, accompanying dispersions, and vibration directions whose orientations are limited by the crystal symmetry.

Derivative optical properties much used in mineral determination are birefringence (difference between the maximum and minimum indices), optic angle and sign, and extinction angle. Optical properties provide information about solid solution composition as well as about the identification of species. Mineral optics are measured in thin sections and in crushed grains immersed in oils of known refractive indices.

Although the obvious gross optical properties (*e.g.*, varieties of nonmetallic lustre, transparency, colour, streak and iridescence) are sufficiently characteristic to aid in the identification of many species and varieties they are likely to vary in unpredictable ways due to impurities, mineral intergrowths, nature of the surface, fractures and state of aggregation. Streak. the colour of the fine powder obtained by rubbing a mineral against unglazed porcelain, is the most useful colour-based property.

Cohesion.—Properties such as hardness, cleavage, parting, fracture, flexibility, elasticity, tenacity, glide, percussion-figures, etch-figures and corrosion forms depend upon the cohesion of the constituent atoms. Of these, hardness and cleavage are of the most use in identification. The others are distinctive only for certain species. Mineral hardness is conventionally measured as the resistance to scratching (resistance to indentation is sometimes used in the microscopic study of ores) in comparison to an arbitrary reference scale, the Mohs (1820) scale of hardness given in the table:

1. Talc	6. Microcline (or orthoclase)
2. Gypsum	7. Quartz
3. Calcite	8. Topaz
4. Fluorite	9. Corundum
5. Apatite	10. Diamond

Hardness is vectorial although this is not usually apparent from the crude method of measurement used in determinative work. Hardness anisotropism is, however, very marked for kyanite; it is 4 to 5 parallel to the *c* axis and 6 to 7 perpendicular to it.

Cleavage, the property of breakage along planar surfaces in rational crystallographic directions, is controlled by the crystal structure and bonding. When present, it is characteristic of the mineral species and, consequently, is a useful diagnostic property.

Magnetism and Electricity.—A great many minerals are attracted by the poles of a strong electromagnet, that is, they are paramagnetic. Each such species is characterized by a particular magnetic susceptibility (or range of susceptibility), a property useful in the electromagnetic separation of fine-grained and intimately intergrown mixtures of rock and ore minerals for chemical analysis and other study. A very few minerals (magnetite, ilmenite, pyrrhotite) are ferromagnetic (having susceptibilities several orders of magnitude greater) and are attracted by an ordinary hand magnet. Still others (zircon, calcite) are diamagnetic and are repelled by a strong electromagnet.

Although electrical properties are rarely used in determinative work certain ones are important in the investigation of the nature of minerals and in technology. Minerals having metallic lustres are good conductors or semiconductors, while those having nonmetallic lustre are nonconductors (they are dielectric). Dielectric behaviour is receiving increasing attention in the investigation of the nature of minerals. Dielectric crystals not possessing a centre of symmetry exhibit piezoelectricity, whereby electrical charges develop upon the application of pressure. The property is used in the production of pressure gauges (tourmaline) and oscillators (notably quartz).

Heat.—Thermal properties include melting and inversion points, thermal conductivity, diathermancy (transparency to infrared radiation), thermal expansion, specific heat (or heat capacity) and the various heats of reaction, formation, solution, crystallization (latent heat of fusion), inversion and hydration. These properties are not used directly for determinative purposes, although the combined effects of several are involved in the property of fusibility and in the method of differential thermal analysis (DTA). Fusibility (a function of melting temperature and viscosity of the melt) ranges from that of stibnite (melting to a globule in a candle flame) to that of quartz (infusible in an ordinary blowpipe flame); it is diagnostic for a few minerals. Differential thermal analysis determines, for samples being heated up at a controlled rate, the intensities of and the temperatures at which thermal effects occur. The effects accompany compositional and structural changes (dehydration, oxidation, reaction, inversion, loss of crystallinity) during heating; they may be endothermic (absorb heat) or exothermic (give up heat to their surroundings). The thermal behaviour is recorded graphically (DTA curve) and is a characteristic property of many minerals. The shape of the curve depends on the various heats of hydration, reaction, inversion and crystallization of the mineral sample and also upon the instrumentation and procedure. The method is invaluable for the identification of many fine-grained minerals such as the clays; it is finding increasingly wide application to many others, including carbonates, hydroxides and hydrous oxides. and sulfides.

Luminescence and Radioactivity.—Luminescence (*q.v.*), the emission of visible light in response to excitation from an external source, is useful in the search for and identification of a number of minerals. Fluorescence is the variety of luminescence resulting from excitation by ultraviolet and shorter wave-length radiation. The colour of fluorescence varies with impurity composition; a semiquantitative estimation of the molybdenum con-

tent of scheelite. $Ca(W,Mo)O_4$, for example, can be made by means of the fluorescent colour. Thermoluminescence (fluorite) results irom thermal excitation. Triboluminescence (fluorite, sphalerite) arises from mechanical excitation by rubbing or scratching.

The radioactivity (see RADIOACTIVITY, NATURAL) associated with uranium and thorium containing minerals is an essential aid in the search for sources (*e.g.*, uraninite, carnotite, monazite) of nuclear energy. It is detected and measured mainly by Geiger and scintillation counters. Radioactivity is indicated in thin sections of rock by discoloured spots (pleochroic haloes) around tiny grains (zircon, allanite, thorite) enclosed in minerals such as biotite, muscovite and cordierite. The crystal structures of such tiny grains are commonly destroyed (metamict state) by the long-continued high-energy bombardment.

Several methods of measuring geologic time depend upon the radioactivity of minerals. The more reliable ones are based on the abundance ratios of isotopes (*e.g.*, $lead^{206}$: $uranium^{238}$, $lead^{204}$: $lead^{X'''}$, $strontium^{87}$: $rubidium^{8'}$, $argon^{''}$: $potassium^{40}$) connected with the radioactive decay. The ratios are measured by mass spectroscopy (*q.v.*)

V. GEOLOGIC OCCURRENCE AND ORIGIN

Minerals are the products of the geological processes and as such provide evidence leading to kno ledge about these processes and about the evolution of the earth. Interpretation of the evidence. however. is a difficult and far from straightforward matter on account of the extreme complexity of the processes and the fact that many of them operate under environmental conditions and durations of time far removed from our ordinary experience. Consequently, not only do a great many challenging problems remain to be satisfactorily explained but many of the genetic explanations already proposed are working hypotheses or trial models rather than proven fact. They are undergoing continual improvement or are being supplanted by alternative models. Consult the articles GEOCHEMISTRY; GEOLOGY; and ORE DEPOSITS for additional information about geological processes and occurrences of minerals. A further consideration to be kept in mind is that mineral evolution is a dynamic process—geologic environments undergo continual change in geologic time and mineral assemblages tend to change in response to the changing conditions.

Igneous Rocks.—The great bulk of the earth's crust is composed of generally massive aggregates of rock-forming minerals termed igneous rocks. The most abundant and characteristic minerals (essential ones) are feldspars, quartz. micas, amphiboles, pyroxenes. olivine, serpentines and feldspathoids. Igneous rock classifications are based largely upon the proportions of these minerals and upon the texture of the aggregate. Small amounts of accessory minerals are also present (e g., sphene, ilmenite, magnetite, zircon, allanite, apatite. fluorite and xenotime).

The problem of the origin of igneous rocks is still far from settled. Volcanic rocks can be observed to form by the crystallization of lava, a complex solution-melt (magma) of silicate, common metallic elements, small amounts of water and traces of many other constituents that have been erupted at the surface The chemically and mineralogically analogous coarser-grained plutonic (deep-seated) rocks. however, form in regions inaccessible to observation and under extremely complex conditions. General agreement has not been reached as to their origin. Many geologists believe that all igneous rocks are magmatic (of molten origin) and that the plutonic ones are deeper-seated equivalents of volcanic rocks. Others believe that at least some plutonic rocks have formed by the transformation of pre-existing rocks without the agency of magma, by a process akin to extreme metamorphism. It is likely that both magmatic and transformational processes are operative in the crust, depending upon the conditions prevailing. ***See*** also PETROLOGY.

Metamorphic Rocks.—Metamorphic rocks are so varied that only a slight indication of the possible mineralogical combinations can be given. The gneisses and schists typical of regionally metamorphosed terrains are composed chiefly of quartz. micas, and feldspar. Many varieties contain minerals such as garnet, staurolite, chlorite, epidote. amphibole and ferroan dolomite (ankerite) uith or in place of some of the first listed ones. Typical accessories are sphene, tourmaline, ilmenite, apatite, magnetite and rutile. Slates are composed of extremely fine-grained quartz, and micalike and chloritic minerals intermediate to those in shales and in schists; marbles consist of calcite and dolomite; and quartzite almost entirely of quartz. Contact metamorphic rock (tactite or skarn) is composed of various combinations of characteristic and often beautifully crystallized garnet, epidote, idocrase, wollastonite. diopside-hedenbergite, tremolite-actinolite and calcite or dolomite.

Metamorphism is the transformation (without melting) of pre-existing rocks in response to changes in the temperature, pressure and composition. The transformations range from recrystallization of the original minerals (marble and quartzite) to complete changes in mineralogy, texture and structure. Some transformations also involve considerable change in bulk chemical composition. or metasomatism (*q.v.*). The intensity of the metamorphic conditions appears to be reflected by the production, for a given bulk composition, of characteristic mineral assemblages (metamorphic facies). *See* also METAMORPHISM.

Sedimentary Rocks.—Sedimentary minerals include carbonates (calcite. siderite), sulfates (gypsum, anhydrite), phosphates (apatite), halides (halite), oxides (hematite, diaspore), and sulfides (pyrite) as well as the silicates. Many of them (notably the clays) are extremely fine-grained (*e.g.*, less than 2 microns, or 0.00008 in.) and commonly are poorly crystallized. Identification arid knowledge about the nature of these has been possible only through the application of techniques such as X-ray diffraction, electron microscopy and differential thermal analysis.

Sedimentary rocks are formed at or near atmospheric conditions from the materials of pre-existing rocks (igneous, metamorphic or older sediments). Minerals such as quartz, and to a lesser extent ilmenite, garnet and zircon. are resistant to weathering and transport and thus survive in clastic (fragmental) sediments. Fragments of pre-existing rocks may also survive under certain conditions. Other minerals such as illite, montmorillonite and clay-chlorite, although inherited from the parent material, may be more or less reconstructed in the sedimentary environment. Still others (*e.g.*, calcite, halite, gypsum) form completely anew in the environment. Organic agents also participate in the formation of sedimentary minerals. Much of the calcite in limestones is produced originally by organisms such as algae, corals and brachiopods; quartz in many cherts commonly originates from opal (amorphous SiO_2) deposited by diatoms and radiolaria.

Ancient sediments generally are consolidated. Some of the more common types are: shale (illite, clay-chlorite, quartz, montmorillonite, organic matter), sandstone (largely quartz), graywacke (quartz, feldspar, micas and micalike clays, chlorite, rock fragments), and limestone (largely calcite). Evaporites are composed mainly of gypsum or anhydrite, commonly with interbedded halite, and less so with sylvite, carnallite and other highly soluble minerals. Recent sediments generally are unconsolidated. They are being intensely investigated in order to obtain mineralogical criteria for sedimentary environments and evolution. ***See*** also SEDIMENTARY ROCKS.

Mineral Deposits.—Mineral deposits include those mineralogic bodies that do not compose a significant part of the earth's crust (*i.e.*, those other than rocks). Their minerals include representatives from every class and they occur in a great variety of ways, such as veins and veinlets, irregular replacement masses, cavity linings, beds and disseminations in rock. Most have no economic value; those that do are ore deposits. Typical ore minerals are galena, chalcocite, hematite and pyrite containing gold. Those not having an economic value (as quartz, jarosite, siderite) are gangue minerals.

Mineral deposits probably form most commonly by deposition from solution. Deposits such as calcite veins in limestones, barite in sediments, bog iron (mainly goethite) and many bodies of quartz have been deposited by ground water at ordinary temperatures. Others, including most metalliferous ore deposits, have formed at elevated temperatures. They are generally surrounded by altera-

tion zones, which may extend into the host rock for tens or hundreds of feet. Mineralogical study of these alteration zones is increasingly important in the search for ore deposits. Mineral deposits also form by sedimentary, metamorphic and igneous processes.

VI. EXPERIMENTAL MINERALOGY

A notable feature of modern mineralogy is the extensive and fruitful use of experimental methods to supplement field and laboratory methods in the endeavor to understand the extraordinarily complex processes of mineral genesis. Common approaches include geochemistry, mineral synthesis, phase equilibria studies, experimental simulation of geological processes and investigation of mineral properties under different conditions.

Almost all the common minerals and a great many rarer ones have been synthesized by one means or another. Synthesis of individual minerals, however, generally is of limited direct application to mineral genesis. On the other hand, it is an important source of technologically useful substances (such as industrial diamonds, corundum and cubic boron nitride for abrasives; quartz for oscillators; soda niter for polarizing prisms); and for gem materials (such as ruby, star sapphire and iron-free rutile, or Titania). The principal techniques are: precipitation from solution (yielding fine-grained products), crystal growth from solution (from seed crystals), crystallization from a melt, flame fusion (the Vernueil process), solid-state reactions and phase transformations, crystallization and reaction from vapour, and hydrothermal synthesis.

Phase equilibria studies of simplified analogues of geological systems are of particular importance in furnishing fundamental knowledge about mineral formation. They are also of great technological value (*e.g.*, in smelting, manufacture of ceramic and refractory bodies, cement production). Inasmuch as mineral stabilities are Influenced by the presence of different components. studies of multicomponent systems are the most informative. One of the earliest major contributions was J. H. van't Hoff's investigation (1896) of saline solutions (at ordinary temperatures and pressures) and its application to the formation of evaporites such as those at Stassfurt. The most notable of all has been the meticulous and comprehensive program at the Geophysical laboratory of Washington, D.C. Following Bonen's classic study (1913) of the plagioclase binary system and its solid solution (see FELDSPAR), equilibrium relations of the mineral phases of a great many systems have been determined at high temperatures (and atmospheric pressures). Such work led Bomen to his fundamental reaction principle (see GEOCHEMISTRY. Geochemistry of the Lithosphere: The Reaction Series). R. W. Goranson's study (1931) of water-containing silicate systems at high temperatures and pressures showed that melts dissolve several per cent of water and that melting temperatures of minerals under these conditions are considerably loner than in the analogous anhydrous systems. With the availability of more practicable apparatus, Bowen and O. F. Tuttle (1949) stimulated systematic hydrothermal investigation analogous to the earlier work on anhydrous systems. More recently, the "simple squeezer" apparatus of D. T. Griggs and G. C. Kennedy has enabled the determination of mineral stabilities to at least 50.000 atmospheres and close to 1,000° C. These investigations reveal that, in the presence of water (and other volatiles) under high confining pressures, mineral reactions occur rapidly even at temperatures of only a few hundred degrees. temperatures at which a great many anhydrous systems show no appreciable reaction even during several months time. This has made possible the observation of many hitherto unknown solid-state reactions. In addition to silicate studies. intensive investigation of carbonate and sulfide systems has been made. Besides the phase equilibria studies. methods for learning about geologic temperatures include use of the pressure-volume-temperature relations of liquid inclusions in minerals, isotopic ratios (e g., $oxygen^{16}/oxygen^{18}$ in quartz and in the calcite of shells). and the thermoelectric potential of pyrite (pyrite geothermometer). (See also SILICON: The Silicates.)

The investigation of the properties of minerals and aggregates under various conditions of temperature. pressure and stress is of considerable technological as well as some geological significance. Properties of interest are: refractoriness. shear strength! electrical conductivity, thermal expansion, viscosity of melts; resistance to abrasion, impact and seismic behaviour at high temperature and pressure. See CRYSTALLOGRAPHY; see also references under "Mineralogy" in the Index volume.

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MINERAL PHOSPHATES. The element phosphorus is known to be present in more than 150 minerals most of which belong to the apatite family of calcium phosphates. (For varieties and chemical composition see APATITE.) Phosphorus, an essential constituent for all living organisms, is one of the least abundant of the mineral nutrients. Its average content in soils and rocks of the earth's crust is 0.12%, whereas iron is 5%, calcium is 3.6%, potassium is 2.6% and magnesium is 2.1%. Thus when phosphorus is removed from the soil by crops, it must be replaced artificially by adding phosphate fertilizers to soils. Phosphorus also is used widely in manufacturing industries. Nearly all of the phosphate fertilizers and phosphorus for industrial uses now are obtained from naturally occurring rocks containing high concentrations of phosphate-bearing minerals. Thus the availability of large quantities of phosphate rock is of primary importance to agricultural and industrial nations.

Uses.--Within the United States about 60% of all phosphate used, and in other countries a larger percentage, is for agricultural purposes. and most of this is made into fertilizers. The remaining production is used in making elemental phosphorus and phosphoric acid. These products are made into organic and inorganic chemicals to be used in preparing detergents, mater softeners, leavening agents (cooking), plasticizers, insecticides and many other products. Elemental phosphorus also is used in military smoke screens and incendiary bombs, phosphorus alloys and pesticides. In addition phosphoric acid is made into fertilizers, animal-feed supplement, beverages, photographic supplies, dental and silicate cements, ceramics, and is used as a catalyst and oil-refining agent. A complete list of all phosphate compounds would embrace almost every manufacturing process and product and nearly all chemical techniques.

Principal Types **of** Phosphate Deposits.— Primary, or original, phosphate deposits are: apatite-bearing igneous rocks, marine sedimentary rock phosphorites and phosphatic shales and limestones, and guano. These deposits may give rise by geological processes of erosion and deposition to secondarily enriched deposits known as: residual phosphorites, river-pebble phosphates and phosphatized rock.

Igneous apatite deposits are formed as a result of differentiation of the constituents of cooling magmas (molten rock material) which have been intruded into rocks of the earth's crust. These deposits are sheetlike or irregular masses associated with other types of igneous rocks and may contain as much as 35% phosphorus pentoxide, designated in the fertilizer industry as P_2O_5 or as phosphoric acid. Although these deposits are of less importance than marine phosphate deposits, they have been the ultimate source of the phosphatic compounds in solution in sea water from which marine phosphate deposits have been derived.

Inorganic and/or organic processes, operating upon phosphoric acid in solution in sea water, precipitated the carbonate-fluorapatite minerals as blanketlike deposits of marine phosphorite and phosphatic shales and limestones on ancient sea floors. Marine phosphorites consist of layers of phosphatic pellets and nodules ranging from less than 0.1 to more than 20 mm. in diameter. Individual layers may be more than six feet thick and contain as much as 35% P_2O_5. Phosphorites are associated with black, carbonaceous, and phosphatic shale, chert and minor limestone. Phosphatic layers generally are thin, but the total thickness of such deposits may be many tens of feet. These deposits consist of a small percentage of phosphate pellets mixed with other sedimentary material such as clay, silt, sand and calcium carbonate. The phosphate content may range from 0% to 30%. Marine phosphate deposits contain reserves calculated to be of the order of several billions of tons. The marine phosphorites and phosphatic rocks contain many minor metals. Of these, vanadium is recovered from western U.S. phosphorite, and uranium is recovered from some Florida phosphates.

Guano (*q.v.*) deposits form by the accumulation of seafowl or bat droppings. The largest deposits are formed on islands in low latitudes along western margins of continents where phosphate-rich sea waters permit a luxuriant growth of marine organisms upon which seafowl feed and where a semiarid climate permits preservation of their excreta. Guano deposits generally are small; the larger contain a few millions of tons at the most. Guano ranges widely in composition, and the phosphatic content generally is less than 25%. The phosphatic minerals in the deposits include hydroxylapatite, carbonate hydroxylapatite, brushite (a hydrous phosphate) or monetite (an ,anhydrous phosphate).

Residual phosphate deposits develop by decomposition of phosphatic limestones, located within humid climatic regions. These deposits, consisting of phosphate pellets and nodules left behind when the calcium carbonate of the limestone is removed by solution, lie on the irregular weathered bedrock surface. In hilly country, the residual phosphate deposits are narrow and conform to the outcrop pattern of the strata, but, in valleys or flat country, the deposits are blanketlike. These deposits range in thickness from one to several tens of feet. The phosphate content varies from a few to about 30%. The higher-grade deposits are utilized directly but lower-grade deposits must be beneficiated (to remove worthless material) by washing, screening or flotation, in order to yield a salable product. Phosphate reserves of residual deposits amount to many millions of tons.

River-pebble deposits consist of phosphate pellets and nodules weathered out of marine phosphatic limestone, located in humid climatic regions of low relief. The pellets and nodules are reconcentrated by stream action. Most river-pebble deposits do not contain sufficient phosphate to be mined profitably, but those in Florida are mined and beneficiated cheaply enough to produce a commercial product. Phosphate reserves in river-pebble deposits range from a few thousand to many millions of tons.

Phosphatized rocks develop in regions of tropical and subtropical climate when phosphate dissolved from phosphatic rocks or guano by percolating water is reprecipitated in openings or replaces the minerals of limestone, igneous rocks or clay that lie at a lower horizon. Phosphatized rocks are not abundant but some contain as much as 30% to 38% P_2O_5, and reserves are estimated in thousands to millions of tons.

Phosphate Deposits in the United States.—Examples of all the principal types of phosphate deposits are present in the U.S. Although phosphate concentrations are known in 28 states, current production is confined to four large fields. These fields, listed in order of their total production are: (1) the land-pebble deposits of Florida, (2) phosphatized (hard-rock) deposits of Florida, (3) the residual (brown-rock) deposits of Tennessee and (4) the marine phosphorites and phosphatic shales of the western field (principally Idaho, Montana, Utah and Wyoming). These fields contain practically all of the minable phosphate rock reserves in the U.S. recoverable under economic conditions prevailing in the second half of the 20th century.

The land-pebble phosphates of Florida are blanketlike deposits covering about 2,600 sq.mi. of west-central Florida. These are a combination of residual and fluviatile concentrations of phosphate pellets and nodules derived from phosphatic limestone of the Hawthorn formation of Miocene age. The phosphate was reconcentrated as the Bone Valley formation of Pliocene age. The phosphate deposits range from 1 to 50 ft. thick and average 12 ft. The deposits consist of nearly equal amounts of phosphate pellets and nodules, sand and clay. The phosphate zone is overlain by as much as 60 ft. of overburden which is removed by large draglines before the phosphate is mined by similar methods. Phosphorite particles are beneficiated by washing, screening and flotation methods. The recovered product is sold according to its B.P.L. (bone phosphate of lime) content which is 2.18 times the P_2O_5 content.

The hard-rock phosphate deposits of northwestern Florida are of Pliocene age and also were derived by weathering of the Hawthorn formation. These deposits are small but some contain as much as 35% P_2O_5. They are mined and beneficiated by the same methods as are used in the land-pebble fields.

The Tennessee brown-rock or residual deposits, located in the Mt. Pleasant region of Tennessee, have been derived from Ordovician age phosphatic limestones of the Hermitage, Bigbey and Leipers formations. The deposits conform closely to the outcrop pattern of the parent limestones on the rolling, hilly topography. The thickest phosphate deposits fill solution-enlarged joints (locally called cutters) in the phosphatic limestones. These deposits also are mined by open-pit methods and beneficiated to produce a marketable product.

The marine phosphorites and phosphatic shales of the western field are in the Phosphoria formation of Permian age. Phosphate rock is mined in Idaho, Wyoming, Montana and Utah by open-pit and underground methods. Minable layers range from 3 to 20 ft. in thickness and contain from 20% to 32% P_2O_5. Most of the reserves in this field will have to be mined by underground methods.

The United States is self-sufficient in phosphate and has sufficient phosphate reserves to last for many centuries even under conditions of increased production.

Phosphate Deposits in Other Countries.—The principle resources of phosphate rock outside the United States are North Africa (the former French section of Morocco, Tunisia, Algeria and Egypt), U.S.S.R., the islands of the Pacific and Indian oceans and Brazil. In addition to these there are many others which are little developed and about which not much is known. These deposits are of the same types described above for the United States.

For information on occurrences, world reserves, production and processing, *see* FERTILIZERS AND MANURES: *Phosphorus-Supplying Fertilizers. See* also PHOSPHORIC ACIDS AND PHOSPHATES; PHOSPHORUS.

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(V. E. M.; W. R. LL.)

MINERAL WATERS. Mineral waters, used in the treatment of various diseases since the dawn of time, may be classified on the basis of temperature, mineral constituents, gaseous content and physical characteristics such as colour, taste, odour, gravity, etc. More complex classifications permit a more complete subdivision of various mineral waters.

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(W. S. M.; X.)

MINERS' PHTHISIS: *see* PNEUMONOCONIOSIS.

MINERVA, an Italian goddess of handicrafts who presided also over the professions and the arts. She is commonly identified with the Greek Athena (*q.v.*), and some scholars believe that she is not of native cult but is Athena introduced at Rome from Etruria. Indeed she is one of the Capitoline triad in association with Jupiter and Juno (*qq.v.*), traditionally introduced by the Etruscan kings, and it would be difficult to find traces of her cult at Rome before this time. Her name, on the other hand, is Italian, not Etruscan, and is connected with the roots in *mens,* "mind," and *memini,* "remember" (the archaic spelling is Menerva).

She had several temples at Rome. Besides her cult on the Capitoline she had an important shrine on the Aventine which was a meeting place for guilds of craftsmen, particularly dramatic poets and actors who made it their headquarters during the second Punic War. A shrine on the Caelian was dedicated to Minerva Capta, probably in consequence of the destruction of Falerii in 241 B.C.

ALINARI

ETRUSCAN BRONZE STATUE OF MINERVA REPRESENTED AS THE GODDESS OF WAR. IN THE ARCHAEOLOGICAL MUSEUM, FLORENCE

Her worship as a goddess of war encroached upon that of Mars (*q.v.*) and she is sometimes confused with Mars's cult partner Nerio (see BELLONA). The festival known as the Quinquatrus, falling on the fifth day after the Ides of March (*i.e.,* March 19), was originally a festival of Mars but was taken over entirely by Minerva: apparently from the coincidence that this was the founding day of her temple on the Aventine.

The festival eventually was extended over five days to include March 23, the Tubilustrium or purification of the trumpets. The fact that the tuba was used in military as well as religious ceremonies made this festival not inappropriate to a war deity, although it was probably not originally connected with Minerva. After the first day. which was devoted to a lustration of the arms announcing a new military season: the remaining four were given over largely to gladiatorial shows. The whole season was a school holiday. There was a festival called the lesser Quinquatrus celebrated on June 13, the feast day of the flute players, of whom Minerva was the patron deity.

The erection of a temple to her by Pompey out of the spoils of his eastern conquests shows that she was the bestower of victory like Athena Nike. Under Domitian. who claimed her special protection, the worship of Minerva attained its greatest vogue in Rome. His forum (dedicated as the Forum of Nerva) was dominated by a temple of Minerva, and he built a second shrine to her in the Roman Forum.

See Platner-Ashby, *Topographical Dictionary, s.v.* "Minerva," "Jupiter Optimus Maximus" and "Forum Nervae." (R. B. LD.)

MING, a major dynasty that governed China. 1368 to 1644. providing an interval of native rule between eras of Mongol and Manchu dominance. The dynastic name means "bright." The dynastic capital was Nanking through 1420 and Peking thereafter.

The Ming emperors reigned over a unified China that included Manchuria and at times extended into Vietnam on the south and to Hami in Chinese Turkistan on the west. Their armies campaigned through Mongolia almost to Lake Baikal, through Manchuria to the Xmur river, in Korea. in Vietnam and in Burma; and their fleets roamed Indonesian waters and the Indian ocean almost to Zanzibar. The rulers of Korea. Mongolia! Chinese Turkistan. Burma. Siam and Vietnam regularly acknowledged Ming overlordship, and at times tribute was received from as far away as Japan. Java and Sumatra. Ceylon and south India. the east African coast, the Persian gulf region and Samarkand. Modern Chinese honour the Ming rulers especially for having restored China's international power and prestige. which had been in decline since the 8th century. They probably exercised more far-reaching influence in east Asia than any other native rulers of China, and their attitude toward the representatives of modern Portugal, Spain. Russia, Britain and Holland. who appeared in China before the end of their dynasty, was a condescending one.

The Ming state included several notable new institutions: the grand secretariat (*Nei-ko*), provincial governors (*Hsun-fu*) and viceroys (*Tsung-tu*), and the *pao-chia* system of local organization and surveillance. The gpvernment was unusually stable but was gradually undermined by epidemic factionalism among civil officials. corrupting interference by palace eunuchs and a succession of weak and inattentive emperors.

The dynasty encompassed the reigns of 16 emperors:

1. Chu Yuan-chang (1328–98), reigned 1368–98; reign title Hung-wu; temple name T'ai-tsu.

2. Chu Yun-wen (1377–?), grandson of T'ai-tsu, reigned 1398–1402; reign title Chien-wen; temple name Hui-ti.

3. Chu Ti (1360–1424), son of T'ai-tsu, reigned 1402–24; reign title Yung-lo; temple name Ch'eng-tsu.

4. Chu Kao-chih (1378–1425), son of Ch'eng-tsu, reigned 1424–2j; reign title Hung-hsi; temple name Jen-tsung.

5. Chu Chan-chi (1398–1435), son of Jen-tsung, reigned 1425–35; reign title Hsuan-te; temple name Hsuan-tsung.

6. Chu Ch'i-chen (1427–64), son of Hsuan-tsung. reigned 1435–49, reign title Cheng-t'ung; restored 1457–64, reign title T'ien-shun; temple name Ying-tsung.

7. Chu Ch'i-yu (1428–57), brother of Ying-tsung, reigned 1449–57; reign title Ching-t'ai; temple name Ching-ti.

8. Chu Chien-shen (1447–87), son of Ying-tsung, reigned 1464–87; reign title Ch'eng-hua; temple name Hsien-tsung.

9. Chu Yu-t'ang (1470–1505), son of Hsien-tsung, reigned 1487–150j; reign title Hung-chih; temple name Hsiao-tsung.

10. Chu Hou-chao (1491–1521), son of Hsiao-tsung, reigned 1505–21; reign title Cheng-te; temple name Wu-tsung.

11. Chu Hou-tsung (1507–66), cousin of Wu-tsung, reigned 1521–66; reign title Chia-ching; temple name Shih-tsung.

12. Chu Tsai-kou (1537–72), son of Shih-tsung. reigned 1566–72; reign title Lung-ch'ing; temple name Mu-tsung.

13. Chu I-chun (1563–1620), son of Mu-tsung, reigned 1572–1620; reign title Wan-li; temple name Shen-tsung.

14. Chu Ch'ang-lo (1582–1620), son of Shen-tsung, reigned only one month in 1620; reign title T'ai-ch'ang; temple name Kuang-tsung.

1j. Chu Yu-chiao (160 5–27), son of Ruang-tsung, reigned 1620–27; reign title T'ien-ch'i; temple name Hsi-tsung.

16. Chu Yu-chien (1611–44), brother of Hsi-tsung, reigned 1627–44; reign title Ch'ung-chen; canonized by Manchus as Chuang-lieh-ti, by various Ming loyalists as Ssu-tsung, Huai-tsung and I-tsung.

The founder of the dynasty, T'ai-tsu, was one of the strongest and most colourful personalities of Chinese history. His 30-year reign established the governmental structure, policies and tone that characterized the whole dynasty.

T'ai-tsu left his throne in 1398 to a grandson. Hui-ti. In trying to assert central control over the government. Hui-ti provoked a rebellion on the part of his uncle the prince of Yen and was overwhelmed in 1402. The prince of Yen, posthumously titled Ch'eng-tsu, took the throne for himself and proved even more ambitious and aggressive than T'ai-tsu. He subjugated Annam (north Vietnam), personally campaigned against the reorganizing Mongols in the north and sent naval expeditions overseas. chiefly under the eunuch Cheng Ho, to demand tribute from rulers as far away as Africa.

For a century after Ch'eng-tsu the empire enjoyed peace, stability and prosperity. State administration began to suffer from corrupt domination by eunuchs—Wang Chen in the 1440s, Wang Chih in the 1470s and 1480s and Liu Chin from 1505 to 1510. But Jen-tsung. Hsuan-tsung and Hsiao-tsung were model Confucian rulers — unaggressive, benevolent, trustful of their civil ministers. The only serious disruption of the peace occurred in 1449 when Wang

Chen led Ying-tsung into a disastrous military campaign against the Oirats (western Mongols). The Oirat leader Yesen ambushed the imperial army, captured the emperor and besieged Peking. The defense minister Yu Ch'ien forced him to withdraw unappeased and for eight years dominated the government with emergency powers. When the interim emperor, Ching-ti, fell ill in 1457, Ying-tsung mas restored, having lived in retirement after being released by the Mongols in 1450. Yu Ch'ien was then executed as a traitor.

Wu-tsung and Shih-tsung were probably the least capable Ming emperors. Wu-tsung was an adventure-loving carouser, Shih-tsung a lavish patron of Taoist alchemists. For one period of 20 years, during the regime of the unpopular grand secretary Yen Sung, Shih-tsung withdrew almost entirely from governmental cares. Both emperors cruelly humiliated and punished hundreds of officials for their temerity in remonstrating.

China's long peace ended in Shih-tsung's reign. The Oirats, under the vigorous leadership of Anda (Altan), were a constant threat on the north from 1542 on; in 1550 Anda raided the suburbs of Peking itself. Concurrently, Japan-based pirates plundered China's southeastern coast. Japanese piracy, a problem in the early Ming years, had been suspended in Ch'eng-tsu's time, when the Ashikaga shogunate offered nominal submission to China in exchange for trading privileges. But non the Japanese grew dissatisfied with the trading arrangements, and during the 1550s pirate fleets looted the Ningpo-Shanghai region almost annually, sometimes sending raiding parties as far inland as Soochow.

The Ming government was still able to respond vigorously when challenged. Chinese fleets crushed Japanese pirates in 1559 and 1563. and the coastal raiding ceased. Anda was repeatedly defeated in the 1560s and made peace in 1571. For the next decade. during the last years of Mu-tsung and the early years of Shen-tsung, the Ming state was probably at its peak of stability. The government was dominated by Chang Chu-cheng. the outstanding grand secretary of Ming history: and two generals. Ch'i Chi-kuang and Li Ch'eng-liang, maintained effective military defenses.

In 1592, when Japanese troops under Hideyoshi invaded Korea, Ming China was still strong and responsive enough to campaign vigorously in support of its vassal. But the Korean war dragged on indecisively until 1598, when Hideyoshi died and the Japanese withdrew. It made heavy demands on Ming resources and apparently precipitated a military decline in China.

The reign of Shen-tsung was a turning point of Ming history in other regards as well. Partisan wrangling among civil officials had flared up in the 1450s in reaction to I'u Ch'ien's dominance and again in the 1520s during a prolonged "rites controversy" provoked by Shih-tsung. After Chang Chu-cheng's death in 1582 it became the normal condition of court life. Through the remainder of Shen-tsung's long reign a series of increasingly vicious partisan controversies absorbed the energies of the officialdom, while the harassed emperor abandoned more and more of his responsibilities to eunuchs. The decline of bureaucratic discipline and morale continued under Kuang-tsung, whose sudden death after a reign of only one month in 1620 provoked new controversies. Hsi-tsung was too young and indecisive to provide leadership. In 1623 he finally gave broad powers to Wei Chung-hsien. the most powerful eunuch of Chinese history. Wei brutally purged hundreds of officials, chiefly those associated with a reformist clique called the Tung-lin party, and staffed the government with sycophants.

A new threat had meantime appeared on the northern frontier. The Manchus, quiet occupants of far eastern Manchuria from the beginning of the dynasty, in 1583 were aroused by an ambitious young leader. Nurhachu, and during Shen-tsung's latter years steadily encroached on central Manchuria. In 1616 Nurhachu proclaimed a new dynasty, and overwhelming victories over Ming forces in 1619 and 1622 gave him control of the whole northeastern segment of the Ming empire, down to the Great Wall at Shan-hai-kuan.

Chuang-lieh-ti tried to revitalize the deteriorating Ming government. He banished Wei Chung-hsien but could not quell the partisan strife that was paralyzing the bureaucracy. The Manchus, bypassing Shan-hai-kuan, repeatedly raided within the Great Wall, even threatening Peking in 1629 and 1638. Taxes and conscriptions became more and more oppressive on the Chinese population, and banditry and rebellions spread in the interior. The Ming government became completely demoralized. Finally a domestic rebel, Li Tzu-ch'eng. captured the capital in April 1644. Chuang-lieh-ti committed suicide. The Ming commander at Shan-hai-kuan accepted Manchu help in an effort to punish Li Tzu-ch'eng and restore the dynasty, only to have the Manchus seize the throne for themselves.

Ming loyalists ineffectively resisted the Manchu Ch'ing dynasty from various refuges in the south for a generation. Their so-called Southern Ming dynasty principally included the prince of Fu (Chu Yu-sung, reign title Hung-kuang. d. 1646), the prince of T'ang (Chu Yu-chien, reign title Lung-wu, d. 1646), the prince of Lu (Chu I-hai. no reign title, d. 1662) and the prince of Kuei (Chu Yu-lang, reign title Yung-li, d. 1662). The loyalist sea raider Cheng Ch'eng-kung (Koxinga) and his heirs held out on Formosa until 1683.

Direct contact between China and modern Europe was established in Wu-tsung's reign, when in 1517 a Portuguese squadron under Fernão Peres d'Andrade landed at Canton. Despite Chinese hostilities and some persecutions, the Portuguese got a permanent trading base at Macao by 1557. Other Europeans soon joined in the China trade Christian mission work began on the mainland in 1582 under Matteo Ricci and by the end of the Ming dynasty had won influence and converts even at the Peking court.

Chinese culture under ?\ling rule was distinguished more by productive competence than by creative brilliance The period is specially known for architectural construction (Peking, the Great Wall). blue and white porcelain manufactures, prodigious scholarly production, the melodious *k'un-ch'u* form of opera, vernacular fiction (novels and short stories) and the idealistic philosophy of Wang Yang-ming (*q.v.*).

See also CHINA: *History*.

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MINGHETTI, MARCO (1818–1886), Italian economist and statesman. was born at Bologna on Nov. 18, 1818. In 1846 he was appointed member of the state council summoned to prepare the constitution for the Papal States. In the first constitutional cabinet. presided over by Cardinal Antonelli, Minghetti was minister of public works. but after the allocution by Pius IX against the Italian war of independence he resigned and joined the Piedmontese army as captain on the general staff. Returning to Rome in Sept. 1848, he refused to form a cabinet after the assassination of Pellegrino Rossi. and spent the next eight years in study and travel. He was in 1859 appointed by Cavour secretary-general of the Piedmontese foreign office. In the same year he was elected president of the assembly of the Romagna, after the rejection of pontifical rule by those provinces, and prepared their annexation to Piedmont.

Appointed Piedinontese minister of the interior, he resigned office shortly after Cavour's death. but was later made minister of finance by Farini, whom he succeeded as premier in 1863. With the help of Visconti-Venosta he concluded (Sept. 15, 1864) the "September convention" with France, whereby Napoleon agreed to evacuate Rome, and Italy to transfer its capital from Turin to Florence. Minghetti was then driven from office. He took little part in public life until 1869. when he became minister of agriculture in the Menabrea cabinet. Both in and out of office he exercised his influence against an Italo-French alliance and for an immediate advance upon Rome, and in 1870 was sent to Lon-

don and Vienna by the Lanza-Sella cabinet to organize a league of neutral powers. In 1873 he overthrew the Lanza-Sella cabinet and mas premier and minister of finance until the fall of the right on March 18, 1876. During his premiership he inaugurated the *rapprochement* between Italy, Austria and Germany; and, as finance minister, restored equilibrium between expenditure and revenue for the first time since 1860. After the advent of the left Minghetti remained for several years in opposition, but toward 1884 joined Depretis in creating the *trasformismo,* which consisted in bringing Conservative support to Liberal cabinets. Minghetti died at Rome on Dec. 10, 1886.

MINHO, the province of northwestern Portugal, is known also as Aquem-0s-Montes, in contradistinction to Tras-0s-Montes in the northeast. It comprises the administrative districts of Viana do Castelo and Braga. Pop. (1950) 825,788; area 1,868 sq.mi. The coastal plain forms a narrow belt about 70 mi. long and 2–10 mi. wide, narrowing north of the Lima valley, where the mountains of Santa Luzia (1,790 ft.) rise steeply from the coast. Most of the region consists of undulating granitic plateaus at an altitude of 300–750 ft., traversed by deep river valleys. From the Spanish frontier southward these rivers are: the Minho, Lima, Cávado and Ave, all flowing west-southwest. In the interior, the mountain ranges between the Minho and the Lima (Serra de Suajo 4,642 ft.) are continued by the Serra do Gerez (4,944 ft.) and the Serra das Alturas (4.150 ft.).

The climate is the most favourable for intensive agriculture in Portugal. Mean annual rainfall rises from 50 in. on the coast to more than 70 in. in the mountains. Winters are mild, although snowfall can be heavy in the eastern mountains. Water resources are good. notably on the Cávado (Vila Nova dam has an installed capacity of 156,000 kva.) and on the Lima (Lindoso dam).

The high densities of population ranging from 500 to 700 per square mile explain the intensive cropping. On one-twentieth of the cropped area is grown one-third of the maize of Portugal; haricot beans are also very important. A rapid succession of minter and summer crops is possible with intercultural planting; even the field borders are used for fruit trees and vines. The use of irrigation, the flights of terraces scaling the slopes and the marked dissemination of rural dwellings are all traits of this wooded landscape. Stock rearing is important on the higher lands and the timber industry is significant. Many of the ethnographic features are traceable to the Roman occupation and the ruins of the Celtic castros or hill forts are numerous.

Fishing is of local importance at Esposende, Viana do Castelo (pop. 14,131), Âncora-Gontinhaes and Póvoa de Varzim (pop. 16,994), ports all situated on the north side of the river mouths to avoid the sandbanks built up by longshore drift. Braga (*q.v.*), regional capital and seat of an archbishop, and Guimarães (pop. 18,236) are textile centres. (J. M. Ho.)

MINIATURE LANDSCAPE. The original form of Japanese miniature landscape was *hako-niwa* ("box yard"), a small landscape in a wooden box. It has not retained the popularity it still had at the dawn of the 20th century. nhich was equal to that now enjoyed by *bon-kei.*

Bon-kei ("tray landscape"). also known as *ban kei,* an evolution of *hako-niwa,* took on new life around 1900 when Izumi Chisen introduced *keto-tsuchi,* a sort of peat nhich was easy to model, as a substitute for earth. As *bon-kei* gained popularity many devices were tried, such as coloured earths. sand (representing water) and even newspaper soaked in water, nhich permitted landscapes to be made and remade quickly according to fancy.

Sai-kei (cai, "to plant trees or grass"; *kei,* "scenery") is the name of a movement started by *bon-sai* artists (who work with dwarfed trees); to give permanency to *bon-kez* they introduced natural instead of artificial stones and planted trees by the method called *toriki. Bon-kei* deteriorates nith time. while *sai-kei,* made nith living roots. improves with time. It seems appropriate to call such miniature landscapes *suibanmochi-no ishitsuki* ("*bon-sai* nith roots having rocks").

Bon-seki ("tray stone") is the Japanese art of creating miniature landscapes on black lacquered trays nith stones and sand, but without vegetation Its origin is traced to the reign of Empress Suiko (593–628), when stones of rare shapes were presented to the court from China. Stones were appreciated for their solid reality and their unchanging character; it was believed they had the power to soften the hardened hearts of men. Later, sand was used with stones to suggest water and mountains. In a further development, stones were used to represent the sentiments of poems, or to reproduce famous natural or literary scenes. Brushes are used effectively, but plumes of different birds are indispensable in shaping the *bon-seki.* Stones of different shades are used according to different seasons. Already in vogue at the time of Ashikaga Yoshimasa (1436–90), *bon-seki,* like other forms of Japanese art. passed through different styles; a prominent school is Hosokawa-ryu, which was revived by the rare talent of its chief master, Katsuno Hakuyen.

Another way of enjoying stones; popular for centuries among the Japanese, is known as *sui-seki* ("water stone"). A natural stone of admirable shape is placed in a porcelain or bronze tray with sand and water. Months and years of patient watering and care may. according to the kind of stone used. bring forth a coating of moss, enlivening the stone with verdure like a mountain or like an island with forest and meadow. (J. HAR.)

MINIATURE PAINTING. This article is concerned with the history of the small, portable and finely wrought portraits known as miniatures. The name is derived from the minium, or red lead, which was used by the medieval illuminators for rubrication. In the 16th and 17th centuries the usual name for portrait miniatures was limnings.

Origins. — The heyday of the portrait miniature extended from the beginning of the 16th century down to the middle of the 19th century. The art owed its origin to the interest felt by the men and women of the Renaissance in personality and in its outward revelation by faithful and searching portraiture. This interest had already been seen in a small, intimate compass in the revival of the classical medal by Antonio Pisanello and his contemporaries of the 1jth century. At the same time, the first portrait miniaturists continued with the technique of the illuminators of manuscripts (*see* ILLUMINATED MANUSCRIPTS). painting with detailed precision upon vellum with water colour and body colour. The miniature may therefore be said to have arisen from a fusion of the separate traditions of the illuminated manuscript and the medal.

The emancipation of the portrait miniature from the pages of the hook, as a separate portrait enclosed in either a locket or a covered "portrait box," is most plausibly traced to the illuminators of Ghent and Bruges. of whom the most prominent were the Master of Mary of Burgundy. Simon Bening and Gerard Horenbout. However, the earliest datable portrait miniatures are not Flemish but French, and consist of a group of seven portraits representing the warrior companions of Francis I known as *Les Preux* de *Marignan* and found in the pages of an illuminated manuscript of about 1519. One or two of these were repeated separately as portrait miniatures properly so called; all are probably by Jean Clouet (*q.v.*), whose recognized work consists mainly of portrait drawings of men and women connected with the French court. His son. François Clouet (*q.v.*), succeeded him as painter to the French kings.

French miniature painting in the 16th century is not plentiful; it is closely connected with court circles. and what survives is the work of Jean and François Clouet and their close followers. The attribution of the miniatures generally follows that of the drawings on which they are based, and art historians often disagree about these. It is probable. however, that the miniatures of Catherine de Médicis and Charles IX at Vienna. the Catherine de Médicis in the Victoria and Albert museum. London. and the portraits of Mary. queen of Scots, and Charles IX, as a boy, in the English royal collection are by François Clouet. They agree in a certain hard brilliance. the slightly mechanical quality of which may be due to the fact that they are derived not from life but from drawings.

England, 16th and 17th Centuries. — Soon after Francis I had installed Jean Clouet as his painter, Henry VIII, in a spirit of emulation, encouraged Gerard Horenbout to come to England with his daughter Susanna and with Lukas Horenbout, who was probably

her brother. Lukas Horenbout (d. 1544) painted the first portrait miniatures recorded in England. The portrait of Henry VIII at 35 in the Fitzwilliam museum, Cambridge, is probably by him, and some half dozen other works can plausibly be ascribed to the same hand. These first English miniatures combine the naturalism of the Flemish illuminators with a certain gravity of interpretation which was to pervade the national art till the end of the 17th century. Hans Holbein the Younger (*q.v.*), who was instructed in miniature painting by Lukas Horenbout, soon outstripped his master. He put into this small-scale work all the intensity of vision and fineness of touch apparent in his easel paintings and drawings. so that at the very beginning of the new art form masterpieces were created mhich have never been surpassed. His portrait of Mrs. Pemberton in the Victoria and Albert museum is the finest miniature ever painted. Barely a dozen authentic miniatures by Holbein are known, but they include one of Anne of Cleves, also in the Victoria and Albert museum, which is of great historical interest. This. with the panel in the Louvre, Paris, was the product of an official mission to Diiren so that Henry VIII might decide on the basis of the portrait whether to marry the lady.

Nicholas Hilliard (*q.v.*), the first native-born master of miniature painting in England, modeled his technique upon that of Holbein and was the first artist to devote almost the whole of his working life to the miniature. Unlike his French contemporaries Hilliard, who has left a fascinating account of his methods and ideals in his *The Art* of *Limning,* worked from life, and his portraits in consequence have a greater vivacity and freshness. He adopted the oval form which had recently become fashionable on the continent of Europe in preference to the circular form, and which remained the most popular shape until the beginning of the 19th century. Hilliard's miniatures give the Elizabethan age in a microcosm and are imbued with the imagination and exuberance which pervaded all facets of life in those times. He mas limner to Queen Elizabeth I for over 30 years, and painted her portrait many times; he also painted Mary, queen of Scots, and many of the chief courtiers and adventurers such as the earls of Cumberland and Leicester, Sir Francis Drake, Sir Walter Raleigh and Sir Christopher Hatton. The most famous of his pieces, the "Young Man Leaning Against a Tree Among Roses," is justly celebrated as a romantic interpretation of those romantic times. Hilliard emphasized line rather than gradations of tone in his drawing and modeling, and a bias toward this linear approach has persisted throughout English miniature painting.

Isaac Oliver (*q.v.*) was the chief pupil of Hilliard, and during the reign of James I he rose to enjoy more popularity than his master. His parents were fugitives from religious persecution in Rouen, and though he was probably only a baby when he mas brought to England. Isaac Oliver always retained French sympathies. He traveled in the Low Countries and Italy; his style is more cosmopolitan than Hilliard's, and characterized by more dramatic lighting. Isaac Oliver became a member of the household of Henry Frederick, prince of Wales; he was ably succeeded in his practice by his son Peter, who finished some of his father's works and made a series of small limned copies of oil paintings in Charles I's collection. John Hoskins (*q.v.*) continued in his early work the reticent manner of Hilliard, which was more attuned to the national temper. The effect of Van Dyck's sojourn in England from 1632 is clearly marked in all forms of English portraiture, and especially in the miniatures which Hoskins painted after this date. Samuel Cooper (*q.v.*), who was Hoskins' nephew and pupil, followed directly in this tradition. He is first discerned as an artist with an independent style shortly before 1640, and from then onward his miniatures show a penetration of character and a force of handling which account for his pre-eminent reputation throughout Europe. Horace Walpole justly said of him that, "if a glass could expand Cooper's pictures to the size of Vandyck's, they would appear to have been painted for that proportion. If his portrait of Cromwell could be so enlarged, I don't know but Vandyck would appear less great by the comparison." Cooper's portrayal of the serious and self-reliant characters of the Commonwealth culminates in the sketch portrait of Oliver Cromwell (duke of Buccleuch's collection) to mhich Walpole refers. After the Restoration he showed himself equally capable of mirroring the pleasure-loving court of Charles II. His full-scale sketches of the famous beauties Barbara, duchess of Cleveland, and Frances Stuart. duchess of Richmond. which are among his supreme achievements in this field, are in the royal collection at Windsor castle.

During the second half of the 17th century the other leading miniaturists were Thomas Flatman (*q.v.*), a pupil of Samuel Cooper, Nicholas Dixon (worked 1667–1708), a follower of Hoskins. and Lawrence Crosse (d. 1724), who embodies certain continental traits in his style of stippling, and whose work stands at the end of the first great period of English miniature painting. Its strength had lain in the breadth of patronage available as well as in the talent of the artists. There were already in the 17th century collectors of miniatures for their artistic or antiquarian interest, and part of Charles I's cabinet is still in the royal collection at Windsor castle.

Continental Miniatures, 17th and 18th Centuries. — During the 17th century there was neither so plentiful an output of miniatures on the continent of Europe nor so continuous a tradition as in England. Patronage was confined more narrowly to the immediate circle of the court. In France the most striking feature was the introduction of the portrait miniature on enamel and its early perfection in the hands of Jean Petitot (*q.v.*). Petitot was born and died in Switzerland and worked for several years in England, but his fame rests on the many portraits of Louis XIV and his entourage which he produced in Paris with the help of his brother-in-law Jacques Bordier. In Denmark Jacob van der Doordt (d. 1629) painted some miniatures for Christian IV; Paul Prieur (d. 1682 or 1683) worked as an enamelist from 1663; and Louis Goullon (d. 1680) painted miniatures in the next decade. Alexander Cooper (*q.v.*), the scarcely less gifted elder brother of Samuel Cooper, worked in Holland and went subsequently to Stockholm. where he worked for Queen Christina. Pierre Signac was miniature painter to the Swedish court from 1646 till his death in 1684, and mas succeeded by Elias Brenner (1647–1717).

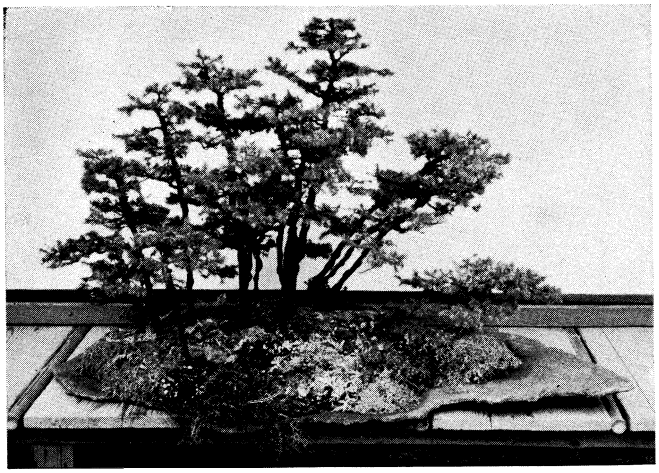
Throughout the 17th century some miniatures mere painted in oils on copper, particularly in the Netherlands and Italy. Though often of excellent quality, these oil miniatures do not rival in interest works carried out in the usual mediums of water colour and body colour; and since such works are rarely signed little is known about the artists who produced them.

About 1700 the whole future course of miniature painting was influenced by the introduction of ivory as the painting ground in place of the vellum or prepared card which had been universal before the development of enamels. The artist responsible for the new departure was Rosalba Carriera (1675–1757), who is well known also as a pastelist in Venice; it was probably suggested to her by the ivory snuffboxes for which she made decorative paintings. The advantage of ivory is that it provides a luminous glowing surface for transparent colours and correspondingly heightens their effect. However; it was some time before the full possibilities of the new method were appreciated. Many of the earlier painters upon ivory. such as the English artist Bernard Lens (1682–1740), used opaque colour, and so deprived themselves of one of ivory's chief advantages.

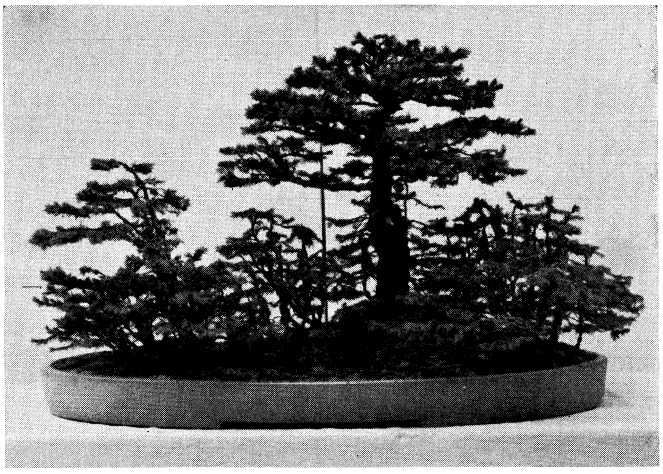
In the early 18th century the enamel miniature enjoyed the greatest popularity among English patrons. The Swedish-born Charles Boit (1662–1727) produced work in this medium in London for William III and Queen Anne. and the German-born Christian Friedrich Zincke (1684?–1767) painted most of the celebrities of the Augustan era in enamels of a remarkably even quality. Benjamin Arlaud, who worked in the first two decades of the 18th century, was one of the last miniaturists to paint on vellum in England; in France his brother Jacques Antoine Arlaud (1668–1746) pursued a similarly successful career. In that country Jean Baptiste Massé (1687–1767) was one of the first to paint miniatures on ivory, and a leader of the French revival of the art.

The second half of the 18th century witnessed a great expansion of miniature painting and the complete absorption in the various national schools of the technique of painting on ivory. The English still favoured a linear approach to drawing and modeling, thus preserving a continuity with the methods used as far back as

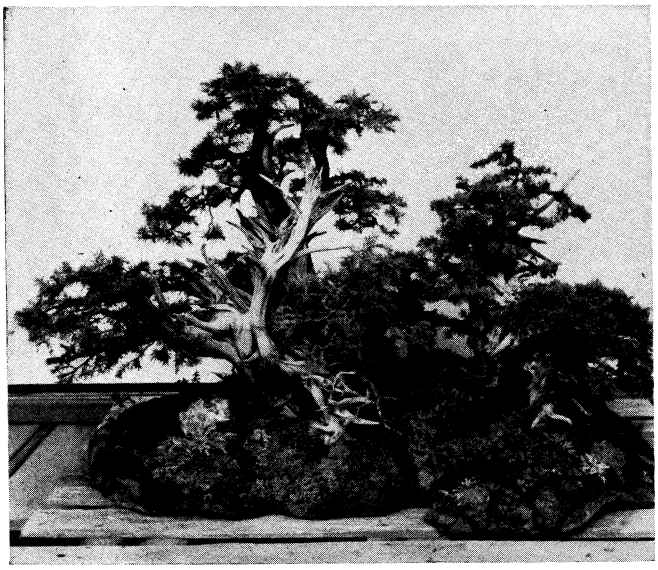
MINIATURE LANDSCAPE



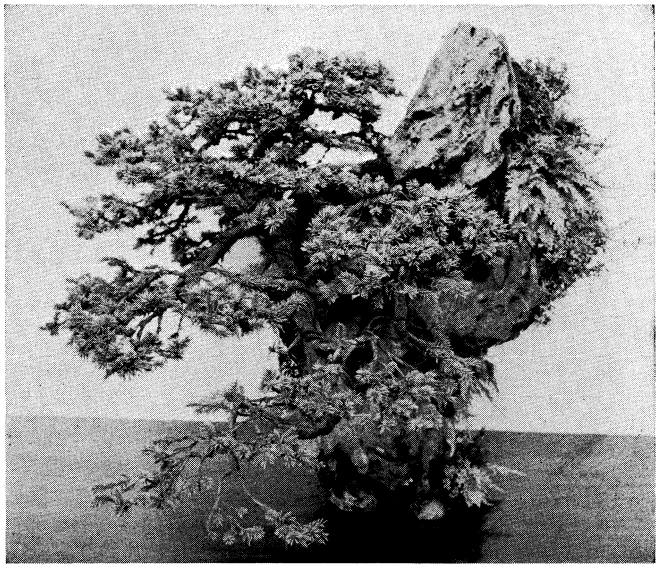
Grove of 15 spruce trees all joined by a single root. Designed and executed by the Kato brothers



Another Kato design, a forest scene with 70 spruce from a single root of a 15-year-old tree. Almost 20 years of wsrk were required to produce this sai-kei

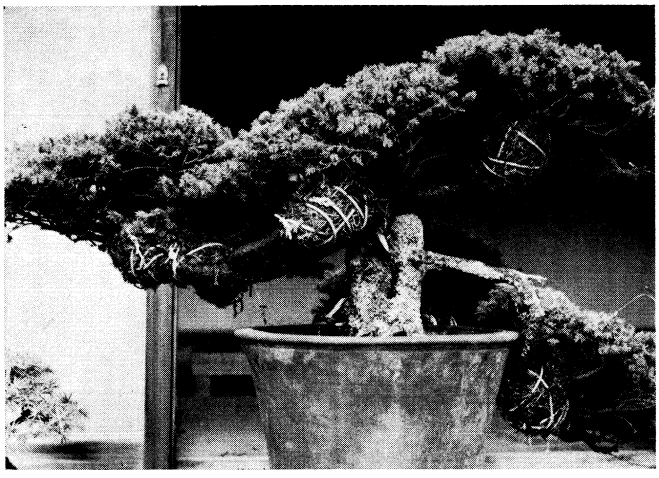


Ise province junipers, about 300 years old, growing on a rock. In the Manseiyen collection, Bonsai village



Rock and spruce scene suggested by an island in Matsushima bay. Manseiyen collection

Stunted growth of spruce and five-needle pine on a rock. Manseiyen collection



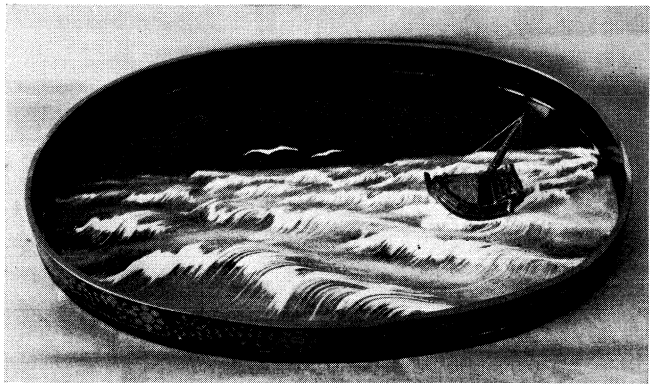
Air-layering a spruce. Moss and earth are bound around the branches with wire until the branches root. The rooted branches are then potted individually

SAI-KEI OF JAPAN

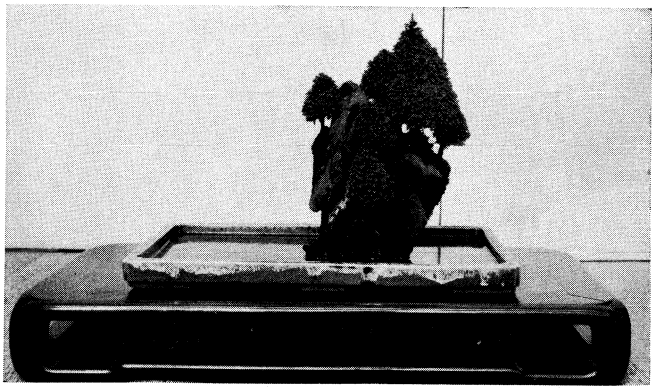
Miniature trees growing from roots propagated by air-layering (*toriki* method)

BY COURTESY OF JIRO HARADA

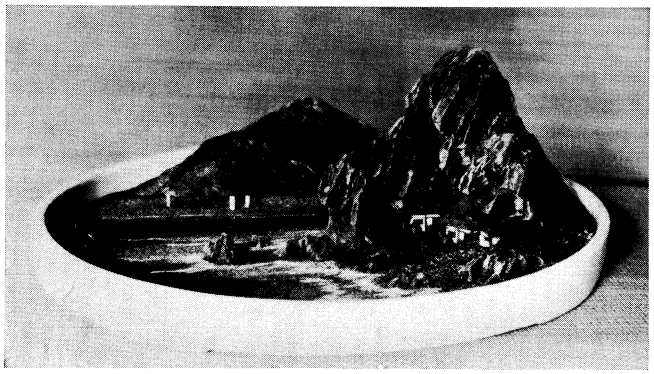
MINIATURE LANDSCAPE



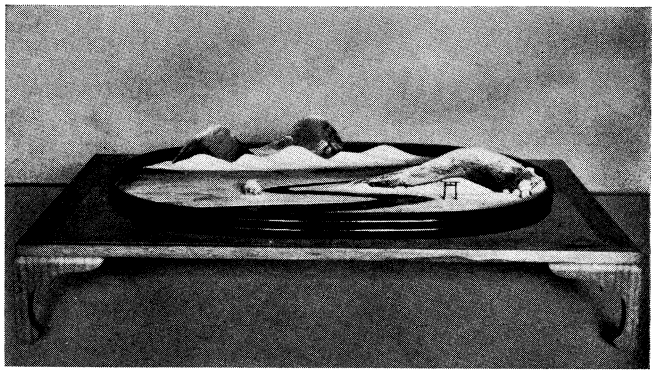
Bon-seki, a landscape of sand and stone, without vegetation, on a black lacquered tray. This one depicts a boat on a stormy sea



Bon-sai of cedars and rock. Similar to sai-kei, but propagation is from cuttings (*sashime*) rather than by air-layering. By Sadasuke Uchida

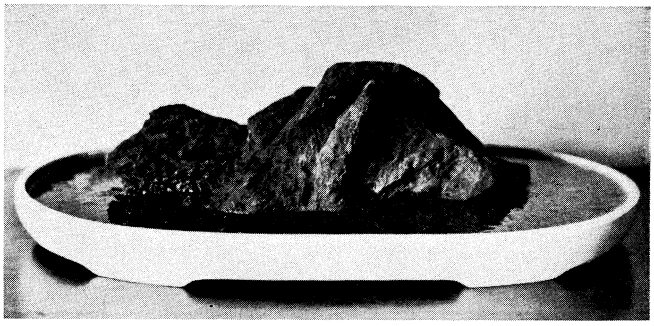


Bon-kei of a coastal scene. This type of landscape is artificial, the mountains and other objects are modeled in peat or earth, and coloured earth is used to represent water and paths

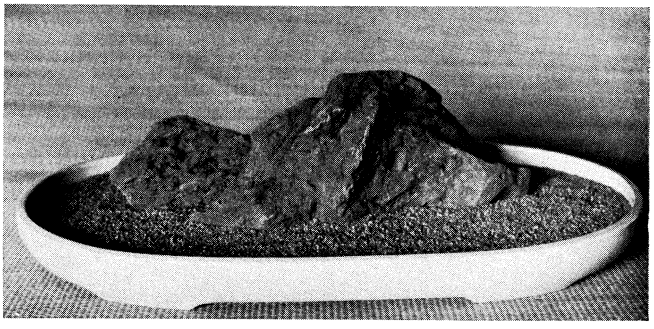


Bon-seki showing a landscape with torii (Shinto gateway)

Complete miniature garden with running water in a Tokyo store; 9x12 ft.



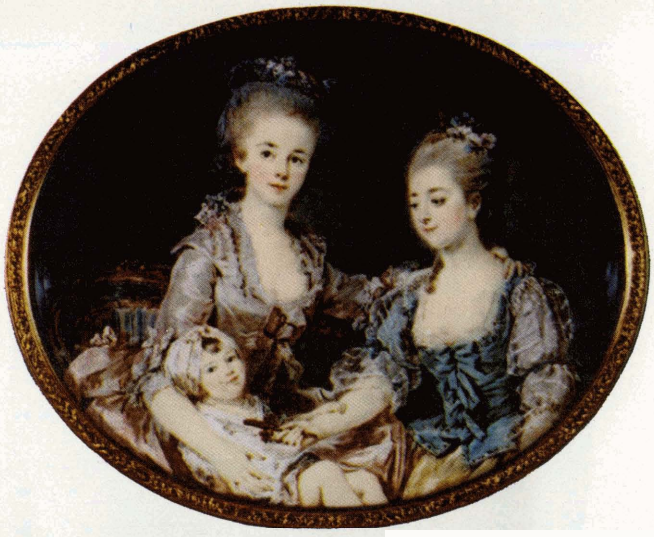
Sui-seki, a landscape consisting of a natural stone and water in a porcelain or bronze tray



Sui-seki. After years of watering a coating of moss may appear on the rock

OTHER TYPES OF JAPANESE MINIATURE GARDENS

MINIATURE PAINTING



"The Painter's Family" by Pa& Adolph IVE (1739–93), Swedish born; paint4 in France. Wallace Collection, London

"Mrs. Pemberton" by Hans Holbein the Younger (1497?–1543), German. Victoria and Albert Museum

"Mme. Dugazon" by Jean Baptiste Isabey (1767–1855), French. Wallace Collection

"James II" by Samuel Cooper (1609–72), English. Victoria and Albert Museum

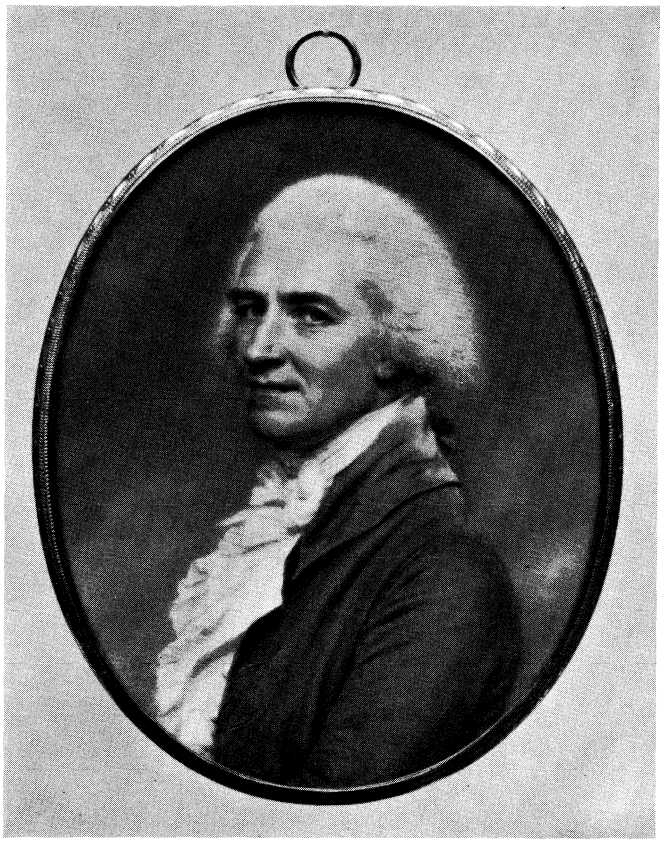
"A Young Man Leaning Against a Tree Among Roses" by Nicholas Hilliard (1547–1619), English. Victoria and Albert Museum

MINIATURES OF THE 16TH–19TH CENTURIES

BY COURTESY OF (TOP LEFT, CENTRE LEFT) WALLACE COLLECTION, (TOP RIGHT, BOTTOM LEFT, BOTTOM RIGHT) VICTORIA AND ALBERT MUSEUM

MINIATURE PAINTING

"The Duc de Berri" by Jean Baptiste Jacques Augustin (1759–1832), French. Bernard Falk collection



"Self-Portrait" by John Smart (*c.* 1742–1811), English. Victoria and Albert museum

"An Unknown Lady" by Jeremiah Meyer (1735–89), English. Victoria and Albert museum

"Countess Thun" by Heinrich Friedrich Füger (1751–1818), Austrian. Cleveland Museum of Art

"A Lady in Masque Costume" by Isaac Oliver (d. 1617). English. Victoria and Albert museum

"Mr. Bigland" by Richard Cosway (*c.* 1742–1821), English. Bernard Falk collection

"Self-Portrait" by Thomas Flatman (1637–88), English. Victoria and Albert museum

ENGLISH, FRENCH AND AUSTRIAN MINIATURES

BY COURTESY OF (ALL EXCEPT CENTRE) VICTORIA AND ALBERT MUSEUM, (CENTRE) CLEVELAND MUSEUM OF ART. EDWARD B. GREENE COLLECTION

Holbein and Hilliard and giving full scope for the transparency of the water-colour pigment and the translucence of the ivory. The continental miniaturists, on the other hand, preferred broad washes of opaque water colour with delicate gradations of tone, a method more akin to rococo oil painting. The chief master of the latter style is Peter Adolf Hall (1739–93), who was born in Sweden. settled in Paris in 1766 and was unquestionably the leading miniaturist there until the Revolution. His style is remarkable for its texture and subtlety of colouring, as well as for the geniality it displays; it is seen at its most characteristic in "The Painter's Family" in the Wallace collection, London, and in his portrait of Augustin Pajou in the National museum, Stockholm. A fellow Swede, Niclas Lafrensen (1737–1807), is best known for his miniatures of *galant* scenes of a type made popular by Jacques Charlier (c. 1720–90). Jean Baptiste Weyler (1747–91), Jean Laurent Mosnier (1743 or 1744–1808), Marie Gabrielle Capet (1761–1818), Louis Marie Sicard (1746–1825), Antoine Vestier (1740–1824) and François Dumont (*q.v.*) are among the many gifted miniaturists who laid the foundations of their success in France before the collapse of the monarchy. The leading Danish miniaturist was Cornelius Høyer (1741–1804), who worked also in France. Germany, Russia and Sweden. Augustin Ritt (1765–99) studied in Antwerp and Paris before achieving renown as court miniaturist in his birthplace, St. Petersburg. Heinrich Friedrich Fiiger (1751–1818), miniaturist to the imperial house in Vienna. is exceptional in that he reveals an English influence in his style, which is of extraordinary accomplishment; he has been called "the Austrian Cosway."

England and America, 18th Century.— In the mid-18th century English miniature painting began to recover from a rather dull period. Nathaniel Hone (1; 18–84), Luke Sullivan (1705–71) and Gervase Spencer (d. 1763) painted works of small compass—often intended for wearing in bracelets—and of a simple charm. The first of the remarkable miniaturists who were fashionable from about 1770 was Jeremiah Meyer (1735–89), a foundation member of the Royal Academy, London. He modeled the features of his sitters with a succession of fine hatched hairlines scarcely distinguishable at the ordinary viewing distance) and rendered their colourful costume with rococo abandon. His skill was equaled by Richard Cosway (*q.v.*), who drew with a soft, curving gray line. Cosway was the miniaturist of the fashionable world and echoes the beauty and elegance of the entourage of the prince regent. The closely wrought enamellike finish of John Smart (*q.v.*) has many admirers among modern collectors; this same period also sam the masculine portraiture of Ozias Humphry (*q.v.*) and the prolific output of George Engleheart (*q.v.*) and Richard Crosse (1742–1810). The taste for the miniature spread through wide sections of society, and scores of able miniaturists were available to meet this greatly increased demand. Among the better known were Samuel Cotes (1734–1818), Andrew Plimer (*q.v.*), Samuel Shelley (c. 1750–1808), William Wood (1769–1809) and Edward Miles (1752–1828). Ireland supported a school of miniaturists at this time, leading members of which were Charles Robertson (1760–1821), George Place (d. c. 1809) and John Comerford (c. 1770–1832). All these and many others have their individual styles and sense of the sitter's character: the remarkable uniformity of merit in the work even of secondary artists is a testimony to the wide proliferation of good taste in the period.

American miniature painting began in the second half of the 18th century and was strongly under English influence. John Singleton Copley (*q.v.*) is said to have copied English miniatures in the 1760s; Charles Willson Peale and Rembrandt Peale (*qq.v.*) were trained in London. The miniatures of Edward Greene Malbone (1777–1807) are outstanding for their refined handling; his work ranks with that of Benjamin Trott (c. 1770–1843) and Charles Fraser (1782–1860) as the most notable produced by American miniaturists. Among other able miniaturists who worked in America are John Ramage (c. 1748–1802), Walter Robertson (c. 1750–1802), Robert Field (c. 1769–1819), Joseph Wood (c. 1778–1830), Sarah Goodridge (1778–1853), Henry Inman (1801–46) and Thomas Seir Cummings (1804–94j.

The 19th Century.— The sharper lighting and more incisive rendering of features introduced by J. L. David into easel portraiture is reflected after the French Revolution in the miniatures of Jean Baptiste Jacques Augustin (1759–1832), a complete master of naturalism in this genre. A similar approach is seen in the works of the Italian miniaturist Ferdinand Quaglia (1780–1853), who settled in Paris. and in that of his countryman Domenico Bossi (176j–1853), who worked in most European centres. Jean Baptiste Isabey (*q.v.*) followed the same principles of naturalism in his earlier works, but his later portraits, the mirror of the first empire, are light. atmospheric and fluid in treatment. Paris remained a prolific centre for miniatures of the highest quality; of the many followers of Augustin and Isabey, Jean Urbain Guérin (1760–1836), Daniel Saint (1778–1847), Jean Baptiste Singry (1782–1824), André Leon Larue. called Mansion (1785–after 1834), and Mme. L. A. Z. de Mirbel (1796–1849) were much in vogue. In Austria, however. Moritz Michael Daffinger (1790–1849) pursued a style wholly English in its affiliations.

A pronounced break in style is seen in English miniature painting at the start of the 19th century, caused by the resolve of Andrew Robertson (1777–1845) to give his miniatures the force of oil paintings. The taste for larger miniatures of rectangular shape asserted itself from then on. Though there were more miniaturists practising than ever before, fewer stand out; John Cox Dillman Engleheart (1784–1862), John Linnell (1792–1882) and Frederick Cruickshank (1800–68) are among the more individual, while Alfred Edward Chalon (1781–1860) and the Frenchman Simon Jacques Rochard (1788–1872) painted with a liveliness attuned to the court of George IV. A final achievement was added to the history of the art in England by the immense talents of Sir William Charles Ross (1794–1860), who infused his portraits of the notabilities of Queen Victoria's early years with his own serenity of temperament, The invention of photography was the greatest single factor in bringing the annals of miniature painting to a close: the art lingered both on the continent of Europe and in England and the United States into the second half of the 19th century and even into the 20th, but had effectually lost all continuity with the traditions of its former excellence.

See also INDIAN ART; PERSIAN ART.

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MINIM: see MUSICAL NOTATION.

MINIMI (or Minims), members of a Catholic monastic order founded in Italy in 1435 by St. Francis of Paula. The first rule of the order followed closely that of St. Francis of Assisi, but the second (1501) and third 11506) showed more independence. By the year of the death of St. Francis of Paula, 1507, the order had spread to France, Spain and Germany. After the French Revolution its number declined rapidly.

MINIMUM WAGE. A wage rate fixed either by collective agreement, or (more commonly) by legal enactment, or by some other means! as the lowest wage payable to workers either generally or in a particular craft or grade. The phrase is most frequently used in connection with the various minimum wage laws passed by numerous countries in the 20th century. . 'The idea of enforcing a legal minimum wage was closely bound up with the idea that society has certain obligations to safeguard the life standard of its members. This motive was in certain cases intertwined with another— that of checking the development of strikes and industrial unrest. In Australia especially the laying down of enforceable minimum rates was often combined with the prohibition of strikes and lockouts and the enactment of compulsory arbitration. Where this was the case the rates of wages enforced by law mere in effect maximum as well as minimum rates. Under the British Wages Councils act of 1945. which replaced the earlier Trade Boards acts of 1909 and 1918, only minimum rates were prescribed, and workers, or their unions, were free to claim. and, if they thought fit. strike for. higher rates. On the other hand, the rates of wages fixed hy the justices after the Black Death and in Elizabethan times began as maximum rather than minimum rates. At

the time of their institution, the object was to prevent, not sweating or underpayment, but the rise of wages above a conventionally accepted standard.

The Elizabethan wage legislation, which fell gradually into disuse during the 17th and 18th centuries, was finally repealed in 1813, after the weavers and other classes of workers, whose wage standards had been depressed by the Napoleonic wars and the Industrial Revolution. had vainly attempted to use it for the raising of wages by state aid. A minimum wage bill introduced by Samuel Whitbread in 1795, largely on behalf of the agricultural workers, was thrown out in face of the dominance of the ideas of free contract and the iron law of wages. Not for more than a century after Whitbread's failure was the British state to begin the direct legal regulation of wage rates, though factory legislation made a timid beginning in 1819, and important truck acts, regulating the form in which wages might be paid, were passed early in the 19th century. In Great Britain, until the Trade Boards act of 1909, the state contented itself with legislating against truck and with providing voluntary machinery for conciliation and arbitration under such acts as the Conciliation acts of 1867 and 1896.

Minimum Wage Acts.—The provision by law of boards for prescribing legally enforceable minimum rates of wages began in 1896 in the Australian state of Victoria. Under the act of 1896, with later amendments, wages boards were set up in one trade after another, consisting of equal numbers of employers and aorkers with an impartial chairman. These boards were given power to fix minimum rates enforceable on the employer; and provision was made for a court of industrial appeals. South Australia followed Victoria's lead. and established boards of a broadly similar type. Other Australian states and later the Commonwealth of Australia followed a different plan, already started by New Zealand in 1894, and introduced in varying forms the system of compulsory conciliation and arbitration, under which the rates fixed were binding on both parties.

The British Trade Boards act of 1909 was based on the Victorian precedent, in that it set up boards for particular trades, with impartial chairmen (to whom it added certain impartial appointed members), with power to fix binding minimum rates, but without any powers of compulsory arbitration. Widely varying experiments in minimum wage legislation were made in other countries. (See WAGES, and under the countries concerned.) It need only be said here that in both Europe and the U.S. the greater part of this legislation was confined to wsmen workers, while many of the earlier European acts dealt only with homeworkers. The French act of 191j, for example, was limited in both these ways; and the comprehensive systems of wage regulation in France at mid-20th century rested mainly on emergency powers of uncertain duration. There was a movement, especially among non-Socialist parties, for a return to free collective bargaining.

The decision to institute minimum wage legislation in Great Britain followed the Liberal election victory of 1906 and the return to parliament of a Labour party able to exert an influence on the policy of the state. The ground was prepared by the exposures of the evil of sweating by the National Anti-Sweating league, as well as by trade union agitation. Two possible courses presented themselves. The state could have aimed at enforcing, over the whole range of employment, a single minimum rate of wages (or perhaps different minima for men and women, boys and girls). But any such rate or rates would necessarily have been very low. As in Victoria, the alternative was preferred of setting up a distinct board for each trade or industry. The boards were also given power, if they thought fit, to prescribe different minima for different localities; but they chose, as a rule, rather to fix minimum rates for a trade over the whole country, with the object of bringing the worse areas up toward the level of the better.

The act of 1909 covered only a few trades. The act of 1918 brought in many more; but the regulation by the state was still treated as exceptional, and was extended only to trades in which wages were abnormally low or no satisfactory machinery for collective bargaining existed.

Extensions under special acts took place to cotton weavers (1934) and to road haulage workers (1938); and in 1945 the Wages Councils act made it possible not only to regulate wages in any occupation or industry in which adequate arrangements for collective bargaining were held not to exist but also to deal with wages and conditions of work on a wider basis, including higher rates for skilled work. In the great mass of British industries, including most of the great basic services, no legal minimum wage existed at mid-20th century. The Wages Councils act applied to about 3,000,000 workers, out of a total employed population of 22,000,000. The agricultural labourers, whose wages were first regulated by law by the Corn Production act of 1917, had a minimum wage fixed separately for each county under the Agricultural Wages act of 1924, which was extended to Scotland in 1937 and was strengthened in 1940.

Though the wages council method was gradually extended to new trades, some classes of low-paid workers remained outside the scope of any form of state wage regulation. With some of these it would be possible to deal by the creation of more councils; but any such project was bound to encounter at least two difficulties. Wages Councils had usually been set up only in trades in which a large proportion of the total number of workers employed had been in receipt of exceptionally low wages. But many sections of low-paid workers were to be found in industries in which, taken as a whole, the rates of wages were relatively high. If the act were applied to these cases, it would be necessary either to apply it to the whole trade or to the underpaid sections only. Trade unions and employers would probably be opposed to the former method: the latter would involve difficulties of demarcation.

Moreover, even if the act were extended as widely as possible to clearly defined trades, there would remain a large residue of workers, including many of the worst paid, employed in ill-defined or scattered occupations for which it would be difficult to establish any special wage-fixing machinery. It was suggested that, in order to legislate for workers of this type, there should be set up some sort of general board, with power to prescribe minimum rates for any classes of workers for whom the establishment of a special board was inexpedient; but this was opposed by the trade unions, which feared that a state-enforced general minimum would react on the wage differentials set up by collective bargaining.

Coal Mines Minimum, 1912.—The Coal Mines Minimum Wage act of 1912 stood in a different class and could not properly be regarded as a minimum wage act. It was passed primarily in order to remedy a grievance peculiar to the mining industry—that of the man who, finding himself in an "abnormal place" in which coal-getting was especially difficult, is unable at piecework prices to earn a reasonable wage. The act provided for the payment to such a man of a minimum wage based on the wages actually in force in the district concerned. Thus, if the district wage fixed by collective bargaining fell, the legal minimum fell too. The act was designed, not to secure a particular rate of wages, but merely to protect individuals from earning, because of conditions beyond their control, less than a standard established by the ordinary process of collective bargaining. The Cotton Weavers' act of 1934 rested on a similar principle, as it provided merely for enforcing generally the rates agreed on between the union and the Employers' federation.

In general, the question of the legal minimum wage was bound up with the wider question of the state's duty to secure for all its citizens a reasonable standard of life. In Australia, where the conception was furthest developed, the minimum wage was gradually forced up in accordance with an expanding conception of the minimum standard of civilized living. The growing practice there was to define in relation to human needs a basic wage, which was then established as a general minimum, rates in particular trades being fixed at varying levels above the basic wage. In other countries, including Great Britain, legislation was introduced only with great caution, and the bodies entrusted with the task of fixing minimum rates were guided largely by the immediate ability to pay of the trades concerned, with the result that they had relatively little effect in raising the general standard of living. Under these circumstances, fears that the fixing of minimum rates might "drive trade out of the country" were not verified. In certain trades—notably tailoring—there was some tendency to stimulate factory production

and the use of machinery in place of homework and the small workshop. But on the whole the acts had relatively little effect on the structure of organization of industry. Their effect was in practice limited to preventing some of the grosser forms of sweating.

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United States.— hlinimum u-age establishment by law in the United States concerned only basic minimum standards, with the objective of establishing a floor ior the lowest-paid workers. It was not intended to replace the normal processes of wage determination. under collective bargaining or otherwise, ior the bulk of U.S. employees paid above the minimum rates. First in importance of three separate systems for establishing minimum wages was the iederal Fair Labor Standards act of 1938. As amended in 1955 this act, besides regulating hours and child labour. required that employees in interstate commerce or producing goods ior interstate commerce (with certain exceptions) be paid no less than $1 per hour. This law provided a flat-rate minimum (see *History* below) for covered employees, preventing substandard competition on wage rates below this minimum throughout the various geographical sections of the United States. It is thereiore of interest to employers in high wage areas as well as to employees and their union representatives. Exemptions are provided for executive, administrative and proiessional employees, and for labour in agriculture and certain other specified industries.

Employees engaged in industries of an intrastate nature are subject to state legislation only. By 1956, 29 states, the District of Columbia, Alaska, Puerto Rico and Hawaii had passed minimum wage laws. generally applicable to n-omen and minors. Eight states. Puerto Rico, Han-aii and Alaska had applied laws to men and women. Most laws were general in scope, covering virtually all gainful employment escept agricultural anti domestic service. Unlike the federal act, most state lan-s provided for minimum wage setting. generally or by industry, on a standard such as a living wage through recommendations of representative wage boards. By 1956, 11 laws fixed statutory rates, although 3 of these also provided ior a wage board procedure. State wage orders. issued ior particular occupations or industries, are revised irom time to time. In cases where both a state and a federal rate applied, the higher rate prevailed as the legal minimum. The state wage orders also experimented with a weekly wage applicable to a specified range of working hours.

A third minimum wage system established in the United States was that for workers employed in the production of goods for government use. Under the Public Contracts (Walsh-Healey) act of 19.36 minimum wage rates fixed by the U.S. secretary of labour must be incorporated in all iederal government contracts for supplies or equipment in excess of $10,000. The standard to be applied by the secretary in setting these rates was set as the prevailing minimum wage for similar work in the locality. Many states also provided for the fising of minimum wage rates ior their public work on the basis of prevailing wages

In the United States minimum n-age legislation has been sharply distinguished from the setting of wage ceilings or maxima as in the case of direct inflation controls in wartime and also from wage-fixing in labour dispute settlement under public emerrency circumstances. Wage stabilization controls were established during World War II and during the Korean war, but were administered by quite separate agencies. Since statutory minimum wage rates have traditionally been substantially below average or maximum rates, only occasional instances occurred requiring liaison to prevent conflicting regulations. Similarly, state public utility dispute laws are rarely if at all rrlated to minimum wage laws, since employer wage determination or collective bargaining with the right to strike for wages above the statutory minimums are widely accepted.

History.—U.S. state minimum wage legislation dates from 1912. In the preceding years various investigations had revealed the prevalence oi excessively low wages. especially among women workers. following the Rritish Trade Boards act of 1909. The period 1911–13 was one of great activity in the enactment of labour laws oi various kinds. In minimum wage. Massachusetts took the lead in 1912 and eight other states acted in 1913. These laws, reflecting social interest, applied only to n-omen and minors. Organized labour opposed the fixing of legal minimum rates ior men, preferring to win wage increases through collective bargaining. Moreover, it was assumed that minimum wage laws ior men would be unconstitutional. All but one of these acts provided ior the fixing oi minimum rates by wage board procedure with cost of living as the standard.

After 1913 thr wave of progress in labour legislation receded and minimum wage spread more slowly. In 1917 a iavourable decision by the Oregon supreme court (in *Stettler* v. *O'Hara,* 69 Ore. 519) was left standing when the U.S. supreme court divided equally (243 C.S. 629), Justice Louis D. Brandeis not voting because of prior participation in thr case as attorney. By 1923, 15 states, Puerto Rico and the District of Columbia had passed laws. In 1923, however, the minimum wage movement came to a halt when the U.S. supreme court again passed on a minimum wage law, and this time a clear majority held it invalid (in *Adkins* v. *Children's Hospital,* 261 *U.S.* 525). It then had to be assumed that all the minimum wage laws were unconstitutional (except as applied to minors).

With the deepening of the depression beginning in 1929, seven states passed minimum wage laws ior women and minors in 1933, including some of the chiei industrial states. Several additional state rninimuin wage acts were passed in 1935–39, two of them made applicable to men as well as women and minors, so that by 1941 26 states. the District of Columbia, Alaska, Puerto Rico and Hawaii had laws mostly for women and minors. In 1937 the U.S. supreme court by a 5–4 vote had upheld the constitutionality oi a cost of living minimum wage law oi the state of Washington (in *West Coast Hotel Company* v. *Parrish,* 300 U.S. 379), overruling the Xdkins decision, and upholding state minimum wage laws for women. No additional state laws were passed ior almost 15 years until three additional states enacted laws in 1955.

Federal minimum wage legislation sprung from the depression oi the 1930s. Following experimentation with minimum wages in industry codes under the short-lived National Industrial Recovery act (1933–35) and special public contract and construction wage legislation, the Fair Labor Standards act (F.L.S.A.) was passed in 1938. Its constitutionality was established in the case of *U.S.* v. *Darby Lumber Company,* 1941 (312 U.S. 100). The flat minimum of 25 cents per hour set by the act n-as scheduled to increase automatically to 30 cents per hour in 1939 with an ultimate goal of 40 cents per hour ior all industries by no later than 1945. The industry wage board procedure was provided to hold industry hearings ior setting rates above 30 cents per hour but not to exceed 40 cents per hour as soon as economically feasible before 1945. Expansionary economic conditions accompanying the spread oi World War II made it possible for the administrator, folloning industry hearings. to issue wage orders at 40 cents for most covered industries before the close of 1941 and ior all industries well beiore the 1945 target date. In fact war and postn-ar inflation made the 40-cent level obsolete and resulted in the 75-cent flat rate established by the 1949 amendments to the F.L.S.A. Industry wage board procedures were abandoned at that time except for Puerto Rico and the Virgin Islands. With the 1955 amendments, wage hoard procedures in Puerto Rico and the Virgin Islands were modified to provide for final and binding recommendations by such boards after hearings ior industry minimum rates designed to reach the new flat rate of $1 per hour as rapidly as economically feasible without substantially curtailing employment and without giving any industry in Puerto Rico or in the Virgin Islands a competitive advantage over any industry elsewhere in the United States.

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MINING, METAL. Mining, broadly, is the industrial process of removing a mineral-bearing substance from the place of its natural occurrence in the earth's crust. When the term is used with specific reference to producing a metallic material. it is called metalliferous mining or. more simply, metal mining.

History. — Through the discovery and identification of tools and weapons and similar artifacts found in various archaeological sites over the world. it became evident that mining has been practised since before the beginning of written history. Because of the coincidence of man's ingenuity and his more or less accidental discovery of metals, he was able to fabricate devices with which he could survive and exert his will as master of his environment.

Perhaps the first great scholarly and practicable treatise of mining was *De Re Metallica,* compiled by Georgius Xgricola (George Bauer) and published in 1jj6. This classic journal. the writing of which took over 2j years. was translated from the Latin in 1912 by Herbert C. Hoover and his wife. The descriptions in *De Re Metallica* are remarkable for their claritv and detail: the text is also profusely illustrated and serves as an excellent source of knowledge of early mining practices. Many of the procedures described are similar to those of the 20th century. In addition to their translation and treatment of Agricola's text. the Hoovers assembled notes about even earlier written works on mining. For example. as early as the 4th century B.C., Aristotle and some of his students, such as Theophrastus. had written of mining matters: Pliny likewise contributed notenorthy writings. Other authors. including Avicenna (an Arabian physician), Xlbertus Magnus and Roger Bacon. compiled treatises on mining. For the most part, however, few records of importance were developed prior to 1500.

Preceding *De Re Metallica* there were three works of major consequence issued in the 16th century about mining technology: *Nützlich Bergbuchlin,* probably by Calbus of Freiberg, according to the Hoovers; the *Probierbüchlein,* a collection of essays by several authors; and an Italian treatise, the *De* La *Pirotechnia* by Vanucci Biringuccio.

After Agricola, the printing of dissertations on mining waned, until the latter part of the 19th century. Technical articles then began to be published in Korth America in many journals and many formal treatises mere issued. The American Institute of Mining and Metallurgical Engineers (A.I.M.E.) was founded in 1871 (in 1956 it mas renamed the American Institute of Mining. Metallurgical and Petroleum Engineers) and became an outstanding medium whereby the mineral industry profession has grown and expressed itself with respect to the discovery and production of mineral wealth.

Some mines. such as the Almadén mercury mines of Spain, the tin mines oi Cornwall, Eng.. and the zinc deposits of Silesia (Poland), have been worked for many centuries in the old world, but not until colonization of the western hemisphere started about 1500 did mining of consequence begin in Korth America. It is true that the Inca and the Aztec peoples of South America and Mexico had accumulated wealth of gold and silver but industrialized mining does not appear to have been an outstanding feature of these agrarian cultures. Although the North American Indians used some metallic substances for weapons, paints and utensils, they crudely fabricated them from minerals which they exploited only by 111-directed surface scavenging. Neither the Indians nor the Eskimos had even small mines, and they give evidence of having had little, if any. use for gold. silver and other precious metals.

The first recorded copper mining in the western hemisphere was in Cuba in 1524 and it was followed early in the 17th century by activity in Massachusetts and elsewhere along the eastern seaboard of North America. A little later, copper mining was started in Vermont and, as early as 1718, De la Motte Cadillac, a French mineral expert, and Philip Renault located and began to work the famous Mine la Motte lead deposits of southeast Missouri. However, it was not until the discovery of the tremendous iron and copper deposits in hlinnesota and Michigan and the finding of zinc deposits in Missouri, Kansas and Oklahoma, together with those of gold and silver in California, Nevada and elsewhere, that the development oi modern metal mining began.

The growing populace, contemporaneous development of transcontinental railroads and, of course, the discovery of great mineral deposits contributed to a pronounced expansion of mining in the mid-19th century. Mining enterprises were spurred especially by the discovery of gold at Sutter's mill in California and later by the famous developments of Grass valley and the Feather river; by those of the Comstock lode and Tonopah in Nevada; Cripple Creek. Leadville and Silverton, Colorado; Tombstone, Jerome, Bisbee and Morenci, Arizona; Virginia City, Helena and Butte, Montana; Bingham, Park City, Ophir and Eureka in Utah; Orofino, Bay Horse and the Coeur d'Alene oi Idaho; the Homestake of the Black hills of South Dakota; the gold rush to the Yukon in Alaska; and many other fabulously productive mining camps.

The search for mines was particularly intense after the Civil War and much of the speed of the development of the western U.S. is attributable to it. The great wealth that accrued also served as an incentive to people of other lands, and great mines were discovered elsewhere in the world. Just as the Cornishmen of the tin-copper mines of England, for example, brought their skills to assist in the building of the great mines of the U.S., American craftsmanship and ingenuity joined in the building of flourishing mining enterprises throughout the world. From Canada, Mexico, Venezuela: Brazil, Peru, Chile, Bolivia, South Africa, Rhodesia: Australia, Burma, India and other countries, there has been a steadily growing production of an expanding range of metals. By the mid-20th century, the trend was to the increasing production of such comparatively uncommon metals as cobalt, titanium, nickel and columbium, and a great mining rush to search out and develop deposits of uranium and related radioactive minerals swept much of the world.

The Broad **Scope** of Metal Mining. — The tendency in mining has been toward the increased use and improvement of mining machinery so that modern mines are characterized by tremendous capacities. This has contributed to: (1) better working conditions; (2) the exploitation of lower-grade metal-bearing substances; and (3) the building oi mines of great dimension and iurther promise.

The mining of any metalliferous deposit is basically an enterprise conducted for economic gain. The work may be done as a surface operation or it may be done by an underground method. The mode of occurrence of the sought-for metallic substance governs to a large degree the type of mining that is practised. Each mineral deposit has its unique characteristics and may require a special method of mining for maximum efficiency. Some mineral deposits are very rich in metal content while others are lean (low grade). Some are large, irregularly shaped masses of hard rock; others have more or less flat-lying, tabular forms such as those of many rock beds or strata. Some ore bodies are tabular in shape but are inclined or tilted. These are called veins or lodes. Deposits in nhich the metal is associated uith loose or semiconsolidated sand and gravel masses are known as placer gravels or, simply. as placers. The added problem of depth also affects the mining method. If the rock containing the metallic substance is at a shallow site and is massive and widespread, it may be most economically excavated by a pit or quarrylike opening on the surface. If the metal-bearing mass is tabular, as a bed or vein, and goes to a great distance beneath the surface, then it will entail the adaptation of some method of underground mining

The mining industry is not a stagnant one. New uses are constantly found for metals. More efficient operating practices, lower costs per ton and better working conditions for employees always are sought. There has been a prevailing trend to supplant handwork by machinery, thus lightening the worker's physical burden. Because of the achievements aiter 1900, and especially after about 1925, in the development of large mining machines, metalliferous underground mining by the mid-20th century was pursued at remarkable depths and through very wide reaches of the earth's crust. At Butte, Mont., the underground openings reach to depths of about a mile beneath the surface and a labyrinth of over 3,500 mi. of passageways has been made under an area of the city extending about 2 mi. in an east-west direction and approximatelv 1 mi. north and south.

Many underground mines go to more than 5,000 ft. in depth. Some noteworthy operations are conducted on the iamous gold-bearing Witwatersrand of South Airica where several mine shaits are reported to have depths of almost 10.000 ft. Another example of the magnitude of some underground mines is at the St. Joseph Lead company in southeast Missouri. There, excavations are so extensive that they are served by two completely equipped underground machine shops that are 5.51 and 3.67 ac. in dimension. These shops are about 6 mi. apart and are connected by mine passageways so that very flexible service is available. All types of the mining equipment used in the mines are repaired in these underground shops and some new devices of major size actually are built in them. Many other illustrations of the scope of underground mining ventures might be given.

In several near-surface occurrences of iron- and copper-bearing substances, tremendous surface excavations have been made. These enterprises are outstandingly successful, particularly at the iron mines of Minnesota and at many copper deposits in the Cordilleran mountain systems of North and South America. As one illustration. the great opencut mine at Bingham. Utah, of the Utah Copper division of the Kennecott Copper corporation can be cited. It is reported that over 180,000 tons of barren rock and 90,000 tons of ore (rock which is rich enough in metal content to be profitably mined) are excavated each 24-hour period. The opencut which has been developed is about 2 mi. across from rim to rim and deep enough to accommodate two upright Empire State buildings, one on top of the other. It resembles a great stadium where all of the people of New York city could be seated.

Approximately 4 tons of explosives are used to break each 80,000 tons of the rock material. The rock is loaded into 100-ton railroad cars by electric shovels that scoop up 12 to 15 tons at each "bite."

Because modern mining operations involve so many types of machines and because they are frequently carried on in a subsurface environment where the responsibilities of the individual worker often are of abnormal scope, safety becomes of prime importance. However. when mining is pursued properly, it is not more dangerous than most other activities involving the use of heavy machinery and equipment. The good miner has a knowledge of the use of mining apparatus, the handling of explosives and the installing of artificial roof and wall supports. He has an ear for judging the stability arid uniformity of the ground in which he may be working; he knows the unfortunate effects that may result from breathing bad air or noxious gases. He is thoroughly skilled in the responsibilities of his trade. Mining organizations generally recognize his importance as a worker and as a citizen. Companies commonly maintain recreational facilities, and hospital and life insurance protection frequently is provided for the worker and his family. Housing often is made available at very nominal rentals and schools in mining camps usually are excellent. The miner's work often is done on a contract basis or bonus system. These practices benefit the mining company because of the incentive given for vigorous work, and the worker profits from the premiums returned for diligence and skill.

The **Mining** Cycle.—Most mining ventures entail an operating cycle which. in its usual sequence. is comprised basically of: (1) rock breaking (drilling and blasting); (2) mucking (loading); and (3) transporting (hauling and hoisting). Because of the wide variation of earth materials encountered in mining and because some are surface operations and others underground, the mining cycle is very flexible in its application. Some soft, earthy materials will not require drilling and blasting but, if the work is underground, they will require the installation of roof and wall supports. Underground mining is carried on in stronger rocks, and the placing of roof props or roof bolts often will not be necessary. Roof bolts are devices to stabilize ground by fixing heavy nuts to the free ends of steel rods which have been hammered into drill holes that have penetrated sound rock deep enough to reach undisturbed material in depth. A semblance of a form of truss support thus is provided.

In addition to the basic work cycle of mining, other activities usually must be performed. These generally include the disposing of spoil rock (unprofitable. barren rock sometimes called waste), shaft sinking, distribution of power supply. ventilating, lighting, draining. surveying.. making of geologic investigations and the installing and maintaining of mine plants.

As most mining operations are pursued in rock materials that must be forcibly broken from the solid medium. they entail the use of explosives confined in holes placed in the rock mass. Rock breaking consists basically of drilling of blast holes. emplacing of explosives in the holes, and blasting or detonating. Before the perfection of explosives for mining, rock was broken from the solid with picks. hammers and wedges and. even earlier, by a. method which used heat. A fire was built against the rock and when it became sufficiently heated. water was dashed onto it. Because of the sudden contraction, spalling and fracturing would ensue.

General drilling methods are: fire setting as described above; drilling by hand tools; and drilling by machine tools, usually of a percussion type and operated by compressed air. Drilling by hand tools is done by driving a sharpened steel rod like a chisel or pointed wedge into the solid rock which is to be broken. The rod is caused to penetrate by being struck with a heavy, hand-held hammer. The hammer may be used either in one hand and is called single jacking, or it may be swung by both hands and is then called double jacking. In machine drilling, the unit is made up of three basic components, the machine. the rod and the bit. Most drilling machines employed for blast hole drilling are of the hammer-drill type. They are classified as hand-held hammers (jackhammers, sinkers, etc.), drifters (light or heavy) and stopers, and are of many sizes, varying in weight and rotative power. The machines are designed to strike a blow on one end of a drill rod which has a drill bit attached to the opposite end. Drill rods. which come in various shapes and sizes, are made of carbon steel or alloy steel that can be forged. annealed. machine-threaded and hardened. Detachable bits that are screwed or driven onto the drill rod have almost replaced the use of the forged bit which is an integral part of the rod. One important exception to this is found in Coromant. the trade name of an alloy steel drill rod tipped with a chisel-type tungsten carbide bit. There are three kinds of removable rock bits, the multiple-use bit. the single-use or "throwaway" bit and the tungsten-carbide insert bit. Each has special efficiencies.

The drill holes generally are drilled in patterns or systems, the number and depth of holes being largely governed by the character and size of the rock mass to be broken and by the mining method followed.

The explosives employed in metal mining of hard rocks may be of special design and composition, but. for most operations, gelatin dynamites fabricated into sticks or cartridges are used. Cartridges are amenable to good emplacement in drill holes and have relatively high density and resistance to breakdown under moist conditions. In addition, they produce a minimum of toxic fumes when detonated. The gelatins commonly are furnished in strengths from 40% to 75%. The higher strength explosives (60% to 75%) are especially well-suited to firing "tight" drill hole patterns. For underground blasting practice, the *Blasters'* Handbook issued by E. I. du Pont de Nemours and company, Wilmington, Del.. is recommended as a reference. Because of the environmental conditions of underground blasting, it is imperative that all safety precautions be observed and proper blasting techniques employed. Other explosives include black powder, liquid oxygen and carbon dioxide. The explosive violence of the release of compressed air is used in some operations.

Mucking and transporting. though of distinct character. are difficult to divorce in a discussion because of their close sequential relationship and interdependency. The method of mucking is reflected in the choice and design of the haulage system. In fact, if maximum speed and efficiency are to be realized, the capacity of the haulage system must be correlated to the rate of loading.

Loading in many underground operations is from chutes where the ore has been dropped into binlike excavations called raises (see later discussion of underground mining [stoping] methods). In other cases, the muck is loaded by shoveling or some similar means. Prior to the introduction of mechanical loaders for underground use, mucking often was the bottleneck of efficient progress in mining operations. Hand loading is slow, tedious and laborious whereas mechanical loading appreciably reduces both the time of loading and the number of men required. The flexibility of mechanical loading in large scale surface mining operations demonstrates how mechanization can reduce the unit cost of a mining venture.

Loading procedures can be classified as follows: (1) Loading from chutes or bins. (2) Hand loading (shoveling), almost obsolete, especially in larger mining operations. (3) Scraper loading (sometimes called slusher loading), either surface or underground mining, may be driven by compressed air or by electricity. (4) Overshot loaders in which the digging element crowds, lifts and discharges directly into a car or truck. The action is similar to the way a hand shoveler would throw a shovelful over his shoulder. the cycle being controlled by the operator and the machine moving by means of flanged wheels on rails or on caterpillar treads. (5) Conveyor-type shovel loaders, machines which dig on the forward motion and deliver the load on the backward motion to an integrated conveyor belt that discharges into the hauling device. (6) Continuous-type loaders. which have gathering arms or rakes that move the muck onto a shaker pan or conveyor belt that in turn moves it into a car or truck. (7) Stationary shovels or dippers. machines which crowd and load from a stationary position, are mounted on flat wheels, railroad wheels or continuous tread, and are motivated by steam, electricity or diesel engines. They are commonly used in surface mining and often are of very large

capacity.

Before leaving the discussion of loading, a special mining procedure known as dredging should be described, It is a method of surface mining of appreciable economic consequence and, though somewhat restricted in its industrial application, is the means whereby major quantities of gold, tin, platinum and other heavy mineral materials often are obtained. Where the sought-for metals occur in loose or semiconsolidated sand and gravel deposits and where sufficient water is available. dredging frequently is economically feasible. A dredge may be either a chain-bucket or dragline type. The former is a boat-supported machine with an endless chain of scoop buckets which dig down and forward through a pond of water and load the metal-bearing gravel onto concentrating (separating) tables on the dredge deck. After the metal values have been recovered, the gravel is dumped out the rear of the dredge by means of a conveyor belt, called a stacker. Some of the larger dredges can reach gravels at depths of over 100 ft. and the buckets can be constructed to scoop 15 cu.ft. or more during each pass. The common dragline dredge is a conventional dragline loading machine mounted on crawler tracks and is operated to pick up loads of gravel in a scraper bucket by an intermittent scooping process. Each scraperload is dumped into a bin or hopper for subsequent treatment on concentrating tables. The dragline unit is used on land and thus it does not require a large supply of water as does the typical bucket dredge, described above.

Transporting of rock is not a critical problem if the loading is done by hand shoveling, since almost any type of conveyance will move the muck as rapidly as it is supplied; *e.g.*, wheelbarrows, sleds, carts, mine cars (sometimes pulled by beasts of burden), small locomotives (usually electric or compressed-air powered) or cable hoists. However, in larger underground mining operations and at most surface mines the haulage is primarily by electric locomotives pulling trains of cars, or by pneumatic-tired trucks. The trucks usually are diesel or gasoline powered. In some large operations, they can cost $60,000 and transport as much as 40 tons to the unit load. These remarkable conveyances commonly have power steering and automatic transmissions, minimizing driver fatigue and enhancing flexibility and efficiency of handling.

In the operation of most underground mines, it is necessary to move ore, men and supplies through a shaft from the surface This is accomplished by a process known as hoisting, which employs elevatorlike devices called cages and skips that move on signal or at the mill of the hoistman. A nell-designed hoisting plant must not only be capable of efficiently moving ore from the mine. but it also must accommodate the handling of all machinery, drills, drill carriages, rails and ties, ventilation equipment, timbers, explosives and all other items of supply. Hoisting arrangements must be safe for moving personnel, strong. of adequate capacity, smooth working and fast.

The surface headframe, the hoist engine to which the hoisting cables are attached, and a suitable bucket, cage or skip are integral parts of the system. In most larger mines, tno cages or skips are installed to move up and down in controlled unison. This is called balanced hoisting and contributes to an efficient practice because the weight of the skip that is descending helps to pull up the loaded vessel.

Successful mining requires a working environment that is as equitable as possible. As underground mining steadily grows deeper and of wider lateral extent, it requires more extensive and complex ventilation practices. Deeper mining and the increasing use of mechanized equipment steadily induce complicating conditions. The purpose of ventilation in subsurface mining is to provide an atmospheric environment that is safe and comfortable. To do this, it is necessary to remove or dilute undesirable gases, dusts and smoke. to introduce fresh air into the system and to condition the atmosphere for proper temperature and humidity.

One of the first problems in designing a ventilation system is to determine how much air is required to maintain a safe, healthful atmosphere in the mine. In general, 100 to 200 cu.ft. of fresh air is needed each minute for each man working underground. Peculiar local situations such as the extent of the mine, the type and amount of explosives used, the frequency of blasting, geologic phenomena, humidity and temperature affect the amount of ventilation required. Air movement occurs by a differential pressure sufficiently great to set a given mass of air in motion and to overcome friction and shock losses caused by protuberances and abrupt bends of the line of travel. Devices capable of producing air movements are: airscrews. such as propellers; centrifugal fans; rotary, positive blowers; injectors, such as Venturi blowers; discharge of compressed air; ventilating furnaces, such as free, hot-air systems; water sprays; deflectors and sails.

To suitably condition the atmosphere at great depths below the surface, it is commonly necessary to establish cooling systems as well as direct ventilating devices. The cooling units may be mechanical refrigerating machines or they may be designed to work as heat exchangers of the cooling-tower or spray-tower types.

CLASSIFICATION OF METAL MINING METHODS

As has been discussed, the choice of a mining method to exploit any metal-bearing deposit depends on several related factors, of which the chief ones are: size and shape of ore-bearing mass; degree of richness of the ore; depth of occurrence; geographic location; and labour supply. A classification of the general methods of metal mining, as modified after the arrangement used by the American Institute of Mining, Metallurgical and Petroleum Engineers, follows:

- Opencut Mining (with or without stripping)
  - Benching
  - Glory-hole Mining
  - Placer Mining
    - Sluicing and hydraulicking
    - Dredging
- Underground Mining
  - Breast Stoping (tabular, flat-lying deposits or beds)
    - Continuous horizon
    - Drift mining
    - Casual pillars
    - Rooms and pillars
  - Underhand Stoping (veins and large masses)
    - Glory-holes with pillars
    - Open stoping
      - Stulls
      - Square sets
  - Overhand Stoping (steeply inclined veins or masses)
    - Open stopes
      - Pillars
      - Stulls
      - Square sets
    - Filled stopes
      - Horizontal cut-and-fill (flat back)
      - Inclined cut-and-fill (rill)
      - Square sets
      - Resuing or stripping
    - Shrinkage stopes
    - Sublevel stopes
  - Top Slicing (wide veins or masses)
    - Continuous horizon
    - Panel slicing
    - Block slicing
    - Inclined slicing
  - Caving (large masses)
    - Sublevel caring
    - Block caving
      - Undercut from main level
      - Cndercut from sublevel
      - Block caving into chutes
      - Block caving with branch raises

Opencut Mining.—Opencut mining practices comprise the working of metalliferous deposits which either outcrop at the surface of the ground or are covered by a shallow overburden or capping. There is an economic limit to the maximum thickness of overburden that can be removed and, when such a limit is exceeded, some method of underground mining must be adopted. The depth of capping may vary from a few feet up to 300 ft.

Benching.—Power-driven shovels working on benches load the ore into railroad cars or diesel-powered trucks. The muck is loosened by blasting, and care is taken that the pieces are small enough to be handled readily by the shovels. The height of bank is determined by the thickness of the deposit, the size of the shovels, the physical character of the ore and climatic conditions.

The higher the bank, the more material the shovel can handle from one position, but the greater is the danger of a slide burying the shovel and of falling rock injuring the men. The material may stand at a high angle when dry. but slides may occur in wet weather. Thick deposits are worked in several benches; the slope of the banks which extend from bench to bench varies at different mines, but for preliminary investigations may be taken as 45° from the horizontal. This gives a general slope (including both benches and banks) of from 38" to 40° for the entire side of the cut.

The shape of the ore body has an important bearing on the feasibility of opencut mining. Because of the slope which the sides of

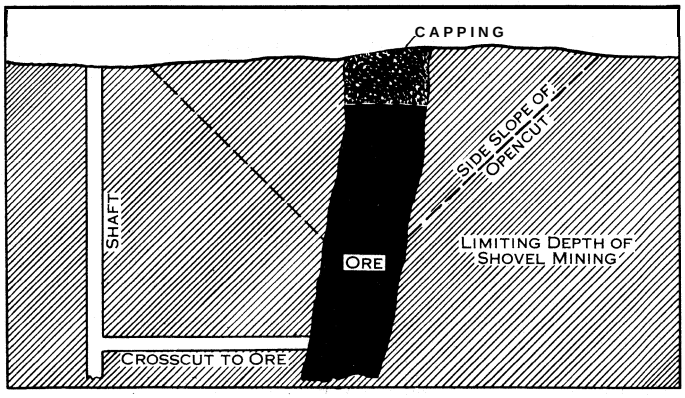

FIG. 1

the cut must take, a narrow ore deposit cannot be mined as economically by this method as can a large flat-lying one. If the deposit is irregular in outline, it may be difficult to prevent diluting the ore with waste. Even under favourable conditions, it is seldom possible to mine the entire body without resorting to underground mining for some part of it. Fig. 1 illustrates in what manner the side slopes may limit the economical depth of opencut mining.

The electrically operated shovel fitted with caterpillar tread has largely superseded the steam shovel, especially in large scale work. The electric shovel eliminates the problems of water and fuel supply. a fact which makes it particularly advantageous in cold weather. Power-shovel work. because of the high cost of equip-

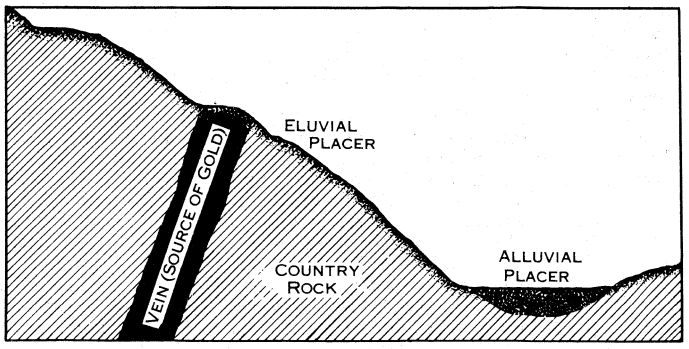

FIG. 2

ment, must be on a large scale, and consequently can be economically applied only to big ore deposits.

Glory-hole Mining.—In this case a vertical connection, called a raise, is driven to the surface from an underground haulage way. The top of this raise is broken out to form a funnel-shaped opening. which is widened and deepened by blasting around the inside.. The broken ore slides down the funnel into the raise which serves as a chute. the ore being drawn off through gates into cars on the haulage level. This is a cheap method of mining, but it is dangerous especially if pieces of the wall tend to break off and the excavation is large.

A series of holes may be mined and widened until they intersect. The intervening ridges then are worked out.

Placer *Mining*.—This is a surface mining method applied to deposits of minerals accumulated into workable quantities of economic importance through the natural geologic processes of weathering, erosion and deposition. An alluvial placer occurrence is one formed by the mechanical action of moving water, whether of streams or lakes or along a seacoast. Eluvial is a term applied to placers formed mainly by weathering and thus it is found close to the parent rock (*see* fig. 2). Erosion of the parent rock has set free the heavy. metallic components and these have worked down the slope because of the combined action of gravity and washing by rains. Once a flowing stream is reached, the metal may be carried a long distance before it is deposited. A placer deposit may be formed by concentrations of gold or tin or by a number of other minerals,, but mining for gold is generally the most common. A few workable placers have been formed also by the action of wind. which carried away the lighter minerals leaving a residual, heavier mineral deposit which is of economic importance.

The size of placer gold varies from nuggets of 2,000 oz. troy or more to such fine flakes that 2.000of them are worth only one cent. Small pockets of auriferous or gold-bearing gravel may be worked by hand by using a pan or a rocker to separate the gold from the gravel mass. A rocker is a small wooden trough or box mounted on two transverse rockers so the device can be given a shaking or rocking motion which tends to cause the heavy metals to sink out or go to the bottom of the mass.

By diligent work an experienced panner can handle about 1 cu.yd. of gravel in ten hours. Two men with a rocker can work from 3 to j cu.yd. of gravel in approximately ten hours under average conditions.

Sluicing and hydraulicking broadly are mining methods in which a slightly sloping wooden trough (box sluice) or a ditch cut in hard gravel or rock (ground sluice) is used as a channel along which gold-bearing gravel is carried by a stream of water. Riffles, in the form of cobblestones, wooden blocks, wooden poles or steel rails, are placed transversely along the bottom of the sluice to cause the water to eddy into small retarding basins so that the current is reduced and the gold may settle and thus be trapped. Sluices vary from 1 to 6 ft. in width and from 1 to 4 ft. in depth, their cross section being proportional to the volume of material passing through them. Their length should be sufficient to allow the gravel to disintegrate and the gold to settle. This usually takes place in the first 100 to 300 ft. The slope or grade of sluices is commonly specified as the number of inches that are dropped in a length of 12 ft

Sluicing is the term applied to working placers where the gravel is carried to the head of the sluice by shoveling, in wheelbarrows, in small cars, by scrapers or by dragline excavators. Large placer deposits are norked by hydraulicking, gravel being loosened from place and washed into the sluice by powerful jets of water from nozzles called hydraulic giants. To be effective, the head of water on the giant should not be less than 200 ft.. which is equivalent to a pressure of 86 8 lb. per square inch Water for the hydraulic giant is measured in terms of the miner's inch, or a flow of 1.5 cu.ft. per minute. As a rough guide. under average conditions a miner's inch will move from 3 to 6 cu.yd. of gravel per 24 hours.

As previously noted. dredging is an important mining process often used to recover heavy metallic materials from some sand and gravel deposits that are sufficiently value-bearing.

Underground Mining.— There are numerous types of underground mining or stoping (see classification outline above). Their general characteristics are presented below. Stoping is used as a general term to indicate the process whereby ore-bearing materials are produced commercially during an underground mining operation. The underground excavation in which the miners perform their work is called a stope.

Breast *Stoping*.—Breast stoping is a method of mining that may be applied to thin ore deposits that either are flat-lying or inclined (dipping) at a small angle to the horizontal. The thickness of deposits worked by this method usually is not over 12 ft., although in modified form this system may be applied to beds up to 70 ft. In thin deposits the entire thickness of ore is mined at one time. thus advancing the work in a vertical face or breast. In thicker deposits the ore is mined in a series of crude or rough benches.

Continuous horizon implies a long working face which is attacked simultaneously at a number of points.

Drift mining. as it is used with reference to the exploitation of placer deposits, is a variety of breast stoping. The paystreak or zone of major concentration of sought-for values is reached through a horizontal, tunnellike opening called a drift or sometimes under special cases an adit (*q.v.*), or through a shallow, vertical shaft. Small cars commonly are used for transporting the gravel which is removed in some system of regular cuts or slices across the paystreak.

Timber posts and headboards usually serve to support the roof but, if the gravel is so loose as to "run," tight timbering or a method of forepoling (which is the lengthwise driving ahead of sharpened supporting timbers before the ground is excavated) must be used.

Gravel that is frozen, such as that which is quite often encountered in Alaska and other places of the northern latitudes. must be thawed before it can be mined. Steam, hot water or cold water have been used successfully for thawing, being forced into the frozen gravel through pointed pipes that are applied somewhat as hypodermic needles.

Breast stoping in the Missouri lead and zinc region is done by leaving casual pillars of ore deposit to support the roof. These pillars. left at irregular intervals as the name signifies, range from 10 to 40 ft. in diameter. From 10% to 17% of the ore generally is left in the pillars, depending upon the hard or soft nature of the floor, the strength of the roof and total weight supported. The recovery of ore from the pillars is low, it being usually more economical to leave some of the ore than to use artificial means of roof support.

Small power shovels or scrapers commonly are used in the stopes for gathering and loading the broken ore.

The room and pillar method of stoping is that of cutting the ore deposit into regular lines of square or rectangular pillars, which later are removed as much as possible. It is not uncommon to leave, temporarily at least, as much as 50% of the ore in the pillars.

Underhand Stoping.—As the name implies this is a method of working a vertical or steeply inclined ore body irom the top down. Holes ior blasting are drilled downward and the rock which is broken must be shoveled and hoisted as in digging a pit, or in more extensive operations it may be moved downward to a previously iormed excavation lying below. In the mining process, it is customary to concentrate the handling of ore and waste and the distribution of supplies on certain horizons called levels, which are commonly spaced 100 it. apart vertically, though this distance may be lessened or increased in some mines. On any level, the passageways driven lengthwise of the vein are called driits and those driven across the vein from wall to wall are called crosscuts. If the vein is inclined, the upper or overhanging wall is the hanging wall, and the lower, underfoot wall is the footwall. Two levels may be interconnected by vertical or inclined openings, called raises if driven upward irom a level, and known as winzes if excavated downward from a level. Thus, a connecting opening may be a raise or a winze depending upon which level it has been driven irom. Raises

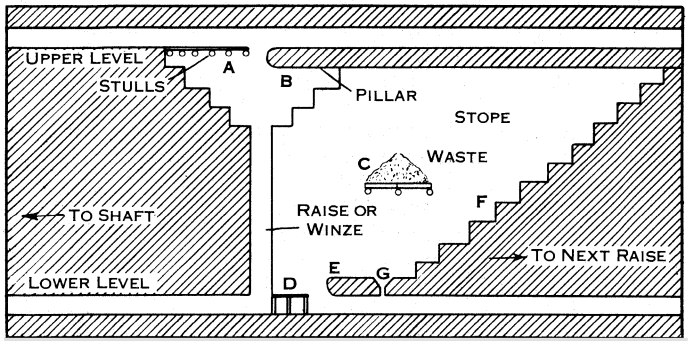

FIG. 3

and winzes are ordinarily timbered to afford at least two closed compartments. one to be used as a chute for ore or waste and the other fitted with a ladder to serve as a manway. The term back is applied to both the roof of an underground opening or to the entire body of ore lying between a level and the next one above.

An underhand stope (see fig. 3) is started by working outward from the top of a winze in a series of horizontal slices, which operation leaves the underlying unmined ore in a rough, steplike iorm. To protect a lower level during the stoping process and to provide a means of loading cars, the lower level is either timbered, as shown at D. or a pillar of ore, E, is left, through which chutes, G, are cut at intervals of 25 to 50 ft. The iace of the ore iorms a rough slope or series of steps as indicated at F. The angle oi repose of broken ore in the stope is irom 3j° to 45°, the steeper angle being for hard ores. If possible, the slope should be maintained of such steepness that the ore which is mined will slide downward. If the ore is rich, timbers called stulls or props are covered with planks, called lagging, to form the bottom of the upper drift, as at A, but if the ore is lean (low grade). it is usually more economical to leave a pillar of ore as at B. Should the level bc the lowest level in the mine. the ore must be hoisted to the top of the winze, but as the cost is comparatively high, this procedure is used only ior recovering small bodies of ore below a level. When underhand stoping is applied to large ore bodies it generally takes the form of underground glory holes, sometimes called mill holes, one series of holes being separated from another group by an intervening pillar oi ore. In these cases, as in the working oi a narrow vein, the men are in danger of rock ialling irom the back or walls of the stope, hence the desirability of having a firm back and strong walls.

Overhand *Stoping.*—In this system oi mining where open stopes are used, they are advanced upward, the ore being removed in horizontal, vertical or inclined slices. The stopes are started irom the bottom of a raise: either from the top of a protecting pillar of ore, as at P, fig. 4, or directly off the level, as at S, in which case the level is protected by stulls or drift sets (framed-timber units) which are covered with lagging. As the stoping proceeds upward the miners must have some support on which to work. For veins having an inclination or dip of 40° or less, the men can work directly by standing on the footwall, but in steeper ore bodies, the stulls'or other timbers are covered with lagging to afford temporary working platiorms.

The practice of filled stopes is used if the ore is likely to fall very soon aiter it is undercut and if the walls are weak. This is done because a stronger support than can be given by timbering alone is required and thus. the filling of the stope with rock material of uneconomic value is resorted to. This nonvaluable rock is secured by sorting the ore. by driving small drifts or inclined raises into the barren walls of the deposit or getting the rock from outside the mine. The horizontal-cut-and-fill or flat-back system of overhand mining is shown in fig. 4. At H the cut is being made horizontally to the rigbt, the miners drilling holes from the top oi the pile oi broken ore at O. Chutes, C, are ior drawing off the ore to the level below. These timbered chutes are built to keep the top just above the waste filling. W, which is brought in on the upper level and dropped down the waste chute in the raise to be distributed by cars or scrapers through the stope. As the mining progresses away from the main raise, additional waste raises, B, are driven at intervals to save hauling distance. Beiore a slice of ore is shot down, the waste filling is leveled and covered with planks. The planks are removed when waste is to be dumped. After the slice H has been carried beyond the first waste raise. another slice may be started irom the main raise. In this way several sets of miners may be working simultaneously in a stope. The ore chutes may be built of large pieces of waste arranged in circular iorm and some support to the back may be afforded by cribs built on the waste or on the ore as at A, fig. 4, but no heavy weight can be supported in this way.

The method oi mining called inclined-cut-and-fill stoping, known also as rill stoping, is a type oi overhand stoping in which inclined slices are taken, as is shown at R, fig. 4. The method works well where the ore is hard and the walls are firm and regular. The slices or cuts are made either irom the top down or the bottom up, the miners standing on the broken ore. After a slice has been shot down and the ore has drawn off at the level below, waste is brought down the raise from the level above. The waste runs in under the influence oi gravity and takes its own angle of repose. A layer oi planks then is laid on the waste, another slice of ore is shot down and drawn off, and the planks are removed for the next layer of waste filling. Both ore and waste require a minimum of handling. At T, fig. 4, stulls and posts are used as support. Here, the broken ore is shown lying on the plank-covered waste, W. As the stope increases in height, the lower point, or toe, moves away irom the raise. The danger of falls of rocks irom the back limits the length of the stopes, which in some cases may be only 50 to 60 ft. An ore chute is started irom the level at the toe of the slope and is carried up, keeping pace with the waste filling. Sometimes no planks are used in the stope inasmuch as water is used to met and thus to compact the surface of the waste before the ore is shot down. After the ore is drawn off, the fine material remaining is careiully scraped off the waste before additional filling is run in.

A flexible method of stoping is one wherein filled square sets are used for mining of especially heavy (insecure) ground. The term square sets reiers to a particular type or system oi timber supports in which each of the several component units is known as a set. That is, a complete set is composed of 12 pieces oi timber, as shown in fig. 5, four each of posts P, caps C and girts G. As additional sets are added each timber becomes common to four adjacent sets. Round timbers also may be used in sets, but they require a slightly different iraming or end design. Sets are held in place by short blocks

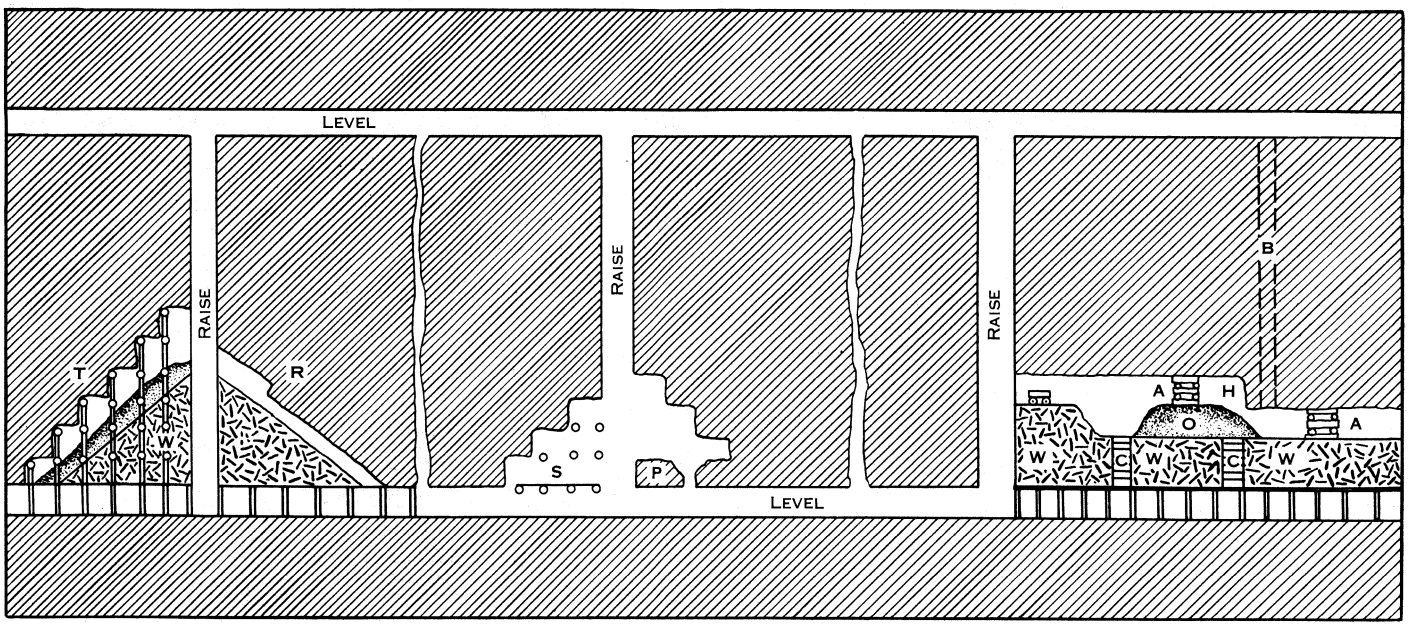

FIG. 4

placed at the corners and wedged tightly against the walls of the stope. By extending sets vertically and horizontally this skeleton framework of timber may be shaped to fit a stope oi very irregular outline. By varying the number oi sets opened laterally on the bottom or so-called sill floor of a stope, and by limiting the vertical number of sets leit unfilled, this system can be made to suit the nature (degree of instability) of the ground being mined. If no great pressure is brought on the timbers, a sill floor 12 to 1j sets wide, or even more, may be opened. However, in the mining of ground that has a tendency to slough, the sill floor may be only two or three sets in width. This area of horizontal or lateral cut is carried up to the level above, and then another similar cut is started next to the filled sets, and the operations are repeated. Thus a large block of heavy ground may be safely mined in a series of small vertical slices. Chutes and manways are made by lining square sets tightly on the inside with vertically placed planks or lagging.

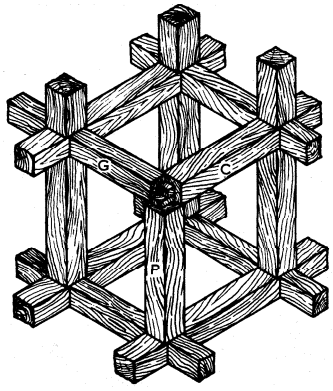

FIG. 5

Resuing or stripping is applied to the mining of narrow veins or of veins in which rich ore lies in a streak of less width than the vein as a whole. The object of resuing is to mine the ore clean and free from waste, and thus save diluting the ore with waste and sending a larger tonnage of lower grade ore to the mill or smelter. In fig. 6, A is the rich streak and V is the lean part of the vein. A level L is opened and the stoping is carried upward. The level is driven largely in the worthless rock, which is first removed, and then the rich streak is shot down.

Shrinkage stoping is a type oi overhand stoping in which only enough ore is drawn progressively from the stope to afford working space so that the miners can stand on broken ore while drilling holes in the back. Broken ore occupies about 60% more volume than ore in place; consequently, about one-third of the ore must be drawn off, as it is broken, through chutes closely spaced, irom 25 to jo ft., along the bottom of the stope. Two-thirds of the ore is leit in the stope. This method is best suited to veins or tabular masses of hard, uniform character, in mhich the walls are firm and regular and which are dipping (tilted) at not less than 50° irom the horizontal A disadvantage of this method lies in the long time the ore is leit in stopes, two or three years in some cases.

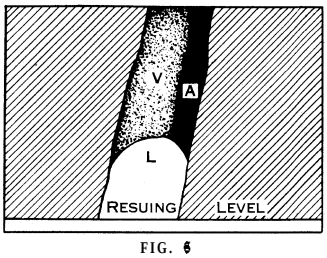

FIG. 6

Fig. 7 is a longitudinal diagram showing shrinkage stoping as applied to a large ore body. The lower level is protected by a pillar through which short raises, C, ior chutes are put up at 25-ft. intervals. Raises are driven through the pillars at the end of the stope. Short cuts, driven through the pillars at small vertical intervals, connect with the working space in the stope, as shown at M. To prevent large pieces of ore from clogging the chutes, grizzlies (bar screens), G, are placed at the top of the chutes C. A pillar of ore, as indicated at P, may be leit to protect the upper level. Later, the pillars are mined by another method.

The principles oi sublevel stoping are illustrated in fig. 8. Main levels usually are from 100 to 150 it. apart, and are connected by raises as needed. At vertical intervals of 20 to 25 ft., sublevels 7 to 8 ft. high are driven from the raise to the end of the stope. Each sublevel is commonly a single drift down the centre of the stope. By

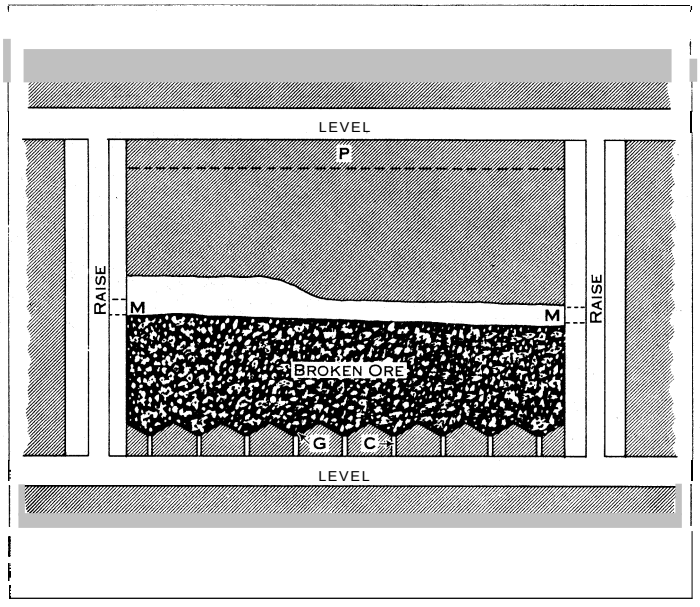

FIG. 7

driving crosscuts at the end, sublevel No. 1 is for a short distance widened to the limits of the stope. Inclined holes are drilled around the chute raises C which are put up from the haulage level at intervals of 2j ft. or even less. These holes are blasted to give a funnel-shaped top to the chutes. The sublevels are taken back in benches by progressive stoping from each sublevel to the one above. For example, after stoping has begun in sublevel No. 1, sublevel No. 2 is taken back by first crosscutting to the full width of the stope, and then drilling down-holes in the floor to remove part of the lower pillar and "uppers" in the back to take out half of the upper pillar. Thus miners in No. 2 sublevel retreat toward the raise, drilling down-holes in slice B and up-holes in slice D. The same sequence is followed for sublevel No. 3,

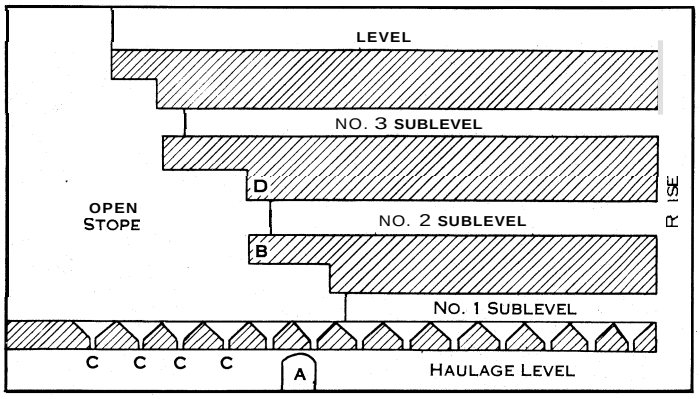

FIG. 8

the broken ore ialling toward and into the funnel-shaped chutes. In wide stopes, 40 to 100 ft. in width, two parallel haulage drifts may be driven. These are connected at intervals by crosscuts as at A This method entails a high cost for development, but requires little timber and gives a large output irom each stope because of the several working places.

Top Slicing.— Top slicing by the continuous horizon method is done in horizontal slices, 10 to 12 ft. thick. working downward irom the top of the deposit. The first slice is taken just beneath the capping, which is supported by timbering. As the slice of ore is taken out, lagging is laid on the floor to cover tightly the ore below. The posts supporting the capping are then shot out and the capping caves onto the timber floor or mat. This mat is temporarily supported by the timbering that is installed as the second slice is taken. After the ore in the second slice has been removed. a timber floor again is laid and the posts are shot out. Thus, the timber mat, which serves to prevent the capping from mixing with the ore. receives additions as each slide is progressively stoped. From the haulage level a raise, containing a chute and manway, is put up to the top of the ore and a main driit is driven to the boundaries of the block. Cross drifts are turned off at right angles to the main drift and are driven to the limits of the block. The ore is broken by breast stoping, and is shoveled into cars to be hauled to the chute. After a cross drift has been completed, the floor is covered with a layer of timber and the posts are shot out, using small charges of dynamite. The overlying capping or timber mat settles down onto the new floor. In variations of this mining practice a form of square-set timbering is used, and successive cuts may be two sets wide and two or three sets high.

By using a stoping method of either panel, block or inclined slicing, a large ore body is not worked in one continuous horizon, but rather in a series of blocks or panels. Inclined top slicing was devised to save shoveling the ore. The cuts (frequently called slices) are inclined upward from the chute at an angle of 33" with the horizontal, so the ore will roll or slide down to the chute. This method does not permit sorting of the ore in the stope and is more difficult to work than horizontal slicing. Top slicing is applicable to weak ore with poor walls. It is most suitable for deposits of large horizontal extent which have a capping that caves readily. It is a saie method and gives as much as 98% extraction of ore.

Caving.— Sublevel caving is suitable for the large-scale mining of ore that is moderately hard, and that has fairly regular limits and a capping which caves readily. Fig. 9 illustrates the principles of the

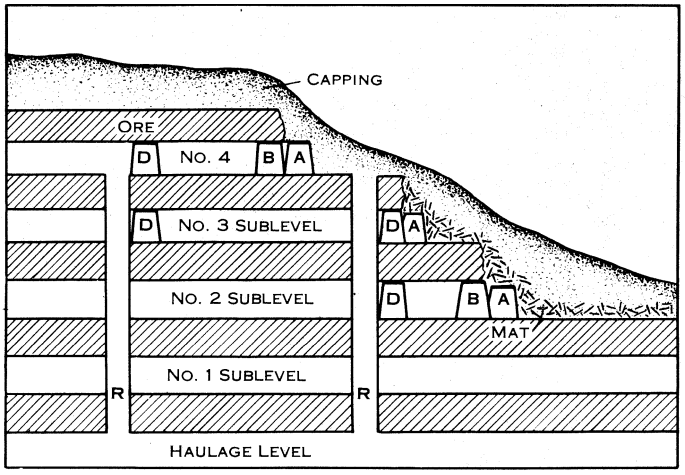

FIG. 9

practice although details vary at different mines. From the haulage level, raises are put up at about 50 ft. intervals, and sublevels are driven from the raises at vertical intervals of irom 1j to 18 ft., leaving a horizontal pillar of ore about 9 it. thick between the sublevels. The development work on each sublevel consists of longitudinal drifts, marked No. 1 sublevel, No. 2 sublevel, etc., and cross driits marked D.

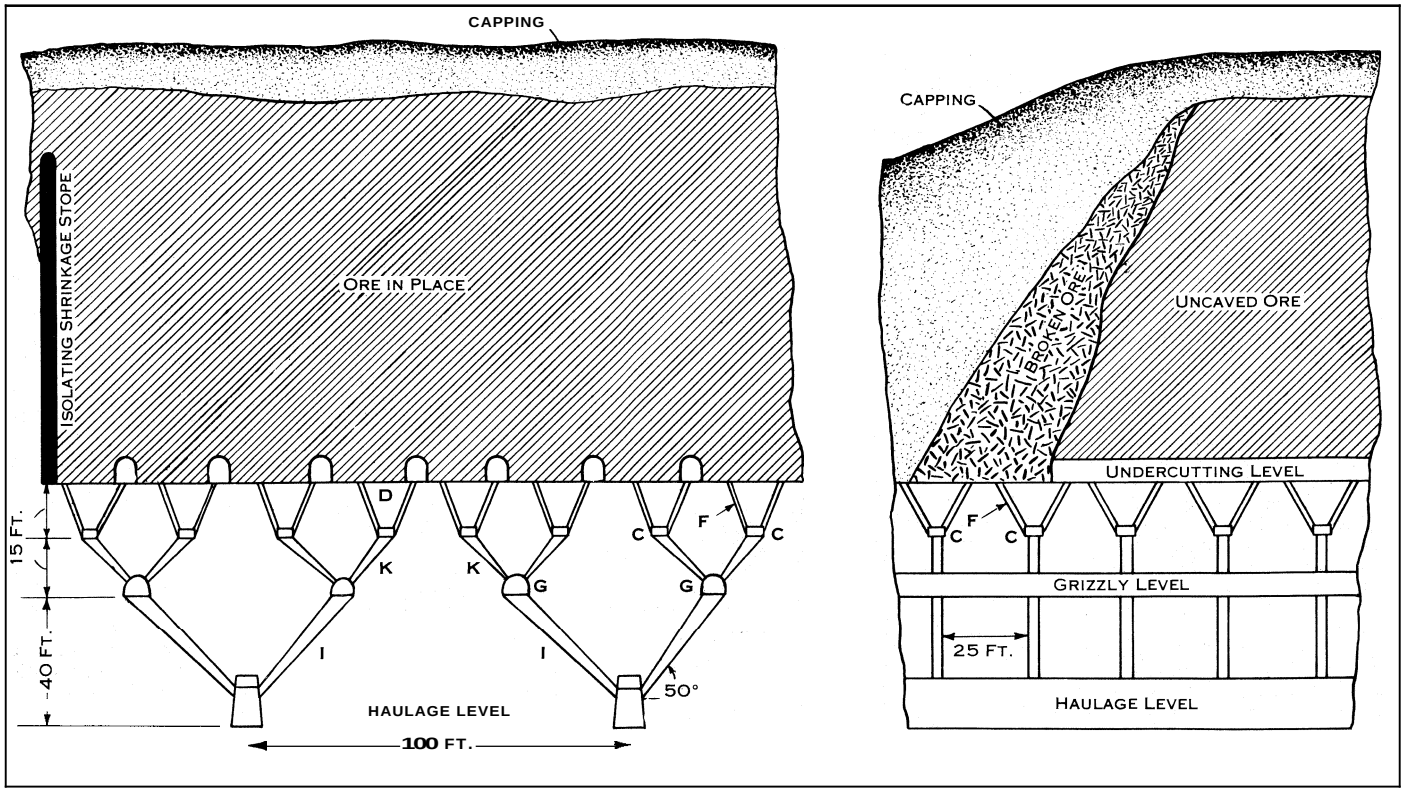

FIG. 10 AND 11

These are spaced about 50 it. apart. Mining is started on the top sublevel, No. 4 in fig. 9, by driving a cross drift parallel to D across the block of ore at the end of the sublevel. The drift is timbered with three-piece sets of two slightly inclined posts and a cap and is lagged (slabbed over) overhead. A second drift is driven alongside the first one, the feet of the posts in the two driits overlapping slightly. By removing a little of the lagging over the first driit, shallow holes can be drilled in the back and the ore blasted. Men in the second driit shovel the ore into cars ior tramming to the chutes in the raises. After the ore is removed, the floor of the first drift is covered with a layer of timber, and a third driit is driven alongside the second driit and the operations are repeated. The capping subsides and, as it is caught on the timber mat, enough pressure is developed by this weight on the end oi the horizontal pillars of ore to reduce considerably the amount of blasting needed to break the ore.

In fig. 9 the ore over driits A has been shot down. Shovelers in driit B have removed this ore and have laid planks on the floor. As soon as a new drift has been driven alongside driit B, mining of the ore above B will he started. As in sublevel stoping, mining is done in a series of steps. From one-half to two-thirds of the ore is broken by the caving that ensues.

In the block caving method, a block oi ore is undercut, and then subsides through the height of the undercut. This relatively minor movement of the ore is suificient to break it into small pieces. Ore bodies should be large, and the ore must be firm enough to stand well during the work of undercutting and yet be brittle enough to break up well during the process of settling, The capping should cave readily. The broken ore is drawn off at the bottom of the block until capping appears. If undercut from the main level, the block is cut by intersecting driits and cross driits into a series of pillars, which are as small as safety permits. The pillars are drilled and blasted, and time is allowed ior the ore to settle. The broken ore is mined by driving a series of closely timbered drifts into the shattered material. The ore runs in at the ends of the driits and is shoveled into cars. When waste appears a few sets in the drift are blasted down and drawing is resumed at a new point, thus iollowing a retreating system. If a block is undercut from sublevel, the general ieatures are similar to those just described. From the main haulage level, driits are turned off at right angles at. say, 50 ft. intervals, and are driven to the limits of the block. A sublevel is driven above the main level, and the block is undercut by intersecting driits and cross driits on the sublevel. Chutes are put up to the sublevel irom the haulage level. The pillars are blasted and the ore is worked into the chutes.

Block caving by using branch raises is a method followed at several large copper mines. It is illustrated in fig. 10 and 11. From the haulage level. main inclined chutes (also called transier raises), I, are driven to the grizzly level, where driits, G, are used to connect a line oi chutes. The tops of the chutes are covered mith a grizzly made of rails to catch the large pieces of ore which would tend to choke the chutes. From the grizzly level, inclined chutes, K, are carried up and terminate in a square set, C, irom which two or four inclined "finger" raises, F, are driven to the undercutting level at the bottom of the block. The tops oi the finger raises are spaced 12.5 ft. apart each way, thus offering an ample number of points ior drawing off the caved ore.

The ore is undercut by running a series of drifts, D, 25 ft. apart to the limits of the block. At one end of the block the ends of the drifts are widened. Holes then are drilled in the intervening ribs or pillars and in the back. Blasting these holes generally starts the caving. Shrinkage stopes, called boundary stopcs, are made across the ends or sides oi the block before the ore is undercut to separate it irom the adjoining ground and thus to facilitate the caving. This method is suitable for ore that is soft or of medium hardness in which there is little or no waste. The capping should follow down freely and the ore should break into fragments small enough to run well into the chutes.

A thick body of ore may be worked in more than one lift. For a given amount of development work, the higher the lift taken the less is the cost per ton for the development work, as the cost is spread over all the ore in a block. However, other iactors such as the horizontal extent of the ore and the economic life of the working also must be considered. Because the method is applied to low-grade copper ores bearing generally between 1% and 2% copper, special care must be taken to keep the diluting of the ore by waste to a minimum. The line of contact between the broken ore and the cappings (*see* fig. 11) is usually between 40° and 70° mith the horizontal. The flatter the angle the greater is the amount of broken ore in the stope, and trouble irom packing of the ore is increased.

As has been noted, each ore deposit has its peculiar and often complex characteristics. These frequently induce special adaptations and combinations of the foregoing methods, or even a practice that is unique for efficient exploitation. *See* also ORE DEPOSITS; Index references under "Mining, Metal" in vol. 24.

BIBLIOGRAPHY.—The best contemporary and continuing references about mining practices generally are those made available through various technical magazines, such as *Mining Engineering* (A.I.M.E.), *Engineering and Mining Journal, Mining Congress Journal, Mining World,* all oi which are published in the U.S. Other detailed information is offered by the U.S. Bureau of Mines, especially through its *Information Circulars* and *Technical Papers* and by separate works, such as *Metal-Mining Practice,* Bull. 419, and *Open-cut Metal Mining,* Bull. *433,* and others. See *List of Publications,* U.S. Bureau of Mines, July 1, 1910–January 1, 1948, and January 1, 1949–January 1, 1954. Supplements to these lists are issued periodically.

Additional reierence works are texts and handbooks of mining practice such as: R. Peele and J. Church, *Mining Engineers' Handbook,* 3rd ed. (1941); and *Blasters' Handbook,* 11th ed. (1942).

(J. D. FR.)

MINING ENGINEERING is one of the oldest branches of engineering, having evolved soon after military and civil engineering were recognized as distinct professions. In the late 19th and early 20th centuries the opening up of new areas provided many opportunities for the discovery and exploitation of rich mineral deposits. There were great demands for competent mining engineers and in the United States schools of mines were established in many of the states; the profession attracted many students.

In these early days the isolated location of most mines forced the mining engineer to assume many duties. He was responsible for prospecting; construction of buildings. roads and structures; provision of compressed air. water and electricity; analysis of ores; and possibly even supervision of crushing, grinding and concentration of the ore, all in addition to the main task of actually getting the ore excavated. The profession of mining engineering was generally assumed to include some knowledge of these many overlapping fields.

With the tendency toward specialization typical of all fields, mining engineering has become confined to the problems of breaking ore and excavating it from underground mines and surface pits. *See* BLASTIKG; DRILLING MACHINERY; COAL AND COAL MIXING; MINE PROSPECTING AND DEVELOPMENT; MINING, METAL; QUARRYIKG; SHAFT SINKING.

The discovery of ore deposits relies heavily on the theories of GEOLOGY and the techniques noted under GEOPHYSICAL PROSPECTING. Analysis of ores makes use of many procedures described under ASSAYING; CHEMISTRY: *Analytical Chemistry* and SPECTROCHEMICAL ANALYSIS. The milling of ores has become a separate field described under ORE DRESSING. *See* also METALLURGY: ***History*** and *Ores and Ore Treatment.* (A. W. S.)

MINISTER, an official title both civil and ecclesiastical. *See* AMBASSADOR; CABINET; DIPLOMACY; MINISTRY, GOVERNMENT; MINISTRY, THE CHRISTIAX.

MINISTRY, GOVERNMENT. This term denotes a department of government or group of departments under the control of a minister (*see* GOVERNMENT DEPARTMENTS) or the whole body of persons holding political office in the country.

Great Britain.— In the United Kingdom the ministry, in the collective sense, consists of (1) ministers in the cabinet; (2) ministers of cabinet rank nho are not in the cabinet; (3) ministers of state, parliamentary undersecretaries of state parliamentary secretaries. financial secretaries and others of equivalent rank; (4) lords commissioners of the treasury (other than the first lord or prime minister and the chancellor of the exchequer) and other government nhips; and (5) certain officers of the royal household. They are appointed by the sovereign on the advice of the prime minister; they are, with rare exceptions. either peers or members of the house of commons: and they are considered to hold their offices at the prime minister's disposal; ie, if the prime minister wishes to change any of them he advises the sovereign accordingly. Also, they go out of office forthwith if the prime minister resigns because of a defeat in the house of commons or at a general election. For this reason the whole ministry, and not merely the cabinet, is said to be "collectively responsible to parliament." However. the ministry as such has no corporate existence because the decisions are taken by the members of the cabinet, who are formally described as "her majesty's confidential servants" and who are sworn of the privy council. (*See* also CABIXET; PRIME MINISTER. BRITISH)

The privy council (*q v*) grew out of the *curia regis,* the court of the Norman kings Much of the judicial work of the king's court passed to the court of common pleas, exchequer and king's bench and, at a later stage, the court of chancery. A large council,

to which the commons had been summoned, became a parliament. The ministers formed the nucleus nhich remained, the perpetual or (to use the later term) privy council. The close relation between council and parliament is, honever. shown by the fact that the holders of the older ministerial offices are still summoned to parliament as such. They are not, however, members of the house of lords unless they are peers, nor members of the house of commons unless they have been elected to that house. The only exception is the lord chancellor, who presides over the house of lords even when he is not a peer. After 1688 there was doubt nhether the ministry should be represented in the house of commons at all, since the presence of servants of the crown was thought by some to threaten the independence of the house. This question was settled by legislation under Queen Anne. Holders of new offices could not sit in the commons unless authorized by legislation—which has invariably been passed nhen it was desired to add offices to the ministry—while holders of old offices were disqualified from sitting but could be re-elected. This arrangement continued (subject to a modification in 1919) until 1926, when the rule that a member of parliament lost his seat on being appointed to political office was abrogated.

The composition of the council (i e, the identity of the sovereign's confidential advisers) mas for long a matter of contention betneen the crown and the magnates. Under the Tudors and the Stuarts, however, the privy council ceased to be a policy-forming body. though it had important judicial functions until 1642 The attempt to revive the council under Charles II failed because the king refused to discuss his affairs nith a "set of fellows" and preferred to consult his advisers wrivately in his cabinet.

The cabinet did not become a formalized institution, however, until the reign of George I. Power was in fact passing from the crown to the cabinet because of the king's dependence upon parliament after 1688. The legislation of Anne. referred to above. made it possible for the sovereign to control parliament through her ministers in the house of commons, but it also enabled the house of commons to control the sovereign through the power to grant or refuse supplies. Hence there arose that peculiarly English concept, cabinet government, or government by a ministry responsible to the house of commons. The development of the ministry into a politically homogeneous body was, however, very slow. The existence of Whigs and Tories in the revolutionary period at the end of the 17th century and the continuation of those names throughout the 18th century give a false impression of a two-party system which did not really exist until the 19th century. For most of the 18th century there were small and fluctuating political groups following the leadership of such peers as the duke of Bedford or the marquess of Rockingham or such commoners as Sir Robert Walpole. Henry Pelham and George Grenville. But no ministry was or could be formed consisting exclusively of members of one of these connections or even two of them, and in no sense could the ministry be described as a party ministry. The modern Tory party began to coalesce around William Pitt the younger after 1783, and especially after the Portland Whigs joined the government in 1794 in consequence of the French Revolution. But the first really Tory ministry was that of Lord Liverpool in 1812. Lord Grey's ministry of 1830, which secured the passage of the first Reform act. has been described as Whig, though it included Canningite Tories. The Tories called themselves Conservatives in 1832 (in contrast with the reformers), but they split in 1846, and there was no strict two-party system until after the death of Lord Palinerston in 1865, when the Whigs, Radicals, etc., coalesced into the Liberal party.

Meanwhile the modern conventions were being established by and under Queen Victoria. From 1783 the sovereign had progressively withdrawn from political controversy, and William IV was almost a constitutional monarch in the modern sense. After 1841 it was clear that the essential duty of the sovereign was to find a prime minister whose party (or, if a coalition was necessary, whose group of parties) could command the confidence of the house of commons. This implied that the whole ministry would be drawn from one party or a coalition of parties. The ministry so appointed was collectively responsible to the house of commons and resigned in a body if defeated there or at a general election.

After 1831 the size of the ministry greatly increased. After 1945 the number reached 90. The decrease in the powers of the house of lords resulted in a tendency toward a concentration of ministers in the house of commons, though the Ministers of the Crown act, 1937, made it necessary that some senior ministers and some junior ministers be peers. Apart from the household officers there are usually five or six ministers and tno or three junior ministers in the lords. Consequently, in 1960, about 70 or 75 members on the government side of the house of commons held paid office under the crown.

A new ministry is assumed to come into existence when a new prime minister kisses hands (of the sovereign at the time of appointment in traditional acknowledgment of the king's favour) or when the existing prime minister. having submitted his resignation, is asked to form a new government.

For further details the articles CABINET and PRIVY COUNCIL should be consulted, as well as the separate treatment of the more important offices under their own headings, as LORD HIGH CHANCELLOR; PRIME MINISTER, BRITISH; SECRETARY OF STATE; ADMIRALTY; FOREIGN SERVICE; and WAR OFFICE. (See also ENGLISH HISTORY.) The corresponding lists of officers in the United States will be found under the title CABINET.

TABLE OF LORD TREASURERS, OR FIRST LORDS OF THE TREASURY, FROM 1603, AND OF THE PRIME MINISTERS FROM 1721

[For the origin and history of the lord treasurer's office, *see* EXCHEQUER and LORD HIGH TREASURER. After the Commonwealth the office oi lord treasurer was executed by a board of commissioners known as the lords of the treasury, with the exception of the six lord treasurers whose names are printed in italics. Special rank was given to one of the commissioners as first lord of the treasury, and from the end of the 17th century it was customary ior the leading minister of the crown to occupy the office of first lord; in later times, therefore (with the few exceptions noted in the list given below), it mas usually held in conjunction with the premiership The lord treasurer's commission sometimes enabled the first lord to act also as chancellor oi the exchequer (see *Table of Chancellors of the Excheauer*). The office of lord-high treasurer of Scotland was united with that of England at the union, and in 1816 the separate Irish treasury was similarly incorporated.]

1603. Lord Buckhurst, cr. earl of Dorset, 1604.
1608. Earl of Salisbury.
1612. Earl of Northampton and others. (Commissioners.)
1614. Earl of Suffolk.
1618. Archbishop Abbot and others. (Commissioners)
1620. Sir Henry Montagu, cr. Viscount Mandeville, 1620. afterward earl oi Manchester.
1621. Lord Cranfield, cr. earl of Middlesex, 1622.
1624. Sir James Ley, cr. Lord Ley, 1625, and earl of Marlborough, 1626.
1628. Lord Weston, cr. earl of Portland, 1633.
1635. Archbishop Laud and others. (Commissioners.)
1636. W. Juxon, bishop of London.
1641. Sir Edward Littleton and others. (Commissioners.)
1643. Lord Cottington.
1649. Commissioners under the Commonwealth.
1660. Sir Edward Hyde, afterward earl of Clarendon, and others. (Commissioners.)
1660. *Earl of Southampton.*
1667. Duke oi Albemarle and others. (Commissioners.)
1672. *Lord Clifford.*
1673 Viscount Dunblane, cr. earl of Danby, 1674, afterward duke of Leeds.
1679. Earl of Essex.
1679, Lord Hyde, cr. earl of Rochester, 1682.
1684. Lord Godolphin.
1685. *Earl of Rochester.*
1687. Lord Bellasyse.
1689. Viscount Mordant, earl of Monmouth, afterward earl of Peterborough.
1690. Viscount Lonsdale.
1690. Lord Godolphin.
1697. C. Montagu, cr. earl of Haliiax, 1700.
1699. Earl of Tankerville.
1700. Lord Godolphin.
1701. Earl of Carlisle.
1702. *Lord Godolphin,* afterward earl oi Godolphin.
1710. Earl Poulett.
1711. *Earl of Ozjord.*
1714. *Duke of Shrewsbury.*
1714. Earl of Haliiax.
1715. Earl of Carlisle.
1715. Sir Robert Walpole.
1717. J. Stanhope, afterward Earl Stanhope.
1718. Earl of Sunderland.
1721. Sir Robert Walpole (commonly regarded as the first of the prime ministers).
1742. Earl of Wilmington.
1743. Henry Pelham.
1754. Duke of Newcastle.
1756. Duke of Devonshire.
1757. Duke of Newcastle (W. Pitt and the duke of Newcastle's administration).
1762. Earl of Bute.
1763. George Grenville.
1765. Marquess of Rockingham.
1766. Duke of Graiton (W. Pitt, earl of Chatham, prime minister until 1768).
1770. Lord North, afterward earl

of Guilford.
1782. Marquess of Rockingham.
1782. Earl of Shelburne, afterward marquess of Lansdowne.
1783 Duke of Portland (prime minister, Lord North, afterward earl of Guilford).
1783. William Pitt.
1801. H. Addington, afterward Viscount Sidmouth.
1804. William Pitt.
1806. Lord Grenville.
1807. Duke of Portland.
1809. Spencer Perceval.
1812. Earl of Liverpool.
1827. George Canning.
1827. Viscount Goderich, afterward earl of Ripon.
1828. Duke of Wellington.
1830. Earl Grey.
1834. Viscount Melbourne.
1834 Sir Robert Peel.
1835 Viscount Melbourne.
1841. Sir Robert Peel.
1846. Lord John Russell, cr. Earl Russell, 1861.
1852. Earl of Derby.
1852. Earl of Aberdeen.
1855. Viscount Palmerston.
1858. Earl of Derby.
1859. Viscount Palmerston.
1865. Earl Russell.
1866. Earl of Derby.
1868. Benjamin Disraeli.
1868. W. E. Gladstone.
1874. B. Disraeli, cr. earl of Beaconsfield, 1876.
1880. W. E. Gladstone.
1885. Sir Stafford Northcote, cr. earl of Iddesleigh, 1885 (prime minister, marquess of Salisbury).
1886. W. E. Gladstone.
1886. Marquess of Salisbury.
1887. W. H. Smith (prime minister, Lord Salisbury).
1891. A. J. Balfour (prime minister, Lord Salisbury).
1852. W. E. Gladstone.
1894. Earl of Rosebery.
1895. A. J. Balfour (prime minister, Lord Salisbury until 1902; after 1902, A. J. Balfour).
1905. Sir Henry Campbell-Bannerman.
1908. H. H, Asquith, cr. earl of Oxford and Asquith, 1925.
1916. D. Lloyd George, cr. Earl Lloyd George of Dwyfor, 1945.
1922. A. Bonar Law.
1923. Stanley Baldmin, cr. Earl Baldwin of Bewdley, 1937.
1924. J. Ramsay MacDonald.
1924. Stanley Baldmin.
1929. J. Ramsay MacDonald.
1935. Stanley Baldwin.
1937. Neville Chamberlain.
1940. Winston Churchill.
1945. Clement R. Attlee, cr. Earl Attlee, 1955.
1951. Sir Winston Churchill.
1955. Sir Anthony Eden.
1957. Harold Macmillan.

Table of Lord Chancellors (C.) or Lord Keepers (L.K.)

(For the history of these offices see Lord High Chancellor and Lord Keeper of the Great Seal.)

1603. Sir Thomas Egerton, L.K., cr. Lord Ellesmere, 1603, and Viscount Brackley, 1616.
1617. Sir Francis Bacon, L.K., cr. Lord Verulam, 1618, and Viscount St. Albans, 1621.
1621. J. Williams, bishop of Lincoln, L.K.
162;. Sir Thomas Coventry, L.K., cr. Lord Coventry, 1628.
1640. Sir John Finch, L.K., cr. Lord Finch, 1640.
1641. Sir Edward Littleton, L.K.. cr. Lord Littleton, 1641.
1645. Sir Richard Lane, L.K.
1649. Interregnum.
1660. Sir Edward Hyde, C., cr. Lord Hyde. 1660, and earl of Clarendon, 1661.
1667. Sir Orlando Bridgeman, L.K.
1672. Earl of Shaftesbury, C.
1673. Sir Heneage Finch, L.K., cr. Lord Finch, 1674, C., 1675, cr. earl of Nottingham, 1681.
1682. Sir Francis North, L.K., cr. Lord Guilford. 1683.
1685. Lord Jeffrej-s. C.
1690. Sir John Maynard and others. (Commissioners.)
1690. Sir John Trevor and others. (Commissioners.)
1693. Sir John Somers, L.K., C., cr. Lord Somers, 1697.
1700. Sir Nathan Wright, L.K.
1705. W. Cowper, L.K., cr. Lord Cowper, 1706, C., 1707.
1710. Sir Thomas Trevor and others. (Commissioners.)
1710. Sir Simon Harcourt, L.K., cr. Lord Harcourt, 1711, C., 1713.
1714. Lord Cowper, C.
1718. Sir Robert Tracy and others. (Commissioners.)
1718. Lord Parker, C., cr. earl of Macclesfield, 1721.
1725. Sir Joseph Jekyll and others. (Commissioners.)
1725. Lord King, C.
1733. Lord Talbot of Hensol, C.
1737. Lord Hardwicke, C., cr. earl of Hardwicke, 1754.
1756. Sir John Willes and others. (Commissioners.)
1757. Sir Robert Henley, the last lord keeper, cr. Lord Henley and C., 1760, and earl of Northington, 1764.
1766. Lord Camden.
1770. Charles Yorke.
1770. Sir Sidney Stafford Smythe and others. (Commissioners.)
1771. Lord Apsley, succeeded as Earl Bathurst, 1775.
1778. Lord Thurlow.
1783. Lord Loughborough and others. (Commissioners.)
1783. Lord Thurlow.
1792. Sir James Eyre and others. (Commissioners.)
1793. Lord Loughborough, cr. earl of Rosslyn, 1801.
1801. Lord Eldon.
1806. Lord Erskine.
1807. Lord Eldon.
1827. Lord Lyndhurst.
1830. Lord Brougham.
1834. Lord Lyndhurst.
1835. Sir Charles Christopher Pepys and others. (Commissioners.)
1836. Lord Cottenham.
1841. Lord Lyndhurst.
1846. Lord Cottenham.
1850. Lord Langdale and others. (Commissioners.)
1850. Lord Truro.
1852. Lord St. Leonards.
1852. Lord Cranworth.
1858. Lord Chelmsford.
1859. Lord Campbell.
1861. Lord Westbury.
1865. Lord Cranworth.
1866. Lord Chelmsford.
1868. Lord Cairns.
1868. Lord Hatherley.
1872. Lord Selborne.
1874. Lord Cairns, cr. Earl Cairns, 1878.
1880. Lord Selborne, cr. earl of Selborne, 1882.
1885. Lord Halsbury.
1886. Lord Herschell.
1886. Lord Halsbury.
1892. Lord Herschell.
1895. Lord Halsbury, cr. earl of Halsbury, 1898.
1905. Lord Loreburn.
1912. Lord Haldane.
1915. Lord Buckmaster.
1916. Lord Finlay.
1919. Lord Birkenhead, cr. earl of Birkenhead, 1922.
1922. Lord Cave.
1924. Lord Haldane.
1924. Lord Cave.
1928. Lord Hailsham.
1929. Lord Sankey.
193j. Lord Hailsham.
1938. Lord Maugham.
1939. Viscount Caldecote.
1940. Viscount Simon.
1945. Viscount Jowitt.
1951. Lord Simonds.
1954. Viscount Kilmuir.

Table of Chancellors of the Exchequer

The chancellor of the exchequer, as finance minister of the crown, is required to bc a member of the house of commons and is the person named second after the first lord of the treasury in the patent appointing commissioners for executing the office of lord high treasurer (see Table of Lord Treasurers). The title dates from the separate existence of the exchequer court, as the king's revenue court, in the reign of Henry III. (See Exchequer.) In Scotland the lord high treasurer presided over the court of the exchequer, and this court was reserved by the Act of Union. But the judicial functions of the English and the Scottish courts of exchequer were transferred to the high court of justice and the court of session, respectively, in the early part of the 19th century. The office of chancellor of the exchequer has sometimes been held jointly with that of prime minister and first lord of the treasury, and is so indicated by an * in the list.

1714. Sir Richard Onslow.
171j. *Robert Walpole.
1717. *Lord Stanhope.
1718. John Aislabie.
1721. *Robert Walpole.
1742. Samuel Sandys.
1743. *Henry Pelham.
1754. Hon. Henry Bilson-Legge.
1761. Viscount Barrington.
1762. Sir Francis Dashwood, afterward Lord Le Despencer.
1763. *George Grenville.
176j. William Dowdeswell.
1766. Hon. Charles Townshend.
1767. Lord North.
1770. *Lord North.
1782. Lord John Cavendish.
1782. William Pitt.
1783. Lord John Cavendish.
1783. *William Pitt.
1801. *Henry Addington.
1804. *William Pitt.
1806. Lord Henry Petty.
1807. Spencer Perceval.
1809. *Spencer Perceval.
1812. N. Vansittart, afterward Lord Bexley.
1823. F. J. Robinson, afterward Viscount Goderich, and earl of Ripon.
1827. *G. Canning.
1827. J. C. Herries.
1828. H. Goulburn.
1830. Viscount Althorp, afterward Earl Spencer.
1834, *Sir Robert Peel.
1835. T. Spring-Rice, afterward Lord Monteagle.
1839, F. Baring, afterward Sir Francis.
1841. H. Goulburn.
1846. C. Wood, afterward Sir Charles.
1852. B. Disraeli. afterward Lord Beaconsfield.
1852. W. E. Gladstone.
1855. Sir George C. Lewis.
1858. B. Disraeli.
1859. W. E. Gladstone.
1866. B. Disraeli.
1868. G. W. Hunt.
1868. R. Lowe.
1873. *W. E. Gladstone.
1874. Sir Stafford Northcote.
1880. *W. E. Gladstone.
1882. H. C. E. Childers.
1885. Sir Michael Hicks-Beach.
1886. Sir William Harcourt.
1886. Lord Randolph Churchill.
1887. G. J. Goschen.
1892. Sir William Harcourt.
1895. Sir Michael Hicks-Beach.
1902. C. T. Ritchie.
1903. (Sir) Austen Chamberlain.
1905. H. H. Asquith, cr. earl of Oxford and Asquith, 1925.
1908. D. Lloyd George, cr. Earl Lloyd George of Dwyfor, 1945.
1915. R. McKenna.
1916. A. Bonar Law.
1919. (Sir) Austen Chamberlain.
1921. Sir Samuel Hoare, cr. Viscount Templewood, 1944.
1922. Stanley Baldwin, cr. Earl Baldwin of Bewdley, 1937.
1923. N. Chamberlain.
1924. P. Snowden.
1924. Winston Churchill.
1929. P. Snowden.
1931. N. Chamberlain.
1937. Sir John Simon, cr. Viscount Simon, 1940.
1940. Sir Kingsley Wood.
1943. Sir John Anderson.
1945. Hugh Dalton.
1947. Sir Stafford Cripps.
1951. Richard Austen Butler.
1955. Harold Macmillan.
1957. Peter Thorneycroft.
1958. Derick Heathcoat Amory.

Table of Secretaries of State

[With substitution of two secretaries for one. there was, at first, no distinction of departments. Probably in the reign of Charles II. and certainly as early as 1691, two departments, northern and southern, mere instituted In 1782 they were changed to home and foreign. Later other departments mere added; see Secretary of State.]

1603. Sir Robert Cecil, cr. lord, 1603, Viscount Cranborne, 1604, earl of Salisbury, 1605.

1612. Vacant.
1614. Sir Ralph Winwood.
1615. . . . . Sir Thomas Lake.
1618. Sir Robert Naunton.
1619. . . . . Sir George Calvert, cr. Lord Baltimore, 1625.

1623. Sir Edward Conway, cr. Lord Conway, 1625.
1625. . . . . Sir Albertus Morton.
1625. . . . . Sir John Coke.
1628. Viscount Dorchester.
1632. Sir Francis Windebank.
1640. . . . . Sir Henry Vane.
1641. Sir Edward Nicholas.
1642. . . . . Viscount Falkland.
1643. . . . . Lord Digby.
1643. Interregnum.
1660. Sir Edward Nicholas. . . Sir William Morice.
1662. Sir Henry Bennet, cr. earl of Arlington. 1665.
1668. . . . . Sir John Trevor.
1672. . . . . Henry Coventry.
1674. Sir Joseph Williamson.
1678. Earl of Sunderland.
1680. . . . . Sir Leoline Jenkins.
1681 Lord Conway.
1683. Earl of Sunderland.
1684. . . . . S. Godolphin.
1684. . . . . Earl of Middleton.
1688. . . . . Viscount Preston.
1689. Earl of Shrewsbury. . . Earl of Nottingham.
1690. Viscount Sidney.
1692. Sir John Trenchard.
1694. . . . . Earl of Shrewsbury.
169;. Sir William Trumbull.
1697. J. Vernon.
1700. Sir Charles Hedges. . . Earl of Jersey.
1701. . . . . Earl of Manchester.
1702. . . . . Earl of Nottingham.
1704. . . . . R. Harley, cr. earl of Orford, 1711.
1706. Earl of Sunderland.
1708. . . . . H. Boyle, cr. Baron Carleton, 1714.

1710. Lord Dartmouth, cr. earl of Dartmouth, 1711. H. St. John, cr. Viscount Bolingbroke, 1712.
1713. W. Bromley.
1714. J. Stanhope, cr. Earl Stanhope. 1718 Viscount Townshend.
1717. Earl of Sunderland. . . J. Addison.
1718. Earl Stanhope. . . . J. Craggs.
1721. Viscount Townshend. . . Lord Carteret.
1724. . . . . Duke of Newcastle.
1730. Lord Harrington.
1742. Lord Carteret, became Earl Granville, 1744.
1744. Earl of Harrington.
1746. Earl Granville.
1746. Earl of Harrington.
1746. Earl of Chesterfield.
1748. Duke of Bedford.
1751. Earl of Holderness.
1754. . . . . Sir Thomas Robinson, cr. Baron Grantham, 1761.
1755. . . . . H. Fox.
1756. . . . . W. Pitt.
1761. Earl of Bute.
1761. . . . . Earl of Egremont.
1762. G. Grenville.
1763. Earl of Halifax. . . . Earl of Sandwich.
176;. Duke of Grafton. . . . H. S. Conway.
1766. Duke of Richmond.
1766. Earl of Shelburne.
1768. . . . . Viscount Weymouth.
1768 Earl of Hillsborough, *Colonies.*
1768 Earl of Rochford.
1770. . . . . Earl of Sandwich.
1771 . . . . . Earl of Halifax.
1771 . . . . . Earl of Suffolk.
1772 Earl of Dartmouth, *Colonies*
1775. Viscount Weymouth, cr. marquess of Bath, 1789
1776 Lord George Sackville Germain, cr Viscount Sackville, 1782, *Colonies.*
1779. . . . . Viscount Stormont.
1779. Earl of Hillsborough, cr. marquess of Downshire, 1789.
1782. W. Ellis, cr. Baron Mendip, 1794, *Colonies.*

	Home Office	*Foreign Office*
1782.	Earl of Shelburne. . .	C. J. Fox.
1782.	Lord Grantham. . . .	T. Townshend, cr. Baron Sydney, 1783.
1783.	Lord North.	C. J. Fox.
1783.	Marquess of Carmarthen. .	Earl Temple.
1783.	. . . . .	Lord Sydney.
1789.	W. W. Grenville, cr. Baron Grenville, 1790.	
1791.	H. Dundas.	Lord Grenville.
1794.	Duke of Portland. . .	Lord Grenville.
1801.	Lord Pelham, afterward earl of Chichester.	Lord Hawkesbury.
1803.	C. P. Yorke.	
1804.	Lord Hawkesbury. . .	Lord Harrowby.
1805.	. . . . .	Lord Mulgrave.
1806.	Earl Spencer. . . .	C. J. Fox.
1807.	Lord Hawkesbury, afterward earl of Liverpool.	G. Canning.
1809.	R. Ryder.	Earl Bathurst.
1809.	. . . . .	Marquess Wellesley.
1812.	Viscount Sidmouth (H. Addington).	Viscount Castlereagh, afterward marquess of Londonderry.
1822.	R. Peel.	G. Canning.
1827.	W. S. Bourne. . . .	Earl of Dudley.
1827.	Marquess of Lansdowne.	
1828.	R. Peel.	Earl of Aberdeen.
1830.	Viscount Melbourne. . .	Viscount Palmerston.
1834.	Viscount Duncannon, afterward earl of Bessborough.	
1834	H. Goulburn. . . .	Duke of Wellington.
1835	Lord John Russell. . .	Viscount Palmerston.
1839.	hlarquess of Normanby.	
1841.	Sir James Graham, Bart. .	Earl of Aberdeen.
1846.	Sir George Grey. . . .	Viscount Palmerston.
1851.	. . . . .	Lord Granville.
1852.	Spencer H. Walpole. . .	Earl of Malmesbury.
1852.	Viscount Palmerston. . .	Lord John Russell.
1855.	Sir George Grey. . . .	Earl of Clarendon.
1858.	S. H. Walpole. . . .	Earl of Malmesbury.
1859.	Thomas Henry Sutton Sotheron-Estcourt.	
1859.	Sir George Cornewall Lewis.	Lord John Russell, cr. Earl Russell, 1861.
1861.	Sir George Grey.	
1865.	. . . . .	Earl of Clarendon.
1866.	S. H. Walpole. . .	Lord Stanley, afterward 15th earl of Derby.
1868.	H. A. Bruce, cr. Baron Aberdare, 1873.	Earl of Clarendon.
1870.	. . . . .	Earl Granville.
1874.	Sir Richard Assheton Cross.	Earl of Derby.
1878.	. . . . .	Marquess of Salisbury.
1880.	Sir William Vernon Harrourt.	Earl Granville.
1885.	Sir Richard Assheton Cross, dr. Viscount Cross. 1886.	Marquess of Salisbury.
1886.	Hugh Culling Eardley Childers.	Earl of Rosebery.
1886.	H. Matthews, cr. Viscount Llandaff, 1895.	Earl of Iddesleigh.
1887.	. . . . .	Marquess of Salisbury.
1892.	H. H. Asquith. . . .	Earl of Rosebery.
1894.	. . . . .	Earl of Kimberley.
1895.	Sir Matthew White Ridley, cr. Viscount Ridley, 1900.	hlarquess of Salisbury.
1900.	Charles Thomson Ritchie, cr. Baron Ritchie, 1905.	Marquess of Lansdowne.
1902.	A. Akers-Douglas.	
1905.	Herbert John Gladstone, cr. Viscount Gladstone, 1910.	Sir Edward Grey.
1910.	Winston Churchill.	
1911.	R. McKenna.	
1915.	Sir John Simon.	
1916.	Herbert Samuel. . .	A. J. Balfour, cr. earl, 1922.
1916.	Sir George Cave.	
1919.	E. Shortt.	Lord Curzon.
1922.	W. C. Bridgeman.	
1924.	A. Henderson. . . .	J. Ramsay MacDonald.
1924.	Sir William Joynson-Hicks.	(Sir) Austen Chamberlain.
1929.	J. R. Clynes. . . .	Arthur Henderson.
1931.	Sir Herbert Samuel. . .	Lord Reading.
1931.	. . . . .	Sir John Simon, cr. Viscount Simon, 1940.
1932.	Sir John Gilmour.	

1935. Sir John Simon. .	Sir Samuel Hoare, cr. Viscount Templewood, 1944.
1935.	(Sir) Anthony Eden.
1937 Sir Samuel Hoare.	
1938.	Viscount Halifax.
1939 Sir John Anderson.	
1940. Herbert Morrison. . .	(Sir) Anthony Eden.
1945. Sir Donald Somervell. . .	Ernest Bevin
1945. J. Chuter Ede.	
1951. .	Herbert Morrison.
1951. Sir David Maxwell-Fyfe. .	(Sir) Anthony Eden.
1954 Gwilym Lloyd-George.	
1955.	Harold Macmillan.
1955.	Selwyn Lloyd.
1957. Richard Austen Butler	

(W. I. J.)

CONTINENTAL EUROPE

The development of the cabinet system on the continent of Europe moved, on the whole, in the same direction as in Great Britain: ministers, from their being personally responsible to the crown (and in some countries responsible for all aspects of the government of one province), tended to become politically responsible to parliament for all the administrative acts of their department dealing with one aspect of government for the whole country. But, in contrast with the slow and gradual evolution in Great Britain, changes on the continent tended to occur suddenly—the result of a newly written constitution, often in the wake of a revolution or the collapse of a political system after a war—and frequently they were arrested or even sharply reversed.

In addition to this difference in the way in which a minister's position evolved, in many European countries certain other differences from Britain may also be noted. both in the relationship of ministers to the legislature and in the internal organization of government departments. The present article can deal only with a few points of difference from the British system in a few key countries.

France.— The French Revolution put an end to government by ministers chosen by and responsible to the crown. The constituent assembly in 1791 set up six ministries whose heads were declared responsible to the representatives of the people. These were the ministries of justice. the interior. public contributions (later renamed finance), war, the navy and colonies. and foreign affairs. Under Napoleon I and later under Napoleon III ministers were again responsible primarily to the head of state, and under the constitution of 1852 also to the upper house:

> The Ministers depend only on the Head of State; they are responsible for the acts of the government each only in so far as he is concerned in them; they can be arraigned only before the Senate

In the third republic they were responsible to both the upper and the lower house, nhich found its committees, specialized according to subject, a very powerful weapon of day-to-day control:

> Ministers are collectively responsible before the Chambers for the general policy of the Government, and individually responsible for their personal acts

The fourth republic made them responsible only to the national assembly.

In their desire to strengthen the executive against the legislature the founders of the fifth republic greatly increased the legislative discretion of the government. substantially reduced the possibility of day-to-day control by the assembly and gave a new importance to the office of prime minister as against the other ministers:

> The Premier directs the action of the Government. He is responsible for national defence. He ensures the execution of the laws . . He may delegate certain of his powers to the ministers . . The acts of the Premier are countersigned where applicable by the ministers responsible for their execution.

There was never any obligation for French ministers to be members of the assembly (indeed, Léon Blum appointed a woman as a minister before women even had the vote), but they had to appear before the assembly when requested to do so The fifth republic made ministerial office and membership of the legislature incompatible and its first government in fact included a number of civil servants.

In the internal organization of a French ministry (and those of a number of other Latin countries) the most striking difference from Britain is the nature and importance of the minister's cabinet or private office. This consists of a handful of personal nominees whose appointments lapse with the resignation of the minister: career civil servants (particularly members of the *grands corps* seconded for the duration of the minister's stay in office), younger political aspirants, journalists, friends and relatives. This private "brains trust" essentially serves three functions: first, it deals with the minister's own constituency and the responsibilities he may have in local government; secondly. it deals with the minister's relations with the assembly, exercising in the lobbies the functions of a British parliamentary private secretary; and, lastly, the cabinet is responsible for the co-ordination of the work of the department itself.

This last is in some ways its most significant function, since a French ministry, even when it contains an official entitled *secrétaire-général,* lacks any effective permanent head. The functions exercised in Britain by the permanent undersecretary are exercised in France by these temporary personal appointees, to whose head. the *chef de cabinet,* the directors of each department of the ministry report. By their direct impact on each separate department of the ministry (without passing through a single permanent head), the minister and his personal team hope to give a greater political impulsion to the department and thus reduce the influence of the civil service.

In fact, even some of the directors within ministries are not career civil servants or from the ministry in question, but the appointment of a director in a ministry is thought to be sufficiently important to be made by the *conseil des ministres,* and not by a minister alone.

German Federal Republic.— Variations on the French and British systems are used in most of the parliamentary democracies of western Europe. In the Federal Republic of Germany there are both federal and *Land* ministries: some (such as that of foreign affairs) existing only on the federal level; some (such as those for educational and religious affairs) existing only on the level of the ten *Länder;* and others (such as those of justice and the interior) existing on both levels. The federal government is dominated by the federal chancellor:

> The Federal Ministers are appointed and dismissed by the Federal President upon the proposal of the Federal Chancellor . . . The Federal Chancellor determines, and is responsible for, general policy. Within the limits of this general policy, each Federal Minister conducts the business of his department independently and on his own responsibility

Switzerland.—In strong contrast to these systems stands the Swiss constitution. Each of the seven ministers (called federal councillors) is elected by a joint session of the two houses of the legislature for four years coterminously with the legislative period. Each takes charge of one of the seven departments, but "decisions shall be in the name and by the authority of the Federal Council" as a nhole. The presidency of the federal council rotates among the members for annual periods in accordance with seniority. The ministers may not be members of the legislature and must come from seven different cantons: in practice they tended, after 1943, to represent all or almost all the three or four chief parties in the legislature and to be re-elected to their particular office, often for decades, until death or retirement.

The legislature itself also elects the federal chancellor, who acts as secretary to the federal council and as head of the civil service.

Sweden.—A further variation from the usual pattern may also be noted in Sweden, where there is a rigid division of labour between the tasks of policy formation and those of routine administration.

A minister with his staff is responsible. for the planning of policy and the drafting of legislation; administration is the task of about 50 administrative agencies subordinate to the council of state as a whole, not to the minister in charge of the particular aspect of government.

(U. W. K.)

BIBLIOGRAPHY.—Sir William Ivor Jennings, *Cabinet Government,* 3rd ed. (1958); Herbert Morrison, *Government and Parliament* (1954); Gwendolen M. Carter *et al, Major Foreign Powers* (1957).

MINISTRY, THE CHRISTIAN. This article is concerned chiefly with the development of local ministries. We cannot con-

sider the authority or the actions of Apostles or prophets except as they shaped the constitution of the primitive churches.

That they did so is clear. We find St. Paul appointing in the churches which he founded officers named "bishops" or "elders," titles which are synonymous. As his was a spiritual office it was a spiritual authority that he conveyed. In fact, a generation which expected an immediate and sudden return of the Lord could have no interests that were not spiritual. There was one Christian duty that was pre-eminently spiritual. It was that of reproducing the Last Supper. It was dramatic. The leading Christian took the place of our Lord; he was, whether permanently or for the occasion, the chief of the body of bishops or elders. The rest of them sat at meat with him, while the congregation stood around. The sacred acts were repeated. Before liturgies were thought of, the president uttered an extemporary prayer; he spoke as an inspired prophet. Soon, as part of the same process which led to the use of written Gospels in lieu of reminiscences which were growing faint or came to be at second hand. a fixed form of service was composed. There was no longer the primitive confidence. Soon also, some unknown man of genius changed the actual into a symbolic meal. When those three steps had been taken, the church had advanced far towards its permanency. There was no necessity for an exceptional or prophetic ministry. The apostles who claimed to be such in the third generation were regarded with suspicion, and the class soon died out.

Thus the local ministry had the field to itself. It has been seen that the celebration of the Eucharist was its characteristic office. On this ground Ignatius calls the bishop the representative of Christ. and the presbyters the representatives of the Apostles. But the whole tendency of Christian thought was monarchical. Perhaps the original churches were collegiate, the authority which came to be vested in the bishop being at first held collectively by the body of presbyters or bishops. But this soon ceased. The government passed into the hands of the bishop, with the body of presbyters as his council. In fact there was an analogy with the mediaeval guilds of western Europe. In them, as they survive in the city of London, the society is divided into two classes, the "court" which governs and the "livery," from which the "court" is elected, but which has itself no powers of administration. So. under the Roman empire, the guild or *collegium* mas divided into the *ordo* which ruled and the plebs which obeyed. the whole membership being often called the *populus*. When the Christian societies grew in numbers it was natural that they should avail themselves of the liberty allowed to humble folk of combining in collegia *illicita*, *i.e.*, unlicensed. rather than illegal, guilds for such purposes as that of a burial club. No doubt other definitely religious ends were served by these organizations, in which the lead was naturally taken by the *ordo*.

It is strange that in Latin and in those languages derived from Latin the technical term "orders" should have been borrowed from this quite secondary side of the office. In several languages the word plebs has similarly. come to mean "parish"; Italian *pieve*, Welsh *plwyf*.

The authority of the ministry has been attributed to a grant from the Christian community, regarded as directly inspired by its Founder, of powers with which He had endowed it as a corporate body, to certain of its members. It has also been regarded as a power over the members of the church which was bestowed by the Founder, first upon His Apostles and subsequently, through them, on a permanent line of successors. In explanation of this was developed the doctrine of Orders as sacramental. In its final form, as held in the Roman communion, there are three distinct sacraments of orders, those of bishop, priest and deacon. The papacy, in spite of its authority, is not regarded as having the same sanction, for it has "no outward and visible sign." A pope is regarded as becoming invested with his office from the moment that he signifies his assent to his election.

But this doctrine, which was to become classical, in the form of a theory of the transmission of authority by the laying on of the bishop's hands, could not be older than the systematic development of Christian thought on the subject of sacraments. St. Ignatius had not asserted more than that the Eucharist of the bishop is more securely authentic than that celebrated by any other; he had not claimed that it, received at his hands or at those of his delegate, is alone valid. And the argument of St. Irenaeus that the test of orthodoxy is the doctrine handed down from the Apostles through the bishops is an appeal to succession in office, not to transmission of office. The successors of St. John. who had learned each from his predecessor what St. John had taught, were witnesses who could be trusted, especially as the line was still brief and therefore the opportunities of error few.

In any case, the position of the bishop became secure, and he was universally established in the Christian churches. This pre-eminence of the one member of the ministry had the inevitable effect of depressing the others. The presbyters, or priests, remained as the council of the local church under the bishop's presidence. They still sat while others stood at worship, they were consulted by the bishop in all matters of importance, and they had the dignity of a corporate body. To this day, at the ordination of a priest, all members of that order nho are present join in laying their hands upon the candidate for admission to their order. This has never been done at the ordination of deacons, upon uhom the bishop alone lays hands. The reason is that originally deacons were the personal officers of the bishop, chosen by him to be his assistants, and were not a corporate body. He was only concerned in their admission to orders. Presbyterate and diaconate were two separate branches of the clerical office, as in England now the professions of solicitor and barrister are distinct within the legal calling, nor was it usual to pass from the one to the other. But election to the episcopate was equally within the reach of both. In fact, a deacon had in early times the better chance, especially if at the time of vacancy he held the office of the bishop's chief deacon, or in later terms of archdeacon. At Rome the deacon usually succeeded.

This deacon was the administrative officer of the diocese. He managed its finance, he supervised the conduct of the minor clergy and the laity. He was better known to the congregation than anyone except the bishop, for he, like the other deacons, gave his whole time to his work, while the presbyters, apart from their duty as the bishop's counsellors, were only occasionally employed when the bishop had need of their services. This is strikingly shown in the consistent use of the title sacerdos, till well into the fourth century, for the bishop and for the bishop alone. St. Cyprian never uses it otherwise, and though other writers are not equally uniform in their usage, the word "priest" as we understand it and as it is employed in the Old Testament, normally means both in Greek and Latin none other than the bishop. He was still the regular celebrant, though he would from time to time charge one of the presbyters to execute this office for him; and indeed, as the churches grew larger and places of worship more numerous, these presbyters came regularly to preside at the Eucharist in places to which they were appointed, though that where the bishop himself for the occasion presided was for that day the centre of the local church. With the usual ministration of the Eucharist the deacons were thus more habitually connected than the priest. **A** deacon must be present to assist; it could even be said that he consecrated the chalice, for it was his duty to pour some of the consecrated wine into each of the flagons from which it was drawn for the communion of the laity. In this way as in many others the deacons were always before the public eye. No instance is known of a bishop, however small his see, who had no deacon. Many bishops had no more than one. The traditional number at Rome was seven, which may be due to the fact that Rome was divided for ecclesiastical as well as civil purposes into fourteen regions, over two of which each deacon may have presided. No doubt the record of the Acts, according to which seven was the number of deacons instituted at Jerusalem had its weight; but it is very doubtful whether deacons, as we know them, owe their origin to the Apostolic decision. Rome is the first church which is known to have had deacons with local authority; Alexandria the first with priests who had "parishes," to use the later term of their own. Perhaps we may trace the definite subordination of deacon to priest,

which ended in the former office becoming a mere apprenticeship for the latter. to the idea, which sprang up in the fifth century, of a correspondence between the three orders of the Christian with the three orders of the Jewish. The name "levite" came to be not infrequently used for "deacon." It is more important that the second order of the ministry, in accordance with the same analogy, gained the title of *sacerdos,* the bishop being identified with the Jewish high priest. This must have led to the impression that the chief and characteristic function of the priest (a name which survived in general use) was that of celebrating the Eucharist. In fact, as Christianity spread so widely that it was beyond the power of the bishop to satisfy the need, the ordinary minister of both sacraments came to be not the bishop but the priest.

Passing over the minor orders, which are very ancient but only of archaeological interest. we must turn to the organization of the ministry, the theory of which had come to be that of transmission by laying on of hands. The bishop elect was approved and also consecrated (though the formal distinction between "consecration" to the episcopate and "ordination" to lower grades of the ministry is comparatively late) by neighbouring bishops who assembled at the vacant see on news of the late bishop's death. They admitted him to their own community by a corporate laying on of hands, just as the priest was admitted to his order by a similar act, the significance of which has been made less conspicuous by the lead taken by the bishop in the ordination. In any case, but perhaps wrongly, the validity of the rite, whether it be sacramental or no, has been regarded as dependent on the fact that the bishop's hands have been imposed. In regard to the third order there is no doubt of the historical justification for the bishop's acting alone.

When his staff was duly constituted by ordination, it was inevitable that it should be organized. We have seen the beginnings of local priests and deacons. But general organization could only be arranged after the peace and favour conferred by Constantine the Great. It was his will that the church should be co-extensive with his empire, that all its subjects should be induced — and persuasion before long was changed into compulsion — to become Christian, and that the doctrine throughout the Church should be uniform. Thus there arose a problem of administration, which was solved by making the area of civil administration that of the ecclesiastical diocese; and by constituting metropolitan and patriarchal regions corresponding to higher areas of civil government. As men grew familiar with these arrangements, which survived in principle, and often in detail, the fall of the western empire, they came to attach a certain sacredness to them; to the most important of those arrangements, that which gave unique authority to the patriarchate of Rome, they gave an actually theological signi'ficance. And the systematizing genius of an age which worked out scholasticism made the whole scheme of religious thought coherent; it was assumed that all was equally true and equally important.

Towards the end of the middle ages the weakest point in the system came to be the personal life, as contrasted with the official claims, of the clergy. Notorious scandals led men on to dispute the current theory of the ministry; and the religious practices which hitherto had satisfied the public conscience lost their impressiveness. Not to speak of earlier attempts at revolt, when Luther proclaimed his new system it was in fact a contradiction to the old. The clergy, though necessary for religion, were not authoritative; they were simply means towards the end of promoting the spiritual life of the community. Luther revived the mediaeval conception of the monarch as the vicar of God on earth. It was for him to provide religious ministrations for his people, and to compel them to take advantage of the provision The theory had been worked out by opponents of the papal autocracy, especially in the fourteenth century, and was now to be put in practice. A sufficient justification was found in abuses which Rome, itself notoriously unreformed, refused to correct. The monarch (and the class was construed to include quite insignificant princes of Germany) was therefore bidden by virtue of his God-given *summepiskopat,* as it was called in Prussia till 1918, to correct the Church, and to provide for the continuance of a satisfactory ministry. Of its character the prince was to be judge; in Luther's eyes it was a heinous crime for anyone to officiate as a minister of religion without the prince's sanction. Such was the external authority of the Church; inwardly it was verified by the assurance which Luther and his followers enjoyed that they were in a satisfactory spiritual state. But Lutheranism has laboured under the difficulty of reconciling the two standards, that of loyalty to the society and that of inward feeling. The latter, known as Pietism, has always been suspected as tending to breed insincerity and disloyalty.

The rival school of reformed thought, while agreeing with the Lutheran in such traditional essentials as acceptance of the Bible, the Augustinian theology, and the duty of enforcing conformity to the recognized Church, assigned a higher office to the ministry and the Church. The latter is not under the authority of the state, but is the immediate organ of Christ, and its ministry has authority from Him, not from the monarch. It has also a pattern prescribed in Scripture. As the Old Testament gives direction for civil life, so do the epistles of the New for the organization of the Church. While Luther had been indifferent to systems of church-government, rejecting the opportunity of continuing the historical ministry which the adhesion of several bishops to his cause had given him and satisfied to dispense with any justification for his ministry save that of its efficiency and the monarch's approval, Calvin framed a doctrine which raised the ministry to the mediaeval level. It had for him Divine authority; and its members formed a corporate body which not only should, in national synods, guide the religious life of nations, but also, when the world was fully reformed, assemble to control the universal faith and morals. But there was one profound change; Calvin taught the parity of ministers. There is but one sacred order; for St. Paul bishop was synonymous with presbyter, and his teaching is binding upon later generations. Authority is vested, not in Pope or bishop, but in representatives chosen out of the one order. First at Geneva, and then in Scotland and the Netherlands on a national scale, this government was established, and buttressed with an elaborate theology, which armed the ministry with formidable powers.

Both these novel systems had their weight in England. But there the Reformation began simply as Catholicism without the Pope, though under Edward VI. there was a swift though brief movement towards the continental pattern. The ancient ministry was retained, and survived even when, after the Marian reaction, England became definitely Protestant. This survival of antiquity had to be justified. Why, it was asked, is the English ministry different from that of the other reformed churches? The answer given, and found satisfactory on the continent, was that the ordination of its ministry is a matter within the power of each national church. The English, in its discretion, had chosen to retain the ancient use. It did not condemn other reformed churches which, of choice or of necessity, had dispensed with bishops. It recognized their ministries, and conversely they did the same, though each had no doubt that it had chosen the better course. This was the line taken by Ken, the future bishop and non-juror, when resident in Holland as chaplain to Mary, who was to be the queen of William III. But such tolerance did not satisfy the keener spirits on any side, and when the English Presbyterians under Elizabeth protested that English orders, because conferred by bishops, were invalid, Bancroft and his followers retorted that it was the orders of their critics that were invalid, because given by presbyters. When such arguments were in use reconciliation was no longer possible.

But, at any rate, both sides in this debate believed that it was Divinely ordered that churches should be national, covering the whole ground and including all citizens. Early in the Reformation period a contrary doctrine had been taught, chiefly, though not exclusively, by Anabaptists. This doctrine was that the little Apostolic churches, each independent of the others and united only in love, were the permanent pattern which Christians were bound to follow. Certain devout people felt drawn together. They associated freely; none might be compelled to join the society, nor might it be forced to admit any to membership. Every

such society was complete in itself, and was immediately under Christ. By His authority it chose its minister, or ministers. But the choice, once made, was binding, for it was in the name of Christ, and by His inspiration, that it had been made, and the members must recognize His Will in it. Such was the doctrine in its best and most definite shape. But unhappily there can be no doubt that in many instances the appointment of a minister among Congregationalists has been practically a business agreement in which higher considerations have not lastingly prevailed. Their mode of religious organization has had little vogue outside the peoples of English speech; and in England their chief historical importance is that under Cromwell they frustrated the attempt to set up a Presbyterian church. One effect of this temporary victory was that they reduced the English Presbyterians from an organized society to a number of separate congregations, which were unable to escape the same declension from their original standard in regard to the ministry that had affected their rivals.

It remains to speak of the Methodist ministry. It is often said that John Wesley was driven out of the national church. But Wesley had reached the conviction that the Presbyterians were right as to the parity of ministers; he held that he had as much right to ordain as to administer the Lord's supper. He believed also in the value for practical religion of the societv which he had founded, and organized with much skill. For him it was authenticated by its usefulness, and he was resolved to gain for it the loyalty of his adherents, for so he would be assured of their continuance in piety. To this end he ordained ministers first for America and Scotland, and finally for England. He did not realize that this meant separation; but he had inspired so strong a Methodist patriotism that his followers, many of whom had never been churchmen, had little attachment to the Church of England. They therefore continued to appoint ministers after his death in 1791 though they did not practice the laying on of hands till 1836, when they resumed it while carefully stating that it is not essential. Methodists, in all its forms, reject the Presbyterian theory of the transmission of the ministry. The corporate Methodist body claims to have the nght of conferring the ministry, and holds that spiritual success verifies the claim.

Three great systems, we have seen, lay stress in different ways on corporate life; the historical, within which the authority of the ministry has been differently explained, the Presbyterian, which claimed to be a reversion to a primitive type which ought never to have been forsaken, and the Methodist, which frankly justifies itself by its success in edification. We have also considered the isolating type, in which the single congregation invested by Christ with His authority, appoints its minister. In none of these systems, widely as they may differ, is there any hesitation in asserting that a Power higher than human is at work. Even where, as with the Friends, the ministry may seem to a superficial observation to be reduced to insignificance because it was, and for the most part, except in the United States, still is voluntary, it is really taken most seriously as a Divine appointment. Not only in practice, but in principle, the Christian ministry is recognized universally as a providential ordinance, necessary for the maintenance of the society and for the sustenance of the spiritual life of its members.

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(E. W. W.)

MINK, a small fur-bearing animal belonging, along with the ferret. stoat and ermine. to the genus *Mustela,* of the weasel family. Mustelidae *(see* CARNIVORA). Mink differ from typical neasels in slight ways associated with their semiaquatic mode of life. The best known species are M. *vison* of North America and *M. lutreola* of Eurasia.

The North American mink measures about 20 to 28 in. in length. 6 to 8 in,. of this being tail. Like all weasels the body is long and slender; the legs short; the neck long and flexible: the head broad; and the ears short and rounded. The deep, rich brown pelage consists of a dense, soft underfur overlaid with dark. glossy, almost stiff, guard hairs: one of the most highly prized of all furs. it has long been a luxury fur of commerce.

Mink are accomplished snimmers and able fishers. They forage for food commonly at night. Besides fish, their diet includes frogs. muskrats, crustaceans, eggs, birds. mice. rats and poultry. Few mammals are as voracious and bloodthirsty. Mink are evil-smelling creatures, the stench being produced by anal glands But unlike its cousin the skunk. the mink cannot spray its vile-smelling substance; it deposits it in droplets. Mink live along streams. rivers. ponds, lakes and the sea coast. They are equally at home on dry land and, although they prefer forested areas, are less inclined to climb trees than most weasels. The hunting territory of a family of mink will include several square miles. Usually the den is the bank burrow of another animal—a hollow log, a crevice among rocks or commonly a muskrat house whose builders were devoured by the mink. The den is a temporary home, and a few days later the family moves to other quarters. The family unit disperses in late summer: each member establishing a new territory. The larger males may travel extensively at this time. Breeding takes place from midwinter to spring, one male mating with several females. and eventually remaining with one. The four to eight young are horn after a gestation of 39 to 76 days, spring pregnancies being shortest. The young are born blind and covered with fine hair. They are breast fed at first: but even before their eyes open—at five weeks—they are eating meat.

NORTH AMERICAN MINK (MUSTELA VISON)

In the U.S.—mostly in southern states—mink are raised commercially on mink farms or ranches. The female is of a savage disposition. and in captivity she often kills her young when she becomes excited. Controlled crossbreeding has led to the production of many mutant colours of fur. However, except for the rarer mutant colours. the fur of wild mink is more valued than that of "ranch mink." Few animals—large birds. foxes—prey on mink; trappers and disease account for most deaths. Mink formerly occurred over the Gnited States excluding the southwest, and throughout Alaska and Canada excluding the barrens of the north. They are now rare in the southern parts of this range.

The European mink resembles the North American species but is smaller. measuring 1j to 18in. in length. Formerly it occurred over northern and central Europe but, as in North America! has become rare in the southern parts of this range.

A very large species. *M. macrodon,* once occurred along a limited area of the coast of New Brunswick and Maine. It became extinct about 1860 and only a few bones and faded skins remain. See also FUR: *Fur Farming.* (K. R. KN.)

MINKOWSKI, OSKAR (1858–1931), German clinician and physiopatholbgist who discovered that lack of endocrine pancreatic secretion produces diabetes. was born in Kovno. Russia, on Jan. 13. 1858, but became a naturalized Prussian in 1872. He studied at the *Gymnasium* in Kovno (1867) and at Konigsberg (1875). then studied medicine in Konigsberg and Freihurg. graduating from Konigsberg in 188;. Minkowski was assistant to

Bernhard Naunyn at Strasbourg and later professor of medicine at Breslau, presiding also over the German Insulin committee.

Minkowski discovered that acids are eliminated in the urine combined with ammonia, and found that β-hydroxybutyric acid is the cause of diabetic acidosis and the decrease in sodium bicarbonate in blood plasma. In 1886 he removed the liver from birds and demonstrated that this organ is the site of formation of uric acid (from ammonia and lactic acid or amino acids) and of bile pigments. In 1889 he discovered that extirpation of the pancreas causes diabetes. He had removed the pancreas from a dog so that Joseph von Mering could observe whether certain fats could be absorbed without the action of pancreatic juice. He noticed that the animal passed large quantities of urine, which on being analyzed was found to contain glucose. This discovery was published by Mering and Minkowski in 1889.

Later Minkowski made a profound study of pancreatic diabetes, which he correctly interpreted as resulting from suppression of the still-unknown pancreatic hormone. He also published work on acromegaly, familial hemolytic jaundice, the esophageal pulse, gout, etc.

Minkowski died on July 18, 1931, in Wiesbaden. (B. A. H.)

MINNEAPOLIS, the largest city in Minnesota, U.S., seat of Hennepin county and port of entry, is situated on the 45th parallel by the Falls of St. Anthony at the head of navigation on the Mississippi river, about 350 mi. N.W. of Chicago. Contiguous on the south and east to St. Paul (*q.v.*), which is often referred to as its twin city, its land area (53.8 sq.mi.) lies on both sides of the river but has developed mainly on the west over an undulating glacial plain contained in the angle of the Minnesota and Mississippi rivers. Within the city limits are 22 lakes and lagoons, and in the suburban area to the west lies Lake Minnetonka, 11 mi. long with 110 mi. of irregular shore line. Its outlet, Ninnehaha creek, flows eastward along a residential boulevard and then drops 50 ft. over an escarpment at Minnehaha falls, immortalized by Henry Wadsworth Longfellow in his Song of *Hiawatha.* St. Anthony falls, now flowing smoothly over an apron or cut-off wall, lies in the heart of the milling district whose massive and irregular skyline seems a symbol of the proverbial plenty of the midwest. The handsome stone arch railroad bridge, built in 1881, and three general traffic bridges add interesting perspectives to the scene. Of the many bridges over the river, creeks and lakes, some have great architectural beauty.

History and Industrial Development. — The first recorded white visitor was the French Franciscan missionary, Father Louis Hennepin (*q.v.*), who named the falls in 1680. An adventurous traveler, Jonathan Carver (*q.v.*), came to the area in 1766. The falls provided power for a mill which in 1823 ground coarse flour for the soldiers at Ft. Snelling, built above the confluence of the Minnesota and Mississippi rivers, and in 1849 the same cataracts turned the first commercial sawmill. The village of St. Anthony on the east side of the falls was incorporated in 1855. Meanwhile, settlers, mainly from the eastern states: poured in and occupied C.S. military-reservation land mostly on the west side of the river. In 1855 the government ga e these illegal squatters patent rights and a new village was incorporated in 1856. It derived its name from *minne* (a Sioux word meaning "water") and the Greek *polis* (meaning "city"), with a euphonic a added in between. St. Anthony was chartered as a city in 1860 and Minneapolis in 1867; in 1870 the population of Minneapolis was 13,066 and St. Anthony, 5,013. The two cities were amalgamated under the name of the larger in 1872.

During these years sawmills buzzed on both sides of the river and by 1859 about 31,000,000 ft. of lumber were shipped from St. Anrhony in addition to the timber which was marketed locally. The lumber business reached its height in 1899 when logs from the seemingly inexhaustible forests of the north jammed the river. As wheat growing in the northwest increased, flour milling superseded lumber as the leading industry (the last lumber mill closed in 1919), and a new milling process involving the "middlings purifier," which improved the quality of flour made from spring wheat, made Minneapolis known by 1883 as "the flour city of the United States." Railroads radiating from the city were completed in the late 19th century, multiplying connections with Chicago and the south and with the east through Sault Ste. Marie. These lines brought favourable transportation rates, but after World War I lower freight rates via the Great Lakes shifted much of the export flour trade to Buffalo, N.Y., though Minneapolis remained the headquarters for five large milling companies. Along with the flour, but somewhat separately, developed the grain trade, stimulated in 1881 by the organization of the chamber of commerce, and between 1879 and 1885 Minneapolis advanced from ninth to first place among the primary wheat markets of the country, a position it had not lost by mid-20th century. The Minneapolis Grain exchange is probably the world's largest cash grain market. Two other leading industries of Minneapolis were established in the 1880s: the manufacture of agricultural and railroad machinery and linseed oil from flax of the surrounding country.

The history of Minneapolis was marked by two spectacular events In 1869 the falls. yielding to a geological fault and overuse by man, threatened collapse, jeopardizing the whole economy of the city. With federal aid, the vital water power was restored by an apron which is still intact. In 1878 an explosion of a major mill destroyed half the milling district and killed scores of workmen. This resulted in intensive research on dust control.

The leading industries of the twin city industrial complex are food products, printing and publishing, machinery, paper and metal products, apparel and transportation equipment, which, with the addition of precision instruments, are also the leading industries of Minneapolis, where an industrial park was developed along the Minnesota river. The city is also the retail shopping centre of the area.

Population and Urban Growth. — After 1880, which began the decade of largest population gronth, the dominant foreign-born group was Swedish, followed by Norwegians and Germans. Representative nationalities from southern and eastern Europe increased proportionately between 1900 and 1920 though remaining small in number. In 1940 less than 15% of the population was foreign born and in 1950 the percentage mas 9.4.

The population of Minneapolis was 46,887 in 1880; 202,718 in 1900; 301,408 in 1910; 380.582 in 1920; 492,370 in 1940; 521,718 in 1950; and 482.872 in 1960.

The city became the centre of a standard metropolitan area of 525 sq.mi. and a population of more than 800,000 in 1930, and in 1950 of a land area of 1,721 sq.mi. with a population of more than 1,000.000.

An area of five counties (Anoka, Dakota, Hennepin, Ramsey and Washington), with a population of 1,482,030, was designated in 1960 as the Minneapolis-St. Paul standard metropolitan statistical area Among the small older towns of the area are Stillwater on the St. Croix where lumber manufacture began in 1844, and Anoka, north of Minneapolis, also an early lumber town. The eight tonnships and villages of the Minnetonka lake district, an area famous during the 1880s and 1890s for fashionable summer resorts. have become year round communities. South St. Paul is a typical industrial satellite with meat packing the dominant industry. Middle-class suburban communities have grown rapidly, and St. Louis Park, Richfield (*qq.v.*), Edina and Bloomington, lying contiguous to Minneapolis, showed marked increases in population between 1930 and 1960.

City Planning. — Civic improvement and development, begun abortively in 1917, was renened, and by mid-20th century the face of the downtown area was remarkably changed by the erection of impressive new buildings, both public and private, and by the razing of the blighted area in the heart of the city. Some architectural landmarks are: the Ninth Federal Reserve District bank (established 1915), designed in 1924 by Cass Gilbert, with 12 stories since added; the Foshay tower, built by a utilities baron in 1929 in the form of a shaft 447 ft. tall; and the First National bank building, built in 1958.

In 1917 river improvements begun in 1894 were completed to bring navigation into the heart of the city, and in 1948 the federal government began the upper harbour project with the purpose of bringing barge traffic above the falls. Ten trunk-railroad lines serve Minneapolis, and Wold Chamberlain international air-

port is about 10½ mi. S. of the city loop.

Culture and Recreation.— The Minneapolis campus of the University of Minnesota (established 1851), on the river, in the southeast part of the city, is the centre for many of the cultural activities of the community. The Minneapolis Symphony orchestra, founded in 1903, performs there in Northrop Memorial auditorium, where concerts, ballets and lectures are also held. The university radio station gives cultural broadcasts, and an educational television station was launched in 1957 with the support of community institutions. The Municipal auditorium, built in 1927, seats 10,000 and the Metropolitan Sports stadium in Bloomington, built in 1956, has a capacity of 35,000. The Minneapolis Institute of Arts has been housed since 1912 in a neoclassical building owned and operated by the Society of Fine Arts, incorporated in 1883; the Walker Art centre, built in 1927, specializes in contemporary art. The activities of the American Swedish institute, housed in a late-19th-century mansion, are devoted to the cultural relations of the two countries.

Numerous trade and professional schools include Dunwoody institute, a leading vocational school founded by private endowment in 1914. Augsburg College and Theological seminary (Lutheran; 1869) is a four-year liberal arts college. The public library, its modern building opened in 1961, was enriched in 1885 through an amalgamation contract with the Minneapolis Athenaeum, a private subscription library incorporated in 1859. The Hennepin county library extends the work of the city institution into the surrounding area. A science museum and planetarium are connected with the library. A historic site is the old Ft. Snelling round tower in south Minneapolis.

Though the largest number of church congregations is Lutheran, all denominations as well as several independent evangelistic sects are represented. The Basilica of St. Mary (Roman Catholic), completed in 1915, was built in renaissance style. The city is famous for churches representing various styles of 20th-century architecture.

Early in its history influential citizens of Minneapolis realized the beauty and recreational possibilities of the lakes. A park board was created by the state legislature in 1889, and a system of tree-shaded boulevards and parks, including historic Minnehaha park, has been maintained, extending with the growth of the suburbs into the county. The gateway to a great sports and resort area to the north, Minneapolis is conscious of the out-of-doors, and day camps, skating rinks, ski jumps and swimming facilities are numerous.

An annual summer event is Aquatennial week, featuring aquatic sports and a parade of floats. (MA. C. B.)

MINNESINGERS, the name given to the German lyric poets of the 12th and 13th centuries. The term *Minnesang,* strictly applicable to the poems expressing the homage (*Minnedienst*) rendered by the knight to his mistress, is applied to the whole body of lyric poetry of the period, whether dealing with love, religion or politics. The idea of amour courtois, with its excessive worship of woman, its minute etiquette and its artificial sentiment, was introduced into German poetry from Provenqal literature; but the German Minnesang was no slavish imitation of the poetry of the troubadours. Its tone was, on the whole, healthier and more sincere. The minnesinger usually belonged to the lower ranks of the nobility, and his verses were addressed to a married woman, often above him in rank. He was not permitted to give his lady's name, or to betray her identity, and a direct expression of passion would also have contravened the rules. The poems were from the first sung in open court to a melody (*Weise*) of the poet's own composing, with the accompaniment of a fiddle or small harp.

The Older Songs.—These consisted of a single strophe cast in three divisions, two (known as *Stollen*) identical in form, stating and developing the argument, the third (*Abgesang*) of different form, giving the conclusion. Later on, two or more strophes were used in a single poem, but the principle of their structure was retained. In this form were cast the *Tagelied,* a dialogue describing the parting of lovers at dawn, and the crusading song.

Side by side with these existed the *Spruch,* written in a single undivided stanza, destined for recitation and often cast in the form of a fable. The lay (Leich) was written in unequal strophes, each formed of two equal divisions. It was applied in the first instance to sacred lyrics, and was first used in love poems by the Alsatian minnesinger Ulrich von Gutenberg.

The earliest minnesinger whose name has come down to us is der von Kiirenberg (fl. c. 1160), a scion of an Austrian knightly family whose castle lay on the Danube, west of Linz. His songs, however, contradict the root idea of *Minnedienst,* since the lady is the wooer and the poet, at the most, an acquiescent lover. They take the form of laments for an absent lover, complaints of his faithlessness and the like.

Among the other Austrian and south German lyrists who show small trace of foreign influence was Dietmar von Aist (d. *c.* 1171), though some of the songs attributed to him seem to be of later date.

While the love song remained in the hands of noble singers, the *Spruch* was cultivated by humbler poets. The elder of the two or three poets concealed under the name of Spervogel was a wandering singer who found patronage at the court of the burgraves of Regensburg, one of whom himself figures among the earlier minnesingers.

Characteristic Period.—In German *Minnesang* this begins at the close of the 12th century with the establishment of the Provençal tradition in western Germany through the poems of Heinrich von Veldeke and Friedrich von Hausen. National elements abound in Veldeke's songs, although the *amour courtois* dominates the whole; Friedrich von Hausen (d. 1190) followed Provenqal models closely, as did also the Swiss Count Rudolf von Fenis. The greatest name among the earlier minnesingers is that of Heinrich von Morungen, a Thuringian poet who lived on in popular story in the ballad of "The Noble Moringer." He brought great imaginative power to bear on the common subjects of *Minnesang,* and his poetry has a very modern note. The formal art and science of *Minnesang* reached full development in the subtle love songs of Reinmar, the Alsatian "nightingale of Hagenau." He became a member of the court of Duke Leopold V (d. 1194) of Austria, and there Walther von der Vogelweide (*q.v.*) was first his disciple, and then perhaps his rival. Walther, the greatest of mediaeval German lyric poets, had Reinmar's technical art, but in feeling was more nearly allied to Morungen. He raised the *Spruch* to the dignity of a serious political poem, which proved a potent weapon against the policy of Innocent III. The Tagelieder of Wolfram von Eschenbach give him a high place in Minnesang, although his fame, like that of Heinrich von Veldeke and Hartmann von Auc, chiefly rests on his epics. A new style—called by Lachmann *höfische Dorfpoesie*—was developed by Neidhart von Reuental (d. *c.* 1250), who belonged to the lower Bavarian nobility. He wrote songs to accompany the dances of the village beauties, and comic and realistic descriptions of village life to please the court. He was acknowledged by the Meistersinger as one of the 12 masters of song. Nevertheless, with him the decadence may be said to have begun.

The Styrian poet Ulrich von Lichtenstein (d. *c.* 1275) unconsciously caricatured chivalry itself by his *Frauendienst,* in which he relates the absurd feats which he had undertaken at his lady's command, while Steinmar (fl. *c.* 1276) deliberately parodied court poetry in his praises of rustic beauty and good living. In the lays, songs and proverbs of Tannhäuser something of both elements, of the court and the village, is to be found. The Austrian poet Reinmar von Zweter (d. *c.* 1260) left some hundreds of *Sprüche,* political or social in their import. The didactic motive came more and more to the front in the 13th century. The wandering Swabian poet Marner (d. *c.* 1270) cultivated especially the Spruch, laughed at the Provençal and courtly tradition, and there is no very great step from his learning and his feuds to the conditions of Meistergesang.

BIBLIOGRAPHY.—The chief manuscripts containing the work of the 300 or more minnesingers whose work has been partially preserved are the old Heidelberg manuscript (13th century), the Weingarten-Stuttgart manuscript (14th century) and the Great Heidelberg manuscript (14th century), formerly known as the Manasse manuscript.

This last is the most comprehensive of all. It has been printed by F. Piaff (1899). The most complete collection of the minnesingers' verses is F. H. von der Hagen, *Minnesinger,* 4 vol. (1838); K. Lachmann and M. Haupt, *Des Minnesangs Frühling, ed. F.* Vogt, 3rd ed. (1920), is a collection of the minnesingers prior to Walther von der Vogelweide. There is a comprehensive selection of 97 minnesingers by Karl Bartsch, *Deutsche Liederdichter des 12. bis 14. Jahrhunderts,* ed. *W.* Golther, 7th ed. (1914); *see* also F. Piaff, *Der Minnesang der 12. bis 14. Jahrhunderts,* pt. i (1892). English translations of early German lyrics are F. C. Nicholson, *Old German Love Songs* (1907). *See* also WALTHER VON DER VOGELWEIDE.

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MINNESOTA, called the "North Star" or the "Gopher state," a north-central state of the United States. It is bounded north by the Canadian provinces of Manitoba and Ontario: east by Lake Superior and Wisconsin, south by Iowa and west by South and North Dakota. It is the 12th state in size in the union, with a total area of 84,068 sq.mi., of which 4,059 sq.mi. are water surface. It is 406 mi. long and 358 mi. wide. Its name, of Sioux Indian origin, was first applied to the river of that name and probably means "cloudy water." Minnesota was admitted to the union in 1858 as the 32nd state. The state flower is the pink and white lady's-slipper; the state bird is the loon. The state motto is *L'Etoile* du *nord* ("The Star of the North"); there is no official song, but the university song, "Hail! Minnesota," is popularly regarded as such. The state flag consists of a blue background on which, as the chief element, is placed a white circle, in the centre of which is shown the great seal of the state. The capital is St. Paul.

PHYSICAL GEOGRAPHY

Physical Features.—Minnesota is almost at the centre of the North American continent, lying within approximately 43° 30' to 49° 23' N. and 89" 29' to 97° 13' W. It extends farther north than any other state of the union except Alaska. Its landscape is distinguished by variety and beauty, the diversity of its terrain being the result of an unusual geological development that was conditioned markedly by the glaciers that four times covered most of the area. The results of repeated glaciation are seen in the thousands of lakes; in the wilderness areas, rolling prairies, fertile valleys, high bluffs, rocky shores and hills that give a richly varied aspect to the scenery; and in the deep, rich soil, ground fine by the passage of ice rivers.

The highest point in the state is at the summit of the Misquah hills in Cook county in northeastern Minnesota, where the altitude reaches 2,230 ft.; another high point of 1,960 ft. occurs at the crest of the Coteau des Prairies in Murray county in the southnest; and the Mesabi range in St. Louis county rises to an elevation of 2,005 ft. These points were a part of an extension of the Laurentian hills which once extended diagonally across the state from the northeast corner to the vicinity of Pipestone in the southwest corner. The lowest point in the state is the level of Lake Superior, 602 ft.

Climate.—Minnesota has a comparatively low mean annual temperature, but its climate is marked by great variation, the average annual range for Minneapolis and St. Paul being 119°. The lowest temperature on record is −59° recorded at Leech lake in 1903, and the record high is 114° recorded at Beardsley in 1917. It is seldom that extreme temperatures prevail for more than a few days at a time, and the state has been remarkably free from destructive storms. The cold increases not only from south to north but to some extent also from east to west. The amount of rain decreases from east to west, varying from nearly 31 in. to less than 25 in. at some points, but in all sections there is enough moisture for humid farming. Days of snow cover annually average 120 in the north and 60 in the south. The elevation of the state, its fine drainage system and the dryness of the atmosphere, especiaily in the winter, help to make it one of the most healthful regions in the world.

Soil.—Over the greater part of the state the soil consists of surface drift of glacial origin—a dark brown or black sandy loam of great fertility, adapted to cereal crops. In the east-central part of the state the soil is sandy, excellent for hay and root crops.

Drainage.—Glacial action determined the direction and character of rivers, made numerous swamps and created Minnesota's lakes, of which there are more than 11.000. The lakes in the south, which occupy glacial moraines for the most part, are generally broad and shallow, while those in the north, formed by glacial basins scoured in solid rock, are generally deep, with rugged, rocky, pine-covered shores. Most of the larger lakes lie in the forested northern region of the state. Among them are Lake of the Woods and Rainy lake (which are shared with Canada), Red, Mille Lacs, Leech. Winnibigoshish and Vermilion.

The most interesting feature of the glacial epoch is the extinct Lake Agassiz, which the receding ice of the later glacial period left in the Red river valley of Minnesota, North Dakota and Manitoba. As the glacier retreated the lake waters drained northward, leaving Red lake as the most extensive remains of the giant body of water. The resulting flats of the Red river valley provide still another variation to Minnesota's changing landscape.

Minnesota has within its borders more inland water than any other state in the union, 1 sq.mi. of water for every 20 sq.mi. of land. Three of the state boundaries are also at least partly marked by waterways—the northern boundary by the Rainy and Pigeon rivers and the chain of border lakes, the eastern boundary by the St. Louis, St. Croix and Mississippi rivers and the western boundary by the Red river.

The sources of three of North America's great water systems are to be found in the state. From one watershed in the northeast the waters flow southward by way of the Mississippi river into the Gulf of Mexico and northward by way of the Red river to streams that empty into Hudson bay. From another watershed, waters in the northeastern tip of the state flow eastward through the Great Lakes and the St. Lawrence river into the Atlantic ocean. The largest of these three great river systems is, of course, the Mississippi, which, with its tributaries, drains 57% of Minnesota. This largest river on the North American continent begins in Lake Itasca and flows southward through the state, taking in the waters of the Willow, Crow Wing. Prairie, Platte, Elk and Rum rivers before it reaches Ft. Snelling. The largest of the Mississippi's tributaries in the state is the winding Minnesota river, which begins in Big Stone lake on the western border and flows across Minnesota to join the Mississippi near Ft. Snelling. Between Ft. Snelling and the Iowa border the Mississippi gathers in the waters of the Cannon, the Whitewater and the Root rivers, as well as those of the Chippewa and St. Croix flowing in from Wisconsin. The largest of these is the St. Croix, nhich begins as a small stream in northern Wisconsin and flows southward along Minnesota's eastern border, joining the Mississippi at Prescott, Wis. The Des Moines river, in the southmestern corner of the state, is also part of the Mississippi drainage system, emptying into the Mississippi in Iowa. A few other streams in Rock, Pipestone, Murray and Nobles counties in southwestern Minnesota drain into the Missouri river system and through it finally reach the Mississippi.

The next largest of the three great drainage systems whose headwaters are in Minnesota is the one flowing into Hudson bay. Thirty-four per cent of the state is drained by the waters of the Rainy river and the Red river and their tributaries. The Rainy, forming part of Minnesota's northern boundary, empties northward into Lake of the Woods. The Red river, forming a large section of the state's western boundary, begins at the junction of the Bois de Sioux and Otter Tail rivers and flows northward into Canada. In its rambling course it covers more than 545 mi., draining a rich and fertile valley of more than 100,000 sq.mi. Its main Minnesota tributaries are the Otter Tail, Buffalo, Wild Rice Marsh and Red Lake rivers. Across the border it is joined by the Roseau river as it travels to Winnipeg where it is joined by the Assiniboine river.

Less than 9% of the state is drained by waters that reach the

Atlantic ocean through the Great Lakes–St. Lawrence waterway. The Pigeon river and its headwaters. the chain of lakes stretching westuard to North lake. form a part of the northern boundary of Minnesota. The waters of the St. Louis river, emptying into Lake Superior near Duluth, also find their way to the Atlantic. as do the many rugged streams along the north shore of Lake Superior. These small, rapid rivers. full of tumbling falls and cascades, bear such colourful names as Gooseberry, Beaver, Baptism, Caribou, Temperance and Devils Track.

Although the various geographical components of Minnesota have all had a great effect on the development of the state, perhaps no single feature did more to shape its early history than did the rivers.

Vegetation. — The southern part of the state, before colonists arrived, was open, rolling prairie interspersed with groves of oak and other deciduous timber. A region known as the Big Woods, composed of broad-leaved hardnood trees, extended up the Minnesota valley to the "big bend" (centre at Mankato). The northern part, aside from the Red river valley, was once dense coniferous forest, made up largely of white, Norway and jack pine, but containing also some birch, poplar, maple and oak.

Most of the plants and animals of the north temperate zone are found in Minnesota. Along the streams of the southern part thickets of oak, elm, ash, maple, poplar, bassnood, plum and cherry trees are still found in great variety, festooned nith grapevines and sheltering small fruits and other shrubs, especially the hazel bush. Scattered over the prairies are strawberries, and the northern woods produce blueberries for many markets. These woods, though subject to intensive lumbering since the beginning of the 20th century, still contain more white pine than is found elsewhere in the country, besides other varieties of pine, balsam, spruce and hemlock. The state flower, the dainty pink and white lady's-slipper, is found in marshes that also shelter the fringed gentian and glow with marigolds and goldenrod in more than 30 varieties.

Animal Life. — The French explorers of the late 1600s found beavers working along every stream. Two centuries of Indian fur trade almost exterminated this animal, but in the 20th century, under the protection of the state, the beaver is again multiplying rapidly. Marten, otter, mink. muskrat, bobcat, skunk, raccoon, weasel, wolf, red fox and other fur-bearers have always been numerous. In the sparsely settled parts of the state coyotes and timber wolves, black bears, foxes, lynx and various rodents are prevalent. The gopher (really the striped ground squirrel), which gave Minnesota the name of "Gopher state,' is found except where care has been taken to prevent its becoming a nuisance. Deer, moose. bear and elk are the only large game animals; they attract thousands of hunters to Minnesota each year. Game birds — including wild duck, quail, sharp-tailed grouse, upland plover, prairie chicken and ring-necked pheasant — are abundant; more than 1,000,000 wild ducks and 50,000 deer are killed by hunters each year.

The state's streams and lakes are well stocked with pickerel, pike, bass, crappies and sunfish, and some trout are caught by sportsmen. Minnesota has a larger area in game refuges than any state — 5,500,000 ac.

Parks, Monuments and Recreation. — Tourism is an important business in Minnesota. The state park system includes 69 natural, scenic, historical and recreational areas of varying size, comprising a total of 100.000 ac. The national park service administers tno national monuments, and the Minnesota Historical society administers five state historical sites. Two contemporary movements led to the establishment of the state park system in the late 19th century. The first of these set aside as public parks the major battlefields of the Sioux uprising of 1862. Camp Release, near Montevideo, became the first state park in 1839. The second effort, led by J. V. Brower, preserved as a public area the extensive and unusual wilderness area about Lake Itasca, the source of the hlississippi river. Itasca park, established in 1891, is the state's largest and most famous park. Other major state parks are Gooseberry Falls. Jay Cooke, St. Croix, Scenic. Sibley, Whitewater, Lake Carlos, Interstate, Frontenac, Cascade, Fort Ridgely and Mille Lacs Kathio. Pipestone National monument in the southwestern corner of the state was established in 1937. It is the place where for centuries North American Indians quarried the precious red stone from which they carved their peace pipes. Grand Portage National monument, located on Lake Superior at the northeastern tip of the state, was established in 1958 (it had been designated a national historic site in 1951). It was the great inland depot of the British Northwest company and the centre of the North American fur trade from about 1770 to 1804.

(R. W. F.)

HISTORY

The first European visitors to the territory now embraced in the state of Minnesota found it occupied mainly by tno Indian tribes, the Ojibwa (also called Chippeua; Xlgonkian family), who lived in the heavily nooded northern portion, and the Sioux (more properly Dakota), who made their homes in the more open country of the south and west. Betneen the tno tribes there was almost continual warfare. The first uhite men known to have entered the state were Frenchmen. Pierre Esprit Radisson and Médart Chouart, sieur de Groseilliers, may have reached Minnesota territory on an expedition overland from Lake Michigan in 1655. It is more probable that they visited Minnesota on a journey southwest from Lake Superior about 1659.

Daniel Greysolon, sieur du Lhut (Dulhut or Duluth), is known to have penetrated the territory southwest of Lake Superior in 1679 as far as Mille Lacs, nhere he set up the standard of Louis XIV. The following year Dulhut crossed via the Bois Brule–St. Croix route to the Mississippi, where he met a party of three Frenchmen led by Michael Accault. They had been sent up the river by La Salle to make the first exploration of the upper Mississippi. Accompanying this expedition was Father Louis Hennepin. who during his wanderings before meeting Dulhut discovered and named the Falls of St. Anthony, and who later arote the first published description of the country. Nicolas Perrot, a trader, ascended the Mississippi in 1686 to Lake Pepin, on the east shore of which he built a fort. Again in 1688 he visited the region, and in 1689 he proclaimed the sovereignty of France over it. In 1695 Pierre le Sueur, who had traded on the upper Mississippi for some years, established a post on Isle Pelée (Prairie Island) in the Mississippi between Hastings and Red Wing. In 1700 he ascended the Minnesota river to the mouth of the Blue Earth river near Mankato, whereon he built Ft. L'Huillier.

A period of lethargy followed these early explorations because of the death in 1698 of the energetic governor comte de Frontenac, nho had encouraged them. and the absorption of France in the War of the Spanish Succession (1701–14). All French garrisons in the northwest were withdrawn. Not until Sept. 1727 did another French expedition reach the region. Then the sieur de la Perrière landed on the west bank of Lake Pepin and built a fort; the Jesuit fathers who accompanied him established a mission, but both institutions were short-lived. In 1731 a party under P. G. de Varennes, sieur de la Vérendrye, explored the chain of lakes along the northern border of Minnesota, and a detachment under his nephew, La Jémeraye, built Ft. St. Pierre on the north bank of Rainy lake. In the next year the main expedition pushed on to the Lake of the Woods, where, within Minnesota borders, they built Ft. St. Charles, occupied for 20 years, or longer than any French establishment in the territory.

In the treaty of Paris (1763) at the close of the Seven Years' War in Europe. the French ceded to England all their possessions east of the Mississippi except the island on which New Orleans is located; those west of that river they had cautiously ceded to Spain in a secret treaty the previous year.

During the period of the British regime, Jonathan Carver (*q.v.*) was sent out to treat with the Indians, in 1766, by Maj. Robert Rogers, commandant at Mackinac. He spent the winter of 1766–67 among the Sioux of the Minnesota valley, and in the spring he traveled to Prairie du Chien, nhere he joined an expedition under Capt. James Tute sent out by Rogers to find a route to the "western sea." Carver later published a lively account of his travels, which was widely read in Europe.

Another trader of the British period was Peter Pond, a Connecticut Yankee who spent two winters, from 1773 to 1775, on the Minnesota river. David Thompson, who was employed both in trading for the Northwest company and in determining the location of the 49th parallel. passed through northern Minnesota in the winter of 1797–98. His diaries are the earliest known scientific record of Minnesota topography.

United States Ownership. — After the Revolutionary War, the English relinquished their portion of the region (treaty of Paris, 1783) to the newly formed United States. There was no force to expel the English from the northwest nilderness, hcwever, and the British flag remained flying over the trading posts of the Northwest company in Minnesota until after the War of 1812. This company had been formed to organize systematically the fur trade of the northwest. Its headquarters for the region during the last two decades of the 18th century were at Grand Portage, at the east end of the famous portage between Lake Superior and the Pigeon river.

In 1803 the western part of Minnesota was acquired by the United States as part of the Louisiana Purchase. In 1805–06, at the instance of Pres. Thomas Jefferson, Lieut. Zebulon M. Pike led an exploring expedition up the Mississippi as far as Leech lake and Upper Red Cedar or Cass lake. He visited the main posts of the Northwest company and took formal possession for the Cnited States. He also negotiated with the Indians for a tract of land at the confluence of the Minnesota and Mississippi rivers upon which, in 1819, the post later known as Ft. Snelling was established. For many years this remained the northwesternmost military post in the United States, and it was also the centre of the fur trade in the region.

In 1816 the Northwest company's traders were forced out of Minnesota and their posts were taken over by the American Fur company, which was soon doing business throughout the upper valley of the Mississippi.

In 1818 the jurisdiction of Michigan territory was extended to the Mississippi river Its governor, Lewis Cass. attempted to find the source of the Mississippi in 1820. In 1823 extensive explorations of the Minnesota and Red river valleys were conducted by Maj. Stephen H. Long, and subsequently knowledge of the Minnesota country was extended by investigations of the region by Henry R. Schoolcraft, who discovered Lake Itasca, the source of the Mississippi, in 1832; by George Catlin, whose journey of 1836 took him to the famous pipestone quarry; by Joseph N. Nicollet, ahose tours of the late 1830s resulted in the first accurate map of the region; and by Maj. Samuel Woods, who explored the Red river valley in 1849. A settlement grew up about the headquarters of the American Fur company at Mendota, on the Minnesota river opposite Ft. Snelling.

In 1837 two treaties, one with the Chippewa and the other with the Sioux, were negotiated, extinguishing the Indian title to the aedge of land between the Mississippi and St. Croix rivers and opening it to settlement. Following these treaties thriving settlements grew up at St. Paul and Stillwater.

Minnesota Territory. — In 1849 the bill organizing the territory of Minnesota was passed by congress, and Alexander Ramsey was appointed governor. The first territorial legislature met at St. Pau! on Sept. 3 of the same year. By the federal census of 1850 the territory had 6,077 inhabitants, most of whom lived east of the Mississippi or along :he Red river in the extreme northwest. Treaties negotiated in 1851 with the Sioux opened to settlement the greater part of the land in the territory west of the Mississippi; and treaties with the Chippena in 1854 and 1855 extinguished the Indian title to nearly two-thirds of the northern half of the state. Such an unparalleled rush to the new lands took place that a census in 1857 showed a population of 150,037. The lumbering business mas booming and building up the towns of Stillwater and St. Anthony (Minneapolis), and St. Paul, at the head of navigation on the Mississippi. became the commercial centre of the territory. Other river towns proved prosperous ports of entry from which settlers trekked to the interior, sometimes individually, sometimes by whole colonies transplanted from eastern states.

In July 1857 a convention met and drew up a state constitution, which was adopted the following October by an almost unanimous popular vote. On May 11, 1858, the state was admitted to the union with its present boundaries.

Statehood. — Minnesota supplied more than 22,000 men for the Federal armies during the Civil War. Even more important to the state than the war in the south was the defense of its frontier against the uprising of the Indians within its borders. The Sioux felt that they had been deceived and outdone in the treaty of 1851. In 1858 their small reservation was halved and most of the payment went to the traders. Many of the natives resented the government's attempts to make them farmers.

When in the summer of 1862 there was delay in the payment of annuities, bands of the Sioux suddenly began to massacre the settlers in the Minnesota valley. These attacks continued with increasing fury (more than 350 whites losing their lives) until forces under Gen. Henry H. Sibley decisively defeated the Indians under Little Crow. their principal leader, at Wood lake. Three days later 269 white captives were released. Many of the Sioux fled into the Dakota country, but expeditions under Sibley in 1863 and Gen. Alfred Sully in 1863 and 1864 marched against them and drove them beyond the Missouri.

The coming of peace marked the beginning of a new period of rapid growth, the federal census of 1870 showing a population of 439,706 or a gain of 155.6% in ten years. During the same decade railway construction, which had begun with a line between St. Paul and St. Anthony in 1862, reached close to 1,000 mi. The period 1870–80 was one of great discontent among the farmers, and one expression of their feeling was their opposition to certain widespread abuses of the railroads.

A number of regulatory laws, usually called the "Granger acts," passed the legislature. Cases arising out of these acts, and carried to the U.S. supreme court, which decided against the railroads, had far-reaching results in establishing principles of public regulation of common carriers. The railways themselves suffered severely in the panic of 1873, and the farmers were troubled by severe and repeated grasshopper invasions that destroyed the crops over large areas. Despite these setbacks, Minnesota's population increased 77.6% in the decade from 1870 to 1880; settlements spread over the prairies of the west and southwest and down the Red river valley. Many of the newcomers were Scandinavian and German immigrants. Wheat became the great crop of the prairies.

In the north the forests were falling under the organized attack of great lumber companies. Agricultural conditions revived, railroads again were being built, and the basis was laid for steady growth in the following decades.

In 1884 the mining of iron ore was begun on the Vermilion range and in 1890 and 1891 the much larger deposits of the Mesabi range were discovered. With the opening of the Cuyuna range in 1911, Minnesota became the source of most of the United States' iron ore. (X.)

Lumbering, flour milling and iron mining were major forces affecting Minnesota's economy in the 19th century and contributed to its industrial and urban development. But other factors were also involved. The combination of agricultural products and fine transportation facilities led to the growth of South St. Paul and Austin as meat-packing centres. The quarries of the St. Cloud area contributed to the growth of the "Granite city." International Falls developed around a by-product of the lumber industry, the manufacture of paper.

During the century from 1850 to 1950 Minnesota's population increased from 6,077 to 2,982,483. By the latter year, more than half of the state's people lived in the three large metropolitan areas of Minneapolis, St. Paul and Duluth.

Minnesota's political experience has been coloured by the rise of a number of strong third parties within the state, and these movements left a heritage of independence that characterizes the voting habits of the people. While the first state officials were Democrats, the Republican party took office in 1860 and remained dominant for a generation thereafter. Challenges from the Democrats and Populists increased toward the end of the century, and in 1898 John Lind, a Democrat, won the governorship. Between

1900 and 1930 Republicans were again in the ascendancy, although their control was less absolute than before. The post-Civil War tradition of the agrarian crusade led by Oliver H. Kelley, founder of the National Grange (*q.v.*), and Ignatius Donnelly was continued in the 20th century by another Minnesotan, **A.** C. Townley. In 1915 he organized the Nonpartisan league, and for some years it was a strong influence in the politics of the middle west. Another of the league's leaders was Charles A. Lindbergh, Sr., who helped found the Farmer–Labor party after World War I. This party elected Floyd B. Olson governor in 1930 and the party held that office until 1938 when the Republicans returned to power under the leadership of Harold E. Stassen. The Republican party held the governorship for 16 years. A merger of the Democratic and Farmer–Labor parties, effected in 1944, was successful in electing a governor—Orville L. Freeman—in 1954. Governor Freeman won re-election in 1956 and 1958. In 1960 he was defeated by Republican Elmer L. Andersen.

In presidential elections, Minnesota supported every Republican candidate between 1860 and 1928, except in 1912 when Woodrow Wilson received more votes than William Howard Taft. In the elections of 1932 through 1948 and in 1960 Minnesota was Democratic. but in 1952 and 1956 Dwight D. Eisenhower carried the state for the Republicans.

GOVERNMENT

The constitution adopted on Oct. 13, 1857, was frequently amended. A proposed amendment must be approved by a majority of the votes cast at a general election. The legislature is composed of two houses, the senate (67 members) and the house of representatives (131 members), members of the former being chosen for four years and of the latter for two years. The legislature passed a reapportionment bill in 1959, the first such action since 1913. The executive department is made up of a governor, lieutenant governor, secretary of state, treasurer and attorney general, all elected for two years, and an auditor elected for four years.

In 1939 state departments and agencies, with a few exceptions, were placed under the department of administration, constituted as a staff agency of the governor, in all matters pertaining to budgeting and finances, purchasing and contracting, and the care and custody of state properties.

The governor has the power of veto, but any bill he fails to return within three days, if the legislature is still in session, becomes law without his signature. A two-thirds vote of each house is necessary to override the veto. The lieutenant governor presides over the senate and succeeds the governor in case of the latter's death.

Two significant constitutional amendments won approval at the polls in 1958; a "home rule" amendment, which encouraged and strengthened home rule and self-government in local communities; and the "four-year term" amendment, which put four-year terms (in contrast with the existing two-year terms) into effect in 1963 for five chief state offices (governor, lieutenant governor, secretary of state, attorney general and treasurer).

The supreme court consists of a chief justice and six associate justices, each elected for a term of six years. There are also 10 judicial districts, each with a district court presided over by from 3 to 14 elective judges. Every county has a probate court, while for the general administration of local justice there are municipal courts and justices of the peace.

POPULATION

Minnesota is thought of as a state of Scandinavians, and in fact it probably does owe more to Scandinavians than to any other one national group. During the 1880s, when the flood of immigration was at its height, Scandinavians made up half of the foreign-born in the state. Early Swedish immigration was attributed in part to the writings of Peter Cassell, whose series of American letters published in local Swedish newspapers after his settlement in Iowa in 1846 had enormous circulation. The original Swedish immigrants were farmers, and they settled immediately on the land, their main stronghold being in east-central Minnesota. Norwegians originally tended to work in the lumbering industry, then turned to farming in the Red river valley and in the southeastern counties. Danish settlers were chiefly responsible for Minnesota's success as a dairying state. Germans were among the earliest of the national groups to come to the state, and between 1890 and 1900 they led in numbers of immigrants. Finns, Poles and Czechs make up the other largest national groups. The 1850 census enumerated 39 Negroes; in 1930 the number was 9,445, and in 1950 it was 14,022.

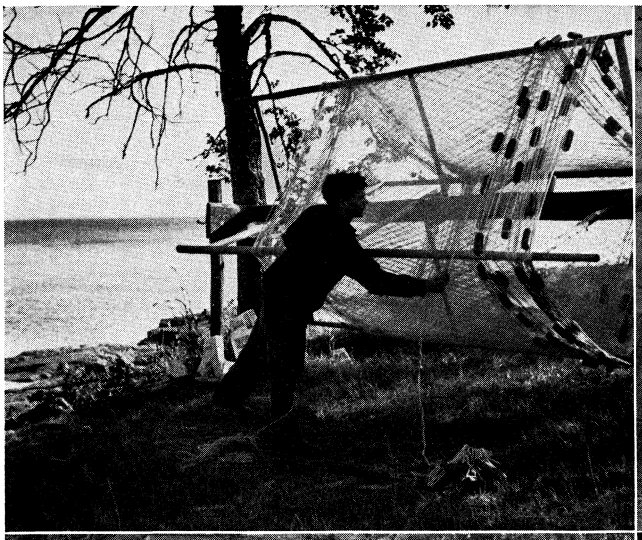
The population of Minnesota in 1850 was 6,077; in 1880 it was 780,773; in 1910, 2,075,708; in 1940, 2,792,300; in 1950, 2,982,-483; and in 1960 it was 3,413,864, an increase of 12.6% over the population in 1950. The population per square mile in 1960 was 40.6, as compared with 49.6 for the U.S.

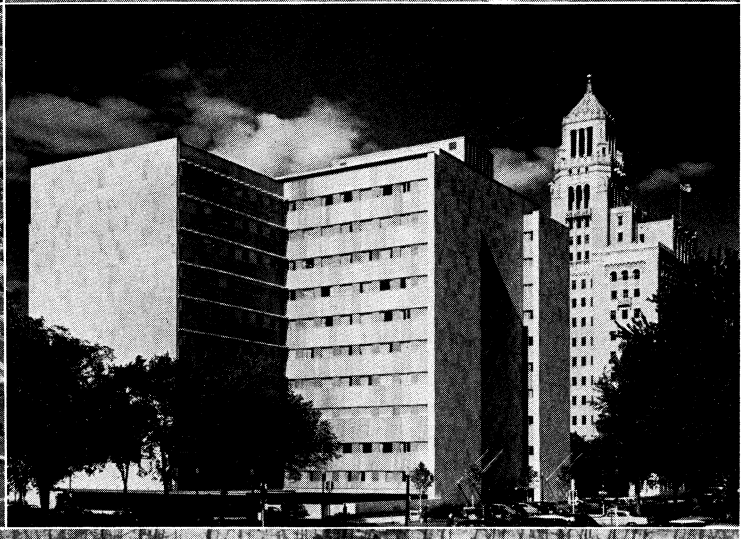
Of the 1960 population, 62.2% lived in incorporated places of

*Minnesota: Places of 5,000 or more Population (1960 census)**

Place	Population				
	1960	1950	1940	1920	1900
Total state	3,413,864	2,982,483	2,792,300	2,387,125	1,751,394
Albert Lea	17,108	13,545	12,200	8,056	4,500
Alexandria	6,713	6,319	5,051	3,388	2,681
Anoka	10,562	7,396	6,426	4,287	3,769
Austin	27,908	23,100	18,307	10,118	5,474
Bemidji	9,958	10,001	9,427	7,086‡	2,183
Blaine	7,570	3,604	921‡	550‡	374‡
Bloomington	50,498	9,902‡	3,647‡	1,330	1,085‡
Brainerd	12,898	12,637	12,071	9,591	7,524
Brooklyn Center	24,356	4,284	1,870	788	1,232♀
Brooklyn Park	10,197	3,065§	1,334§	948§	1,232♀
Chisholm	7,144	6,861	7,487	9,039	—
Cloquet	9,013	7,685	7,304	5,127	3,072
Columbia Heights	17,533	8,175	6,035	2,968	123
Coon Rapids	14,931	—	—	—	—
Crookston	8,546	7,352	7,161	6,825	5,359
Crystal	24,283	5,713	2,373	814	750δ
Detroit Lakes†	5,633	5,787	5,015	3,426	2,060
Duluth	106,884	104,511	101,065	98,917	52,969
East Grand Forks	6,998	5,049	3,511	2,490	2,077
Edina	28,501	9,744	5,855	1,833	749
Ely	5,438	5,474	5,970	4,902	3,717
Eveleth	5,721	5,872	6,887	7,205	2,752
Fairmont	9,745	8,193	6,988	4,630	3,040
Falcon Heights	5,927	3,884	4,777¶	1,562¶	1,076¶
Faribault	16,926	16,028	14,527	11,089	7,868
Fergus Falls	13,733	12,917	10,848	7,581	6,072
Fridley	15,173	3,796	1,392‡	533‡	443‡
Golden Valley	14,559	5,551	2,048	830	680
Grand Rapids	7,265	6,019	4,875	2,914	1,428
Hastings	8,965	6,560	5,662	4,571	3,811
Hibbing	17,731	16,276	16,385	15,089	2,481
Hopkins	11,370	7,595	4,100	3,055	—
Hutchinson	6,207	4,690	3,887	3,379	2,495
International Falls	6,778	6,269	5,626	3,448	—
Litchfield	5,078	4,608	3,920	2,790	2,280
Little Falls	7,551	6,717	6,047	5,500	5,774
Mankato	23,797	18,809	15,654	12,469	10,599
Maplewood	18,519	—	—	—	—
Marshall	6,681	5,923	4,590	3,092	2,088
Mendota Heights	5,028	2,107‖	1,360‖	757‖	813‖
Minneapolis	482,872	521,718	492,370	380,582	202,718
Minnetonka	25,037	11,896‡	6,466‡	2,298‡	1,083‡
Montevideo	5,693	5,459	5,220	4,419	2,146
Moorhead	22,934	14,870	9,491	5,720	3,730
Mound	5,440	2,061	1,189	393	—
Mounds View	6,416	—	—	—	—
New Brighton	6,448	2,218	658	368	350
New Ulm	11,114	9,348	8,743	6,745	5,403
Northfield	8,707	7,487	4,533	4,023	3,210
North Mankato	5,927	4,788	3,517	1,840	939
North Saint Paul	8,520	4,248	3,135	1,979	1,110
Orono	5,643	4,863‡	2,780‡	1,159‡	1,086‡
Owatonna	13,409	10,191	8,694	7,252	5,561
Pipestone	5,304	5,269	4,682	3,325	2,536
Plymouth	9,576	5,813‡	2,989‡	1,275‡	1,164‡
Red Wing	10,528	10,645	9,962	8,637	7,525
Richfield	42,523	17,502	6,750	2,411	1,537‡
Robbinsdale	16,381	11,289	6,018	1,369	520
Rochester	40,663	29,885	26,312	13,722	6,843
Roseville	23,997	6,437	4,777¶	1,562¶	1,076¶
St. Anthony	5,084	1,406	607‡	134‡	93‡
St. Cloud	33,815	28,410	24,173	15,873	8,663
St. Louis Park	43,310	22,644	7,737	2,281	1,325
St. Paul	313,411	311,349	287,736	234,698	163,065
St. Peter	8,484	7,754	5,870	4,335	4,302
Shakopee	5,201	3,185	2,418	1,988	2,047
Shoreview	7,157	—	—	—	—
South St. Paul	22,032	15,909	11,844	6,860	2,322
Stillwater	8,310	7,674	7,013	7,735	12,318
Thief River Falls	7,151	6,926	6,019	4,685	1,819
Virginia	14,034	12,486	12,264	14,022	2,962
Waseca	5,898	4,927	4,270	3,908	3,103
West St. Paul	13,101	7,955	5,733	2,962	1,830
White Bear Lake	12,849	3,646	2,858	2,022	1,288
Willmar	10,417	9,410	7,623	5,892	3,409
Winona	24,895	25,031	22,490	19,143	19,714
Worthington	9,015	7,923	5,918	3,481	2,386

*Populations are reported as constituted at date of each census. †Known as Detroit, prior to 1940. ‡Township. §Brooklyn township, which includes the population of Brooklyn Park. ‖Mendota township, which includes the population of Mendota Heights. ¶Rose township, which includes the populations of Falcon Heights and Roseville. ♀Brooklyn township, which includes the populations of Brooklyn Center and Brooklyn Park. δCrystal Lake township, which includes the population of Crystal.
Note: Dash indicates place did not exist during census, or data not available.



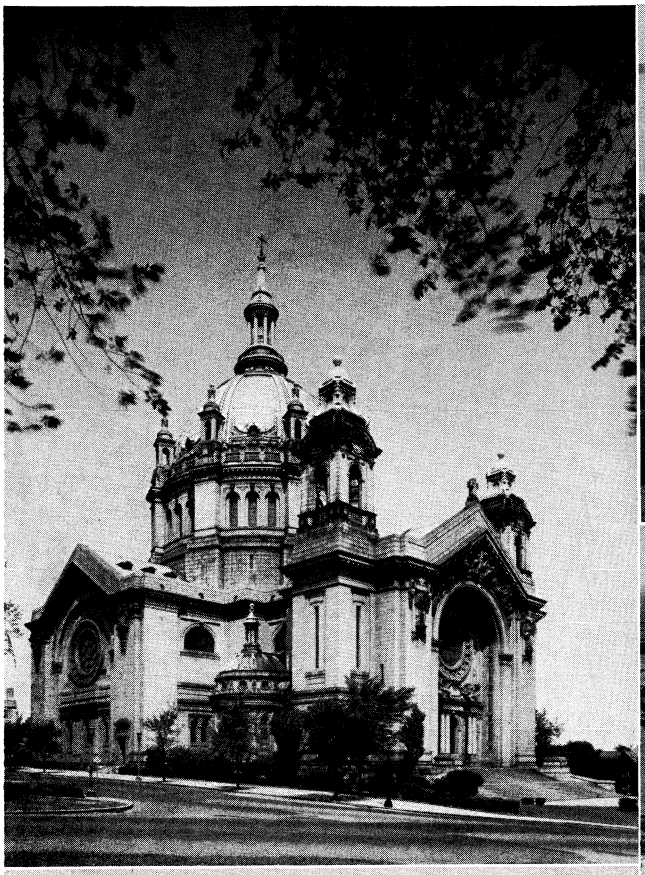


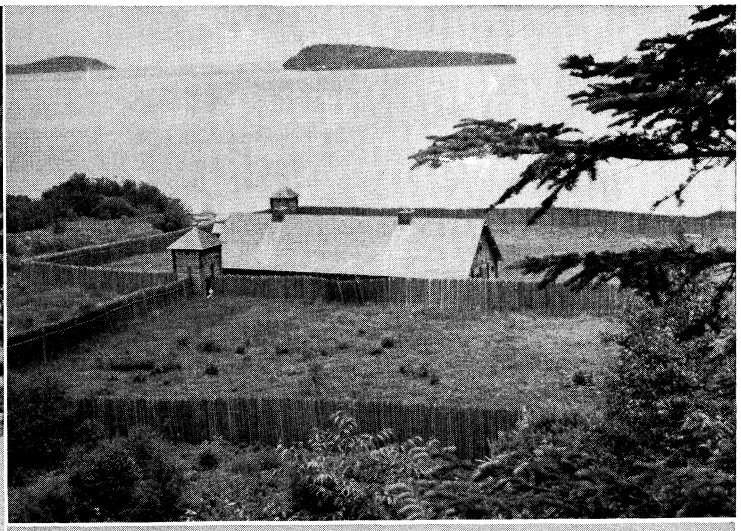
BY COURTESY OF (TOP LEFT) STANDARD OIL CO. (NEW JERSEY), (CENTRE LEFT) MINNEAPOLIS CHAMBER OF COMMERCE, (BOTTOM) MINNESOTA DEPARTMENT OF CONSERVATION; PHOTOGRAPHS (TOP RIGHT) KAUFMANN & FABRY COMPANY, (BOTTOM) WALTER H WETTSCHIECK

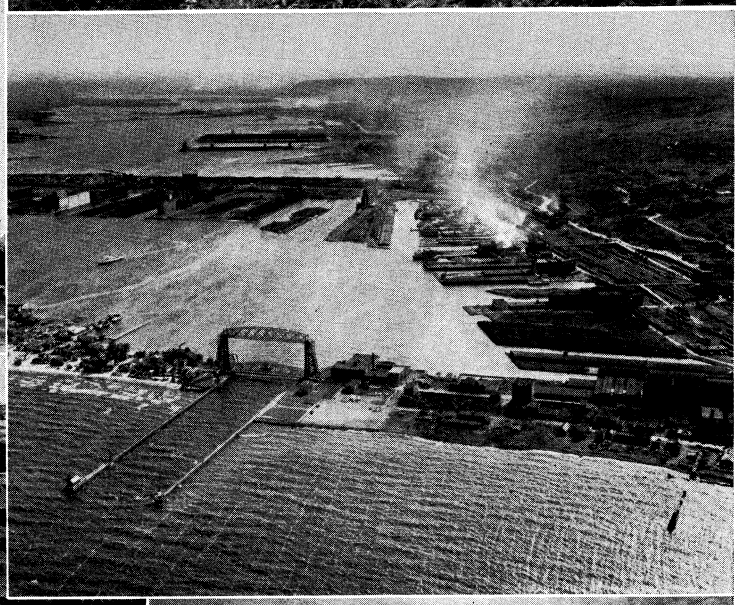
VIEWS OF MINNESOTA

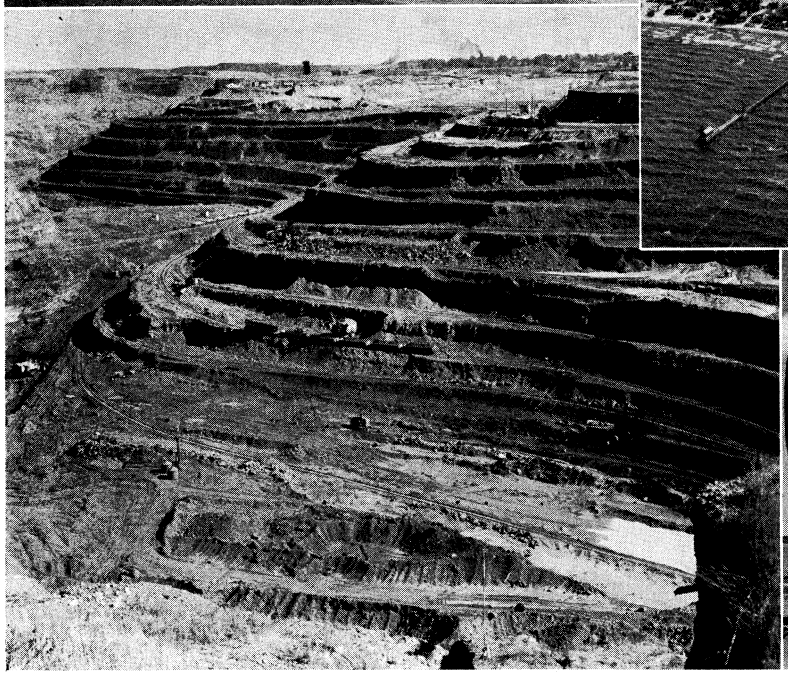
Top left: A fisherman mending his nets along the shore of Lake Superior
Top right: Contour planting on a Minnesota farm
Centre left: Milling district of Minneapolis on either side of the Mississippi river
Centre *right:* The Mayo clinic, medical centre at Rochester
Bottom: An elk herd at Red Lake game refuge, northern Minnesota

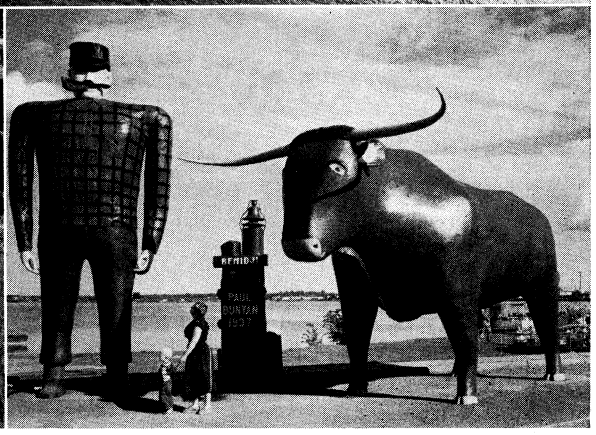
MINNESOTA











BY COURTESY OF (TOP RIGHT) MINNESOTA PUBLICITY DIVISION, (BOTTOM LEFT) STANDARD OIL CO. (NEW JERSEY); PHOTOGRAPHS: (TOP LEFT) AUTHENTICATED NEWS, (CENTRE RIGHT) FAIRCHILD AERIAL SURVEYS, INC., (BOTTOM RIGHT) DAVID CORSON—A. DEVANEY, INC.

SCENES IN MINNESOTA

Top left: Cathedral of St. Paul's, St. Paul
Top right: Reconstructed stockade at Grand Portage, a fur trading centre of northern Minnesota at the end of the 18th century. Rebuilt in 1937–38, made a national monument in 1958
Centre right: Aerial view of the harbour at Duluth
Bottom left: The Hull-Rust-Mahoning open-pit iron ore mine at Hibbing. This mine, started in 1895, is one of the largest open-pit iron mines in the world
Bottom right: Statues of the legendary hero Paul Bunyan and Babe, his blue ox, at Bemidji

2,500 or more, as compared with 53.9% in 1950 and 49.8% in 1910, when these places constituted the urban area. The state has 3 standard metropolitan statistical areas, which are Duluth-Superior, Fargo-Moorhead, and Minneapolis-St, Paul. These areas had a total population of 1,864,653 or 54.6% of the total population of the state in 1960. The population of the state was distributed by colour and nativity in 1950 as follows: 92.0% native white; 7.0% foreign-born white; and 1.0% non-white. Of the foreign-born white, about half were born in Sweden, Norway and Germany.

There were 100.1 males per 100 females in the native white population and 118.2 in the foreign-born; 9.5% of the popuiation mas 65 years old or over; and 57.0% of the population 14 years old and over was in the labour force. Of the total number of employed males, 28.1% was engaged in agriculture, 7.3% in construction and 27.0% in transportation, trade and public utilities.

EDUCATION

General supervision of the state public-school system is the responsibility of the state department of education, and control of the department is vested in a nonsalaried board of education, consisting of seven representative citizens appointed by the governor and approved by the senate. The board's powers are exercised through the state commissioner of education, whom it elects.

As soon as the required standards are met the department metes out state aid in a certain fixed proportion. In addition, there is supplemental aid designed mainly to help the less affluent school districts. There are about 3.000 elementary schools in Minnesota and 670 accredited secondary schools, with a total enrollment of about 650,000. Nearly 30,000 teachers are employed in the public schools, and total state and local expenditures for elementary and secondary education amount to more than $300,000,000 annually. There are a number of junior colleges. Teachers are trained at the college of education at the University of Minnesota and its branches at Duluth and Morris, and at the five state colleges in Mankato (founded 1867), St. Cloud (1869), Moorhead (1887), Bemidji (1913) and Winona (1858).

The largest of the institutions of higher learning is the University of Minnesota, nhich enrolls about 26,000 full-time students yearly. The university was established under the Territorial act in 1851 and began instruction in 1869. It grants degrees on its three campuses at Minneapolis. St. Paul and Duluth, and is governed under its state charter by a board of regents, 12 citizens of the state elected by the legislature. The university's colleges include: the college of science, literature and the arts, the general college (for general education), the Institute of Technology (including a college of engineering, school of architecture, school of chemistry and school of mines and metallurgy), the college of agriculture, forestry and home economics, the college of education, the school of dentistry, the school of nursing, the medical school, the school of public health, the school of business administration, the law school, the college of pharmacy, the school of veterinary medicine, the university college and the graduate school. The university also conducts schools of agriculture of less than college grade, a teacher-training junior-senior high school, a six-year elementary school and a nursery school and kindergarten. It offers extension and correspondence courses in a wide variety of subjects. The Mayo foundation for graduate study and research in the medical sciences works in co-operation with the Mayo clinic at Rochester. The university library numbers about 2,000,000 volumes.

Privately supported colleges of liberal arts are Carleton (founded 1866) and St. Olaf (Evangelical Lutheran; 1874) in Northfield; Gustavus Adolphus (Augustana Evangelical Lutheran; 1862) in St. Peter; Hamline university (Methodist; 1854), Macalester (United Presbyterian; 1885), St. Thomas (Roman Catholic; 1885) and St. Catherine (Roman Catholic; 1905) in St. Paul; Augsburg (Lutheran Free; 1869) in Minneapolis; St. John's (Roman Catholic; 1857) in Collegeville; St. Benedict (Roman Catholic; 1913) in St. Joseph; St. Mary's (Roman Catholic; 1913) and Saint Teresa (Roman Catholic; 1907) in Winona; Concordia (Evangelical Lutheran; 1891) in Moorhead; and St. Scholastica (Roman Catholic; 1912) in Duluth.

HEALTH AND WELFARE

The department of public welfare supervises the county welfare programs, which serve more than 100,000 persons. It also maintains numerous institutions, including hospitals for the treatment of the mentally ill, schools for the mentally deficient, sanatoriums for tubercular patients, a school for the blind, a school for the deaf and a hospital for inebriates. The department of corrections, created by the 1959 legislature, operates a division of adult corrections and a division of youth conservation. The former administers a program for the custody, treatment and training of ofienders committed by the courts to the state prison at Stillwater, the state reformatory for men at St. Cloud and the state reformatory for women at Shakopee. The division of youth conservation maintains a program for the diagnosis, custody and rehabilitation of youths under the age of 21 who have been adjudged delinquents or criminal offenders. It administers a state training school for girls at Sauk Centre, a state training school. for boys at Red Wing and three forestry camps for boys at different locations in the state. The department of employment security assists people to find employment and pays unemployment insurance.

A state board of health, created in 1872. functions through seven divisions: disease prevention and control, medical laboratories, local health administration, environmental sanitation, special services, hospital services and administration.

ECONOMY

Agriculture. — Minnesota has been pre-eminently an agricultural state (though manufacturing is slowly replacing agriculture as the chief source of income). The annual income of nearly $1,500,000,000 in the early 1960s from sale of crops, livestock and livestock products placed Minnesota fifth or sixth among the states in this respect. In production of farm crops Minnesota ranks second among the states in oats, third in corn and fourth in hay; it ranks high also in soybeans, flaxseed, green peas, barley, rye, sugar beets and potatoes. Approximately 22,500,000 ac. are devoted to the cultivation of crops. Apples are the only fruit crop raised commercially to any extent.

The value of all livestock and poultry on farms approximates $675,000,000; horses number about 60,000, cattle about 4,000,000 (including approximately 1,500,000 milk cows), sheep nearly 1,000,000 and hogs about 3,200,000. Minnesota is one of the great dairy states, leading all the states in butter production (about 400,000,000 lb. annually) and producing also 10,000,000 lb. of milk and about 9,000.000 lb. of cheese. Farmers' co-operative creameries were largely responsible for the growth of dairy product marketing.

Total area in farms is about 33,000,000 ac., with an average farm size of nearly 200 ac.

Mining. — Minnesota leads the nation in the production of iron, producing 65% of all iron ore mined in the United States. The ore comes from three districts, the Vermilion, Mesabi and Cuyuna ranges, named in the order of their discovery and development, all lying in the northern part of the state. About 90% of the ore comes from the Mesabi range; from the first shipment of ore from this range in 1892 to 1950, the Mesabi contributed about 1,500,000,000 tons of high-grade ore. An estimated 1,500,000,000 tons of merchantable ore remains deposited in the three ranges. A great deal of the mining is of the open-pit character. Steam shovels in the mines load the ore on trains that run directly to the docks at Two Harbors or Duluth, where steamers wait to carry it to the steel mills at Chicago, Gary or Erie.

After World War II the production of taconite (*q.v.*) developed rapidly in hlinnesota, a commercially feasible concentration process making possible the utilization of low-grade ore. The taconite industry, involving both mining and manufacturing, gave new economic life to northeastern Minnesota. and the state's taconite reserves have been estimated at 24,000,000,000 tons.

The remainder of the state's mineral output is made up largely

of quarry products. Minnesota has extensive deposits of granite, limestone, jasper, sandstone, travertine, mica, feldspar and clay. The state ranks third in the production of granite with St. Cloud as the centre of this industry.

Lumbering.— During the years following the Civil War, the pine forest resources of the state were intensively exploited. Minneapolis and Duluth owed their rapid growth in the 1870s and 1880s in part to the milling and shipping of lumber. In 1905 production of lumber reached its peak with the cutting of 2,000,000,000 board feet of timber. By then the area's magnificent stands of white pine were nearly depleted and the industry declined rapidly. The mid-20th century saw the state's forest industries rise again, with the production of pulpwood, Christmas trees and other wood products. Scientific forestry practices and new uses for the less valuable timber created by modern manufacturing processes resulted in a larger annual income than was ever obtained from the original forests.

There are two national forests in the state, Superior and Chippewa, with a combined area of more than 4,000,000 ac., and 34 state forests with a combined area of 5,500,000 ac.

Manufactures.— Throughout most of its existence, Minnesota has been predominantly an agricultural state. In the mid-20th century, however, its industrialization accelerated, and by 1950 the dollar value of manufactured products exceeded cash farm receipts for the first time in the state's history, Nearly 225,000 persons are employed in manufacturing at wages totaling about $975,000,000 annually. First in order of importance is the food industry, including meat slaughtering and packing (concentrated largely in South St. Paul and Austin), grain and feed mills and manufactured dairy products. Minneapolis has long been a principal centre of the flour-milling industry for the Cnited States, and accounts for much of the manufactured output of grain and feed in the state. Water power from the Falls of St. Anthony was the chief factor for Minneapolis taking the lead in milling. By 1870 twelve mills were operating at the falls, and the industry continued to expand until 1916. Thereafter it declined, though remaining very important. The great grain elevators are a feature of the Minneapolis sky line.

The second largest manufacturing industry is that of machinery (other than electrical) and following that in importance are printing, publishing and allied products; chemical products; pulp, paper and allied products; and fabricated metal products.

Growth in development of electric power was tremendous in the period following World War II. The two chief sources were steam power and water power, with a smaller amount derived from internal combustion. The state's first atomic power plant, constructed at Elk river by the Rural Cooperative Power association in co-operation with the Atomic Energy commission, began to provide electricity for co-op members in 1960. Three types of suppliers of electricity—power companies, municipally owned utilities and rural electric co-operatives—operate in Minnesota. Almost all occupied dwellings in the state are serviced by electricity.

Transportation and Communications.— Minnesota is well provided with transportation facilities by water, air and land. Duluth stands at the head of the Great Lakes, and through its port pass most of the iron ore extracted from the Minnesota mines and a large share of the grain grown in the northwest. It is also a receiving port and distributing point for coal and other products for the area. In gross shipping tonnage Duluth ranks second only to New York city. Several railways connect with Chicago while others reach out into the wheat lands of the Dakotas, Montana and western Canada. At the head of navigation on the Mississippi stand St. Paul and Minneapolis.

River transportation was developed early in the state's history, the first steamer reaching Ft. Snelling in 1823, and it continues to be important in Minnesota's transportation system. In 1930 a nine-foot channel on the Mississippi river with attendant locks and dams was opened to traffic, and after that time barge traffic increased steadily. By the early 1960s about 7,000,000 tons of freight were shipped annually on the Mississippi and its tributaries in Minnesota, as compared with 2,500,000 tons in 1949.

Minnesota's first railroad was completed between St. Paul and St. Anthony in 1862 by the St. Paul and Pacific, the road that was reorganized under the leadership of James J. Hill in 1878 and eventually became the Great Northern. From the older centres in Minnesota, tracks reached out to the west, north and south. The Northern Pacific, the first road to connect the state with the Pacific coast, was completed under the guidance of Henry Villard in 1883. By the 1960s Class I railroads in Minnesota operated approximately 8.500 mi. of track.

Air travel is of significance in the state, numerous communities being served by airlines. An amendment to the state constitution passed in 1944 made available state funds to assist municipalities in improving airports; federal funds also are available. A unique feature of the state's aviation activity concerns the wilderness area of Superior National forest. Fear that the increasing number of flights into the area would destroy its wilderness character led the state legislature in 1949 to take steps to control air activity, and in Dec. 1949 an executive order issued by Pres. Harry S. Truman banned flights over Superior National forest wilderness area beginning Jan. 1, 1951.

The state trunk highway system includes 12,000 mi. of mostly paved roads. All highways and roads total almost 125,000 mi. Annual disbursements for the trunk highway system were increased more than 500% in the decade beginning 1950, from $43,000,000 to approximately $242,000,000. Building and maintenance of the trunk highways was financed by taxes on motor vehicles and gasoline, bond issues and federal aid. The trunk system is kept open for motor travel all winter.

There are 29 daily and more than 300 weekly and semiweekly newspapers in Minnesota. The Minnesota Newspaper association was founded in 1867; though its membership includes all of the state's newspapers, it is primarily the voice of the weekly press.

Commercial radio broadcasting began in Minnesota in 1922 with station WLAG (forerunner of WCCO); network broadcasting came to the state in 1925. By the early 1960s there were 63 AM radio stations, 12 of which were in the Twin Cities and 3 in Duluth-Superior. There were also five FM stations. KSTP began experimenting with television cameras in 1939 and brought telecasting to the state on April 27, 1948. By 1960 there were one educational and ten commercial television stations.

Private experimental telephone lines were run to the Twin Cities in 1877, and the following year the Northwestern Telephone company was operating in Minneapolis. Numerous independent companies sprang up, some of them using the rapidly improving Bell equipment. Eventually, the majority of the companies were consolidated into the Northwestern Bell Telephone company, a subsidiary of the American Telephone and Telegraph company. However, a few independent telephone companies still operate in the rural areas of the state.

See also references under "Minnesota" in the Index volume.

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Current statistics on production, employment, industry, etc., may he obtained from pertinent state departments; the principal figures, together with current history, are summarized annually in *Britannica Book of the Year,* American edition. (R. W. F.)

MINNESOTA, UNIVERSITY OF, an institution of higher learning with campuses at Minneapolis, St. Paul and Duluth. Minn., was established under the 'Territorial act in 1851 and began instruction in 1869 *(see* MINNESOTA: *Education).*

MINNOW, in North America the name given to a variety of small fishes; especially cyprinids (shiners, for example), mud minnows (family Umbridae) and killifishes (Cyprinodontidae); also, in a general way, to the young of many kinds of large fishes. Phoxinus *phoxinus,* of the carp family (Cyprinidae), is the minnow of Europe and northern Asia; it is distinguished from the dace and chub, allied cyprinids, by its small scales. A length of three or four inches is usual, but specimens seven inches long are known. In New Zealand and Tasmania fishes of the family Galaxiidae are called minnows.

Mud minnows are related to the pike, from which they differ in having uniformly small, weak teeth. They live in mud or among weeds of sluggish streams and ponds. Among the killifishes! the top minnow, or mosquito fish (*Gambusia affinis*) is the best known. It occurs naturally in lowland marshes, pools and lagoons of the south Atlantic and Gulf regions of the United States. It bears live young and is exceedingly prolific. This fish is so effective as a destroyer of mosquito larvae that it has been widely introduced to control mosquitoes. Anglers use all kinds of minnowlike fishes as bait. (L. A. WD.)

MINOAN LINEAR SCRIPTS. This term denotes the well-developed varieties of writing used by certain Aegean civilizations (*q.v.*) during the 2nd miliennium B.C. Like other early writing systems in the near east (see CUNEIFORM), this Minoan-Mycenaean type of script had its beginnings in pictography, originating on the island of Crete *(see* CRETE: *Archaeology).* There is no conclusive evidence for more remote outside origin or inspiration. though the latter is an a priori assumption with those scholars who believe in the monogenesis (single origin) of all writing.

Origins.— The origins of this script are seen on stone seals dating from the Middle Minoan period (beginning c. 2000 B.C.), found on the surface in different parts of Crete. and in early archaeological strata of the palace sites, notably Cnossus and Phaistos. The latter contain seal impressions in clay and tags or tablets of the same material which served the practical purpose of identification. The pictographic origin is still clearly visible in the signs at this hieroglyphic stage (*e.g.,* a double axe, an eye, a cat's head). Yet compared with the complicated word-syllabic stage of Egyptian, Mesopotamian. "Hieroglyphic Hittite," and other early systems, with their mixtures of ideographic and phonetic values of signs. classifiers and complements, Minoan writing early developed an everyday practicality; already the hieroglyphs were so limited in number that they indicate the emergence of a rudimentary but purely syllabic method for the phonetic rendering of proper names. A system of ideograms was restricted to a standard shorthand for objects listed on the tablets, accompanied by numerals and fractions; such ideograms were apparently never confused with syllabic writing. An isolated exception to this ancient practice is found on the so-called Phaistos disk, covered with pictographic clay impressions made from niovable types; but it is uncertain that this unique find is truly Cretan, and not an import from Asia Minor.

Linear A.—The finds are rather limited in scope and length; both writing and language remain undeciphered. About 1700 B.C. a more advanced cursive system of writing began to displace the hieroglyphs in Crete; in some archaeological strata the two systems are found side by side. The later system. called "Linear A," occurs at many Cretan sites, but the documents are not numerous; they come from Cnossus. Phaistos. Palaikastro, Mallia, Gurnia. Tylissos and elsewhere. The largest find was made at Hagia Triada (well over 150 page-shaped clay tablets and seals), dating from the Late Minoan period (*c.* 1450 B.C.). Despite the spare range of the texts. Linear A tablets appear to record one and the same language (conjectured to be Minoan or Eteo-Cretan), at least to judge from recurring combinations of the same signs in various localities. The comparatively large uniform corpus of Hagia Triada has about 75 syllabic signs, many of which evidently are partly cursive equivalents of related hieroglyphic forms. The narrow oblong tablets necessitated frequent word-division from line to line, and a raised dot was used as a separator between words. The direction of writing, which varied in the hieroglyphs, ran uniformly from left to right. The system of ideograms continued the hieroglyphic tradition, but it also admits the ideographic use of signs otherwise syllabic, probably by may of an acrophonic abbreviation using the initial syllable of corresponding words. Several phonetic signs might be joined into a complex monogram on the same principle, and phonetic ligatures were added to the ideograms proper. The ideograms were followed immediately by signs for numerals and fractions which differ from the corresponding hieroglyphic signs.

Linear B.—The Linear B script belonged entirely to the Late Minoan period. Sir Arthur Evans found over 3.000 tablets or fragments in the latest (*i.e.,* most recent) stratum at Cnossus at the date of its destruction (c. 1400 B.c.), but not a single trace of Linear B has been discovered elsewhere in Crete. The script was used primarily on the Greek mainland during the chronologically parallel Late Helladic era. The largest corpus came from the site of Pylos in Messenia, where between 1939 and 1958 Carl Blegen excavated well over 1,000 tablets, many of considerable length and in an excellent state of preservation. Mycenae yielded over 50 tablets during the 1950s. Linear B is found also in inscriptions on jars and pots from Tiryns, Mycenae, Eleusis. Boeotian Orchomenus and, especially, Thebes.

There is no trace of monumental writing anywhere in the Minoan-Mycenaean orbit. Linear' B, like its exclusively Cretan predecessor, served mainly for perishable records and inventories of royal palaces and commercial establishments. These temporary

clay tablets (some of them of palm leaf shape, with long lines of text) were preserved by being baked in the conflagrations which destroyed the storerooms. Linear B contains 87 different syllabic signs, of which more than half correspond closely in shape to those of Linear **A,** while one third have no recognizable equivalents. The ideograms and numerals are quite close to the Linear A pattern, but the system of weights and measures contains distinctive signs for fractional quantities. placed after the ideograms but before the numerals; although several signs are obviously related in form to signs for fractions in Linear A, the very system represents a striking departure from the earlier method of reckoning. It might be said that in Linear A the commodities are measured in whole numbers and successively smaller mathematical fractions of an unstated total unit, while the Linear B system measures in terms of smaller conventional units in their own right, which happen also to be fractions of a larger basic unit.

Decipherment of Linear B.—One of the great achievements of decipherment in modern times has revealed that Linear B gives the Greek language of the 14th and 13th centuries B.C. The solution advanced in 1953 by Michael Ventris (*q.v.*) was founded on the surmise that the language is early Greek, and that accordingly Cnossus must have been in the hands of Helladic mainlanders before its final destruction about 1400 B.C. In view of the earlier Minoan influence on the mainland, beginning about 1700 B.C., it is uncertain whether Linear B was adapted from the Cretan type by 1 jth-century Greeks at Cnossus, or was developed on the mainland after Cretan models. The latter is more probable, although the Cnossian corpus antedates all inscriptional evidence from the mainland. The signs generally represent open syllables like *ma,* mi, *mo;* such a system may have suited the Minoan language quite admirably, but for Greek it resulted in very awkward rules of orthography, characterized by superfluous vowels and an inability to note certain grouped or final single consonants, or to distinguish between voiceless, voiced and aspirated orders of phonemes. Thus pa-te may denote *pater* ("father") or *pantes* ("all"); such ambiguity, like the monotonous conciseness of the ledger style and the proliferation of proper names, places limitations on the results to be derived from knowledge of Linear B. Yet the impact of the decipherment has made itself felt in many classical studies.

A distant offshoot of the early Cretan scripts is the undeciphered Cypriote Linear or Cypro-Minoan type, found on a small scale in a number of baked clay tablets from Enkomi in Cyprus and Ugarit in Syria, dated from 1500 to 1100 B.C. A late development of it crops up in the Cypriote syllabary used in Cyprus for writing Greek and Eteo-Cypriote in classical times.

See M. Ventris and J. Chadwick, Documents in Mycenaean Greek (1956), with bibliography, pp. 428–433; J. Chadwick, The Decipherment of Linear B (1958). (J. PL.)

MINOR, a word used both as an adjective and as a substantive for that which is less than or inferior to another. "Minor Friars," or "Minorites," was the name (fratres *minores,* lesser brothers) given by St. Francis to the order he founded (see FRANCISCANS); "minor canons" are clergymen attached to a cathedral or collegiate church, but not members of the chapter, who read and sing the daily service. (For the distinction between holy and minor orders see article MINISTRY, THE CHRISTIAN.) The name "minor prophets" is used collectively of the 12 books of the Old Testament from Hosea to Malachi inclusive. For "minor premise" in Logic, see LOGIC: Traditional *Logic;* SYLLOGISM. In law, a "minor" is a person under legal age (see INFANT). For "minor of a determinant" in mathematics, see DETERMINANT.

In astronomy, the term "minor planets" is given to the members of the solar system which have their orbits between those of Mars and Jupiter (see ASTEROIDS). As used in music the term minor is opposed to major as indicating an interval of smaller size, a minor interval containing a semitone less than the corresponding major interval. (See HARMONY; MAJOR.)

MINORCA (Menorca), the second in size of the group of Spanish islands in the Mediterranean sea, known as the Balearic islands (*q.v.*), 27 mi. E.N.E. of Majorca. Pop. (1950), 41,506; area, 271 sq.mi. The coast is deeply indented, especially on the north, with numerous creeks and bays—that of Port Mahón (1950) 15,732 (mun.), being one of the finest in the Mediterranean. (See PORT MAHÓN.) The climate is not so equable as that of Majorca, and the island is exposed in autumn and winter to the violence of the north winds. Its soil is of very unequal quality: that of the higher districts being light. fine, and fertile, and producing regular harvests without much labour. while that of the plains is chalky, scanty. and unfit for pasture or the plough. Some of the valleys have a good alluvial soil; and where the hills have been terraced they are cultivated to the summit. The Hedysarum coronarium or *zulla,* as it is called by the Spaniards, is largely cultivated for fodder. Wine. oil, potatoes, hemp and flax are produced in moderate quantities; fruit of all kinds, including melons, pomegranates, figs and almonds, is abundant. Horned cattle, sheep and goats are reared, and small game abound. In the district of Mercadal and in Mt. Santa Xgueda are found fine marbles and porphyries; lime and slate are also abundant. Lead. copper and iron might be worked were it not for the scarcity of fuel. There are manufactures of wool, hemp and flax. A road, constructed in 1713–15 by Richard Kane, runs through the island from south-east to north-west, and connects Port Mahon with Ciudadela.

MINORITIES are groups held together by ties of common descent, language or religious faith and feeling themselves different in these respects from the majority of the inhabitants of a given political entity. On this consciousness of difference the minorities base certain political claims, either for equality with the majority, or for special treatment based upon the recognition of these differences, or for autonomy or, in the most extreme cases, separation.

In most cases minorities feel grieved by occupying an underprivileged position. But there are cases when numerical minorities are politically and economically highly privileged like the white population in the Union of South Africa and when the vast majority of the population feels aggrieved. Thus "majority" and "minority" become primarily political and not numerical concepts.

The article is divided into the following sections:

I. Origin and Nature of Minority Problems
1. Religious Minorities
2. The Age of Nationalism
3. Central Europe
4. The Russian Empire
j. Western Europe
II. World War I and its Aftermath
1. Peace Treaties of 1919
2. Europe After 1919
3. Soviet Russia
4. Central and Eastern Europe
5. Protection by League of Nations
6. Activities of Minorities
7. The Near East
III. Developments after World War II
IV. Minorities in the Americas
V. Conclusion

I. ORIGIN AND NATURE OF MINORITY PROBLEMS

Minorities have always existed, but only after the rise of democracy, in the late 18th century, did they become a serious political problem and play a great role in international relations. Modern humanitarianism and law have tried to dull the sharpness of minority conflicts by providing protection, based upon international treaties, for minorities of race, language or religion.

The origin of some of these minorities can be found not only in past conquests but also in the peaceful unions of different groups. Thus the Moslem minority in India was the result of the conquest of a large part of India by Moslem invaders. Yet this minority, differing in religion and civilization from the Hindu majority, formed itself a majority in vast areas where the Hindus were a minority intermingling with the Moslems. The Russian empire included many minorities as a result of three centuries of widespread conquests in east and west. On the other hand, the Habsburg empire was largely built up by dynastic marriages and succession rights.

Poland contained large and important minorities as a result of a peaceful union between Poland and Lithuania, when the latter included White Russian and Ukrainian populations. Other minorities originated in migratory movements. In former times rulers frequently called colonizers from abroad to settle on wasteland or to introduce new skills and trades. These settlers received special privileges and were allowed to live in closed settlements according to their own rules. Thus important German colonies were scattered in the later middle ages and in the period of the absolute monarchs throughout central and eastern Europe. Empress Catherine II of Russia settled them in the distant regions on the middle Volga river. In a somewhat similar way European traders settled in oriental communities and were there granted the privileges of extraterritoriality or, as called in the near east, capitulations. Migrations during the Industrial Revolution created minority problems in many parts of Europe and America. Still other minorities (*e.g.*, many religious minorities in the near and middle east) represent the remnants of an older civilization which has resisted the otherwise victorious progress of new religious movements.

Migration also created strongly entrenched Chinese minorities throughout southeast Asia and equally strong East Indian minorities in East Africa and Guiana.

The term minority is flexible in its application with ever fluid limits and perplexing in its political and social consequences. Oppressed minorities often and easily tend to become, at the first opportunity, oppressive majorities, yet as long as they feel themselves underprivileged, they generally appeal to the principles of liberty and humanity and tend to identify their interests with those of the freedom and peace of mankind. They insist upon respect for their own traditions and cultural pattern, irrespective of whether such an insistence forms a bar to greater progress by the preservation of obsolete ways of life.

1. Religious Minorities. — Before the beginning of the 19th century, the age of nationalism and democracy, minorities scarcely played any decisive role in national or international politics. Only religious minorities played a distinctive role during the later middle ages and especially in early modern times. when states mere often inclined to emphasize their religious homogeneity and therefore tried to eliminate all "heretics." This situation was much aggravated by the Reformation and the ensuing great religious split. Religious minorities were often treated with great severity and sometimes even forced to emigrate. The great international conflicts of the age were often interpreted as religious wars. Catholic or Protestant princes intervened on behalf of their coreligionists in alien lands. Thus Oliver Cromwell, supported by English pubiic opinion, intervened in 1655 with France for the Vaudois Protestants, a step of which John Morley wrote that "never was the great conception of a powerful state having duties along with interests more magnanimously realized." The treaty of Westphalia, 1648, tried to stabilize the situation, at least in Germany, then the classical land of conflicting religions. It confirmed for the princes of German territories the right of deciding by fiat the religion of their subjects (*cuius regio, illius religio*), reserving however in such cases the right of emigration for the dissident subjects.

The intervention in favour of religious minorities expressed itself repeatedly in international treaties. In the treaty of Ctrecht (1713–14) between Great Britain and France the liberation of the French Protestants in prison for religious causes was stipulated. More frequent were guarantees for the religious liberty of the inhabitants of territories ceded in peace treaties to powers where the majority of the inhabitants, and especially the prince, professed a religion different from that in the ceded territory. In the treaty of Oliva (1660) between Sweden, Poland and Brandenburg, the religious rights of the inhabitants of Livonia, ceded by Poland to Sweden, and of Pomerania, ceded by Brandenburg, were recognized. In the treaty of Nijmegen (1678) Louis XIV of France restored to Holland the town of Maastricht, taken by the French in 1673, reserving religious liberty in favour of the Catholic inhabitants. The same measures of safeguard were inserted in the treaty of Ryswick (1697). When Prussia acquired under King Frederick II large territories with Catholic population, Silesia from Austria in 1742, and part of western Poland in the first partition of Poland in 1772, the treaties contained provisions in the interest of the new Catholic minorities of Frederick's realm. All these provisions safeguarding religious minorities applied. however, only to limited territories as a result of territorial transfer; they did not include any principle applicable to the states as a mhole.

In the 18th century growing religious toleration ushered in an era of equal rights for religious minorities in the British empire and in western Europe. The secularization of the modern state with its separation of state and church brought this process of complete equality in religious matters to its conclusion in the 19th century, except in eastern Europe and in the orient. In the Russian empire the religious minorities remained until 1917 under various restrictions and disabilities as compared with the Orthodox Church. In Iran and other Moslem states Islam remained the dominant and privileged religion. In the Ottoman empire the non-Islamic religions were accorded a large degree of autonomy under their religious heads, and in the 19th century they received gradually equality before the law and citizenship rights European powers often acted in the 18th and 19th centuries as protectors of their coreligionists in the Ottoman empire, the Russians for the Orthodox minorities, the French and others for the Catholic minorities.

2. The Age **of** Nationalism. — While the victory of religious toleration and liberalism removed gradually the question of religious minorities from the political scene, the growth of nationalism in the 19th century and its penetration to central and eastern Europe and later to Asia created new and ever more disturbing minority problems. The German philosopher and critic of civilization Johann Gottfried von Herder (1744–1803) emphasized the importance of the mother tongue for the cultural life and grouth of the individual and his education. Under his influence many of the smaller nationalities in central and eastern Europe found their interest in their own languages and folklore rekindled and began to feel conscious of their position as linguistic and ethnic minorities in the Austrian, Russian and Turkish empires. They began to demand the recognition of their languages in the public administration of their countries; their intellectuals began to elaborate a literature in the native vernacular; and the spread of education in the 19th century carried this insistence upon language and nationality to ever wider circles. This cultural nationalism was strengthened by the message of self-determination carried by the French Revolution and spread over Europe through Napoleon's armies. It undermined the feudal dynastic structure of European society on behalf of the rights of the middle classes and the people. The insistence upon popular sovereignty replaced the supranational prince with a rising class of patriots and the supranational language of court and administration, French or Latin, with the vernacular. Historians and poets recreated a half-legendary past in uhich the peoples had supposedly played a great part. The dormant national consciousness was thus awakened, and the closer contact created by the industrial revolution, mith its improved communications and the spread of literacy, made the people more conscious of their unity as well as of their difference from groups speaking other languages or living according to different traditional patterns. The 19th century, the age of nationalism, became thus more and more the century of national minority problems. Race, religion and language began to play their roles as characteristics of the national minorities.

In central and eastern Europe, where the political and social developments lagged far behind western Europe, nationalism produced the theory that each nationality should form its own state and that each state should consist of only one nationality. Nationality, recognizable by language, was thus made to coincide, at least ideally, with the state. While the French never put forward the claim of uniting ail the French-speaking citizens of Belgium and Switzerland aithin France nor the Dutch ever demanded the incorporation of the Flemish-speaking Belgians into the Netherlands, the Germans and the Italians directed their

political energies to the union of all German- and all Italian-speaking peoples within a united Germany and Italy. Italian-speaking provinces outside the Italian peninsula were regarded as "unredeemed" (irredenta) and their movements toward "redemption" by union within a political Italian nation were called "irredentist," a word then applied to other national minority aspirations for separation from the state in which they lived. As far as Italy was concerned, after the unification of the Italian peninsula in the 1860s, the most important centres of irredentism were in Trent in Austrian South Tirol, and in Trieste, the great Austrian port.

While the Italian language minorities lived mostly contiguous with the main territory inhabited by Italian-speaking people, German language minorities were widely dispersed throughout central and eastern Europe, mostly in the midst of Slav populations. These minorities (and later on similar ones in the U.S. and especially in South America) formed the backbone of Pan-German aspirations, which wished to support the expansion of German power and the establishment of German world supremacy by making use of these minorities. In the 20th century Germans and others fostered the national consciousness of their "racial brethren" living "abroad" and tried to forestall the process of their integration with the people in the midst of whom they were living.

On the other hand many Slav people represented minorities in the four great empires of the east, Germany, Austria, Turkey and Russia. The 19th century saw the growth of independence movements among these Slav minorities which often threatened the territorial integrity of the political states in which they lived. Russia, by far the largest Slav nation and in the first half of the 19th century the only independent one, used the Slav aspirations within Austria and Turkey as an instrument of its own power aspirations; Pan-Slavism thus became a vehicle of Russian policy and mas especially used to justify Russian interference in Turkish affairs.

The original motive of religious concern for the Greek Orthodox minorities (which in addition to Slav peoples included Greeks and Rumanians) and for the Armenian Orthodox minority was not dropped but fortified through Russia's interest in its "racial brethren," the Serbs and the Bulgarians. Thus minority problems in central and eastern Europe formed in the 19th century one of the most important issues in international relations. They were the cause of the Russo-Turkish wars and of the Balkan wars; they kept alive the tension between Russia and Austria and between Austria and Italy. The fates of the Serbian minority in Austria and of the German minority in Poland were the immediate causes of World War I and World War II.

While the minorities thus played a most important role in international relations, their role in the domestic policies of central and eastern European states was scarcely less important. The revolutions of 1848, often called "the spring of the peoples," awakened the dormant nationalities of central and southeastern Europe to cultural and political consciousness. The revolution of 1905 did the same for the many more backward nationalities of the vast Russian empire. From 1821, the year of the beginning of the Greek war for independence, until the end of World War I the Turkish empire passed, as a result of minorities' pressure, through a period of progressive territorial disintegration. But it was above all the Habsburg empire which became in the later half of the 19th century the classical land of minority problems and the laboratory for attempts at their solution.

3. Central Europe. — The Compromise of 1867 divided the Habsburg empire into a western or Austrian part, and an eastern or Hungarian part. They followed different policies as regards their minorities, though the term "minorities" cannot be applied in either case in the strict sense of the word. Neither in the western nor in the eastern part was there a numerical majority, but in Hungary the Magyars, though numerically a minority, were politically in the position of a dominant majority. The Magyar language was made the only official language, except for the territory of Croatia-Slavonia which enjoyed a measure of autonomy. Government pressure was exercised to assimilate the minorities to the ruling Magyar group whose concern it was to create a purely Magyar state. The Magyars themselves lived in the centre of the country, in the fertile plains of the Danube and Tisa rivers, while around them the minorities — in the north and northwest Slovaks, in the northeast Ukrainians, in the east (Transylvania) Rumanians and in the south Croatians and Serbs — lived in compact groups. Yet even within these compact minority settlements, there were other minorities interspersed. Thus in Transylvania, among a large Rumanian majority, a Magyar minority, the so-called Szeklers, lived in the eastern part of the land, separated from the majority settlement of the Magyars, while in the south there was a German minority, the so-called Saxons. An even greater mixture of minorities was presented by the Banat in southeastern Hungary, where Magyars, Serbs, Rumanians, Germans and others intermingled, while German minorities, mostly called Swabians, were numerous in many parts of Hungary, especially in the south and the centre. The non-Magyar minorities resented being treated as subject races to an ever growing degree, especially because some of them like the Rumanians, the Serbs, the Slovaks and the Ukrainians were living in direct contact with kindred peoples beyond the frontiers of Hungary, a fact which increased the centrifugal tendencies and prepared for the disintegration of Hungary in 1918.

Similar centrifugal tendencies threatened the existence of Austria, though in its case one cannot speak of any real oppression of the minorities. Article 19 of the constitutional law of Dec. 21, 1867, provided for the equality of the different nationalities ("all nationalities in the state have equal rights") and proclaimed that every nationality had an inviolable right to preserve and promote its national character and language. Austria recognized in its fundamental laws the equality of all usually spoken languages in education, in the administration and in public life. These provisions were by far the most liberal and progressive of the period, but they were vague, and the following half century was largely filled with a conflict for the interpretation of this fundamental act, the Magna Carta of the Austrian nationalities. Fierce national struggles centred around the rights and usages of the different languages and around changes in the economic position of the different nationalities. These struggles often impeded the functioning of the Austrian parliament. Many interesting and promising attempts to solve the minority problem were made, especially in the provinces of Moravia and Bukovina, but on the whole the problem remained unsolved in Austria until under the stress of World War I the state disintegrated and its minority problems were inherited by the so-called succession states.

Of the different provinces of Austria few were inhabited by only one nationality; most of them had their minority problems. In Bohemia, Moravia and Silesia there were Czechs and Germans, in the latter also Poles. In Styria and Carinthia Germans and Slovenes lived side by side; in the territories along the Adriatic coast Italians and Slovenes mingled in the north, Croats and Italians in the south. Southern Tirol had an Italian minority. In the Bukovina Ukrainians, Rumanians and Germans lived interspersed, while in Galicia the western part was predominantly Polish and the eastern part, except for the upper classes in the cities, largely Ukrainian. Many of these minorities were supported by kindred people speaking the same language on the other side of the frontiers. Thus the Austrian-Italian minority looked to Italy for guidance, some of the Croats and Serbs, especially after Austria's annexation of Bosnia-Hercegovina (1908) with its large Serbo-Croat population, saw in the independent Serbian kingdom in the Balkans the centre for the unification of all the southern Slavs, many of the Austrian Germans longed for inclusion in the German Reich created by Bismarck. This Pan-German movement was especially strong in the German-speaking parts of Bohemia, later called the Sudetenland, where Georg von Schonerer started a violently anti-Habsburg, anti-Catholic and anti-Semitic movement, a tradition in which Adolf Hitler later grew up. The Poles in Galicia had no independent nation outside the Austrian borders with which to be unified, but throughout the 19th century they hoped for the restitution of a united Poland, made up of the Russian, Prussian and Austrian parts of the former Polish state.

Of the three groups into which Poland had been divided, the Poles in Austria were by far the best treated; they were the only ones to enjoy full political and cultural liberties, and even occupied in Austria a privileged position and developed a class of high civil servants and well-trained administrators. Some Czechs and the Slovaks, living entirely on Austro-Hungarian territory, looked expectantly to Russia, the big Slav brother, for help in their national liberation. With all these mingled populations and conflicting aspirations, the dissolution of the Habsburg empire at the end of World War I presented a difficult problem for the new ordering of Europe, especially as the victors of World War I emphasized the principle of national self-determination and the liberation of minorities.

Infinitely simpler than in Austria were the minority problems within the German empire. There the minorities lived along the borders of the empire in compact groups contiguous with kindred populations beyond the frontiers, and had been incorporated into the German political system only in relatively recent times as a result of territorial aggrandizement and victorious wars. The Poles, mainly in the provinces of Posen and western Prussia, had come under Prussian domination as a result of the partitions of Poland in the 18th century; the Danes in northern Schleswig were included in Prussia as a result of the Austro-Prussian War of 1866, and finally Alsatians and Lorrainers had been forced against their will into the new German empire after the German victory over France in 1871. All these minorities felt bitterly oppressed within the German empire; its defeat in 1918 offered the opportunity for the liberation of these minorities and their reunion with their Polish, Danish and French conationals. Especially the Polish minority had been subjected to a process of forced denationalization, and drastic methods had been adopted in the "eastern marches" to dispossess the Poles and to settle Germans in their stead. As a result of this German settlement policy and of the germanization of some of the cities within Polish territory, the drawing of the frontier between Germany and Poland presented some difficulty in 1918. In addition to these three more recent minorities, who were backed by their conationals outside Germany, the German empire included some submerged Slav minorities like the Sorbs or Wends in Upper Lusatia and the Masurians of eastern Prussia.

4. The Russian Empire. — In the Russian empire, which had grown rapidly through the conquest of vast territories from the 16th to the 19th centuries, the Russians themselves formed barely a majority of the population. The country was inhabited by almost 100 different nationalities, some of them numerically insignificant, others very sizable, some of a higher cultural level than the Russians themselves. many others in different stages of backwardness, in their totality representing an infinite variety of races, European and Asiatic, and of religions, Catholic and Protestant, Moslem and Buddhist. The highly cultured minorities living on the western fringes of the empire, like the Germans in the Baltic provinces, the Poles and the Finns, enjoyed in the first half of the 19th century varying but on the whole far-reaching degrees of autonomy. In the later part of the century, however, the empire followed increasingly a determined policy of russianization of all the minorities, reserving for the Russian nationality and for the Greek Orthodox Church a position of privilege while oppressing the minority nationalities and religions. This oppression took different forms, but the denial of equality and of political rights was common to all of them. The Jews formed the most oppressed minority. The revolution of 1905 marked the first step in easing the situation of the minorities; the democratic March revolution of 1917 brought the proclamation of their complete equality.

The highly developed border nationalities in the west. the Poles, Lithuanians, Latvians, Estonians and Finns, proclaimed their independence which the new Soviet government was then too weak to deny; the rest of the empire was reconstituted as the Union of Soviet Socialist Republics, which granted equality to all its minorities and, at least theoretically, abolished the privileged position of the Russian element. The unexpected simultaneous disintegration of Austria, Germany and Russia made possible the reconstitution of a unified Poland.

Similarly complex as in the Habsburg and Russian empires was the minority situation in the Ottoman empire in the 19th century. In its European part many minorities, the Greeks, the Rumanians, the Serbs, the Bulgarians and finally the Albanians, achieved their independence, but the intermingling of minorities left many problems unsolved, especially in Macedonia, which was claimed by Greece, Serbia and Bulgaria, and in Albania where in the north Serbs and in the south Greeks lived on territory claimed as Albanian. Asiatic Turkey with its Greek and Armenian minorities among the Christians, Arab and Kurdish minorities among the Moslems, presented a complex problem at the end of World War I which under the then existing circumstances was solved in different ways, by separation (Arabs), by suppression (Armenians and Kurds) and finally by exchange of populations (Greeks).

5. Western Europe. — Fundamentally different from the situation in central and eastern Europe was the problem in western Europe. If we regard as a minority in the technical sense here discussed "a group that does not feel at home" in the state where it lives (Edgar J. Fisher), neither the Scots nor Welsh in Great Britain nor the Bretons nor Basques in France nor the Italians in Switzerland can be regarded as minorities. Before World War I there were only two true minorities in western Europe: the Catalans and to a lesser degree the Basques in Spain, and the Irish in Great Britain since the union. The Catalans, culturally and economically more advanced than the Spaniards, demanded cultural and political autonomy and opposed the centralizing tendencies of the Madrid government which went so far as to suppress the use of the Catalan language. The Irish minority problem was on the way to solution before World War I by Great Britain's readiness to grant Ireland home rule. Efforts in that direction, started when William E. Gladstone's third ministry in 1886 introduced the first Home Rule bill, were crowned by the passage of the (third) Home Rule bill in Sept. 1914, but the Irish situation was complicated by a typical minority problem, the Scottish Protestant minority in northeastern Ireland (Ulster), which appealed to its own right for self-determination against its subjection to Irish Catholic majority rule. A further complication was presented by a large Irish Catholic minority within Ulster, the territory of the Irish Protestants. As in many other cases (Catholic Poles and Protestant Prussians, Catholic Poles and Orthodox Ukrainians, etc.), the national minority problem was aggravated by religious differences, though many of the leaders of the Irish Catholics in their struggle against England were Protestants of English descent.

II. WORLD WAR I AND ITS AFTERMATH

That was the complex minority situation found at the beginning of World War I, a war which from its start involved the rights of small nationalities (Serbia and Belgium). As early as Aug. 5, 1914, the British prime minister, Herbert Asquith, declared that "We are fighting . . . that small nationalities are not to be crushed, in defiance of international good faith, by the arbitrary mill of a strong and overmastering power." From the beginning of the war Germany appealed to the minorities within the Allied nations (the Irish in Great Britain, the Poles and others in Russia) and tried to enlist them in the service of the German cause. Similarly the Moslem Turks tried to enlist the Moslem subjects of Great Britain, Russia and France in a "holy war" on the side of Germany and Turkey. Later on the Allies appealed to the minorities in Austria-Hungary, in Turkey and in Germany, and tried to win them for collaboration with the Allies for the realization of what soon became one of their declared war aims, the recognition of the principle of nationality and self-determination. The British entered into negotiations with the Arabs and succeeded in enlisting Sherif Husain ibn Ali of Mecca, to raise the banner of Arab independence and unity in 1916. The Russians, followed by other Allied nations and the United States, held out the prospect of autonomy or independence for the Armenians in Turkey. Leaders of the various non-Germanic and non-Magyar peoples of the Habsburg monarchy entered into nego-

tiations with Allied and U.S. statesmen.

The principles of nationality and self-determination were accepted as an official war aim by President Wilson in his address to congress, Jan. 8, 1918, when he demanded in point 9 "a readjustment of the frontiers of Italy along clearly recognized lines of nationality"; in point 10 that "the peoples of Austria-Hungary should be accorded the freest opportunity of autonomous development"; in point 11 the adjustment of Balkan relations along historically established lines of nationality; in point 12 "an absolutely unmolested opportunity of autonomous development" for the minorities in Turkey; and in point 13 the erection of an independent Polish state to include the territories inhabited by indisputably Polish populations and assured a free and secure access to the sea. In his address to congress Feb, 11, 1918, the president repeated that "All well-defined national aspirations shall be accorded the utmost satisfaction," but he introduced also the warning and restricting qualification: "that can be accorded them without introducing new or perpetuating old elements of discord and antagonism that would be likely in time to break the peace in Europe and consequently of the world." Wilson's 14 and supplementary points were unfortunately as vague as regards national self-determination as in most other respects, proclaiming general principles rather than the clear bases of a policy to be followed.

1. Peace Treaties of 1919.—The peace treaties of 1919 created east of the Rhine and the Alps a new Europe. The intention was to bring central and eastern Europe into line with the progressive development of western Europe and to introduce there the principles of constitutional liberty and of the nation-state based upon self-determination. In reality, the new Europe was not shaped exclusively or even predominantly by the good intentions of the peace treaties but by events which preceded the deliberations and decisions of the peace conference—such as the revolution and disintegration in Russia and the dissolution of the Habsburg empire—and by events following the peace treaties and settling international disputes without reference to the peace treaties (the Russo-Polish campaign of 1920, the seizure of Vilnius and Memel, the events in Turkey, etc.). The intention of creating the new Europe of individual and national liberty could not be fully realized; too many conflicts of the past, some of them reaching back for centuries, continued to influence the political life of Europe and to arouse the emotions of the masses. But even within the narrow limits in which the new Europe was ordered by the peace treaties themselves, the complete realization of the principle of national self-determination was found impossible. Minorities continued to exist and to present serious problems for international relations and domestic policies alike.

Had the principle of self-determination been carried out with complete disregard of all considerations of strategy and welfare, there would have remained important minorities in central and eastern Europe as a result of the intermingling of populations. Many minorities lived separated from their conationals, so that it would have been entirely impossible to include them in states with a predominant population of their own nationality. The partition of Austria-Hungary and the realization of the principle of national self-determination along the western borders of the Russian empire created a situation which had to a certain degree to continue the many centuries' old cohabitation of minorities of race, language and religion. One of these minorities, the Jews, who in eastern Europe had not undergone the process of assimilation which integrated them into the western nations, but had preserved in their mass settlements their own language and civilization, lived dispersed over several of the eastern European states and thus represented—at least until the time when progressive assimilation would possibly change the situation—a permanent minority. The newly created or enlarged states, Czechoslovakia, Poland, Rumania and Yugoslavia, resembled the Habsburg monarchy by the composite character of their populations. But on the whole the peace settlements of 1919 created a map of Europe much more in accordance with the principle of national self-determination than the map of 1914 had been. While in 1914 about 100,000,000 persons did not "feel at home" in the states in which they lived, their number was reduced as the result of World War I to about 25,000,000.

But in their effort to promote the growth of liberty and equality the peacemakers of 1919 did not stop at redrawing the map of Europe. They developed a system of protection by international treaties for minorities of race, language or religion. Such protection by international treaty had already been applied on a very limited scale in the 19th century, without however any supervision by an international body. In the case of the new Balkan states the protection of religious minorities and their rights was made a condition for the recognition of the new states. The treaty of Berlin (1878) stipulated in article 44 that differences of religion should not cause any differences in civic and political rights. The treaty of Berlin sought to guarantee, above all. the civic and political rights for the Jewish inhabitants of Rumania, which had refused to recognize them as citizens. But even after 1878 Rumania deliberately refused for 40 years to naturalize its Jewish inhabitants and to treat them as citizens. In view of this experience and of the violent anti-Semitism prevailing in Rumania and in the western part of the Russian empire (Poland and Ukraine), the Committee of Jewish Delegations at the Peace conference in Paris petitioned the peace conference on May 10, 1919, to secure to the people of the newly created or enlarged states of Europe, with adequate constitutional guarantees under the sanction of the League of Nations, admission to citizenship, civil, religious and political liberties as individuals and the right of organization and development as national minorities.

2. Europe After 1919.—No provisions for the protection of national, religious and racial minorities were incorporated into the text of the covenant of the League of Nations, though the Japanese delegation pressed for such a provision. But at the eighth plenary session of the peace conference on May 31, 1919, the French prime minister Georges Clemenceau and President Wilson emphasized the need for special protection for minorities in certain states. As a result of all the preceding deliberations and negotiations a treaty was signed between the principal Allied and associated powers on the one hand, and Poland on the other, at Versailles on June 28, 1919, the same day when the treaty with Germany was signed. The treaty with Poland served as a model for similar minority treaties concluded with other nations. In the treaty, Poland, "desiring to conform her institutions to the principles of liberty and justice, and to give a sure guarantee to the inhabitants of the territory over which she has assumed sovereignty," undertook to assure full and complete protection of life and liberty to all inhabitants of Poland without distinction of birth, nationality, language, race or religion. All inhabitants of Poland were to enjoy religious freedotn, persons residing in Polish territory at the time of the treaty were to become, if they so desired, Polish citizens, and all Polish citizens should enjoy the same civil and political rights. In addition to these general provisions characteristic of any progressive or democratic country, there were special provisions about the right of the free use of non-Polish languages in private intercourse and in publications and about adequate facilities for the use of these languages before the courts. Minorities received the right to establish at their own expense social and educational institutions, and Poland promised to provide adequate facilities to the minorities for education in elementary schools through the medium of their own language. Finally Poland agreed that these obligations should be placed under the guarantee of the League of Nations, and that any member of the council of the League should have the right to draw the attention of the council to any infraction, or any danger of infraction, of any of these obligations, whereupon the council might take proper and effective action. Poland also agreed that the minority protection could not be modified without the assent of the majority of the council of the League of Nations. Any difference of opinion as to the minority treaty should be held to be a dispute of an international character under article 14 of the League covenant and should, if the other party so demanded, be referred to the Permanent Court of International Justice.

Minority treaties were concluded only with a number of newly formed and enlarged states; similar provisions were inserted in

the peace treaties with certain defeated states; and finally some new states, at the time of their admission to the League of Nations, accepted in solemn declarations the principles of the minority treaties. The states thus entering into international obligations for the protection of minorities formed finally a belt from the Finnish gulf in the north to the Persian gulf in the south. Minority treaties were signed, in addition to Poland, by Yugoslavia (Sept. 10. 1919), Czechoslovakia (Sept. 10, 1919), Rumania (Dec. 9, 1919) and Greece (Aug. 10, 1920). In the peace treaties with Austria, Bulgaria, Hungary and Turkey special chapters for the protection of minorities were inserted. In addition the following states when admitted to the League of Nations made declarations regarding minorities before the council of the League: Finland (in respect of the Aland Islands), June 27, 1921; Albania, Oct. 2, 1921; Lithuania, May 12, 1922; Latvia, July 7, 1923; Estonia, Sept. 17, 1923; Iraq, July 13, 1932.

In addition to these treaties and declarations, minority questions were also dealt with in a number of bilateral international agreements. The most important among these agreements were the German-Polish convention regarding the protection of minorities in Upper Silesia of May 15, 1922, and the Graeco-Turkish agreement on the compulsory exchange of minority populations of Jan. 30, 1923. The convention regarding the Memel territory of Lithuania on May 8, 1924, also dealt with minority problems.

The international protection of minorities was not extended to old established states, not even to defeated Germany. As a result of World War I Italy incorporated into its national territory certain parts of the former Austro-Hungarian empire which were inhabited by Italians. South Tirol, Trieste and the Austrian maritime provinces, the main centres of the Italian irredentism of the 19th century. But while point 9 of Woodrow Wilson's 14 points had demanded the readjustment of the Italian frontiers along clearly recognizable lines of nationality, the new frontiers granted Italy by the peace treaty included large minorities, German in the case of South Tirol, Slovene and Croat in the case of Trieste and the maritime provinces. These minorities were not only not protected by any minority treaty, but were soon subjected by the fascist regime in Italy to an especially ferocious process of denationalization and persecution.

World War I did not create any new minority problems in western or northern Europe. One of the thorniest existing minority problems, the Irish problem, was solved by the treaty which the British government signed on Dec. 6, 1921, mith the Irish representatives and which was accepted by *dail eireann* the folloving month. The Protestant minority in Northern Ireland received home rule under the Government of Ireland act of Dec. 23, 1920, and retained this position in agreement with the right of self-determination even after the rest of Ireland had been granted one year later dominion status as the Irish Free State. The large Catholic minority in Northern Ireland continued however to present a minority problem, especially in view of the strong support nhich it found in the Free State.

In Spain the Catalans demanded with ever-growing insistence the autonomy of Catalonia. On July j, 1917, the Catalan deputies and senators in the Spanish parliament asked the convocation of a Catalonian constituent assembly to draw up a constitution for Catalonia, and on Jan. 24, 1919, a Catalonian union met in the Catalonian capital, Barcelona, to draft a program for home rule. The Spanish dictatorship of Gen. Miguel Primo de Rivera (1923–30) rejected all these demands, but the Spanish republic granted limited local autonomy to Catalonia in its constitution of Dec. 9, 1931. Catalonian agitation resulted in a far more liberal and comprehensive measure in the Catalan charter of autonomy of Sept. 25, 1932, in which Catalonia was granted the right to its own flag and officiallanguage and its own president. parliament and cabinet. The Basques received a more limited autonomy on Oct. 8, 1936. But the victory of Gen. Francisco Franco's forces in the Spanish civil war and the establishment of a fascist nationalist dictatorship in 1939 led to the abolition of autonomy in Catalonia and in the Basque provinces and to a regime of persecution of the minorities, of their languages and cultural aspirations.

3. Soviet Russia.—The minority problem in the vast Russian empire remained of importance even after World War I. Movements for national independence on the part of the larger and more developed national minorities, the Ukrainians, the Caucasians and the Moslems in central Asia, were ruthlessly suppressed, the potential leaders of such national independence movements were executed or imprisoned, and the totalitarian direction of all life and all administration by the one strictly centralized Communist party throughout the empire provided an iron framework of uniformity. But within this framework the minorities of race and language at first received a formerly unknown legal equality, and the minority religions—hfoslem, Jewish. Buddhist. Catholic, Protestant—were held to be on a footing of equality with the Orthodox Church. The Russian empire, though maintaining in its main body its unity and even strengthening the hold of Moscow over the vast extent of the empire, was transformed in 1922 into the Union of Soviet Socialist Republics, in which the European and Asian peoples were organized in federal republics, originally 7, 11 in 1939 and 16 in the early 1950s.

According to the census of 1926 the Union of Soviet Socialist Republics was inhabited by 18j peoples, speaking 147 different languages. Of these nationalities the Russians formed a bare majority of 52.9% (in 1939 the figure was 58.2%). Many of these nationalities were small groups, numbering less than 100,000; only 13 comprised more than 1,000,000 each. While some of these nationalities formed the republics of the Soviet Union, many more of them formed autonomous districts within one or the other of the republics. The largest of these republics, the Russian Soviet Federated Socialist Republic or R.S.F.S.R., which in the census of Jan. 1960 accounted for 117,494,000 out of a total population of 208,826,650 for the Soviet Union, dwarfed, however, all the other national republics in space and importance. Thus the U.S.S.R. remained predominantly Russian.

The practical policy of the Soviet government promoted actively and consistently the fullest development of the languages spoken by the minorities. The fight against illiteracy, the introduction of compulsory education, the spread of socialistic and popular scientific literature among the masses, the new equality of women, all this was accomplished through the medium of the mother tongue of each nationality or minority. While thus linguistic autonomy was granted, and no legal distinction was made between the Russian majority and the minorities in their rights and status, neither cultural autonomy nor political liberty in the accepted sense of the word existed, because the cultural and political life of all inhabitants, irrespective of race, nationality or language, was uniformly molded in the pattern of the totalitarian dictatorship.

The success of the Soviet minorities policy was tested in World War II. It became clear that many non-Russian nationalities were not loyal to the Soviet government, which in their eyes represented Russian domination. With the German attack in 1941 the Soviet government found itself obliged to dissolve the autonomous soviet socialist republic of the Volga Germans which it had established in 1924. Its German inhabitants were moved to Siberia and their autonomy liquidated. The capital of the republic, which had been renamed Engels, regained its former Russian name, Pokrovsk. At the end of World War II it became known, nithout any previous announcement by the Soviet government and without any explanation, that four other former autonomous republics and regions had been liquidated, the Crimean (Tatar) A S.S.R., the Kalmuck A.S.S.R. west of the lower Volga, the Chechen-Ingush A.S.S.R. and the Karachai Cherkess Autonomous Region in the Caucasus. Their cities were deprived of their native names and received Russian names. What happened to the populations was not revealed. The reason for these measures was believed to be the disloyalty of these minorities during World War II.

In a special report to the 20th congress of the Communist party of the Soviet Union. Nikita S. Khrushchev, the first secretary of the party, on Feb. 24. 1956, included the treatment of these minorities among the crimes of the Stalin era. He called the mass deportations from their native places of whole nations, together with all their Communists and Komsomols without any exception,

a monstrous act. He revealed a fact unknown until then when he said that "the Ukrainians avoided meeting this fate only because there were too many of them and there was no place to which to deport them. Otherwise, Stalin would have deported them also." Khrushchev continued that "no man of common sense can grasp how it is possible to make whole nations responsible for inimical activities, including women, children, old people, Communists and Komsomols, to use mass repression against them, and to export them to misery and suffering for the hostile acts of individual persons or groups of persons."

After 1956 steps were taken by the Soviet government to restore some of the autonomous republics and regions abolished during World War II and to bring the populations back to their native places. Two of the autonomous republics liquidated during the war on Stalin's orders were not mentioned by Khrushchev and were not re-established, the Volga German and the Crimean Tatar republics. Apparently their populations remained in Siberia and Kazakhstan, distant regions to which they had been deported.

During the last 15 years of Stalin's rule the position of the minorities throughout the U.S.S.R. had rapidly deteriorated compared with the relative equality granted them under Lenin. Under Stalin's successors greater emphasis was placed again upon the theoretical recognition of equality and the cultural development of the non-Russian nationalities in the U.S.S.R. The only exception were the Jews who, under Khrushchev too, were denied freedom of cultural activity in their own language (Yiddish).

4. Central and Eastern Europe.---Different from these developments in western and eastern Europe was the evolution of minority rights in the 14 states in central-eastern and southeastern Europe which had accepted, by treaty or solemn declaration, the protection of minorities within their territories. It was with these states and their minority problems that the League of Nations dealt in the period between World Wars I and II. These states were the following:

Albania, with a population of 1,003,000 (1930), of whom 50,000 belonged to the Greek and 7,000 to the Yugoslav minority.

Austria, pop. 6,760,000 (1934), of whom 52,000 were Czechoslovaks, 25,000 Hungarians, 191,000 Jews and 85,000 Yugoslavs.

Bulgaria, pop. 5,479,000 (1926), of whom 27,000 mere Armenians, 11,000 Greeks, 47,000 Jews, 69,000 Rumanians and 578,000 Turks.

Czechoslovakia, pop. 14,729,000 (1930), of whom 3,318,000 were Germans, 719,000 Hungarians, 357,000 Jews, 81,000 Poles and 569,000 Ukrainians.

Estonia, pop. 1,126,000 (1931), of whom 16,000 were Germans, 4,000 Jews, 7,000 Letts and 92,000 Russians.

Greece, pop. 6,205,000 (1928), of whom 20,000 were Albanians, 35,000 Armenians, 82,000 Bulgarians, 70,000 Jews and 103,000 Turks.

Hungary, pop. 8,684,000 (1931), of whom 105,000 were Czechoslovaks, 479,000 Germans, 444,000 Jews, 16,000 Rumanians and 34,000 Yugoslavs.

Iraq, pop. 3,189,000 (est. 1935), of whom 45,000 were Assyrians, 89,000 Jews, 485,000 Kurds and 80,000 Turks.

Latvia, pop. 1,900,000 (1930), of whom 8,000 were Estonians, 62,000 Germans, 93,000 Jews, 20,000 Lithuanians, 50,000 Poles, 233,000 Russians and 36,000 White Russians.

Lithuania, pop. 2,220,000 (1931), of whom 71,000 were Germans, 166,000 Jews, 14,000 Letts, 73,000 Poles and 44,000 Russians.

Poland, pop. 32,694,000 (1931), of whom 30,000 were Czechoslovaks, 1,700,000 Germans, 2,700,000 Jews, 300,000 Lithuanians, 56,000 Russians, 4,200,000 Ukrainians and 1,500,000 White Russians.

Rumania, pop. 17,793,000 (1930), of whom 361,000 were Bulgarians, 740,000 Germans, 1,426,000 Hungarians, 725,000 Jews, 415,000 Russians, 578,000 Ukrainians and 289,000 Turks.

Turkey, pop. 13,629,000 (1927), of whom 134,000 were Arabs, 64,000 Armenians, 96,000 Circassians, 120,000 Greeks, 82,000 Jews and 1,184,000 Kurds.

Yugoslavia, pop. 13,934,000 (1931), of whom 342,000 mere Albanians, 176,000 Czechoslovaks, 499,000 Germans, 468,000 Hungarians, 77,000 Jews, 229,000 Rumanians and 132,000 Turks.

Thus the most important minorities in the 14 minority states were 6,885,000 Germans (mostly in Czechoslovakia, Poland, Rumania, Yugoslavia and Hungary), 2,638,000 Hungarians or Magyars (in Rumania, Czechoslovakia and Yugoslavia), 5,045,000 Jews (mostly in Poland, Rumania, Hungary and Czechoslovakia), 1,669,000 Kurds (in Turkey and Iraq), 5,347,000 Ukrainians (in Poland, Rumania and Czechoslovakia) and 1,536,000 White Russians (in Poland and Latvia).

Of these minorities the Germans and Hungarians (Magyars) presented internationally the greatest problem. They had formerly belonged to the ruling majorities in Germany and in Austria-Hungary, and their new position was a result of the defeat of the Central Powers in 1918. Both in Germany and in Hungary tendencies were dominant, from 1918 on, to undo the defeat of 1918 and to re-establish the former German and Hungarian hegemony in central Europe. German and Hungarian policy was dominated by the goal of revising the peace treaties, and with them the new minority situation in central Europe.

Different was the problem presented by the Ukrainian, Jewish and Kurdish minorities. The Ukrainians, a nation of about 40,000,000 people, found after 1918 their claim to national independence denied and the territory settled by them divided among the Soviet Union, Poland. Czechoslovakia and Rumania, the Ukrainians forming everywhere a minority. In the Soviet Union the Ukrainians, forming the second largest national group, were organized into one of the federated republics according to the Soviet pattern. Czechoslovakia promised in the minority treaty to grant to the Ukrainians, living on the eastern fringe of Czechoslovakia south of the Carpathian mountains, the fullest degree of self-government compatible with the unity of the state. This autonomy was very gradually realized and finally established only in 1938, shortly before the complete dismemberment of Czechoslovakia. A similar autonomy was promised by the Polish government to the Ukrainians in eastern Galicia, a province consisting of the three districts of Lvov, Stanislawow and Tarnopol. The Polish law of Sept. 26, 1922, provided for diets in these districts to deal with all questions relating to religion, education, welfare, local communications and local economic coqditions. The law also prohibited the Polish colonizing of these districts, made the Ukrainian language one of the two official languages, and promised the establishment of a Ukrainian university. On the strength of this law the Conference of Ambassadors recognized on March 14, 1923, the Polish claims to eastern Galicia, not without pointing out that Poland had recognized for eastern Galicia "that the ethnographical conditions made a regime of autonomy necessary." After 25 years a plebiscite should decide, according to the Conference of Ambassadors, the status of eastern Galicia. But the Polish government refused to carry out the law of Sept. 26, 1922, and the 3,500,000 Ukrainians in eastern Galicia remained without the promised autonomy. After 1940 the Soviet Union, by the annexation of Bessarabia and northern Bukovina from Rumania and of eastern Galicia, Volhynia and Polesia from Poland, united all the Ukrainians, with the exception of those in Czechoslovakia, within the Soviet Union and its Ukrainian republic. In 1945 the Carpatho-Ukraine was ceded by Czechoslovakia to Russia, thus completing the process of the inclusion of all Ukrainians, for the first time in history, into the Soviet empire.

The Jews formed a minority in all the states involved. Special provisions were made in the treaties with Poland, Lithuania and Greece in the interests of the observance of the Jewish Sabbath. No elections should be held on Saturday. This provision did not, however, exempt Jews from such obligations as were imposed on all other nationals for the necessary purposes of military service, national defense or the preservation of public order. Similar regard for religious minorities was expressed in the treaties with Albania, Greece and Yugoslavia as far as Moslems were concerned. Greece also promised to maintain the traditional rights and liberties enjoyed by the monks of Mt. Athos, of whatever country they might be natives.

Like the Ukrainians, the Kurds formed no national state of their own but lived as minorities in Turkey, Iran and Iraq. There was no question of protection for minorities in Iran. Turkey assumed certain obligations, but it did not grant any minority rights to the Kurds nor did it make any provisions for the use of the Kurdish language in education or public life, though the Kurds formed a considerable minority living in compact settlements in the eastern parts of the country. The treaty of Sèvres (1920) had foreseen autonomy for the Kurds, but it was never ratified. The Turkish government suppressed repeatedly movements for independence or autonomy on the part of the Kurds and subjected them to a process of turkification. Only in Iraq the Kurdish minority in the northern districts enjoyed full mi-

nority rights and a limited cultural and administrative autonomy.

More extended and better defined than in any other of the minority treaties were the rights of the German and Polish minorities in Upper Silesia as set forth in part iii of the German-Polish convention of May 15, 1922. The contracting parties agreed to observe, for a period of 15 years, certain detailed provisions concerning civil and political rights, religion, private education, public elementary education, vocational training and extension classes, secondary and higher education, the official language of education and the language to be employed in all legal proceedings of whatever nature. In both parts of Upper Silesia, German and Polish, a minorities office was set up to which persons belonging to a minority could, after having filed a complaint with the highest administrative authority of their territory, submit a petition for consideration. If the minorities office did not succeed in obtaining satisfaction for the petitioners, it transmitted the petition, with any comments of its own, to the president of a mixed commission. This commission was composed of two Germans and two Poles with a president of a third nationality. This commission communicated its views to the proper administrative authorities. If the petitioners were not satisfied with the findings of the administrative authority, they could appeal to the council of the League of Nations. This convention remained in force for the full duration contemplated in it and ended on May 15, 1937.

5. Protection by League of Nations. — Thus in the new system established by the peace treaties after World War I minorities of race, religion or language were to receive for the first time protection under an effective system of international law. Though, as in all the other provisions of the peace treaties, much remained vague and undefined and lacked sanction, nevertheless the arrangement marked important progress in a most delicate question, namely. how far effective protection of minorities could be achieved internationally without seriously impairing the national sovereignty of the states themselves. A principle, experienced by the assembly of the League of Nations in 1922, interrelated the duties of the state toward its minorities with the duties of the minorities toward the state. While the assembly recognized the primary right of minorities to be protected by the League from oppression, it also emphasized the duty incumbent upon persons belonging to racial, religious or linguistic minorities to co-operate as loyal fellow citizens with the nations to which they belonged.

In that connection nothing could be more disastrous than an appeal of the minority to some protecting outside government, especially a great power. Such appeals had been used successfully in the 19th century by minorities in the Ottoman empire, and this kind of protection of minorities by the intervention of some great powers had produced disastrous results by complicating international relations and provoking wars. The new procedure of protecting minority rights under the League of Nations should render, so the framers of the peace treaties had intended, such appeals of minorities to single powers superfluous. The necessity of striking a delicate balance between the sovereign rights of states and the protection of minorities within those states was always taken into consideration by the League of Nations, which tried to achieve its aims by conciliation and pacification rather than by judgment and sanctions. The resolution of the assembly in 1922 stated in this spirit that:

> While in cases of grave infraction of the minorities treaties it is necessary that the Council should retain its full power of direct action, the Assembly recognizes that in ordinary circumstances the League can best promote good relations between the various signatory governments and persons belonging to racial, religious or linguistic minorities placed under their sovereignty by benevolent and informal communications with those governments.

In the course of the years the League of Nations worked out a procedure to be followed by the council in the settlement of minority questions. The minority treaties were extremely general in their wordings and vague about the procedure and the powers of the council. Only members of the council had the right to bring officially to the attention of the council any infraction or danger of infraction of any of the provisions relating to minorities. Other states not represented on the council, or minorities themselves, could petition the council or report to it, but only an action by a council member brought the question officially before the council. When the council dealt with such a question, the state involved. if it was not a member of the council, was invited to sit as a member during the consideration of the matter specially affecting its interests. The council could also ask the Permanent Court of International Justice for an advisory opinion or refer the question to it.

The procedure laid down by the council concerned petitions and communications for the examination of minority questions not sponsored by any of the members of the council. The council, anxious to give minorities a guarantee that their petitions would receive serious consideration, instituted out of its midst a minorities committee. A petition regarding minority protection was first submitted by the League secretariat to a preliminary examination as regarded its acceptability; if found acceptable, it was submitted to the government in question for its own observations, before being brought to the notice of the council. The observations of the government, if any, were communicated together with the petition. The council became competent to deal with the question, however, only if one of its members notified it that the subject of the petition constituted an infraction or danger of infraction of the treaties. To enable its members to decide whether the petition constituted such an infraction, the council instituted the minorities committee, consisting of the president of the council and two members appointed by him. According to a resolution of the council of June 10, 1925, the members of the minorities committee could not include either the representative of the state to which the persons belonging to the minority in question were subject, nor the representative of a neighbouring state or of a state a majority of whose population belonged from the ethnical point of view to the same people as the persons who were members of the minority in question. In such a way the impartiality of the minorities committee was to be assured. As a result, nationals of Latin-American or Asian states played a great role in these minorities committees.

This procedure was further improved by the resolution of the council of June 13, 1929. The secretary-general of the League was required to inform the petitioner when and why his petition was unacceptable. In exceptional cases the minorities committee could be expanded from three to five persons. It was declared desirable that these minorities committees hold their meetings not only during the sessions of the council but also in the intervals between them. The committees had to inform all the members of the council of the result of their findings regarding minority petitions, so that members who were not in agreement with the findings could raise the question before the council. The secretary-general of the League had to keep the relevant documents available for the members of the councii and to transmit to them an annual compilation of all the findings of the minorities committees.

The League of Nations tried to proceed in all minority questions with due regard for the susceptibilities and sovereign rights of the states pledged to the protection of minorities by international treaties. Nevertheless, some of these states resented and opposed the minority treaties or at least repeatedly made the attempt to generalize a system of protection of minorities and to apply it to all states. As a result of Latvian proposals, the assembly of the League of Nations adopted on Sept. 21, 1922, a resolution expressing the hope:

> That the states which are not bound by any legal obligations to the League with respect to minorities will nevertheless observe in the treatment of their own racial, religious or linguistic minorities at least as high a standard of justice and toleration as is required by any of the treaties and by the regular action of the Council.

When the assembly met for its sixth session in Sept. 1925, the Lithuanian delegation proposed to set up a special committee to prepare a draft convention to include all the states members of the League of Nations, setting forth their common rights and duties in regards to minorities. Only the Rumanian and Polish representatives favoured the proposal, which was finally withdrawn.

At the meeting of the council on Dec. 9, 1925, M. de Mello Franco, the Brazilian delegate and *rapporteur* on minorities ques-

tions, expressed himself definitely against generalizing the system for the protection of minorities. He said:

The mere co-existence of groups of persons forming collective entities, racially different, in the territory and under the jurisdiction of a state is not *sufficient* to create the obligation to recognize the existence in that state, side by side with the majority of its population, of a minority requiring a protection entrusted to the League of Kations. In order that a minority, according to the meaning of the present treaties, should exist, it must be the product of struggles, going back for centuries, or perhaps for shorter periods, between certain nationalities, and of the transference of certain territories from one sovereignty to another through successive historic phases.

This definition would exclude all minorities in the two Americas from protection as envisaged by the League of Nations, perhaps with the exception of the Mexican minority in New Mexico and other territories ceded by Mexico to the Gnited States as a result of 19th-century wars.

Though some states which had accepted the minority treaties, such as Poland, owed their existence to the peace treaties of 1919, and though the minority provisions formed an integral part of the peace settlement, these states, especially Rumania and Poland, protested from the beginning against the minority provisions and thereby helped to undermine the whole peace settlement. With the progressive weakening of the peace settlement of 1919 the system of minority protection and the whole League of Nations was weakened. On Sept. 13, 1934, Col. Jozef Beck, Polish minister of foreign affairs, declared that Poland henceforth would refuse to collaborate with the League of Nations in the field of minority protection, and on Nov. 5, 1937, Poland concluded with Germany a bilateral minorities agreement outside the League of Nations.

In Sept. 1934, when Poland refused further co-operation with the League of Nations "in the matter of the supervision of application by Poland of the system of minority protection," a resolution was offered and discussed for extension of the contractual provision of minority protection to all nations, or at least to the whole of Europe. This was the last time that any important debate on the minorities problem was held before the League of Nations. Between July 1, 1938, and June 30, 1939, only four minorities petitions were sent to the League of Nations. Finally in 1939 the minorities section of the secretariat of the League of Nations was liquidated.

6. Activities of Minorities. — The minorities themselves tried to protect their rights by forming international organizations. Congresses of "oppressed nationalities" were held in 1912 and 1913 in Paris and in 1916 in Lausanne. After World War I the German minorities took the initiative in forming an international organization of national minorities of Europe, including the minorities not protected by treaties, such as the minorities in Spain, Italy and Germany. The Baltic German Ewald Ammende founded in 1925 the congresses of the organized national minority groups in Europe (outside the Soviet Union). The annual meetings, presided over by the Slovenian Josip Wilfan, were held until 1931 in Geneva, and afterward in Vienna. The last or 14th congress met in July 1938. These congresses, however, were torn by violent dissensions among the minorities themselves, especially among those who before 1918 had belonged to ruling majorities and those who had then been oppressed by them. As a result of these conflicts, the minorities within Germany, which were not protected by treaty, left the congress as early as Aug. 1927. The German minorities dominated the congresses more and more and turned them into spokesmen for the German cause. In Aug. 1933 the representatives of the Jewish minority left the congress, which threatened to become an organ for irredentist propaganda.

With the growth of German influence throughout Europe, the concept of minority and of its duty of loyalty to the state of which it was a member changed fundamentally, at least as far as the German minorities were concerned. They regarded themselves now openly as members of a *Volksgemeinschaft* which transcended state frontiers. The spokesman of the Union of German *Volksgruppen* declared that:

Volksgemeinschaft is not only an identity of language but represents also in the cultural aspect the identity of experience. It would be a denial and an offense against the divinely intended division of mankind into individual folk entities to demand of the *Volksgruppen* that they cut themselves off from the regenerative experience of the main body of their people. Wherever sections of the German people consciously exclude themselves from this experience, the *Volksgemeinschaft* is imperiled (*Nation und Staat*, vol. xi, p. 352).

The blood was regarded as stronger than the citizen's loyalty to the state to which he belonged. The Germans denied that members of different ethnic groups could live peacefully side by side in one and the same state, a supposition accepted as valid in the United States and in western Europe. Prince Bernhard von Bülow, the former German chancellor, wrote in his *Imperial Germany* (New York, 1914, p. 291): "It is a law of life and development in history that where two national civilizations meet they fight for ascendency. . . . In the struggle between nationalities one nation is the hammer, the other the anvil; one is the victor and the other the vanquished." The peace settlement of 1919 and the minorities treaties under the supervision of the League of Nations were animated by the very opposite feeling of the possibility of the peaceful and orderly cohabitation of different nationalities in one state. This was possible only if the 19th-century principles of liberal democracy, constitutional guarantees and mutual tolerance prevailed. Unfortunately these ideas had not yet taken firm root in the soil of central and eastern Europe at the end of World War I.

As a result of this lack of a genuine atmosphere of tolerance in central and eastern Europe, the minorities had frequent cause for complaints which produced numerous petitions to the League of Nations. This body received the largest number of petitions in any single year: namely 204, in the period between July 1, 1930, and June 30, 1931. The most frequent complaints concerned economic discrimination, limitation in the use of minority languages and restriction of educational opportunities. Some of the economic complaints had their origin in economic and social measures which in spite of legal equality worked to the factual disadvantage of the minorities, as in the case of agrarian reforms, when estates owned by members of the minority were divided up among peasant members of the majority, or when new middle and professional classes were helped into existence at the expense of the minorities. In such an atmosphere even a very minor difference of interpretation or any minor shift in the existing balance of power became a source of deep irritation. The vague and much too broad phrasing of the treaties aggravated the situation. But it was not the imperfect letter of the treaties which formed the chief obstacle to a smooth cohabitation of the different minorities and majorities, it was the lack of the right spirit, an obstacle which even a more precise wording of the treaties could not have overcome.

To eliminate the threat which the existence and aspirations of powerful minorities present to the peaceful relations of neighbouring states, the compulsory exchange of minority populations has been suggested. Such an exchange was accomplished successfully between Turkey and Greece. But it was done under unique circumstances which do not easily allow favourable conclusions for general acceptance of the principle involved. The victorious Turks who had driven out the Greek army from Asia Minor, where lived a large and prosperous Greek minority, established since time immemorial, forced the Greeks in the agreement of Jan. 30, 1923, to accept the definite removal of the Greek minority in Turkey, comprising more than 1,000,000 persons, to Greece in exchange for the much smaller number of Turks living in Greece. Religion was to determine the question of who was to be regarded as Greek or Turk. The Greek Orthodox inhabitants of Istanbul and the Moslem inhabitants of western Thrace were allowed to remain in their countries. Mutual property settlements for the benefit of dispossessed persons were supervised by a commission including a majority of neutral members appointed by the League of Kations. The task was made much easier by the fact that far more than 1,000,000 Greek Orthodox citizens of Turkey had fled from Turkey to Greece with the retreating army even before the agreement was concluded. Thus only about 200,000 Christians had to be removed from Turkey and about 350,000 Moslems moved to Turkey under the supervision of the commission, which concluded its work on Jan. 1, 1935.

The League of Nations never ceased to stress the importance of the protection of minorities. When Iraq, after a relatively brief political education under British mandate, was to be admitted in

1932 to the League of Nations as a sovereign state, the Permanent Mandates commission wished to make the independence of mandated territories dependent upon guarantees ensuring the effective protection of racial, linguistic and religious minorities. Iraq, upon entering the League of Nations, declared its acceptance of the protection of minorities. At the council meeting of May 19, 1932, the committee reporting upon the situation of minorities in Iraq declared:

As regards the substantive provisions, the Committee desires first, to emphasize the satisfaction with which it has noted that many of the constitutional and legislative provisions of Iraq are based on a very liberal conception of the rights to he accorded to racial, linguistic and religious minorities. It is happy to recall the fact that during the course of the proceedings, the [Iraqi] Prime Minister made it clear that that conception has as its starting point the idea that all Iraqian nationals, irrespective of race, language or religion, form part, on a footing of equality, of the body of the state.

7. The Near East.—With the rise of nationalism and the demand for constitutional rights, under western influence? minority problems began to play a great role in the near and middle east and throughout Asia. At the same time the new nationalism acted as an integrating factor in overcoming the religious cleavages which until the beginning of the 20th century were as dominant in oriental countries as they had been down to the 17th century in Europe. Egypt, a predominantly Moslem country, has a native Christian minority, the Copts. Immediately before World War I much bitter antagonism between majority and minority had flared up. When Great Britain, in accordance with its liberal tendencies, set the example of emancipating colonial countries by granting independence to Egypt on Feb. 28, 1922, it reserved for further discussion the protection of minorities in Egypt. But the fast-growing feeling of national unity fused the Copts with the Moslem majority, so that when the Anglo-Egyptian treaty of alliance was signed on Aug. 22, 1936, no mention was made of the protection of minorities, and Egypt was admitted to the League of Nations on May 26, 1937, without the requirement of a declaration regarding the protection of minorities.

Minorities continued to play a great role in Syria and Lebanon, the part of the Arab world put under French mandate after World War I. The minorities in Syria and Lebanon were religious rather than linguistic minorities, but the difference of religion involved a deep difference in the whole way of life and in the social structure of the various communities which for many centuries had lived in strict segregation. But there too the national Arab movement brought the different Moslem and Christian communities ever more closely together. The Syrian and the Lebanese constitutions included elaborate provisions for the safeguard of the rights of the minorities, and in Lebanon the minorities received a proportionate share in the legislative body, in the administration and in the public service.

Palestine offered a special minority problem of its own. The Arab majority of the country felt itself threatened by the growth of the Jewish minority, which interpreted the Balfour declaration of Nov. 1917 and the mandate charter of 1922 as a promise for the establishment of a Jewish majority and a Jewish commonwealth in Palestine. The Zionist movement wished to "redeem" the Jews from their permanent and ubiquitous minority status by the creation of a Jewish majority and state in Palestine, the ancient homeland of the Jewish people. The British government had from the beginning rejected the interpretation that the promised "Jewish national home" meant that Palestine would become a Jewish commonwealth. Even the Zionist demand for the promise of the "reconstitution of Palestine as the national home" was rejected in 1917 in drafting the Balfour declaration for the broader and much less definite phrase "the establishment in Palestine of a national home." The British government insisted that the national home must be interpreted in such a limited sense that the interests of the indigenous population should not suffer.

The actual developments, however, did not bear out British expectations. The rise of Hitlerism, which led to a wholesale extermination of Jews not only in Germany but throughout all the lands of central and eastern Europe which fell under German influence or occupation, produced the demand for large-scale Jewish immigration into Palestine. In a resolution adopted at a meeting in New York city the Zionists demanded in 1941 the creation of a Jewish state in the whole of Palestine. The United Nations recommended in 1947 partition of Palestine into an Arab and a Jewish state. The Arab states, however, refused to accept this recommendation and when in 1948 at the termination of the British mandate, the Zionist settlers in Palestine proclaimed the creation of the state of Israel, the Arab states intervened; they were defeated in the ensuing war. About 800,000 Arabs fled from the territory conquered by Israel, and in the 1950s they represented one of the thorniest of refugee problems.

III. DEVELOPMENTS AFTER WORLD WAR II

Minority questions had received a great deal of attention in the League of Nations after World War I. They were given far less attention by the United Nations after World War II. There was nothing comparable to the minority legislation and minority treaties of the earlier postwar period. On the other hand, the draft covenant on human rights contained articles on the rights of minorities and on the prohibition of advocacy of national, racial or religious hostility. The Commission on Human Rights in the United Nations recommended also that member states uphold the principle of self-determination of all peoples and nations, facilitate the right of self-determination in territories under their administration—preferably through plebiscites under the auspices of the United Nations—and that the General Assembly establish a commission to conduct a full survey of the status of the right of peoples to permanent sovereignty over their natural wealth and resources.

The situation of minorities in various countries after World War II constituted a problem of refugees on an infinitely larger scale than before the war. Accordingly, the general assembly of the United Nations established in 1950 an office of the United Nations high commissioner for refugees with his office in Geneva, Switz. His mandate extended to all persons who had fled from their native lands for political, racial or religious reasons and who were unwilling or unable to claim the protection of their own governments. The three main functions of the office were international protection, promoting permanent solutions to the problems of refugees, and administering emergency aid. Separate from this office was the United Xations Relief and Works Agency for the Palestine Refugees in the Near East, with its headquarters in Beirut, Lebanon. Other groups of refugees who did not come under the United Nations office were those in India, Pakistan and in the Federal Republic of Germany. Though they were refugees from their native lands, they were given the full right of citizenship by their countries of residence and were fully integrated in them.

To a degree unknown before modern times, expulsion of minorities from their native lands was used after World War II as a "solution" of minority problems. German minorities in Poland and Czechoslovakia for example, were expelled and most of them settled in western Germany. To a lesser extent, the German minorities in Yugoslavia, Hungary and Rumania and the Magyar minorities in Czechoslovakia faced a similar fate. Because of these expulsions the problem of minorities in Europe lost much of the great importance it had both before and after World War I. In Europe there were only two minority problems in the 1950s which created domestic and international tensions. The one was the position of the German-speaking South Tirolese in Italy who demanded autonomy and the protection of their economic and administrative position against increasing Italian pressure. The Austrian government made itself the spokesman of the complaints of the South Tirolese who until 1918 had formed part of Austria, and brought their case up in the United Nations at its fall session of 1959.

The other problem was presented by the Turkish minority in Cyprus. This problem became acute when the Greek majority in Cyprus attempted to end the status of the island as a British colony and to become united with Greece. The Turkish minority feared that such a development nould undermine its own position. In Feb. 1959 the parties reached an agreement in which the British, Greek and Turkish governments concurred. The Greek Cypriot

majority would in effect govern the island, but this agreement gave to the Turks a secure minority position under international guarantee. In this case, a spirit of compromise after long and bitter struggle was able to solve one of the seemingly intractable minority problems.

Not so fortunate was the situation in Asia and Africa. In Palestine the establishment of the state of Israel over territory largely inhabited by Arabs brought with it a thorny minority problem that contributed to international tension throughout the whole middle eastern area. About 800,000 Arabs who fled from their homeland during the mar of 1948 nere not allowed to return to their homes, nhich were now in the state of Israel; over 200,000 Arabs who remained in Israel found themselves in an underprivileged position.

Less acute were the minority problems in Lebanon, which were not based on nationality but on religion, and in Iraq nhere in the northern part of the country a strong Kurdish minority lived The various religious groups living in Lebanon enjoyed full equality. and the Kurds in Iraq enjoyed not only equality but also the recognition of autonomy, which was not the case with the Kurdish population in neighbouring Turkey and Iran.

The new nations in Asia had their minority problems. too The independence of India and the partition of that subcontinent into Pakistan and the Republic of India led to Hindu-Moslem riots, as a result of which many Hindus migrated from Pakistan to India and many Moslems migrated from India to Pakistan. In the Republic of India, divisions by descent and religion as well as language and caste created a number of problems nhich the Indian government tried to overcome by the principles of democrdcy and federalism. One of the most vexing minority problems was that of the untouchables in India. The inferior status of this minority had been regarded as sanctioned by the Hindu religion. Although the almost unique, depressed situation of this very large minority, which comprises about 60,000,000 persons, was legally alleviated under British rule and then in the constitution of the Republic of India, by 1960 the force of social tradition was still much too strong to allow a status of equality or full integration of this minority into Indian life.

Other minority problems leading to disputes and even to internal strife were created by the Pathans who lived on both sides of the border of Pakistan and Afghanistan. In the 1950s, Afghanistan made itself the spokesman for the independence of the Pakistani Pathans In Burma the Karen people demanded independence; their army of national liberation kept up an armed struggle against the Burmese government after the declaration of Burmese independence in 1948. In the Republic of Indonesia various movements for independence or autonomy in the southern Moluccas, Sumatra and Celebes led to much fighting and violent suppression throughout the 1950s. An outstanding example of bitter minority conflicts was supplied by the attempt of the Sinhalese majority in Ceylon to curtail the equality of the Tamil minority. In the Communist Chinese empire the wish for independence or autonomy of the Noslem population in Sinkiang and of the Tibetans was suppressed after bitter fighting.

With the growing desire of the African peoples for independence and uith the establishment of a number of African nations in accordance with this desire, various minority problems were created, partly by the fact that tribal and linguistic differences continued in most African countries, and partly by the fact that minorities of white settlers, especially in the Union of South Africa and in Algeria, appeared as a hindrance to the realization of the wish of the majority of the population for independence.

IV. MINORITIES IN THE AMERICAS

In the two Americas only the French Canadians in Canada present a minority problem in the European sense of the word. Canada presents the same struggle for the right of language and for economic positions, mitigated by the British traditions of democracy, federalism and tolerance. French was recognized as an official language in 1848 and confirmed in the British North America act of 1867. The French Canadians wished to maintain their own traditional way of life and not fuse with the majority of the Canadian nation.

Such a tendency of segregation and cultivation of differences runs counter to the fundamental policy of the United States, where from the beginning of its nationhood a policy of amalgamation of the different ethnic and linguistic strains forming the new nation was pursued. English was the official language; without any strong pressure in that direction, it quickly supplanted, by the sheer weight of the American tradition, the many languages of the immigrant peoples. From the end of the 18th century on, the United States was regarded as a melting pot where people of the most different origins. religions and languages formed a new nation, based upon a common loyalty and common ideals. This process of assimilation was relatively simple at the beginning. But in the later 19th century, with the rapid growth of immigration, the new immigrants, settled in the large cities in the east and in the agrarian spaciousness of the middle nest in compact groups, preserved their own languages, their own national traditions and ideas and partly even their former loyalties. The theory of the melting pot apparently did not work sufficiently well or fast. This new situation created a twofold reaction. Some suggested that the melting pot theory be replaced by the theory of cultural pluralism, which mould maintain, within the common political nationhood, the cultural traditions and potential contributions of the various minority groups. Others saw in the rapid growth of the minority groups and in their adherence to their onn cultural pattern a danger to the unity of the nation. To preserve the American character, the quota laws of 1921 and 1924 severely restricted immigration to the United States and established quotas in such a may as to strengthen those elements believed most easily assimilable to the American cultural pattern.

But the principle of the melting pot was from the beginning a fundamental factor in the building of the nation. fusing in a spirit of tolerance and liberty various religious and ethnic groups as never had been done in Europe, so that minorities, at least theoretically, became one nith the majority in a common cultural tradition and a common political loyalty. As far back as 1782 M. G. J. de Crèvecoeur, a French settler in Pennsylvania. stressed in his *Letters From an American Farmer* the variety of groups mingling in the American melting pot:

> What then is the American, this new man? He is either a European, or the descendant of a European; hence that strange mixture of blood, which you will find in no other country. I could point out to you a man, whose grandfather was an Englishman, whose wife was Dutch, whose son married a French woman, and whose present four sons have now four wives of different nations. He is an American, who, leaving behind him all his ancient prejudices, and manners, receives new ones from the new mode of life he has embraced, the new government he obeys, and the new rank he holds. He becomes an American by being received in the broad lap of our great Alma Mater. Here individuals of all nations are melted into a new race of men, whose labors and posterity will one day cause great changes in the world.

And more than a century later Israel Zangwill in his play *The Melting Pot* made one of his characters say:

> Now understand that America is God's crucible, the great melting pot where all the races of Europe are melting and reforming! . . . Yes, east and west, and north and south, the palm and the pine, the pole and the equator, the crescent and the cross-bow, the great Alchemist melts and fuses them with his purging flame! Here shall they all unite to build the Republic of Man and the Kingdom of God.

The minority problems in the United States differ fundamentally from those in central and eastern Europe. Minorities came to the U.S. (with the exception of the Negroes) voluntarily and as individual immigrants, abandoning gladly their homeland and seeking assimilation to higher standards of political liberty and economic equality; their assimilation, always in theory and very often in practice, has been welcomed and facilitated. But there is no doubt that ethnocentricity and strong group solidarity within some of the immigrant groups, and prejudice on the part of the majority. have often strained the relations between majority and minorities. Evidence of incomplete assimilation among minority groups was widespread in World War I, though much less in World War II, and has sometimes presented a real danger. Conscious and well-organized propaganda on the part of the German and Italian governments

preceding World War II threatened to undermine the loyalty of the German and Italian minorities. The events of World War II, however, proved that in the overwhelming number of cases even those minorities whose conationals in Europe or Asia fought against the United States remained loyal to the United States and that the process of assimilation had taken much deeper root than many had supposed. With the act of 1924 the period of large-scale immigration to the United States came to an end. The attitude of the first-generation minority groups, fusing themselves completely with the majority, was well expressed in 1937 by one of the prominent foreign-born citizens of the country, Ales Hrdlicka, when he declared of America:

> It received them without any sentiment, without any care, often, perhaps, with outright neglect and selfishness. But it gave them freely of the precious new air of spiritual liberty. It dealt with them perhaps at times rudely, but frankly. It gave them a chance, a chance to educate themselves and their children, a chance to progress in every direction if they were willing and capable. What wonder that with all the initial difficulties and even sufferings, so many of the immigrants became deeply grateful to the country of their adoption, became fused with it like so many wholesome grafts on a healthy virile tree, and became within less than a generation true, loyal Americans.

The most difficult minority problems of the United States are presented by the factual and sometimes even legal position of the nonwhite minorities — Negroes, Asians and American Indians. In Latin-American countries minority problems are of a twofold character: in some of them large European immigrant groups have yet to be fully integrated into the cultural pattern and the political loyalty of their new country; in others the numerical majority of native Indians live, as regards actual political rights, educational facilities and economic opportunities, in the status of an underprivileged minority.

V. CONCLUSION

With all the diversity of the positions and problems of minorities all over the world, it can be said that in the 20th century the awareness of the rights of minorities to equal opportunities grew, in spite of the fact that German national socialism and other totalitarian movements, on behalf of the absolute authority and uniformity of the state, rejected the liberty and equality of minority groups. These tendencies represented the most extreme form of racial or ideological (or religious) exclusivism. Only the growth of the liberal tradition of individual liberty and tolerance can solve the minority problems in a form acceptable to the conscience of civilized humanity.

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MINOR PLANET: see ASTEROIDS.

MINOS, a semilegendary king of Crete, the son of Zeus and of Europa. By his wife Pasiphae he was the father of Ariadne, Phaedra, and others. Ariadne is equated with Aphrodite; Pasiphae has been explained as a lunar deity, and a goddess of that name was worshipped in Laconia (Plutarch, Agis, 9). Minos reigned over Crete and the islands of the Aegean three generations before the Trojan war. He "reigned for eight years and was the gossip of Zeus" (Odyssey, xix, 178), which may mean that he was a divine being, an incarnate god, replaced every ninth year (so Frazer). He was the author of the Cretan constitution and the founder of its naval supremacy (Herodotus iii, 122; Thucydides i, 4).

In Attic tradition and on the Athenian stage Minos is a cruel tyrant, the heartless exactor of the tribute of Athenian youths to feed the Minotaur (*q.v.*). Recent discoveries in Crete (*q.v.*) prove the existence of a civilization, the "Minoan" culture, the lord of which may well have had Athens and many other places tributary to him. Minos himself is said to have died at Camicus in Sicily, where he had gone in pursuit of Daedalus, who had given Ariadne the clue by which she guided Theseus through the labyrinth. He was killed by the daughter of Cocalus, king of Agrigentum, who poured boiling water over him in the bath (Diod. Sic. iv, 79). Subsequently his remains were sent back to the Cretans, who placed them in a sarcophagus, on which was inscribed: "The tomb of Minos, the son of Zeus." After his death he became judge of the shades in Hades, associated with Aeacus and Rhadamanthus.

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MINOT, GEORGE RICHARDS (1885–1950), U.S. physician and, for his work on liver therapy in pernicious anemia, cowinner of a Nobel prize, was born at Boston, Mass., on Dec. 2, 1885. He received his medical degree from Harvard university in 1912. After serving as intern at Massachusetts General hospital in Boston, he became resident at Johns Hopkins hospital, Baltimore, Md., and next year research fellow in physiology at Johns Hopkins, under William H. Howell. In 1915 he returned to Boston and continued work on transfusion and disorders of the blood while serving on the medical staff of the Massachusetts General hospital until 1923. In 1921 he developed severe diabetes and was among the first patients in Boston to receive insulin. After appointments at the Huntington Memorial (cancer) and Peter Bent Brigham hospitals, he became in 1928 professor of medicine at Harvard and director of the Thorndike Memorial laboratory at Boston City hospital.

Minot and another Boston physician, William Parry Murphy (*q.v.*), by systematically employing a liver diet, achieved in 1926 the first successful treatment of pernicious anemia. This followed earlier nutritional experiments of the pathologist George Hoyt Whipple (*q.v.*) on dogs kept anemic by bleeding, and in 1934 all three shared the Nobel prize in medicine. Meanwhile, with the physical chemist Edwin J. Cohn, Minot had prepared efficient liver extracts. His research on anemia and nutritional disturbances continued at the Thorndike Memorial laboratory, where many subsequent leaders in U.S. medicine came under his influence. Minot died in Brookline, Mass., on Feb. 25, 1950.

See Francis Minot Rackemann, *The Inquisitive Physician: the Life and Tinzes of George Richards Minot* (1956). (W. B. C.)

MINOT, LAURENCE (*fl.* 1333–1352), English poet, the author of 11 battle songs, first published by Joseph Ritson in 1795 as *Poems on Interesting Events in the Reign of King Edward III.* They had been discovered by Thomas Tyrwhitt in an early 15th-century manuscript (Cotton Galba, E. IX., British Museum) which bore on the flyleaf the misleading inscription: "Chaucer, Exemplar emendate scriptum." The poems were evidently written contemporaneously with the events they describe. The first celebrates the English triumph at Halidon hill (1333) and the last the capture of Guines (1352). Nothing whatever is known of Minot's life, but

the minuteness of his information suggests that he accompanied Edward on some of his campaigns. Though his name is Norman, he nrites vigorous and idiomatic English of the northern dialect with some admixture of midland forms.

MINOT, a city of North Dakota, U.S., 55 mi. S. of the Canadian border on the Souris river is the seat of Ward county. Settled in 1886 when the Great Northern railroad reached the Souris, Minot had 5.000 inhabitants within a year and was incorporated as a city in 1887. Because of its location in the short-grass ranching country, cowboys and horse and cattle thieves gave it a "wild west" atmosphere. After 1892. when its hinterland, about the size of Indiana. was opened to homesteaders, it became the largest city and the leading retail and wholesale centre between the Red River valley and Great Falls, Mont. A steady population increase was brought about by the growth of small industries, lignite shipment and the location of a U.S. air force base nearby. (For comparati e population figures see table in NORTH DAKOTA: Population.)

Minot's business centre is built on the flood plain of the Souris, nhich ninds eight miles through the city. The rugged hills up which it has spread give Minot a striking appearance uncommon on the plains. Among its attractions are the North Dakota State Teachers college. opened in 1913, and 300 ac. of parks, one of which, Roosevelt, contains a large zoo. Minot has a council-manager form of government, in effect since 1933. Its name is in honour of Henry D. Minot, eastern capitalist and friend of Theodore Roosevelt. (R. P. WI.)

MINOTAUR, in Greek mythology, a fabulous Cretan monster having the body of a man and the head of a bull. This creature was supposed to be the offspring of Pasiphae, the wife of Minos, and a snow-white bull, sent to Minos by Poseidon for sacrifice. Minos, instead of sacrificing it, spared its life, and Poseidon, as a punishment, inspired Pasiphae with an unnatural passion for it. The monster which was born was shut up in the Labyrinth (*q.v.*). It happened that Androgeus. son of Minos, had been killed by the Athenians, who were jealous of the victories he had won at the Panathenaic festival. To avenge the death of Androgeus, Minos demanded that seven Athenian youths and seven maidens should be sent every ninth year to be devoured by the Minotaur. When the third sacrifice came round Theseus volunteered to go, and with the help of Ariadne (*q.v.*) slew the Minotaur.

It seems possible that a confused reminiscence of actual bull baitings, perhaps a sacred rite, which are attested by Cretan wall paintings, has something to do with this story. Pictures of half-human monsters are also common; see especially the seal impression of a minotaurlike creature (Brit. *Sch.* Ath., vol. vii, p. 18). But their meaning, like the original significance of the myth, awaits explanation.

MINSK, the capital of the Belorussian S.S.R. and Minsk *oblast,* U.S.S.R., on the Svisloch river, a nonnavigable tributary of the Berezina, in 53° 54' N., 27° 33' E. Pop. (1959) 509,000.

Various educational institutions, including the Belorussian state university, an academy of sciences and an institute to study the problems of White Russian agriculture and forestry, were established there.

Minsk became an important commercial and industrial city; products manufactured include tractors and automobiles, machinery and machine tools, radios and phonographs and leather goods. Other products include cotton and linen cloth goods, lumber and wood products such as furniture. The numerous small Jewish traders were thrown out of their occupations after the 1917 revolution, and efforts were made to settle them in other parts of Russia in order to relieve local unemployment.

Its position near the west has always made it liable to invasion. Minsk is mentioned in Russian annals in the 11th century under the name of Myen'sk, or Menesk. In 1066 and 1096 it was devastated, first by Izyazlav and afterward by Vladimir, prince of Kiev. It changed rulers many times until the 13th century, when it became a Lithuanian fief. After the 15th century it was part of Poland, but as late as 1505 it was ravaged by Tatars and in 1508 by Russians. In the 18th century it was taken several times by Swedes and Russians. Russia annexed it in 1793, but within a few years it was laid waste by Napoleon I (1812).

It was the headquarters of the 4th army corps under the tsarist government. Its close proximity to the west Russian front involved it in the disorders of the Russian retreat during World War I. In Nov. 1917 an executive committee of workers, soldiers and peasants was formed in the town, but in 1918 Minsk was occupied by German troops, which advanced as far as the Dnieper river, but withdrew after the revolution in Germany. In the spring of 1919 a Polish army occupied the district, and Minsk did not settle down to peaceful development until 1921. During World War II, it nas again occupied by Germany, 1941–44.

MINSTREL. The word "minstrel," derived from the Latin *minister,* a servant, was used after the 13th century to signify a household entertainer, its earlier equivalent being "jogelour" (Fr. jongleur). Still earlier the same part was played by the Teutonic gleeman, or *scôp.* In the Anglo-Saxon poem that bears his name, Widsith, the far-traveler, wanders from place to place, from the Picts and Scots in the west to the Medes and Persians in the east, singing and telling stories and welcomed everywhere; from the Ostrogoth Eormanric (Hermanric, d. 37j) he receives a collar of gold, and on his return home he is given an estate. Other early poems, such as *Beowulf,* show the honour in which these minstrels were held in pagan times; but. although patronized by Charlemagne, they were denounced by the church with a vigour and frequency nhich show how ineffective such denunciations were in stemming their popularity.

The term minstrel covered a great variety of performers. At the head of the profession the place of the *scôp* nas taken in the 11th century by the *trouvère* (*q.v.*) or the *troubadour* (*q.v.*), nho was often a man of high social standing. Such a *trouvère* was Taillefer, who led the Norman attack at Hastings, singing the song of Roland and juggling with his sword. After the conquest, Berdic. *joculator regis,* is shown by Domesday to have been given estates in Gloucestershire; and the traditions that Rahere. founder of St. Bartholomew's priory at Smithfield. had been minstrel to Henry I, and that Richard I was discovered in his captivity by his minstrel Blondel, if not true to fact. show the position occupied by such persons in popular opinion. Master Henry, *versificator regis,* to whom Henry III made various gifts, may have been one of the last of the English *trouvères;* certainly after that king's reign the minstrels seem to take a lower place in society. Kings and nobles still kept their minstrels. even so strict a churchman as Bishop Robert Grosseteste having a private harper, but they were more professional musicians. For these there were professional schools at Beauvais, Cambrai, Lyons and elsewhere, and in many towns they formed themselves into guilds, of which the earliest known is the Pui of Arras, founded in 1105. The minstrels' guild of Paris, of which the head was called roy *des ménestriers,* was founded in 1321 and lasted to 1776; in London the minstrels were incorporated in 1469, and all minstrels in the country were ordered to join the guild, but this order was ignored, and when a new charter was granted in 1604 the guild's jurisdiction was limited to three miles beyond the city. The guild still exists as the Corporation of Musicians of London. Canterbury had such a fraternity in 1526, and that of Beverley claimed to date from the time of Athelstan, certainly existed in the 15th century, and was reorganized in 1555, when rules were made that members must be minstrels to men of honour, "waits" to some town[1] or otherwise approved. The minstrels of the county of Chester were from an early date (traditionally 1210) under the control of the head of the family of Dutton, whose rights were recognized in all the vagrancy acts from 1j72 onward; as late as 1756 the heir of Dutton held a court at Chester fair and issued licences to musicians. Similarly at Tutbury John of Gaunt in 1380 established a roy des *ministralx,* whose court was still held at the end of the 17th century.

Medieval account rolls of the expenses of royal and noble households, towns and monasteries are full of payments, often

[1] The chief English towns, such as London, York, Chester, Bristol, Coventry, etc., had minstrels, usually called "waits," who wore a livery arid silver badge and combined the duties of town band and night-watchman, "piping the watch" at fixed hours of the night.

lavish, to all kinds of minstrels, musicians, players and jugglers, and at the marriage of Princess Margaret in 1290 no fewer than 426 minstrels, English and foreign, attended. Most of these came with noble guests, and the king himself, Edward I, had a large staff of musicians, partly minstrels and partly military band, as had his successors. But by the 1 jth century the day of the real rninstrel was passing; and with the coming of printing the taste for listening to long chanted ballads and romances died out, and the minstrel became more and more an instrumental performer, just as the "minstrels' galleries" in the halls of Tudor houses were purely for instrumental or choral music. With the 16th century the minstrels became players, in ihe sense of actors, or degenerated into that "thing of shreds and patches," the wandering minstrel.

Even from early times there had been many of these unattached, vagrant entertainers, picking up a precarious living by performing in fairs and village taverns, or thrusting themselves brazenly into the halls of the great, risking kicks for the sake of halfpence. It was against these, headed by the Goliards (*q.v.*), that the church chiefly fulminated for their ribaldry, indecency and lack of reverence. The state also viewed them with disfavour as men who wasted their own time and that of their listeners, and, not unjustifiably, as promoters of sedition. For these masterless men carried the news from place to place, sang biting lampoons against unpopular ministers, or voiced the wrongs of the poor; and such revolts as the Peasants' rising of 1381, Jack Cade's of 1450, and other more local riots seem to have owed much to their activity. Consequently from the time of the Black Death (1349) onward, and particularly after 1572, they were continually in danger oi the stocks, the whipping post and prison.

The best account of the subject is in E. K. Chambers, *The Mediaeval Stage*, i, 23–86, and ii, 230–266 (1903); where references are given to other works. *See* also A. Schultz, *Das höfische Leben zur zeit der Minnesinger* (1889); J. Jusserand, *English Wayfaring Life* (3rd ed., 1925). (L. F. S.)

MINSTREL SHOW. Negro minstrelsy, the only indigenous American theatrical form, was based upon the singing and dancing of Negro slaves. While in its early forms the minstrel show often presented accurate delineations of southern Negro types, later forms showed diminishing relationship to Negro life and feeling.

Individual Negro impersonators appeared early in the 19th century, the most famous being Thomas Dartmouth Rice, whose "Jim Crow" song and dance was first performed in 1828. The pioneer company, the Virginia minstrels, a quartet headed by Daniel Decatur Emmett, first performed in Jan. 1843. Emmett, who wrote "Dixie" as a "hooray song" or "walk-around" in 1859, became one of the more prominent minstrel performers. The most important of the early companies was the Christy minstrels. Organized in Buffalo, N.Y., they were in New York city by 1846, and, in 1847, leased Mechanics hall on Broadway, where they played for nearly ten years. Stephen Foster wrote his greatest songs for this company. Other noted companies were Bryant's, Campbell's and Haverly's. Negro minstrelsy, popular in England as well as the U.S., reached its zenith between 1850 and 1870, then gradually declined until it became purely a vehicle for amateurs. Its influence, however, was sometimes evident in vaudeville, radio, television and motion pictures of the mid-20th century.

The form of the minstrel show was established by the Christy company and changed little thereafter. The performance usually was in two parts. In part one, the performers were arranged in a semicircle, with the "interlocutor" in the centre, and the endmen, "Mr. Tambo," who played the tambourine, and "Mr. Bones," who rattled the bones, at the ends. The interlocutor, played white-face, usually wore full dress; the others, their faces blackened with burnt cork, wore gaudy swallow-tailed coats and striped trousers. The program opened with a chorus, often with a grand entrance, and at the conclusion of the song, the interlocutor gave the stereotyped command, "Gentlemen, be seated." Then followed a series of jokes between the interlocutor and endmen, interspersed with ballads and comic songs and instrumental numbers, chiefly on the banjo and violin. The second part, or olio, consisted of a series of individual acts which concluded with a "hoe-down" or "walk-around" in which every member of the company did a specialty number while the others sang and clapped. Occasionally there was a third part, consisting of a farce, burlesque or comic opera. Sometimes this feature was made the last item of part two.

The minstrel show disappeared from the professional theatre. Its chief significance lay in its "folk" music, which made a permanent contribution to American culture. (C. L. S.)

MINT. A place where coins are manufactured, usually with the authority of the state.

The first mint probably was established by Gyges in Lydia toward the end of the 8th century B.C. for the coining of electrum, a natural alloy of gold and silver. Silver was coined in the island of Aegina soon afterward. The art of coining was introduced by the Greeks into Italy and other countries bordering on the Mediterranean and into Persia and India. Subsequently the Romans laid the foundations of modern minting. Coining originated independently in China at a later date than in the western world and spread from China to Japan and Korea.

In Britain gold and silver were coined before the arrival of the Romans, and after the Norman Conquest the nurnber of mints increased to about 70, more than now exist in the world. The necessity for so many mints arose from the poor means of communication. The coins occasionally were tested at Westminster, and if any deficiency in their weight or fineness was found the "moneyers" or minters were punished as traitors. Officers were appointed *c.* 1180 to supervise the coinage on behalf of the king and to collect the seigniorage (*q.v.*), which generally took the form of a deduction from the amount of bullion sent to the mint for coinage. The work was done by contractors at a great profit. Sir Isaac Newton was appointed master of the mint and contractor of the coinage in recognition of his services as a scientist. In 1850 the contract system was abolished, and after that the work was conducted by civil servants, all profits becoming part of the revenue. The London mint was built in 1810, when the old mint in the Tower of London was closed after being in use for centuries.

In the United States the Philadelphia mint was opened in 1702, and there are other mints at San Francisco, Calif., and Denver, Colo. Many countries do not possess a mint, their coinages being executed under contract.

The Supply of Bullion to Mints.—In England, in the middle ages, the king was accustomed to send to the mint the produce of his own silver mines. The king's right of levying seigniorage was retained until 1666, but the rate was sometimes modified to encourage his subjects to bring gold and silver to the mint. In spite of this inducement supplies often were deficient, and several instances are recorded in which alchemists were called in to attempt transmutation of baser metals into gold.

Silver bars, which weigh about 1,000 to 1,200 oz. troy each, usually are bought by the mints only when new or additional issues of silver coin are required for circulation or reserve. In the first years after World War I very little new silver was required for coinage in Great Britain, thanks to the widespread melting down of old silver coin for sale and its replacement by silver of lower standard. The intrinsic value of the silver in coins is usually much iess than the nominal or face value at which they pass in circulation in their own country. Thus in ,Great Britain from 1920 to 1946 one ounce of a silver alloy containing 50% of silver was converted into 5*s.* 6d. in silver coin, whatever the market price of silver bullion might be. The difference between the minted and unminted values is retained by the state to cover the cost of manufacture and as a source of revenue. The system in other countries is similar. Thus the United States dollar contains 371.25 gr. or 0.77 oz. of fine silver.

Refined gold ingots suitable for minting (the "bar gold" of commerce) are usually about 400 oz. troy in weight. They could be taken to the London mint for coinage without charge previous to 1925, but in that year the right was withdrawn except from the Bank of England. In the United States, Canada, Australia, India and Japan the mints also receive unrefined gold and refine it.

Alloys **Used** in Coinage. — The earliest gold and silver coins made by the Greeks consisted of the pure metals (990–997 fine;

i.e., 990–997 parts in 1,000) or of electrum. After electrum had fallen into disuse, pure gold continued to be used; but under the Roman emperors copper was intentionally added, and in the two centuries preceding the fall of Rome very base alloys of gold were coined, some containing only 2% of gold or even less. In the middle ages these base alloys were discarded, and the bezant of Constantinople and the early coins of western Europe were intended to be absolutely fine. The gold standard of $\frac{11}{12}$ or 916.6 (22 carats fine) was adopted in England in 1526.

The silver standard of 925 (11 oz. 2 dwt. of silver and 18 dwt. of alloy) probably was introduced first in England by the Saxons but has not been maintained continuously. Henry VIII reduced it to 10 oz. silver and 2 oz. alloy and afterward to 4 oz. silver and 8 oz. alloy. Under Edward VI the standard, at first debased further to 3 oz. silver and 9 oz. alloy, was afterward raised again; the standard of 925 was restored by Elizabeth I. In 1920 it was reduced to 500, but the name "standard silver" generally means silver 925 fine. The 900 standard for both gold and silver coins was introduced in France soon after the Revolution and later was adopted in most other countries. The standard in India was 916.6 for both gold and silver until 1941, when the silver standard was reduced to 500.

Copper was originally added to gold in coins to reduce the cost of metal, but it has long been recognized that gold-copper and silver-copper last longer in circulation than pure metals because of their greater hardness. Rate of wear, however, depends not only on hardness but also on the resistance of coins to corrosion. Coins become greasy in circulation and the fatty acids corrode the copper, forming a friable crust on the surface which is easily rubbed off. Accordingly coins containing much copper are not so resistant to wear as those of higher standard and more often present a dirty appearance in circulation. The average life of silver coins of the 925 standard in circulation in Great Britain was about 40 years in the 19th century, the larger coins lasting longer and the smaller ones for a shorter time.

Subsidiary coins in the past generally consisted of copper, but in France soon after the Revolution of 1789 copper became scarce and the church bells were melted down to eke out the supply. The bells consisted of an alloy of copper and tin with a little zinc, and coins containing some of it were found to have advantages over coins of pure copper. A mixture of these metals in the proportion of copper 95%, tin 4% and zinc 1% ("coinage bronze") was adopted in 1851 by France for subsidiary coins, and afterward by almost every country in the world.

An alloy (copper 75%, nickel 25%), introduced in Belgium in 1861 and generally known as cupronickel, replaced 500 silver in the British coinage in 1947. It is used widely throughout the world. Aluminum bronze (copper 91%, aluminum 9%) replaced silver for franc and two-franc pieces in France after 1921 and was adopted elsewhere. Nickel-brass (copper 79%, zinc 20%, nickel 1%) is used extensively, notably in the coinage of West Africa.

The president formally revalued the U.S. gold dollar by proclamation of Jan. 31, 1934, under the act of May 12, 1933, as amended by the Gold Reserve Act of 1934. This proclamation declared the gold dollar to be $15\frac{5}{21}$ gr. of gold nine-tenths fine, which is equivalent to $35 per troy ounce of fine gold. Thereafter the U.S. mints and assay offices resumed the purchase of proffered eligible gold, at the price of $35 per fine troy ounce.

Manufacture of the nickel-copper (75% copper and 25% nickel) five-cent coin was discontinued in May 1942 by reason of the need of these metals for other uses in connection with World War II. The Second War Powers act, 1942 (March 27, 1942), contained provision for a five-cent coin of half silver and half copper, with authority to vary those proportions and to add other metals if in the public interest.

Production of the new five-cent coin under authority of the Second War Powers act was started on Oct. 1, 1942. The alloy for the coins, developed by mint technologists and adopted after considerable experimentation, was finally determined as 35% silver, 56% copper and 9% manganese. This alloy was discontinued Dec. 31, 1945. The alloy after Jan 1, 1946, was 75% copper and 25% nickel.

Production of bronze one-cent coins was sharply curtailed beginning in July 1942 and entirely discontinued in Dec. 1942, because of the necessity of saving copper for war industries. After extensive experimentation a zinc-coated steel coin was finally adopted, and production was commenced on Feb. 23, 1943, pursuant to the act of Dec. 18, 1942, public law 815, 77th congress. The standard weight of the zinc-coated steel one-cent coin was 42.5 gr., compared with 48 gr. for the bronze one-cent coin.

Production of the zinc-coated steel cent was discontinued Dec. 31, 1943. The total number struck from the beginning of production in Feb. 1943 to their discontinuance Dec. 31, 1943, was 1,093,838,670 pieces, value $10,938,386.70.

The silver coins of the U.S. are composed of 90% silver and 10% copper. (See also ALLOYS.)

Assay Commission. — The Assay commission, appointed by the president of the U.S., meets in February each year to examine and test the weight and fineness of the silver coins reserved at the mints at Philadelphia, San Francisco and Denver during the preceding calendar year. The coins, one from each 2,000 pieces or fraction thereof made at each mint, are deposited in sealed packages in a pyx for delivery to the annual Assay commission.

Trial of **the** Pyx. — Periodical examinations of the coins issued by the mint were made from very early times in England by persons appointed by the crown. Specimens are drawn at random from the finished coins and are put into a box or "pyx." At intervals these coins are weighed and assayed by a skilled jury and the results reported to the government. The trial is now held annually by the Company of Goldsmiths.

Manufacture of Coins. — Until the middle ages coins were struck between engraved dies by hand hammers, and hand minting persisted in the native states of India until the 19th century. The Romans cast their larger copper coins. Modern methods may be said to date from 1553, when rolls for reducing the thickness of cast bars, machines for punching out round disks from sheets of metal and screw presses for striking coins were introduced in Paris. In England the new machinery was tried in 1561 and finally adopted in 1662. (For detailed history, see NUMISMATICS.)

The coinage operations in the U.S. mints are as follows: (1) Refining the bullion to obtain pure metals for coinage. Electrolytic refineries are operated at the Denver and San Francisco mints and the U.S. assay office at New York city. (For a description of the process, see GOLD: MINING AND METALLURGY; SILVER: Metallurgy, ***Mining*** *and Production*.) (2) Melting the alloy and casting it into ingots. (3) Rolling the ingots into strips or "fillets." (4) Cutting out disks or blanks. (5) Annealing and cleaning the blanks. (6) Upsetting or edge rolling the blanks to produce a raised rim. Lettering is sometimes impressed on the edge in this operation. (7) Weighing the blanks to separate the light and heavy pieces which are condemned for remelting. One-cent and five-cent blanks are not weighed. (8) Striking the blanks between dies in the coining presses.

In 1948 modern brass mill melting and rolling equipment was installed in the U.S. mint at Denver. This equipment permits the processing of a 400-lb. ingot to a coiled strip 185 ft. long and 12 in. wide. All rolling operations were mechanized. The coiled strip is slit in half, each half is recoiled and subsequently is automatically fed through the blanking press. Many other innovations were introduced, such as a dual automatic feeding device which permits the stamping of two coins with each stroke of the coin press. Automatic feeding devices were installed on all equipment performing the operations of blank annealing, cleaning, upsetting, weighing, stamping, inspecting and counting.

Rolling. — The cast bars are reduced to the thickness of the coin by repeated passages between rolls, which are divided into breaking-down, thinning and finishing or gauging rolls, the last named being of the smallest diameter. The reduction of thickness in the bars is accompanied by a slight increase in their width and a very great increase in their length, so that it is generally necessary to cut them into two parts.

By repeated passages through the rolls the bars are hardened, and to facilitate further reduction they usually are softened by

annealing before being passed to the finishing rolls. In the United States mints the use of very carefully refined metal has made it possible to discontinue strip annealing. When the strips are reduced to the correct thickness they are examined by the "tryer," who cuts out one or two blanks from each strip with a hand machine and weighs them on a delicate balance. If the blank is too heavy the strip is again passed through the rolls.

The degree of accuracy required is indicated by the tolerance or "remedy" allowance in weight, which is different for each coin and is the maximum difference from the standard weight which is allowed by law. In the sovereign it is 0.2 gr. or about 12.96 gr. per 1,000. As the mean thickness of a sovereign is 0.0466 in., the remedy in weight corresponds to a difference of less than $\frac{1}{10,000}$ in. in the thickness of the strip. Remedies in weight and fineness are intended to cover accidental variations.

Cutting Blanks.—In the cutting machine (fig. 1) the revolution of a cam causes two or more short steel cylinders or cutters to enter holes in two parallel plates fixed to the bed of the machine. When the coinage strip is brought between the plates, the cutters descend and force disks of metal through the holes in the lower plate. After each descent of the cutters, the strip is advanced by small gripping or feeding rolls to the next position. The disks fall down a tube to a receptacle.

Annealing, Blanching and Marking the *Blanks*.—The blanks are softened by annealing and then thoroughly cleaned before being passed to the coining presses. The blanks to be annealed are charged into a hopper at one end of the furnace and conveyed toward the other end by a revolving Archimedean screw. In a few minutes they are raised to a dull red heat and become blackened by the formation on the surface of a film of oxide of copper. They leave the furnace by falling through an aperture into water. The oxide of copper is removed by solution in hot dilute sulphuric acid, sometimes with the addition of hichromate, and a layer of pure frosted silver is left on the surface, which appears dead white in colour and has lost its metallic lustre. The operation is called '(blanching." The blanks are washed in water to remove all trace of acid and then are dried.

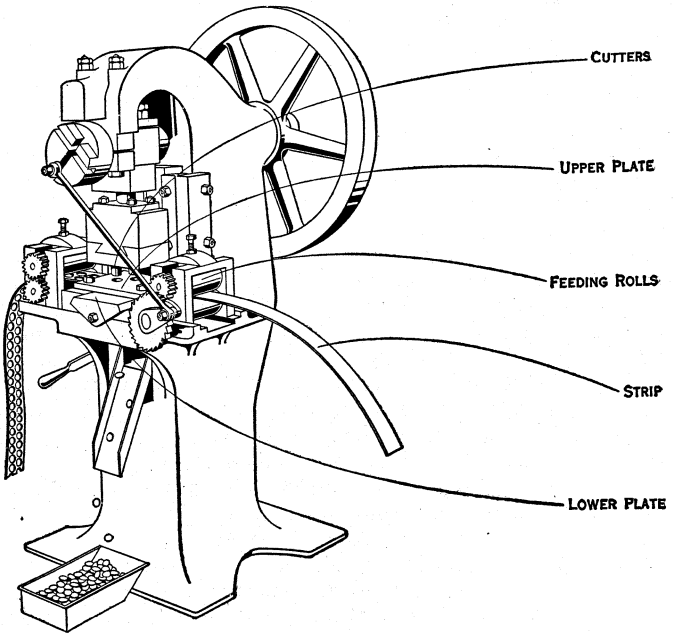

FIG. 1.— CUTTING MACHINE SHOWING HOW THE COIN BLANKS ARE PUNCHED, TWO AT A TIME, FROM THE STRIP OF SILVER BY THE DESCENT OF STEEL CYLINDERS

The blanks then are passed to an edge-rolling machine, by which they are thickened at the edge so as to form a rim to protect the finished coin from wear. The operation is called marking, because originally the edges not only were thickened but also were marked with an inscription, as is still done in some mints. The letters sometimes are sunk and sometimes raised. For instance, the British crown piece has a sunken inscription, whereas the Swiss five-Franc piece and some of the former Spanish, French and Belgian gold coins had raised inscriptions. Like the graining or "milling" on the edges of coins, the inscriptions were intended to put a stop to the practice of clipping and filing coins, which was prevalent in the 16th and 17th centuries.

Striking the Coins.—The blanks are converted into coin by receiving an impression from engraved dies. Each blank is placed on the lower of two dies and the upper die is brought down forcibly upon it. The pressure causes the soft metal to flow like a viscous solid, hut its lateral escape is prevented by a collar which surrounds the blank while it is being struck. The collar may be plain, crenated (milled) or engraved.

Modern coining presses are improved forms of the lever press invented by Uhlhorn in 1839 which replaced screw presses. One of the London mint presses is shown in fig. 2. The blanks are fed by hand

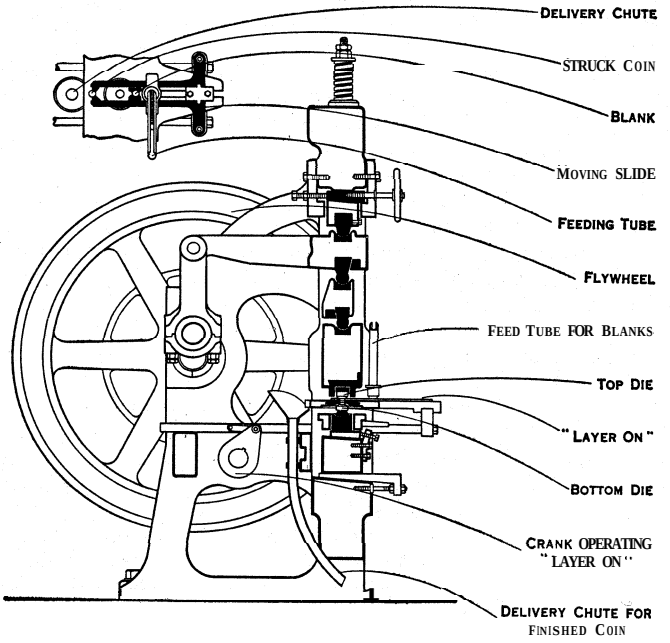

FIG. 2.— COINING PRESS SHOWING THE MASSIVE STRUCTURE OF A MODERN PRESS. WHICH RETAINS ITS RIGIDITY WHILE STRIKING A HEAVY BLOW EQUIVALENT TO A PRESSURE OF MANY TONS

or by an automatic feeder into the machine, which performs the rest of the operations. A blank is carried forward by a moving slide and placed exactly on the lower die by iron fingers, the "layer-on." This imitates the action of the human finger and thumb which it has superseded. The collar encircles the blank and the upper die is brought down and pressed upon it. By means of continued revolution the machine next lifts the upper die, and the lower die rises simultaneously and pushes the coin out of the collar. Lastly the layer-on pushes off the finished coin (which falls down a tube into a bowl) and places another blank on the die. Coining presses strike about 100 coins a minute.

The dies consist of hard carbon steel, and the process of making them is complicated. The original design of the artist, in the form of a large plaque of plaster of paris, is reproduced in relief in iron or bronze by casting or in nickel by electrodeposition. An exact copy of the plaque in miniature, of the diameter of the coin to be produced, is made by a reducing machine.

The machine has two adjustable heads and on these are mounted the model or plaque and a block of soft steel. In front of them is a balanced arm, pivoted at one end and carrying both the tracer point, which presses against the model, and the revolving cutter. The model and steel block are rotated synchronously, and at the same time the free end of the balanced arm gradually falls. The result is that the tracer and cutter are made to travel in fine spirals over all parts of the model and steel block, respectively, converting the block into the "reduction" punch.

The old way of making the original steel copy of the artist's design was by hand engraving (see NUMISMATICS), a method still in use for slight changes in the design, as for example a change of date, and for all purposes in some mints.

Dies strike about 50,000 coins before they are worn out.

Weighing the Coins.—Gold and silver coins are examined individually by eye on the overlooking machine, upon which the coins are spread on a travelling belt, arranged so that both faces of the coins are exposed in succession. Each coin, excepting those of smaller denomination, is then tested by ringing and finally weighed separately by being passed over delicate automatic balances. Automatic balances for weighing single coins were introduced at the Bank of England in 1843.

In the London mint both light and heavy coins are returned to the melting pot. The proportion of rejected gold coin varies with the quality of the bullion and may exceed 10%. The percentage of rejected silver is usually less than 1%.

(See MONEY.)

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1953); *Annual Reports* of the Deputy Master of the Mint (London, 1870 onward); *Annual Reports* of the Director of the (United States) Mint (Washington). (T. K. R.; H. W. L. E.; N. T. R.; L. HD.)

MINT, botanically *Mentha,* a genus of plants of the family Labiatae, comprising about 25 species of perennial herbs, widely distributed throughout the temperate and subtropical portions of the globe, but chiefly in the temperate regions of the old world. The species have square stems, opposite, aromatic leaves, and a stoloniferous creeping rootstock. The flowers are arranged in axillary clusters, which either form separate whorls or are crowded together into a terminal spike. The corolla is usually small and of a pale purple or pinkish colour; it has four nearly equal lobes and encloses two long and two short stamens.

In Great Britain a number of species are indigenous or naturalized but the forms easily hybridize so that there is great confusion in the genus. *Mentha spicata* is the garden mint or spearmint (*q.v.*), which is commonly used for culinary purposes; it is distinguished by its smooth, sessile leaves and lax tapering flower spikes. *Mentha longifolia* chiefly differs from the above in its coarser habit and hairy leaves, which are silky beneath, and in its denser flower spikes. This plant is supposed to be the mint of Scripture, since it is extensively cultivated in the east; it was one of the bitter herbs with which the paschal lamb was eaten. M. *aquatica,* the nater mint. grows in ditches and is easily recognized by its rounded flower spikes and stalked hairy leaves. M. *piperita,* or peppermint (*q.v.*), has stalked smooth leaves and an oblong obtuse terminal spike of flowers; it is cultivated for its volatile oil. *M crispa* belongs to a group in which the flowers are arranged in axillary whorls and never in terminal spikes; it otherwise bears some resemblance to *M. spicata.*

M. pulegium, commonly known as pennyroyal, has small oval obtuse leaves and flowers in axillary whorls and is remarkable for its creeping habit and peculiar odour. It was formerly popular for medicinal purposes. All the genus *Mentha* abound in a volatile oil, contained in resinous dots in the leaves and stems. Most mints blossom in summer.

The name mint is also applied to plants of other genera, *Monarda* being called horsemint, *Pycnanthemum* mountain mint, and *Nepetn cataria,* the catnip, is sometimes called catmint.

MINTO, GILBERT ELLIOT, 1ST EARL OF (1751–1814), was the eldest son of Gilbert Elliot (1693–1766), Lord Minto. About 1763 Gilbert and his brother Hugh were sent to Paris, where their studies were supervised by David Hume and where they became intimate with Mirabeau. Gilbert entered Christ church, Oxford, and was called to the bar. In 1776 he entered parliament as an independent Whig. He became very friendly with Burke, whom he helped in the attack on Warren Hastings and Elijah Impey, and on two occasions was an unsuccessful candidate for the office of speaker. In 1794 Elliot was appointed to govern Corsica, and in 1797 he assumed the additional names of Murray-Kynynmond and was created Baron Minto. From 1799 to 1801 he was envoy-extraordinary to Vienna, and having been for a few months president of the board of control he was appointed governor-general of India at the end of 1806. During his viceroyalty he had to provide against the danger from Napoleon, and deal with the nearer menace of the Sikh power at Lahore. Before he gave up office in 1813 Java and the Moluccas had been added to the empire. He was then created Viscount Melgund and earl of Minto. He died at Stevenage on June 21, 1814 and was buried in Westminster Abbey.

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MINTO, GILBERT JOHN MURRAY KYNYNMOND ELLIOT, 4TH EARL OF (1845–1914), was born in London on July 9, 1845. He was educated at Eton and Trinity college, Cambridge, and joined the Scots guards in 1867. In 1870 he sent in his papers and went to live in Lincolnshire, where he acted as a gentleman rider for four years. He rode four times in the Grand National, and in the 1876 race he broke his neck. He survived, and turned newspaper correspondent. In this capacity he was in Spain with the Carlist army in 1874, and in Turkey in the Russo-Turkish war. He was present in an unofficial way at the second Afghan war in 1879, and very nearly went to Kabul with Cavagnari's party who were murdered there next year. He went to the Egyptian war in 1882 in the same casual way, and fought with the mounted infantry at Ismailia.

He married Mary Grey in 1883, and the haphazard part of his life came to an end. In 1883 he went to Canada as military secretary to Lord Lansdowne; here he served in the Riel rebellion campaign and was offered the post of commandant of the North West Mounted Police. He returned to England in 1886, and spent 12 years at home, chiefly occupied with his volunteer corps, the Border Mounted Rifles, and studying the theory of warfare. In 1891 he succeeded his father as Lord Minto. In 1898 he was made governor-general of Canada. Here his great problem was the difference in point of view between Chamberlain, with his vision of Imperial Federation, and Sir Wilfred Laurier, prime minister of Canada, whose vision, concentrated on Canada, included no such thing. Minto's invariably constitutional behaviour and his soothing personal influence helped to surmount some unpleasant situations, notably the Alaskan question and that of the Canadian contingent in the Boer war. Laurier said of him, "He is the most constitutional governor we have had."

Minto returned to England in Nov. 1904, and in Aug. 1905, he was appointed viceroy of India in succession to Curzon. Curzon left him a ticklish legacy; he had changed many things in a very short time, and he had been an autocrat. Not the least of Minto's troubles was the tradition of centralisation he found; not the least of his assets were his great-grandfather's work 100 years before, and India's long memory. Minto started at once to restore responsibility to the viceroy's council. The relation between Minto and his secretary of state, Morley, was interesting. They liked and trusted one another personally, but Morley, as secretary of state, was a difficultman to handle. He tended for more than one reason, to be autocratic; he started by overriding his own council, he went on to ignore the viceroy's council and to attempt to reduce the viceroy himself to a satellite of the secretary of state. Minto handled the situation very cleverly; more than one of his suggestions, quietly thrown out in letters, came back to him in the majesty of Morley's somewhat Olympian despatches. But Morley's constant interference in the details of administration, raised a serious constitutional question, and very nearly provoked Minto's resignation. The breach with Kitchener that Curzon had left was immediately healed, and the two men worked together harmoniously in preparing India's case when the details of the Russian convention were being arranged. Minto took a long step toward the solution of the frontier problem when he made a firm friend of the Amir of Afghanistan, who paid him a visit in Calcutta. But Morley was somewhat inclined to ignore views on the wider aspects of imperial policy coming from India, and in the event of the convention of 1907 nearly undid all Minto's work for the conciliation of the Amir.

But all other aspects of Minto's viceroyalty are of small moment compared with the supreme importance of the Reforms. (See INDIA.) On this matter Minto and Morley saw eye to eye from the start. There were even times when the Tory Viceroy outran the prudence of the Radical secretary, and when the battle was won Morley said to Lady Minto, "I am swimming in a popular tide through victories which are not my own." In spite of strong opposition in India and at home the steps were gradually taken. The first was the appointment of an Indian member to the secretary's council; the second, much more hotly disputed, the appointment of Sinha to the viceroy's council in March 1909. In May of the same year the Reform bill was passed, the foundation of the new policy of gradual extension of self-government to India. Even Minto's enthusiasm for a progressive policy was perhaps not more to his credit than his refusal to let sedition and violence deter him from his chosen path. Lord Minto returned to England in Nov. 1910 and died at his home at Minto on March 1, 1914.

See J. Buchan, *Lord Minto* (London, 1924); Mary, countess of Minto, *India, Minto and Morley* (London, 1934).

MINT PAR OF EXCHANGE. A mint par of exchange can exist only between two currencies based upon the same metal. It is defined as the fixed intrinsic value of the currency unit of one country expressed in terms of the other. It depends solely upon the amount and fineness of the metal which the law of each country enacts that its currency unit shall contain.

Formerly, for instance, in England 20 lb. gold, $\frac{11}{12}$ fine, equalled £934.5; in Switzerland, 1 kg. gold, $\frac{9}{10}$ fine, equalled 3,100 Fr.; and in the United States, 258 gr. gold, $\frac{9}{10}$ fine, equalled $10. The mint par of exchange could then be readily calculated. Take England and Switzerland:

£934.5 = 20 lb. std. gold, $\frac{11}{12}$ fine
= 18.33 lb. fine gold
= 6.841 kg. fine gold
3,100 Fr. = 1 kg. gold, $\frac{9}{10}$ fine
= 0.900 kg. fine gold.

Then $\frac{3{,}100 \times 6.841}{0.9}$ Fr. = 6.841 kg. fine gold = £934.5

or, $\frac{3{,}100 \times 6.841}{0.9 \times 934.5}$ Fr. = £1

or, simplifying, 25.22 Fr. = £1.

Foreign exchange operators used a quicker way of calculating pars, known as the "chain rule." This is illustrated below, in a calculation of the pound against the dollar:

$?	= £1
£934.5	= 20 lb. gold std.
12 lb. std.	= 11 lb. fine
1 lb. fine	= 5,760 gr. fine
9 gr. fine	= 10 gr., $\frac{9}{10}$ fine
258 gr., $\frac{9}{10}$ fine	= $10.

The answer is: $\$\frac{1 \times 20 \times 11 \times 5{,}760 \times 10 \times 10}{934.5 \times 12 \times 1 \times 9 \times 258} = \$4.867$.

The chain rule is: (1) state the question in the top equation; (2) begin each new equation with the same kind of item as ends the preceding one; (3) see that the final equation ends with the same kind of item as began the first; (4) divide the product of the left-hand side into the product of the right. (See also CURRENCY; EXCHANGE, FOREIGN.) (N. E. C.)

MINUCIUS FELIX, MARCUS, one of the earliest if not the earliest, of the Latin apologists for Christianity. He is now exclusively known by his *Octavius*, a dialogue on Christianity between the pagan Caecilius Natalis and the Christian Octavius Ianuarius, a provincial lawyer, the friend and fellow student of the author. The form of the dialogue is modeled on the *De natura deorum* and *De divznatione* of Cicero.

The *Octavius* is admittedly earlier than Cyprian's *Quod idola dii non sint*, which borrows from it; how much earlier can be determined only by settling the relation in which it stands to Tertullian's *Apologeticum*. After A. Ebert's exhaustive argument in 1868, repeated in 1889, the priority of Minucius was generally admitted; the objections are stated in the *Dict. Chr. Biog.* article by G. Salmon.

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MINUET, a dance for two persons in $\frac{3}{4}$ time. At the period when it was most fashionable it was slow, ceremonious, and graceful *(see* DANCE).

The name is also given to a musical composition written in the same time and rhythm. Haydn introduced it into the symphony; in Beethoven's hands it became the scherzo.

MINUIT, PETER (*c.* 1580–1638), Dutch governor of New Netherland, founder of New Amsterdzm and colonizer of New Sweden, was born of Dutch ancestry in Wesel, Rhenish Prussia, about 1580. In Holland he was appointed director-general of the Dutch West Indies company's settlements in North America in 1625. He landed on Manhattan Island on May 4, 1626. Calling the native Indian chiefs into council, he purchased from them for merchandise valued at 60 guilders (about $24) the entire island of Manhattan, which he intended to make the centre of Dutch settlement. On its southern point he built a blockhouse, warehouse and mill, around which the early settlers of New Amsterdam made their homes *(see* NEW YORK *[CITY]: History).*

Minuit was recalled by the company in 1631. A few years later he entered Swedish service and was given command of the two vessels of Swedish and Finn colonists who in March 1638 established the first settlement upon the Delaware river, near Wilmington. There Minuit built Ft. Christina. In June 1638 he set out on a trading expedition to the West Indies, and perished in the storm in which the ship was lost. (E. E. R.)

MINUSINSK, a town in the southwest Krasnoyarsk territory, in the Russian Soviet Federated Socialist Republic, U.S.S.R., in 53° 56′ N., 91° 40′ E., on the Minusinsk river, about 5 mi. from its junction with the Yenisei. Pop. (1926) 20,403. The town is situated in the fertile Minusinsk district, which has rich black earth, where the warm dry summer enables spring wheat to ripen before the autumn frosts. The town has a flour-milling industry and exports flour to the lower Yenisei. Sugar beet grows well and a sugar factory exists. Timber is floated down the river from the forests and saw-milling is one of the chief occupations of the town. The Tatar nomads of the Minusinsk steppes became noted as stock raisers. Before the settlement of Russians in the agricultural area after the 1907 government survey they wandered over the whole region. The mineral wealth of the Minusinsk district has been estimated to be great. There are coal and copper beds, antimony is found in the rivers, Glauber's salt is obtained from the sulfate of sodium found near the left bank of the Yenisei river, and sulfate of soda from two small lakes lying between Achinsk and Minusinsk. The Minusinsk oasis, sheltered by the mountains, well-watered and fertile, has been settled from time immemorial and has remains of the stone, bronze and iron ages.

Among the specimens collected in its fireproof museum are a fine and representative collection of bronze implements, and relics of Chinese origin dating from the Han dynasty of the second century B.C. The collections were arranged by Prince Alexander Kropotkin and M. Martianov when they were exiled to Minusinsk in 1877.

MINUTE MEN, in the American War of Independence, militiamen who had undertaken to turn out for service at a minute's notice. In Massachusetts the minute men were enrolled by an act of the provincial congress of Nov. 23, 1774, and in Boston and vicinity were more prominent than elsewhere prior to the outbreak of the war.

The Americans who fought in the opening action of Lexington were "minute men."

MIOCENE, in geology, the system of strata which occurs between the Oligocene and the Pliocene and thus forms the lower of the two divisions of the Neogene or newer Tertiary period. The term is derived from the Greek μείον, less, and καινός, recent, and was introduced by Sir Charles Lyell. The name indicates that the system has a smaller number of recent species than is found in the overlying Pliocene.

Conditions During the Miocene.—The close of the Oligocene was marked by a very general regression of the sea. The beginning of the Neogene, that is of the Miocene, was marked by a widespread marine transgression, followed later by a general regression. Thus the whole Miocene corresponds to a cycle of sedimentation, quite distinct from the Pliocene cycle which follows it. As in the Older Tertiary period the marine transgression took place in Europe from three directions—from the North sea, the Atlantic and the Mediterranean. The Miocene deposits are found in basins connected with each of these three areas.

The North sea of Miocene times was never as extensive as that of Eocene or Oligocene times, it did not invade the Paris basin and did little more than cover the fringes of eastern England, northern Belgium, Holland and northern Germany. The fauna is entirely different from that of the Mediterranean and correlation is difficult, especially as the North sea seems to have been cut off from the Atlantic by a ridge across the Straits of Dover.

The Atlantic washed the shores of France as it does to-day, and broad gulfs covered part of Brittany and Aquitaine, and there was a wide communication with the Mediterranean across the south of Spain.

The Mediterranean sea of Miocene times has left deposits which are the best known of all Miocene strata. The Alps had already been built up as far as general features are concerned, and the Miocene transgression was restricted to the surrounding peri-Alpine depression. From the Middle Miocene onwards the eastern Mediterranean was cut off from the western and also from the seas of India and the east. It became an inland sea with a specialized fauna.

Life of the Period.—From the beginning of the Miocene there is an entire difference between the faunas of the North sea and the Atlantic-Mediterranean, and it is difficult to give lists of characteristic fossils except for special areas. The fauna of the Atlantic-Mediterranean area is obviously the parent of the existing Mediterranean fauna. Amongst foraminifera nummulites give place to Lepidocyclines, many of large size. Amongst fossils of zonal importance echinoderms such as *Clypeaster, Scutella* and *Echinolampas* are especially abundant; amongst the numerous lamellibranchs and gastropods many species of *Pecten* are of very restricted vertical range. The important mammalian forms are noted below. For an account of the flora reference should be made to the article PALAEOBOTANY. It has been argued that the marked increase of herbivorous mammals in the Miocene, including *Hipparion,* was due to the spread of turf-forming grasses and that animal migration was greatly facilitated by the drying up of the Mediterranean.

Miocene Stratigraphy.—The following stages have been distinguished in the Mediterranean Miocene:

Marine Facies		Eastern European Facies
3 Sahelian		Pontian
2 Vindobonian	Torbonian facies / Helvetian facies	Sarmatian
1 Burdigalian		

The *Burdigalian stage* is here taken as the base of the Miocene, since reasons have been given for regarding the Aquitanian as the highest Oligocene. (*See* OLIGOCENE.) The Aquitanian marks the beginning of the Miocene transgression, but contains a number of characteristic marine shells which are not found in later beds. The Burdigalian (type area Bordelais) is marked by a conspicuous transgression of the sea in the peri-Alpine region. Continental deposits of this age, notably the Orleanais sands, are marked by the appearance of such probroscideans as *Mastodon angustidens, M. turricensis, Dinotherium cuvieri,* of *Rhinoceros aurelianensis, Anchitherium,* etc.

The Vindobonian stage (type in the Vienna basin) is marked by further local transgressions such as in Bas-Dauphin6 and in the enclosed Vienna Basin. The base of the stage, often of a sandy facies, has been designated the Helvetian (from the marine "mollasse" of Switzerland), whilst at the top there are sometimes blue marls with a deep-water fauna of *Pleurotomas*—a facies distinguished as Tortonian (from Tortona, Piedmont). In the continental equivalents, such as the deposits of Sansan and Simorre (Gers) and La Grive-St.-Alban (Isère) the characteristic mammals are *Mastodon angustidens, Dinotlzerium bavaricum, Rhinoceros sansaniensis, Dicrocerus elegans* and the last *Anchitherium.*

The Pontian Stage (from Pont-Euxin) consists of continental fluviatile or lacustrine deposits forming the final stage of the Miocene cycle. The Pontian includes the famous deposits of Pikermi near Athens and is distinguished palaeontologically by the appearance of *Hipparion, Mastodon longirostris,* the presence of M. *turricensis,* the last *Dinotherium; Rhinoceros schleiermacheri, Gazella deperdita.* Marine equivalents of the Pontian occur in certain parts of Algeria and have been called the Sahelian (after Sahel d'Oran). In eastern Europe where the huge stretch of the eastern Mediterranean was separated from the western the true Pontian is underlain by a brackish water series (the Sarmatian, from the country of the Sarmates in the south of Russia), which may be the equivalent of the upper Vindobonian.

Turning now to the North sea Miocene, the regression of the sea at the end of the Oligocene was such that the lowest Miocene is found only in Denmark, Schleswig-Holstein and the neighbourhood of Hamburg and is absent from England, Belgium and Holland. The middle Miocene is marked by a southward transgression, the sea reaching as far south as Bremen and Osnabruck in Germany and covering much of Belgium where ferruginous sands constitute the Bolderian (Bolderberg, near Hasselt, Belgium). The presence of Aquitanian fossils in the Bolderian suggests a connection with the Atlantic at this time. The upper Miocene is represented by glauconitic sands near Antwerp, the Anversian of the Belgians. It is still doubtful whether the Miocene is represented in England except by lavas and some interstratified beds on the west coast of Scotland and northern Ireland. A Miocene fauna is found in the "Boxstones" at the base of the East Anglian Pliocene and it is claimed on palaeontological grounds that part of the Lenham beds, occurring in pockets in the chalk downs of Kent and Surrey, is Miocene.

Outside Europe the Miocene is well displayed in parts of northern India (where the Gaj series is Burdigalian) and has yielded a rich harvest of mammalian remains (especially from the Bugti beds); in the old gulfs of south-eastern Asia it is partly marine, partly continental—including, for example, the upper part of the Peguan of Burma, whilst the lower part of the freshwater Irrawaddian is Pontian. Along the Atlantic slope of the United States and around the Gulf of Mexico the complete Miocene series is present, the Sarmatian and Pontian occur also in California. Miocene rocks are important in the West Indies and the Antilles.

See the writings of G. E. Pilgrim in the *Records* of *the Geological Survey* of *India* on the correlation of Eastern deposits. (L. D. S.)

MIOT DE MELITO, ANDRE FRANÇOIS, COMTE (1762–1841), French statesman and scholar, was born at Versailles (Seine-et-Oise) on Feb, 9, 1762. He was a high official in the war office before the Revolution, and under the Republic he eventually became secretary-general for foreign affairs, and served on many foreign missions. In 1806 he joined Joseph Bonaparte in Naples as minister of the interior, afterwards following him to Spain as comptroller of the household, but he returned to France in the retreat of 1813. He took no part in politics after Waterloo. He was admitted in 1835 to the French Academy for his translations of Herodotus (Paris, 1822) and Diodorus (Paris, 1835–38). He died in Paris on Jan. 5, 1841.

See his diary covering the period 1788–1815, and published by his son-in-la , General von Fleischmann in **1858,** Eng. trans. 2 vols., **1881.** *See* also A. Gaudin, Les *Arrêtés, Miot* (Ajaccio, **1896).**

MIQUEL, JOHANN VON (1829–1901), German statesman, was born at Neuenhaus, Hanover, on Feb. 19, 1829, being descended from a French family which had emigrated during the Revolution. He studied law at Heidelberg and Gottingen. The writings of Karl Marx converted him .to socialism; but though he entered into correspondence with Marx, with the idea of starting a revolutionary movement, he took no open part in the events of 1848–49. He was one of the founders of the German *Nationalverein,* and in 1864 he entered the Hanoverian parliament as a Liberal and an opponent of the Government. He accepted the annexation of Hanover by Prussia without regret, and was one of the Hanoverians whose parliamentary abilities at once won a commanding position in the Prussian parliament, which he entered in 1867. He was burgomaster of Osnabruck from 1865 to 1870, and again from 1876 to 1879, being in the meantime (1870–73) a director of the Discontogesellschaft. In 1879 he was elected burgomaster of Frankfort-on-&fain, where he dealt energetically with social questions, especially that of the housing of the poor. Probably owing to his early study of socialism, he was very ready to support the new state socialism of Bismarck. He was the chief agent in the reorganization of the National Liberal party in 1887, in which year he entered the imperial Reichstag. After Bismarck's fall he was Prussian minister of finance (1890–1900). He reformed the Prussian system of taxation, but failed in an attempt to reform the system of imperial finance in 1893–94. Miquel had

given up his Liberalism, and aimed at practical measures for improving the condition of the people irrespective of the party programmes; some of his measures—such as that for taxing "Waarenhäuser" (stores)—were of a very injudicious nature. He professed to aim at a union of parties on the basis of the satisfaction of material interests, a policy to which the name of *Sammlung* was given; but his enemies accused him of intriguing against the three chancellors under whom he served. His sympathy for the Agrarians increased his unpopularity among Liberals and industrials; he insisted that the State, which for half a century had done everything to help manufactures, might now attempt to support the failing industry of agriculture. He resigned in June 1901, and died on Sept. 8, at Frankfort.

Miquel's *Reden* were edited (4 vols., 1911–14) by Schultz and Thimme. *See* W. Mommsen, *Johannes Miquel* (vol. i, 1928).

MIR: *see* VILLAGE COMMUNITIES.

MIRABEAU, ANDRÉ BONIFACE LOUIS RIQUETI, VICOMTE DE (1754–1792), nicknamed "Barrel Mirabeau," brother of the orator Mirabeau, was one of the reactionary leaders at the opening of the French Revolution. In 1789, he was elected by the noblesse of Limoges a deputy to the States General. He emigrated about 1790, and raised a legion which was to bear his name; but his insolence alienated the German princes, and his command was taken from him. He died in August 1792 at Freiburg im Breisgau.

See Joseph Sarrazin, *Mirabeau Tonneau, ein Condottiere aus der Revolutionszeit* (Leipzig, **1893);** and Eugène Berger, Le *Vicomte* de *Mirabeau (Mirabeau Tonneau), 1754–1792* (1904).

MIRABEAU, HONORE GABRIEL RIQUETI, COMTE DE (1749–1791), French statesman, was born at Bignon, near Nemours, on March g, 1749. The family of Riquet, or Riqueti, originally of the little town of Digne, won wealth as merchants at Marseilles, and in 1570 Jean Riqueti bought the château and seigniory of Mirabeau, which had belonged to the Provencal family of Barras. In 1685 Honoré Riqueti obtained the title of marquis de Mirabeau. His son Jean Antoine married Françoise de Castellane, and left at his death, in 1737, three sons—Victor, marquis de Mirabeau, Jean Antoine, bailli de Mirabeau, and Comte Louis Alexandre de Mirabeau. The great Mirabeau was the eldest surviving son of the marquis. When but three years old he had a virulent attack of small-pox which left his face disfigured, and contributed to his father's dislike of him. He was educated at a military school in Paris, and in 1767 received a commission in a cavalry regiment which his grandfather had commanded years before. He crossed his colonel in love, and the ensuing scandal led his father to ask for a *lettre de cachet,* and Mirabeau was imprisoned in the isle of Ré. This was the first recorded of many affairs of the heart. On his release, the young count obtained leave to accompany as a volunteer the French expedition to Corsica. After his return, he tried to keep on good terms with his father, and in 1772 he married a rich heiress, Marie Emilie de Marignane. His wild extravagance, however, forced his father to forestall his creditors by securing his detention in semi-exile in the country, where he wrote his earliest extant work, the *Essai sur le despotisme. A* violent quarrel brought another *lettre de cachet* and imprisonment in the Chbteau d'If. In 1775 he was removed to the castle of Joux, to which, however, he was not very closely confined, having full leave to visit in the town of Pontarlier. Here he met Marie Thérèse de Monnier, the Sophie of the famous letters. He escaped to Switzerland, where Sophie joined him; they then went to Holland, where he lived by hackwork for the booksellers; meanwhile Mirabeau had been condemned to death at Pontarlier for *rapt et vol,* and in May 1777 he was seized by the French police, and imprisoned by a *lettre de cachet* in the castle of Vincennes.

The early part of his confinement is marked by the indecent letters to Sophie (first published in 1793), and the obscene *Erotica biblion* and *Ma conversion,* while to the later months belongs his political work, the *Lettres de cachet,* published after his liberation (1782). The book exhibits an accurate knowledge of French constitutional history skilfully applied in an attempt to show that an existing actual grievance was not only philosophically unjust but constitutionally illegal. It shows, though in rather a diffuse and declamatory form, that application of wide historical knowledge, keen philosophical perception, and genuine eloquence to a practical purpose which was the great characteristic of Mirabeau, both as a political thinker and as a statesman.

With his release from Vincennes (August 1782) begins the second period of Mirabeau's life. He found that his Sophie was an idealized version of a rather common and ill-educated woman, and she consoled herself with the affection of a young officer, after whose death she committed suicide. Mirabeau first set to work to get the sentence of death still hanging over him reversed, and by his eloquence not only succeeded in this but got M. de Monnier condemned in the costs of the whole law proceedings. From Pontarlier he went to Aix, where he claimed the court's order that his wife should return to him, but he lost his case by accusing his wife of infidelity, on which the court pronounced a decree of separation. He then intervened in the suit pending between his father and mother before the parlement of Paris, and attacked the ruling powers so violently that he had to leave France and again go to Holland. About this time began his connection with Mme. de Nehra, and his life was strengthened by the love of his *petite horde,* Mme. de Nehra, his adopted son, Lucas de Montigny, and his little dog Chico. After a period of work in Holland he went to England, where he was admitted into the best Whig literary and political society of London, through his old schoolfellow Gilbert Elliot. Among his most intimate English friends were the 1st marquess of Lansdowne, better known as Lord Shelburne, and Samuel Romilly. Romilly undertook to translate into English the *Considérations sur l'ordre de Cincinnatus,* which Mirabeau had written in 1785.

The *Conside'rations sur l'ordre de Cincinnatus* which Romilly translated was the only important work Mirabeau wrote in the year 1785. He now turned his thoughts to employment from the French foreign office, either in writing or in diplomacy. He first sent Mme. de Nehra to Paris to make peace with the authorities and then returned himself, hoping to be employed as a political pamphleteer, but he ruined his chances by a series of writings on financial questions. On his return to Paris he had become acquainted with Étienne Clavière, the Genevese exile, and a banker named Panchaud. From them he heard plenty of abuse of stock-jobbing, and seizing their ideas he began to regard stock-jobbing, or agiotage, as the source of all evil, and to attack in his usual vehement style the Banque de St. Charles and the Compagnie des Eaux. This last pamphlet brought him into a controversy with Beaumatchais, who certainly did not get the best of it, but it lost him any chance of literary employment from the government. But after a preliminary tour to Berlin at the beginning of 1786 he was despatched in July 1786 on a secret mission to the court of Prussia, from which he returned in January 1787, and of which he gave a full account in his *Histoire secrète de la cour de Berlin* (1789). He was in Berlin at the time of the death of Frederick the Great., He failed to conciliate the new king Frederick William; and thus ended Mirabeau's one attempt at diplomacy. During his journey he had made the acquaintance of Jakob Mauvillon (1743–1794), whom he found possessed of a great number of facts and statistics with regard to Prussia; these he made use of in his *De la monarchie prussienne sous Fréderic le Grand* (London, 1788). He had offered himself as a candidate for the office of secretary to the Assembly of Notables which the king had just convened, and to bring his name before the public published the *Dénonciation de l'agiotage.* The violence of this book ruined his chance of election, and he had to retire to Tongres; he further injured his prospects by publishing the reports he had sent in during his secret mission at Berlin. But 1789 was at hand; the states-general was summoned; Mirabeau's period of probation was over.

On hearing of the king's determination to summon the states-general, Mirabeau started for Provence, and offered to assist at the preliminary conference of the noblesse of his district. They rejected him; he appealed to the *tiers état,* and was returned both for Aix and for Marseilles. Me elected to sit for Aix. At every important crisis his voice was heard in the Assembly, though his

advice was not always followed. He possessed at the same time great logical acuteness and the most passionate enthusiasm. From the beginning he recognized the need of strong government. At the same time he thoroughly comprehended that for a government to be strong it must be in harmony with the wishes of the majority of the people. He had carefully studied the English constitution in England, and he hoped to establish in France a system similar in principle but without any slavish imitation of the details of the English constitution. In the first stage of the history of the states-general Mirabeau's part was very great. He always knew his own mind, and was prompt in emergencies. To him is to be attributed the successful consolidation of the National Assembly. When the taking of the Bastille had assured the success of the Revolution, he warned the Assembly of the futility of passing fine-sounding decrees and urged the necessity for action. He declared that the famous night of Aug. 4 was but an orgy, giving the people an immense theoretical liberty while not assisting them to practical freedom, and overthrowing the old régime before a new one could be constituted. His failure to control the theorizers showed Mirabeau, after the removal of the king and the Assembly to Paris, that his eloquence would not enable him to guide the Assembly by himself, and that he must therefore try to get some support. He wished to establish a strong ministry, which should be responsible like an English ministry, but to an assembly chosen to represent the people of France better than the English House of Commons at that time represented England. The duchesse d'Abrantès states in her *Mémoires* that he thought of becoming a minister of the crcwn as early as May 1789, but the queen rejected the idea. He tried in vain to work with Lafayette, and then with Necker, for whose financial scheme he obtained the assent of the Assembly. After the events of the 5th and 6th of October the comte de la Marck consulted Mirabeau as to what measures the king ought to take, and Mirabeau, delighted at the opportunity, drew up an admirable state paper, which was presented to the king by Monsieur, afterwards Louis XVIII. The whole of this *Mémoire* should be read to get an adequate idea of Mirabeau's genius for politics; here it must be summarized.

The main position is that the kihg is not free in Paris; he must therefore leave Paris and appeal to France. "Paris n'en veut que l'argent; les provinces dernandent des lois." But where must the king go? "Se retirer à Metz ou sur toute autre frontière serait déclarer la guerre à la nation et abdiquer le trône. Un roi qui est la seule sauvegarde de son peuple ne fuit point devant son peuple; il le prend pour juge de sa conduite et de ses principes." He must then go towards the interior of France to a provincial capital, best of all to Rouen, and there he must appeal to the people and summon a great convention. It would be ruin to appeal to the noblesse, as the queen advised: "un corps de noblesse n'est point une armée, qui puisse combattre." When this great convention met the king must show himself ready to recognize that great changes have taken place, that feudalism and absolutism have for ever disappeared, and that a new relation between king and people has arisen, which must be loyally observed on both sides for the future. "Il est certain, d'ailleurs, qu'il faut une grande révolution pour sauver le royaume, que la nation a des droits, qu'elle est en chemin de les recouvrer tous, et qu'il faut non seulement les rétablir, mais les consolider." To establish this new constitutional position, between king and people would not be difficult, because "l'indivisibilité du monarque et du peuple est dans le coeur de tous les Français; il faut qu'elle existe dans l'action et le pouvoir."

Such was Mirabeau's programme, from which he never diverged, but which was far too statesmanlike to be understood by Louis, and far too positive to be palatable to the queen. Mirabeau followed up his *Mémoire* by a scheme of a great ministry to contain all men of mark — Necker as prime minister, "to render him as powerless as he is incapable, and yet preserve his popularity for the king," the duc de Liancourt, the duc de la Rochefoucauld, La Marck, Talleyrand, bishop of Autun, at the finances, Mirabeau without portfolio, G. J. B. Target, mayor of Paris, Lafayette generalissimo to reform the army, Louis Philippe, comte de Ségur (foreign affairs), Mounier and I. R. G. le Chapelier. This scheme got noised abroad, and was wrecked by a decree of the Assembly of Nov. 7, 1789, that no member of the Assembly could become a minister. The queen utterly refused to take Mirabeau's counsel, and La Marck left Paris. In April 1790 he was suddenly recalled by the comte de Mercy-Argenteau, the Austrian ambassador at Paris, and the queen's most trusted political adviser, and from this time to Mirabeau's death he became the medium of almost daily communications between the latter and the queen. Mirabeau at first attempted again to make an alliance with Lafayette, but it was useless, for Lafayette was not a strong man himself and did not appreciate "la force" in others. From the month of May 1790 to his death in April 1791 Mirabeau remained in close and suspected, but not actually proved, connection with the court, and drew up many admirable state papers for it. In return the court paid his debts; but it ought never to be said that he was bribed, for the gold of the court never rnade him swerve from his political principles. He regarded himself as a minister, though an unavowed one, and believed himself worthy of his hire.

On the question of the veto Mirabeau declared for the king's absolute veto and against the compromise of the suspensive veto. On the question of procedure he got his friend Romilly to draw up a detailed account of the rules and customs of the English House of Commons, in the vain hope that the Assembly might adopt them. On the subject of peace and war he supported the king's authority, and with some success. Mirabeau almost alone of the Assembly held that the soldier ceased to be a citizen when he became a soldier; he must recognize that a soldier's first duty is obedience. Lastly in finance he attacked Necker's "caisse d'escompte," which was to have the whole control of the taxes, as absorbing the Assembly's power of the purse; and he heartily approved of the system of assignats, but with the reservation that they should not be issued to the extent of more than one-half the value of the lands to be sold.

Of Mirabeau's attitude with regard to foreign affairs something must be said. He held that the French people should conduct their Revolution as they would, and that no foreign nation had any right to interfere with them while they kept themselves strictly to their own affairs. But he knew that foreign monarchs were being prayed by the French emigrés to interfere on behalf of the French monarchy. To avoid any pretext for such interference was his guiding idea in foreign policy. He had been elected a member of the *comité diplomatique* of the Assembly in July 1790, and became its reporter at once. As matters became more strained, he entered into daily communication with the foreign minister, Montmorin, advised him on every point, and, while dictating his policy, defended it in the Assembly. How great a work he did is best proved by the confusion which ensued in this department after his death. For indeed in the beginning of 1791 his death was near. The excesses of his youth had weakened his strong constitution, and his parliamentary labours completed the work. Some time before the end he sent all his papers over to Sir Gilbert Elliot, who kept them under seal until claimed by Mirabeau's executors. Every care that science could afford was given by his friend and physician, Cabanis. The people kept the street in which he lay quiet, but medical care, the loving solicitude of friends and the respect of all the people could not save his life. When he could speak no more he wrote with a feeble hand the one word "dormir," and on April 2, 1791, he died.

No man ever so thoroughly used other men's work, and yet made it all seem his own. "Je prends mon bien ou je le trouve" is as true of him as of Molière. His first literary work, except the bombastic but eloquent *Essai sur le despotisme* (Neufchâtel, 1775), was a translation of Robert Watson's *Philip II*, done in Holland with the help oi Durival; his *Considérations sur l'ordre de Cincinnatus* (London, 1788) was based on a pamphlet by Aedanus Burke (1743–1802), of South Carolina, who opposed the aristocratic tendencies oi the Society of the Cincinnati, and the notes to it were by Target; his financial writings were suggested by the Genevese exile, Claviere. During the Revolution he received yet more help; men were proud to labour for him, and did not murmur because he absorbed all the credit and fame. Etienne Dumont, Claviere, Antoine Adrien Lamourette and Etienne Salomon Reybaz were but a few of the most distinguished of his collaborators. Dumont prepared famous addresses which Mirabeau used to make the Assembly pass by sudden bursts of eloquent declamation; Claviere worked out his figures, ahd wrote his financial discourses; Lamourette wrote the speeches on the civil constitution of the clergy; Reybaz not only wrote for him his famous speeches on the assignats, the organization of the national guard and others, which Mirabeau read word for word at the tribune, but even the posthumous speech on succession to the estates of intestates, which Talleyrand read in the Assembly as the last work of his dead friend. He took other men's labour as

his due, and impressed their words, of which he had suggested the underlying ideas, with the stamp of his own individuality; his collaborators were glad to help forward the Revolution through its greatest thinker and orator. As an orator his eloquence has been likened to that of both Bossuet and Vergniaud, but it had neither the polish of the old 17th century bishop nor the flashes of genius of the young Girondin. It was rather parliamentary oratory in which he excelled, and his true compeers are rather Burke and Fox than any French speakers. Personally he had that which is the truest mark of nobility of mind, a power of attracting love and winning faithful friends. (H. M. St.; X.)

Authorities.—The best edition of Mirabeau's works is that published by Blanchard in 1819–22, in ten volumes, of which the first two contain his *Oeuvres oratoires;* from this collection, however, many of his less important works and the *De la monarchie prussienne* are omitted. For details of his life consult *Mémoires biographiques, littéraires et politiques de Mirabeau, écrits par lui-même, par son père, son oncle et son fils adoptif,* which was issued by his adopted son, Lucas de Montigny, 8 vol. (1834–35); *Correspondance entre Mirabeau et le comte de la Marck,* ed. by A. de Bacourt, 2 vol. (1851), some additional letters appeared in the German edition, 3 vol. (Leipzig, 1851–52). Other published correspondence is *Lettres de Mirabeau à Chamfort* (1796); *Lettres du comte de Mirabeau à Jacques Mauvillon* (Brunswick, 1792); *Lettres originales de Mirabeau, écrites du donjon de Vincennes, 1777–1780,* published by L. P. Manuel, 4 vol. (1792); and, on the same subject, Paul Cottin, *Sophie de Monnier et Mirabeau d'après leur correspondance inédite* (1903); *Lettres à Julie,* ed. by D. Meunier and G. Selois (Paris, 1903); *Lettres inédites,* ed. by J. F. Vitry (1806). The *Histoire secrète* forms the basis of H. Welschinger's *La Mission secrète de Mirabeau à Berlin* (Paris, 1900). The most useful modern books are Louis and Charles de Loménie, *Les Mirabeau,* 5 vol. (1878 and 1889); Alfred Stern, *Das Leben Mirabeaus,* 2 vol. (1889); E. Rousse, *Mirabeau* (1891) in the Grands Ecrivains Français; A. Mézières, *La Vie de Mirabeau* (1892); L. Barthou, *Mirabeau* (1919); Meunier, *Autour de Mirabeau* (1926). On his eloquence and the share his collaborators had in his speeches *see* F. A. Aulard, *Orateurs de l'assemblée constituante* (1882). For his death *see* the curious brochure of his physician, Cabanis, *Journal de la maladie et de la mort de Mirabeau* (Paris, 1791), ed. by H. Duchenne (Paris, 1890). English works include P. F. Willert, *Mirabeau* (1898) in the "Foreign Statesman" series; C. F. Warwick, *Mirabeau and the French Revolution* (1905); W. R. H. Trowbridge, *Mirabeau, the Demi-god* (1907); H. E. von Holst, *The French Revolution Tested by Mirabeau's Career* (Chicago, 1894); and F. Fling, *Mirabeau and the French Revolution* (London and New York, 1908).

MIRABEAU, VICTOR RIQUETI, Marquis de (1715–1789), French political economist, was born at Pertuis on Oct. 5, 1715. He abandoned his military career for literature. He first attracted general notice with *L'Utilité des états provinciaux* (anonymous, 1750), which marked an important stage in the movement for the reform of French local government by its radical criticism of Louis XIV's centralized bureaucracy and by its suggestion that provincial estates should be set up throughout the kingdom (*i.e.,* not only in the former *pays d'états*). His prestige as a political thinker and economist was finally established by *L'Ami des hommes, ou traité de la population* (1756). This work reflected the ideas of R. Cantillon, but also anticipated some of the fundamental doctrines of the Physiocratic school (*q.v.*), especially their conception of the primacy of agriculture in economic affairs. Mirabeau then associated himself, under the influence of François Quesnay, with the Physiocrats' attempts to reform the system of taxation. In his *Théorie de l'impôt* (1760) he attacked the system of farming out the indirect taxes, recommending instead the establishment of direct taxes on land and on personal income. This led to his imprisonment at Vincennes and to his temporary exile to his estate at Bignon, near Nemours. Thereafter, despite a protracted lawsuit with his wife, which undermined his health and ruined his personal fortune, he devoted his efforts to the advancement of physiocracy. He died at Argenteuil on July 13, 1789.

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MIRACLE, anything wonderful, beyond human power, and deviating from the common action of nature, a supernatural event. The term is particularly associated with the supernatural factors in Christianity. To the Lat. *miraculum* correspond Gr. *τέρας* in the New Testament, and Heb. פֶּלֶא (Exod. xv. 11; Dan. xii. 6) in the Old Testament. Other terms used in the New Testament are *δύναμις* "with reference to the power residing in the miracle worker" (*cf.* גְּבוּרָה Deut. iii. 24 and בְּרִיאָה Num. xvi. 30), and *σημεῖον* "with reference to the character or claims of which it was the witness and guarantee" (*cf.* אוֹת Exod. iv. 8); that the power is assumed to be from God is shown by the phrases *πνεύματι θεοῦ* (Matt. xii. 28; *cf.* Luke iv. 18) and *δακτύλῳ θεοῦ* (Luke xi. 20).

The two conceptions once common in the Christian church, that on the one hand miracles involved an interference with the forces and a suspension of the laws of nature, and that, on the other hand, as this could be effected only by divine power, they served as credentials of a divine revelation, are now generally abandoned. As regards the first point, it is now generally held that miracles are exceptions to the order of nature as known in our common experience; and as regards the second, that miracles are constituent elements in the divine revelation, deeds which display the divine character and purpose; that they are *signs* and not merely *seals* of truth. Various theories have been advanced which endeavour to discover the means by which the exceptional occurrence is brought about; but the explanation is merely hypothetical, and we are not helped in conceiving the mode of the divine activity in the working of miracles. The important consideration from the religious standpoint is that God's activity should be fully recognised.

An attempt has been made to discover a natural law which will explain some at least of the miracles of Jesus. Matthew Arnold (*Literature and Dogma,* pp. 143–144) and Harnack (*Das Wesen des Christentums,* p. 18) ascribe the healing miracles to the commanding influence of so great a personality as Jesus. While recent *psycho-therapy* (auto- or hetero-suggestion) lends some support to the theory it may be pointed out: (1) that the *nature* or *cosmical* miracles—feeding of the five thousand, stilling of the storm, withering of the fig-tree—are as well attested as the miracles of healing; (2) that many of the diseases, the cure of which is reported, are of a kind with which *moral therapeutics* could not effect anything (*see* Dr. R. J. Ryle in *Hibbert Journal* V. 586); (3) that Christ never failed to ascribe His power to the Father dwelling in Him. Should medical research prove that organic diseases as well as functional disorders, dependent on neurotic conditions, yield to such treatment, Jesus' use of the method in anticipation of this long development of medical science, would demand explanation. Even if it be shown that in His healing acts He was in His compassion for man, and confidence in God bringing into play hitherto unsuspected resources in Himself or in others, His transcendence personally of His age and surroundings would remain.

An attempt is made to get rid of the distinctive nature of miracle when the exceptionalness of the events so regarded is reduced to a *new subjective mode* of regarding natural phenomena. H. E. G. Paulus dismisses the miracles as "exaggerations or misapprehensions of quite ordinary events." A. Ritschl has been unjustly charged with this treatment of miracles. But what he emphasizes is on the one hand the close connection between the conception of miracles and the belief in divine providence, and on the other the compatibility between miracles and the order of nature. He declines to regard miracles as divine action contrary to the laws of nature. So for Schleiermacher "miracle is neither explicable from nature alone, nor entirely alien to it." What both Ritschl and Schleiermacher insist on is that the belief in miracles is inseparable from the belief in God, and in God as immanent in nature, not only directing and controlling its existent forces, but also as initiating new stages consistent with the old in its progressive development.

We may accept Dorner's definition as adequate and satisfactory. "Miracles are sensuously cognizable events, not comprehensible on the ground of the causality of Nature and the given system of Nature as such, but essentially on the ground of God's free action alone. Such facts find their possibility in the constitution of nature and God's living relation to it, their necessity in the aim of revelation, which they subserve" (*System of Chr.*

Doc. II. p. 161). By the first clause inward moral and religious changes due to the operation of the Spirit of God in man are excluded, and rightly so (see INSPIRATION). The negative aspect of miracles is that they are not explicable by the order of nature as we know it; the positive that owing to their character we are led to refer them directly to the divine causality. When the existence of God is denied (atheism) or His nature is declared unknowable (agnosticism), or He is identified with nature itself (pantheism), or He is so distinguished from the world that His free action is excluded from the course of nature (deism), miracle is necessarily denied. It is only the theistic view of God as personal power—that is as free-will ever present and ever active in the world,—which leaves room for miracles. Although the possibility of miracles is often confidently denied, such denial rests on an unproved assumption; since we do not know the continuity of nature so thoroughly as to be able to declare that this or that event is necessarily an interruption of it.

Lotze has shown, not only how the possibility of miracles can be conceived (Mikrokosmos III. 364); but even that the mode of the divine working may be made intelligible (op. *cit.* II. 54).

If we conceive God as personal, and His will as related to the course of nature analogously to the relation of the human will to the human body, then the laws of nature may be regarded as habits of the divine activity, and miracles as unusual acts which, while consistent with the divine character, mark a new stage in the fulfilment of the purpose of God.

The doctrine of Evolution, instead of increasing the difficulty of conceiving the possibility of miracle, decreases it; for it presents to us the universe as an uncompleted process, and one in which there is no absolute continuity on the phenomenal side; for life and mind are inexplicable by their physical antecedents, and there is not only room for, but need of, the divine initiative, a creative as well as conservative co-operation of God with nature. Such an absolute continuity is sometimes assumed without warrant; but Descartes already recognized that the world was no continuous process, "Tria mirabilia fecit Dominus; res ex nihilo, liberum arbitrium et hominem Deum." The theory of psychophysical parallelism recognizes that while there is a correspondence between mental and material phenomena, changes in the mind and changes in the brain, the former cannot be explained by the latter, as the transition from the one to the other is unthinkable. William James distinguishes the transmissive function of the brain from the *productive* in relation to thought, and admits only the former, and not the latter (Human Immortality p. 32). Thus as life is transcendent and yet immanent in body, and mind in brain, and both utilize their organs, so God, transcendent and immanent, uses the course of nature for His own ends; and the emergence both of life and mind in that course of nature evidences such a divine initiative as is assumed in the recognition of the possibility of miracles. For such an initiative there must be adequate reason; it must be prepared for in the previous process, and it must be necessary to further progress.

The proof of the possibility of miracle leads us inevitably to the inquiry regarding the necessity or the sufficient reason of miracles. The necessity of miracles is displayed in their connection with the divine revelation; but this connection may be conceived in two ways. The miracles may be regarded as the credentials of the agents of divine revelation, as by Butler (Analogy part II. Chap. vii). This view, however, is now generally abandoned, for it is recognized that acts of superhuman power, even if established by adequate historical evidence, do not necessarily certify their divine origin. Their moral quality must correspond with the character of God; and they must be connected with teaching which to reason and conscience approves itself divine. The miracle and the doctrine mutually illuminate one another. Accordingly, the credentials must also be constituents of the revelation, as the character of Jesus ever shines through His miracles. The wonders and the powers are also signs. As God is the Saviour; and the chief end of the revelation is redemption, it is fitting that the miracles should be acts of divine deliverance from physical evil. This congruity of the miracle with divine truth and grace is the answer to Matthew Arnold's taunt about turning a pen into a pen-wiper or Huxley's about a centaur trotting down Regent Street.

The miracles of Jesus—the relief of need, the removal of suffering, the recovery of health and strength—reveal in outward events the essential features of His divine mission. The divine wisdom and goodness are revealed in the course of nature, but also obscured by it. The existence of physical evil, and still more of moral evil, forbids the assumption without qualification that the real is the rational. God in nature as wsll as in history is fulfilling a redemptive as well as perfective purpose, of which these miracles are appropriate signs. It is an unwarranted idealism and optimism which finds the course of nature so wise and so good that any change in it must be regarded as incredible. On the problem of evil and sin it is impossible here to enter; but this must be insisted on, that the miracles of Jesus at least express divine benevolence under those conditions in which the course of nature obscures it; and are therefore, proper elements in a revelation of grace, of which nature cannot give any evidence.

Having discussed the possibility and necessity of miracles for the divine revelation, we must now consider whether there is sufficient historical evidence for their occurrence. Hume maintains that no evidence, such as is available, can make a miracle credible, Mill states the position with due care. "The question can be stated fairly as depending on a balance of evidence, a certain amount of positive evidence in favour of miracles, and a negative presumption from the general course of human experience against them" (Essays on Religion, p. 221). The existence of "a certain amount of positive evidence in favour of miracles" forbids the sweeping statement that miracles are "contrary to experience." The phrase itself is, as Paley pointed out, ambiguous. If it means all experience it assumes the point to be proved; if it means only common experience then it simply asserts that the miracle is unusual—a truism. The probability of miracles depends on the conception we have of the free relation of God to nature, and of nature as the adequate organ for the fulfilment of God's purposes. If we believe in a divine revelation and redemption transcending the course of nature, the miracle as signs of that divine purpose will not seem improbable.

For the Christian Church it is the miracles of Jesus which are of primary importance. The Gospels assumed their present form between A.D. 60 and go. Their representation of the moral character, the religious consciousness, the teaching of Jesus, inspires confidence. The narratives of miracles are woven into the very texture of this representation. In these acts Jesus reveals Himself as Saviour. In His sinless perfection and filial relation to God He is unique, and His works are congruous with His Person. Of the supreme miracle of His resurrection there is earlier evidence than of any of the others (1 Cor. xv. 3–7, before A.D. 58). His conquest of death is most frequently appealed to in the apostolic teaching. The Christian Church would never have come into existence without faith in the Risen Lord. Yet it must be remembered that the fact of the resurrection does not stand or fall with the mode in which it was conceived; and that the mode of a belief is necessarily dependent upon the pre-suppositions, scientific and religious, of the age in which it is held. The accounts in the Old Testament of miraculous events are obviously conditioned by the presuppositions of the age and would in most cases be recorded differently to-day. The supernatural element that is prominent in the Old Testament is regarded by the authors of its various books as God's providential guidance and guardianship of His people, and His teaching and training of them by His prophets.

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the Scientific World View (1953); John Laidlaw, *The Miracles* of *Our Lord (1956)*; Karl Jaspers and Rudolph Bultmann, *Myth and Christianity (1958)*. (A. E. G.)

MIRA DE AMESCUA, ANTONIO (1578–1644), Spanish dramatist, combined to a high degree creative power with evenness of execution. *La Adversa fortuna de Don Bernardo de Cabrera* and *El ejemplo mayor de la desdicha y capitán Belisario*—*are* the sources of Rotrou's *Don Bernardo de la Cabrère* and *Belisaire.*

Moreto's *Caer para levantar* is simply a recast of Mira's *El Esclavo del demonio,* which also clearly influenced Calderon's *La Devoción de la cruz;* and there is a close relation between Mira's *La Rueda de la fortuna* and Corneille's *Héraclius* and Calderon's *En esta vida todo es verdad y todo es mentira.*

MIRAGE, any of a number of different kinds of atmospheric optical illusion in which the observer sees nonexistent bodies of water, oversize or inverted images of distant objects and various other distortions. A mirage is formed by the refraction, or change in the direction of travel, of light on its passage through an atmosphere having an unusual distribution of air density. An increase in density of the air decreases the velocity of light passing through it; thus as the light goes through a layer. or stratum. of marked density change. its wave front is refracted and a displaced image is likely to appear.

Inferior Mirage.—This phenomenon. very common in desert regions on calm, clear summer days, when the surface of the ground is strongly heated. gives the appearance of an extensive horizontal reflecting surface below the level of the observer's eyes. Often. low-lying distant objects are mirrored. The observer unfamiliar with this illusion instinctively attributes it to reflection by the surface of a lake or other body of water whose wave-lapped shore is only a mile or so distant. But it is a curious body of water. ebbing as far and as fast as the observer may approach it and similarly following him if he should retreat from it. and completely hiding everything below its apparent surface. Distant hills rising from a flat plain often appear as if they were islands or promontories.

Normally, in the atmosphere the density decreases steadily with height. This type of mirage occurs when. owing to the excessive heating of the ground. the density increases upward for the first 20 ft. or more, then decreases in the normal manner above that height. Under this circumstance, light originating along the horizon follows a curved path upward over the observer's head and the light which comes to him horizontally when he is above the level of maximum density also originates above that level. Distant objects may be of such a height that their upper part is seen from a path of light that goes deep downward convexly toward the earth and their lower part from a less deep path, thus producing the inverted effect of a mirrored image.

Road and Street Mirage.—This illusion of people, perhaps, splashing unconcernedly through puddles and streams is a miniature inferior mirage.

Lateral Mirage.—On close observation it is sometimes possible to see along a strongly heated, vertical wall, a mirage of the same origin, and having the same explanation, as that so common along roads.

Superior Mirage.—A superior mirage is the simultaneous appearance in the low sky of a distant low object in the form of two images, one above the other, the lower one being inverted while the upper is not. This occurs under certain conditions, especially over cold waters, when the lower air is very much colder and therefore denser than the air immediately above it. In this case the apparent mirror surface is above the observer at the level where the density exhibits a sharp decrease nith height.

Fata Morgans.-This is the inferior-superior double mirage, involving a combination of the two types of density distribution described above. Under perfect conditions, a distant. simple cottage looks like a wondrous castle, half up in the air, half down in the sea..

It is of rare occurrence, though well known, especially in the Straits of Messina between Italy and Sicily, where it received its name, and over Toyama bay on the western coast of Japan. It is sometimes observed over the Great Lakes in North America.

For explanatory diagrams, illustrations and references, *see* W. J. Humphreys, *Physics of the Air* (1940). (W. J. Hs.)

MIRAMÓN, MIGUEL (1832–1867), Mexican soldier, president and marshal of Maximilian's empire, was born in Mexico City on Sept. 29, 1832. He fought against the United States in 1847. In 1856 he helped establish Félix Zuloaga as Conservative president in opposition to the Liberals led by Benito Juárez. In the bitter Three Years' War which followed he led the Conservative forces and finally succeeded Zuloaga as president only to be overthrown by the victorious Liberals in Dec. 1860. He took refuge in Cuba and then went to Europe. Following various maneuvers he offered his services to Napoleon III and re-entered Mexico as a grand marshal of Maximilian's empire. He served as hlexican minister in Berlin (1864–66), but returned home and again entered the army to bolster the tottering throne. Defeated by Juárez, he fell back to defend the remnant of the court at Querétaro. After the capture of that city in May, he was taken prisoner and executed there with his emperor on June 19, 1867. (W. H. Cr.)

MIRANDA, FRANCISCO (*c.* 1750–1816), Venezuelan revolutionist, belongs to the generation of men who paved the way for independence in South and Central American nations. In the history of the hemisphere his title is "el precursor." the forerunner. Born and educated in Caracas, at the age of 21 he sailed for Europe to enter the Spanish army. During this journey he began to keep a diary, a habit which remained with him to his last days. and the bulk of which forms the 1 j volumes of his *Archivo.* His career in the Spanish army was not a success; he was charged with disobedience and sent to prison. In 1780, however, he was released and sent to Cuba to participate in the Spanish fight against Great Britain. There he was accused of misuse of funds. Protesting his innocence, Miranda fled to the United States. arriving in June 1783.

This event was the turning point of his life. He became a rebel and an adventurer whose aim was to gain partisans and supporters for the liberation of South and Central America from the yoke of Spain. In the United States he met and became the friend of Washington, Paine. Hamilton and others. Hounded by Spanish agents, he went to London. and from there to Germany. Austria. Italy, Turkey and. finally, to Russia, where Catherine the Great showered him with her favours. Miranda's personality matured during these travels. He became proficient in languages, speaking three and reading four others. He was impulsive, opinionated. authoritarian and aggressive.

The French Revolution gave him the first opportunity to advance his revolutionary aims. To William Pitt he outlined a plan for an independent empire stretching from the Mississippi to Cape Horn. under the leadership of a hereditary emperor, called Inca. with a law-giving body of two houses. When the English prime minister showed no interest in his projects. Miranda joined the revolutionary forces of France (1792). He had not changed his goal, only the means to reach it. He fought with distinction for the Revolution. surviving terror and accusation. By 1798 he was once more in England. He tried desperately to convince the British that an attack on the Spanish colonies would be to their advantage. but in 1805 when he realized that his words fell on deaf ears. he set out to liberate Venezuela singlehandedly. The Spaniards. however, aware of his plans. were ready for him. He was twice repulsed and returned to England.

hliranda's last opportunity came in 1810. At that time Venezuela was in rebellion against Spain and Simón Bolivar had been sent to London to secure British support for the nascent state. The two men met and Bolivar persuaded Miranda to return to Caracas. He was made a general. and when the young republic proclaimed its Independence on July 5 1811 he became its dictator But the Spanish counterattack shoned Miranda weak and vacillating Rather than make Venezuela the scene of a long and bloody car he surrendered and signed an armistice that other revolutionaries denounced as treasonable. His attempts to escape were thwarted by his compatriots under the leadership of Bolivar. He was thrown into prison and eventually handed over to the Spaniards. who considered him still "a very dangerous man." His ankles in chains. he was transported to the Prison of the Four Ton-ers in

Cádiz, where he died in 1816.

Miranda's master plan, the liberation of the Spanish colonies with the help of the great powers, had miscarried, and his own action ended in catastrophe. His failure was the result of a personal ambition to which his abilities could not rise. Orator. general, schemer and organizer, he lacked the relentless drive that the revolutionary must have if he hopes to succeed. Miranda was a man of the 18th century. He believed in a world that daily apprehended more fully the dignity of mankind. His all too human private life also derived its character from the century; his many love affairs were pursued with the sensual energy of a Casanova. He is reminiscent at times of his contemporary, Mirabeau. Energetic, epicurean, dynamic, unscrupulous, identifying a great cause with his own personality, he seemed to have all the talents save the ability to put them to good use. Although temporary failures and frustrated ambition may dim his reputation, he is marked by greatness of purpose and by his unquenchable beiief in the freedom of man.

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MIRANBA, a state of Venezuela on the Caribbean sea, lies east of the state of Aragua and southeast of the Federal District. Area 3.069 sq.mi. Pop. (1950) 276.273. The coastal range there reaches its highest elevation. Embracing parts of both agricultural and pastoral Venezuela, Miranda ranks among the leading states, being a producer of bananas, cacao, corn, coconuts, coffee, sugar cane and yuca. The mineral possibilities are little known and have been only slightly exploited. Sugar milling and saw milling are relatively important. The state benefits by proximity to the Federal District, particularly to Caracas. It is well served by highways. The capital, Los Teques (pop. [1950] 21,971) lies southwest of Caracas on the main hard-surfaced highway to the important cities to the west—Maracay, Valencia, Barquisimeto and others. (L. WE.)

MIRBEAU, OCTAVE HENRI MARIE (1850–1917), French dramatist and journalist member of the Goncourt academy, was born at Trevières (Calvados) on Feb. 16. 1850. Educated in a Jesuit school at Vannes, and at the University of Paris, he became dramatic critic of the Bonapartist paper, *L'Ordre.* In 1890 he began to write for *Révolte,* but his anarchist sympathies were definitely checked by the murder of Pres. Marie Franqois Sadi Carnot in 1894. He made his mark as a *conteur* with a series of tales of the Norman peasantry, *Lettres de ma chaumikre* (1886). René Lalon has compared his social drama *Les Mauvais Bergers* (1897) with that of Becque. Equally fine was his *Les Affaires sont les Affaires* (1903), adapted by Sydney Grundy for Sir H. Beerbohm Tree in 1905. He died in Paris on Feb. 16, 1917.

MIRFIELD, an urban district in the Dewsbury parliamentary division of the West Riding of Yorkshire, Eng., 10½ mi. E.S.E. of Halifax and 8¼ mi. W. of Wakefield by road. Pop. (1951) 11,885. It is on the river Calder and is served by the Calder canal.

Its principal industries are carpet and blanket manufacturing, cotton spinning, light engineering, coal mining and chemicals; it is a railway centre. A theological college is attached to the Home of the Community of the Resurrection.

MIRIM, LAKE (Portuguese, LAGÔA MIRIM; Spanish, LAGUNA MERÍN), on the border between Brazil and Uruguay, covers about 1,145 sq.mi., and is 188 mi. long and as much as 30 mi. wide at its widest point. The lake drains through the São Gonqalo canal to Lagôa dos Patos.

It is a typical coastal lagoon, separated from the ocean by a sand bar about 10 to 35 mi. wide, on which there are numerous smaller lagoons and marshes. It is navigable for small lake boats. The international boundary between Brazil and Uruguay crosses the southern part of the lake from the mouth of the Rio Jaguarão to the southern end west of Chuí. (P. E J.)

MIRKHOND (MIRKHWAND; MOHAMMED IBN KHWANDSHAH IBN MAHMUD) (1433–1498), Persian historian, author of the voluminous and famous *Rauzat-us-Safa,* belonged to an old family of *sayyids* (descendants of the Prophet), established in Bukhara. His father lived in Balkh (northern Afghanistan). Mirkhond spent most of his life in Herat, where he enjoyed the protection of Mir 'Ali Shir Nava'i, a celebrated patron of literature, who acted as minister to the last Timurid ruler of Herat, Sultan Husain Baiqara (1468–1506), and was himself a writer of great distinction. He died at Herat on June 22, 1498. It was at Mir 'Ali Shir's request that Mirkhond began about 1474 his general history, *Rauzat us-Safa,* which comprises seven large volumes and a geographical appendix, sometimes considered as the eighth volume. The seventh book (on the reign of Sultan Husain and some later events down to 1523) must have been added by Mirkhond's grandson Khwandamir (Khondamir), whose *Khulasat al-akhbar* is, moreover, merely an abridgement of his grandfather's *Rauzat.* In the 19th century Riza Quli Khan (1800–72) wrote a supplement to the *Rauzat* in eight volumes.

Although he did not examine his sources critically and wrote in a florid and bombastic style, Mirkhond was for a long time the chief source of information on the history of the Persian dynasties, and European scholars published separate chapters of his work accompanied by their commentaries.

In modern times, when many of Mirkhond's sources have been published in the original, his summaries have lost their importance, except for Books v and vi which contain the history of the Mongols and Timurids and give much independent and valuable information.

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MIRO, JOAN (1893–), Catalan painter, one of the foremost exponents of 20th-century art, was born in Barcelona on April 20, 1893. He began drawing at the Lonja in his native city, where he was taught by Modesto Urgell. Miró made his first visit to Paris in 1919. Thereafter he lived in that city, in Barcelona and at his farm in Majorca. His first manner is characterized by an *avant-garde* and antiacademic attitude, with highly stylized and rounded forms. Between 1916 and 1923, however, he began to allow a certain representational element in his paintings, which at the same time are distinguished by an unmistakably passionate use of simple and violent colour; "La Masia" (1921–22), in Ernest Hemingway's collection, is an important picture of this period.

From 1923 onward, Miró discarded the representational element more and more and got free of it through colour and through creating simple and extremely effective forms. His colours are pure, sometime? primary colours only; his line is based mainly on the curve. Influenced by André Breton's doctrines, Miró shows a strong sense of humour, which gives him his special place amongst the surrealists; "Dutch Interior" (1928) is one of the outstanding examples of the art of his time. From 1930 his work became even less representational, as he substituted outline drawings and schematic figures reminiscent of children's drawings or the art of primitive peoples. His feeling for decoration and contrasting masses of strong colour are dominant features of his work. As well as easel-paintings and murals, Miró did sculpture and engraving and also illustrated books and painted on pottery. (J. GL.)

MIRROR. A mirror can be considered as an optical instrument that produces images of objects by reflection.

This article is divided into the following sections:

I. History
II. Reflection by Mirrors
  1. Law of Reflection
  2. Effect of Rotation
III. Astronomical Mirrors
  1. Early
  2. Modern
  3. Plane Mirrors
IV. Astronomical Mirror Making as a Hobby

I. HISTORY

The earliest mirrors of the Etruscans, Greeks and Romans usually consisted of a thin disk of metal, generally bronze, slightly

convex and polished on one side, the other being left plain or having a design incised upon it. Mirrors made from glass coated with tin or silver are mentioned by Pliny as having been made at Sidon, but they appear to have been little used.

Greek mirrors dating from shortly before 400 B.C. have been found. They were usually provided with a handle, which sometimes took the form of a statuette: often of Aphrodite, or consisted of two metallic disks fitting into each other and sometimes fastened together with a hinge.

Small metallic mirrors with highly polished surfaces were largely used during the early centuries of the Christian era, pocket mirrors or small hand mirrors carried at the girdle being indispensable adjuncts to ladies' dress. In 62j Pope Boniface IV sent Queen Aethelberga of Northumbria a present of a silver mirror, and in early Anglo-Saxon times mirrors were well known in England.

The method of backing glass with thin sheets of metal for mirrors was known in the middle ages, at a time when steel and silver mirrors were almost exclusively used. A guild of glass-mirror makers existed in Nuremberg in 1373, and small convex mirrors were commonly made in southern Germany before the beginning of the 16th century. It was in Venice, however, that the making of glass mirrors on a commercial scale was first developed. In 1j64 the mirror makers of Venice formed themselves into a corporation, and their glass mirrors quickly supplanted those of polished metal. The coated glass mirrors were made from blown cylinders of glass, which were slit, flattened on a stone, carefully polished, the edges frequently beveled and the backs silvered by an amalgam of tin and mercury. To do this a sheet of tin foil mas laid on a horizontal blanket lying on a flat surface; then a pool of clean mercury was spread on the tin foil, a sheet of paper being laid over the mercury. The sheet of very carefully cleaned glass was allowed to fall slowly on the paper and the paper drawn off just as the glass reached the mercury, so that a clean surface of the mercury came into contact with the glass. Heavy weights were then laid on the back of the glass and the whole was left for the excess of mercury to be squeezed out, after which the amalgam of tin and mercury adhered to the glass.

BY COURTESY OF THE ORIENTAL INSTITUTE, THE UNIVERSITY OF CHICAG,

EGYPTIAN MIRROR OF BRONZE DATING FROM 1500 B.C. THE HANDLE OF THE MIRROR BEARS A SCULPTURED LIKENESS OF THE GODDESS HATHOR, FIGURED WITH THE HORNS AND EARS OF A COW AND THE FACE OF A WOMAN

These mirrors had a high reflecting power. The glass was remarkably pure and uniform, the silvering bright and the sheets sometimes of considerable dimensions. In the inventory of the effects of the French minister Colbert, a Venetian mirror, 46 in. by 26 in., in a silver frame, was valued at 8.016 livres, while a picture by Raphael was put down at 3.000 livres.

A considerable improvement came in France in 1691 when the art of making plate glass was introduced. The chemical process of coating a glass surface with metallic silver, now called silvering, was discovered by Justus von Liebig (*q.v.*) in 1835 and was put into practice five years later.

II. REFLECTION BY MIRRORS

A mirror is usually associated with the retlection of visible light, though there are also mirrors for the reflection of sound, radio waves, etc. The human eye can receive light directly from an incandescent source or by scattering or reflection of the light from some source. This page scatters or diffusely reflects the light incident on it, some of which may enter the human eye. A mirror, made from a highly polished metal or a smooth surface of glass coated with silver, reflects the light in a definite manner called regular or specular reflection. The surface of a mirror must be smooth or have irregularities that are small compared with the wave length of the light being reflected. For visible light the wave lengths associated with the different colours are of the order of $\frac{1}{10,000}$ in., while sound waves have wave lengths of the order of a few feet and radio waves of the order of fractions of a mile. Thus a surface that can act as a mirror and regularly reflect sound waves can be so rough as to be of no value for reflecting visible light waves. When light falls on a body some of the light may be reflected, some absorbed and some transmitted through the body.

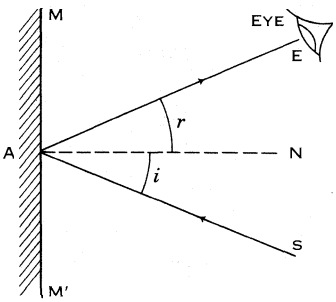

FIG. 1.—REFLECTION BY A PLANE MIRROR

In order for a smooth surface to act as a mirror for visible light, its surface must be bright so as to reflect as much of the light as possible and transmit and absorb as little as possible.

1. Law of Reflection.— Let us consider the reflection of light from a smooth and highly reflecting flat surface such as MM′, fig. 1. An eye at E receives light from a source S by the paths SA and AE. The lines SA and AE are called rays of light. SA is the incident ray and AE the reflected ray. Actually the eye receives more than a single ray of light from the source. The pupil of the human eye is about three millimetres in diameter, so it can receive a bundle or cone of rays. For simplicity me shall consider a single ray that does not invalidate the result. If the lines SA, AE are drawn and a line AN is drawn at right angles or normal to the mirror, then it is found that the angle i made by the incident ray with the normal is equal to the angle r made by the reflected ray with the normal. Thus the fundamental law of reflection by a mirror is that the angle of incidence i is equal to the angle of reflection r.

Fig. 2 shows two rays forming the boundaries of the cone of light that the eye can receive. The two incident rays SA, SA' are reflected along AE and A′E′ respectively so that their angles of reflection are equal to their angles of incidence. If the two reflected rays are projected backward they intersect at I, the image of the source S; that is, at a point as far behind the mirror as the source S is in front. The position of I can be found experimentally by placing behind the mirror a tall pin, the top of which can be seen over the mirror, and using as the source S a smaller pin. The pin behind the mirror is then moved around until it coincides with the image of S seen in the mirror, and thus directly it can be shown that the image of an object seen in a plane mirror is as far behind the mirror as the object is in front. Notice that the image I is never actually formed, or the rays of light do not actually pass through I. For this reason the image I is said to be a virtual image. That the image I is as far behind the mirror as the object is in front can be proved geometrically from the fundamental law of reflection.

As shown in fig. 3, a plane mirror gives an image that is the reversal of the object. Consider the object OO' with a projection, which is on the left-hand side when the object is viewed directly. This projection appears on the right-hand side of the image II′ seen by the eye. When a printed page is viewed in a mirror this reversal can be seen.

By using a combination of two plane mirrors set at right angles to one another, this reversal can be eliminated. An object OO' is placed in front of the two mirrows shown in fig. 4. On looking into the mirrors three images can be seen. The images I_1I_1',

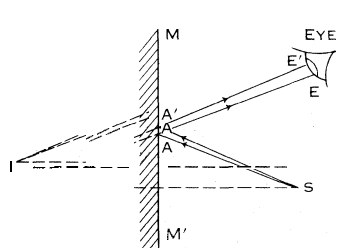

FIG. 2.—CONE OF RAYS ENTERING THE EYE APPEARING TO COME FROM IMAGE I

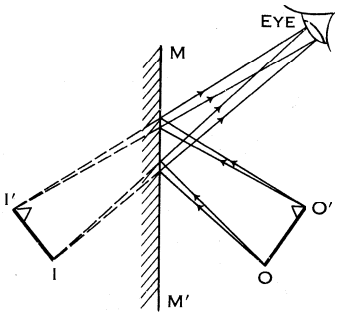

FIG. 9.— IMAGE REVERSAL IN A PLANE MIRROR

I_2I_2' are produced by reflection in one mirror and show the reversal, while the image I_3I_3' is produced after reflection in both mirrors and there is no reversal. The rays producing these reflections can be readily drawn. If the mirrors are set at 60° with one another, then five images may be seen, a result that can be generalized easily.

An interesting result follows when three mirrors are set up so that they are mutually perpendicular to each other and meet to form the apex of a tetrahedron. On looking into such a mirror system each eye sees itself in a line, and no change seems to take place when either eye is closed. This mirror system returns a beam of light from any direction back in exactly the same direction from which it came. In order to show this, consider a sphere whose centre O is at the apex of the mirrors. As shown in fig. 5, three mutually perpendicular lines are drawn, *Ox, Oy* and Oz, which intersect the sphere at *x*, y and *z*. The three mirrors lie in the *x*Oz, *x*Oy and *y*Oz planes and intersect the sphere in the great circles *yz, ZX* and *XY*.

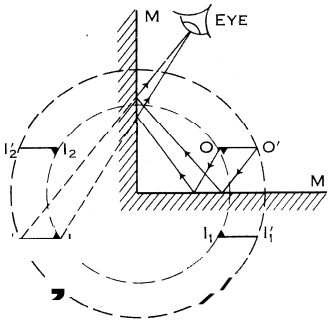

FIG. 4.— IMAGES FORMED IN TWO PLANE MIRRORS RAYS SHOW THE IMAGE FORMED BY TWO REFLEC-

Let a beam of light parallel to *PO* fall on the mirrors. This beam strikes the mirror *z*O*y;* is reflected onto the mirror *y*O*x* and is again reflected so as to fall on the mirror *z*O*x* from which it is again reflected so that it comes from this mirror parallel to the direction of the incident beam *PO*. Draw a great circle through *x*P (point *P* is considered to be on this great circle). This meets the mirror *z*O*y* in M. Continue this great circle to P′ of such a length that *MP'* is equal to *MP*. From the construction it follows that the angles OMP and *x*OM are right angles. For the ray of light parallel to *PO,* incident on the mirror *z*O*y,* its angle of incidence is *x*OP. Since *MP* is equal to *MP'* and *PO* is equal to *P'O,* it follows that the angles *POM*.*P'OM* are equal. Thus the incident ray *PO* is reflected along the direction *P'O*. It can be shown easily that the angle P′O*x*, which the reflected ray makes with the normal *Ox,* is the supplement of the angle of incidence PO*x;* that is, angle *P'Ox* is equal to 180° minus angle PO*x*. Reflection in any mirror changes the angle with its normal into its supplement. Successive reflections in all three mirrors will change all the angles made by *OP* with the normals *Ox, Oy,* Oz into their supplements.

Now the sum of the squares of the cosines of the angles made by *PO* with the normals *Ox, Oy,* Oz is equal to unity. Since the square of the cosine of any angle is equal to the square of the cosine of its supplement, it follows that the sum of the squares of the supplements of the angles made by *PO* with *Ox, Oy,* Oz is also unity. Thus the beam of light *PO,* after reflection in all three mirrors, will return exactly parallel to its incident path. The three mirrors have to be set at right angles to each other with a high degree of precision if the final image is to be single. As the final direction of the beam is simply the opposite of the original direction, it is not affected by rocking the system of mirrors.

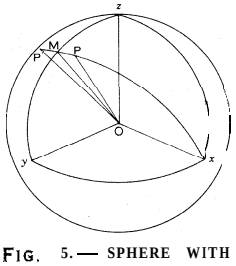

FIG. 5.— SPHERE WITH THREE MUTUALLY PERPENDICULAR MIRRORS (*x*Oz, *x*Oy AND *y*Oz) HAVING THEIR VERTEX AT O, THE CENTRE OF THE SPHERE

Small tetrahedral mirrors are used as reflectors for illuminating roadside signs from the headlights of automobiles at night. The back reflecting surface of these small reflector buttons generally consists of a series of little pits, each one of which is roughly a tetrahedral apex with three perpendicular plane surfaces. Such buttons shine brilliantly when illuminated by the headlights of approaching vehicles, and the intensity of the reflected beam does not vary greatly as the angle of illumination changes.

2. Effect of Rotation.— If a beam of light is reflected from a plane mirror as the mirror is rotated through some angle, then the reflected beam is rotated through twice the angle. For simplicity consider a ray of light (fig. 6) that falls perpendicularly on the mirror MM'; that is, the ray is along the normal NN'. Since the angle of incidence is zero, the angle of reflection is also zero and the reflected ray is along NN'. Now rotate the mirror to the position M_1M_1' through the angle M_1NM. The incident ray is still N′N while the reflected ray is now NN_2. The normal to M_1M_1' is NN_1, so that the angle $N'NN_1$ is equal to the angle M_1NM and the angle of incidence of the ray is now $N'NN_1$. This angle is equal to the angle of reflection N_1NN_2 where NN_2 is the reflected ray. Turning the mirror through the angle M_1NN results in the reflected ray's being turned through twice this angle or through the angle $N'NN_2$.

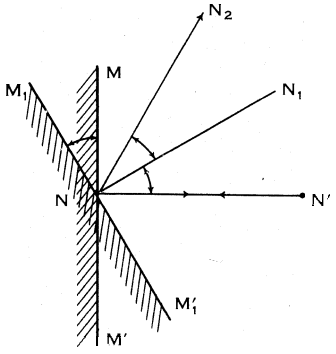

FIG. 6.—ROTATION OF A MIRROR THROUGH A GIVEN ANGLE ROTATES THE REFLECTED BEAM THROUGH TWICE THAT ANGLE

(R. J. SN.)

III. ASTRONOMICAL MIRRORS

1. Early.—During nearly two centuries, from 1668 when Sir Isaac Newton made the first reflecting telescope until the advent of the silvered-glass mirror in 1856, astronomical mirrors were thick, solid disks of a white alloy of copper with proportions of tin usually between 25% and 33.4%, on which the concave curvatures required for reflecting the light rays to a focus were ground with emery grains. and polished and finally figured, or precisely shaped, with optician's rouge. These speculum metal mirror disks were difficult to cast, brittle and hard to work, and when finished did not reflect a high percentage of light. Their chief fault was that when they became tarnished the necessary repolishing destroyed their figure, which then had to be wholly recreated. This not only forced the astronomer to acquire as much skill as the expert who figured the mirror, but interrupted his observing for days or weeks. A means whereby tarnished telescope mirrors could be replaced easily and quickly, without affecting their figure, therefore would have been a boon.

2. Modern.— Such a means arrived in 1856 when Karl August von Steinheil developed a method of coating glass telescope disks with suitable reflecting films of silver which, when tarnished and without altering the figured glass, could be removed in seconds with acid and replaced in minutes with brilliant new films by a chemical process. The mirror proper, the reflecting part, now became a film of silver about $\frac{1}{250,000}$ in. thick; but since such films take their shape from the permanently figured glass to which they adhere and which acts as their rigid support, and also since the creation of the figure on this glass requires much more time than applying the silver film, when telescope makers use the word mirror, they refer mainly to the glass and its figure, of which the film on its surface is a replica.

Quite logically a question is often asked: since glass mirrors, the familiar looking glasses, silvered with tin and mercury, were in use long before telescopes, why did astronomers ever use mirrors of speculum metal with all their drawbacks? The answer is because it was essential, as it still is, that the reflecting coating be on the front of the glass and not on the back, since front-surface mirrors obviate losses of light within the glass and at the surface, as well as spurious reflections and aberrations. But the old tin and mercury method of silvering gave only a dull, irregular surface on the front, though modern methods give excellent surfaces.

Most reflecting telescopes have solid mirror disks of glass, about one-eighth or one-sixth as thick as wide, so that the glass from its own weight will not sag the few millionths of an inch that is sufficient to alter the figure temporarily while the telescope is inclined in different positions. Another source of altered figure is the slight temporary warping of the disk caused by unequal expansion or contraction between surface and interior while it is being warmed or cooled by the surrounding air. On the mirrors of crown glass, similar in composition to plate glass, made before the 1930s, this had an effect several times greater than on the low-expansion Pyrex that came into use for mirrors at about that time. The warping caused by transient air-temperature changes was still further reduced in the Pyrex mirror of the world's largest telescope on Palomar mountain, in California. which is 2 ft. thick, nearly 17 ft. in diameter and contains a 30,000-lb. mass of glass. The reduction was accomplished by honeycombing the back of the disk with deep openings to the air. This leaves only a relatively thin front surface and behind it a grid of ribs or partitions, the two cast integral and mainly only about four inches thick. Few points within the glass lie more than two inches from the surrounding air, and temperatures that in large solid disks require several hours for equalization are equalized rapidly. The ribbed construction also provides maximum stiffness with a minimum of weight.

The common belief that astronomical mirrors are made of costly optical glass, as are good lenses, is erroneous; there is no necessity for this since astronomical mirror disks are not called upon to transmit light but only to support the film of metal that reflects it. Calling an astronomical mirror a lens is also a common error.

The concave curve in the face of an astronomical mirror is seldom more than one inch in depth even in fairly large telescopes and is less than four inches in the zoo-in. telescope on Palomar mountain. The disk is laid flat on a slowly rotating turntable and ground with loose, wet, abrasive grains of sugarlike size beneath a slightly convex disk of metal attached to the lower end of a power-driven vertical shaft. This tool. resembling an inverted mushroom and perhaps one-quarter or one-half the diameter of the mirror, is made to rotate slowly, while a third component is added when lateral motions are given it to keep the curve even. After the glass has thus been roughed out to approximate curve, a convex tool of the same diameter as the mirror. and faced with squares of metal or glass, is used in grinding for several hours with each of a series of finer and finer abrasive grains, ending with powders of flourlike grain size. This leaves the glass uniformly curved from centre to edge and in fine-textured, smoothly frosted condition.

The full-sized tool is next covered with a quarter-inch layer of pitch, an elastic substance that will flow under pressure and thus continually conform to all changes made in the mirror surface. Against this pitch lap the mirror is polished for hours with wet optician's rouge (ferric-oxide) powder, or other polishing powders of microscopic grain size, until all scratches and tiny pits left by the grinding have been polished away and the surface is perfectly smooth to the eye and magnifier.

The next and most difficult but most interesting process is the figuring, in which the precision optician deals often with single millionths of an inch. With modifications of the means already used in polishing—that is. with pitch laps of varying sizes and shapes—the mirror is first brought precisely to a spherical curvature. one into which a huge sphere of which it is a segment would accurately fit. By further polishing in precalculated zones this sphere is then altered slightly to the paraboloid. which mill bring the light rays to a single focus. This process, though the volume of glass removed is relatively infinitesimal, often consumes as much time as all the previous work or even more, especially since the behaviour is not entirely predictable and in removing one imperfection, such as a raised or depressed zone on the glass. others may be introduced. Figuring may be done with the machine described above, with frequent skillful readjustment of stroke, or by hand with small laps of pitch. At mid-20th century no machine had yet been devised to go through this figuring process automatically and to produce a perfect mirror without frequent human intervention guided by judgment based on test.

Prior to 1859 mirror makers enjoyed no satisfactory way of testing the figure of a mirror as it evolved, for the measurements involved are too small to be made by mechanical means: In that year the physicist Jean Bernard Léon Foucault (*q.v.*) invented a delicate test, even more delicate than needed, that reveals, locates and measures. within &<= in., local surface irregularities, employing nothing more complex than a lamp shining through a tiny pinhole in an opaque screen and the edge of a common knife. To make Foucault's test an illuminated pinhole (artificial star) is placed at the centre of curvature of a spherical mirror. The rays go out from it to all parts of the sphere and are reflected back to a focus at the pinhole, the polished glass reflecting sufficient light for this test. To permit the rays instead to enter the eye the pinhole is displaced slightly to one side of the mirror's axis so that the rays will return slightly to the other side where the eye can be placed, a little back of focus, to receive them. The mirror is then seen to be bright all over. If now the knife edge is moved in from the side to cut the rays. the mirror, if everywhere precisely spherical, will darken uniformly all over; if it is not spherical, no point can be found at which it can be made to do this. Zones of longer or shorter radius of curvature than the rest of the mirror will be revealed by apparent shadows on its face, because the rays reflected from these zones encounter the side of the knife and do not reach the eye. The shadows exaggerate the relief of the surface about 100,000 times, and the mirror maker learns to interpret the code of these shaded areas in quantitative terms of mirror figure. Following these examinations he treats the faulty areas by brief. cautious local polishing and tests again; and thus proceeds until the desired paraboloid, free everywhere from irregularities of surface, is attained. By using an accessory plane mirror of high precision and making Foucault tests at the focus of the concave mirror instead of at its centre of curvature as just. described, still greater delicacy may be attained.

Before use. astronomical mirrors must be coated with a metallic reflecting surface. Beginning early in the 1930s, silver deposited chemically on glass gave way to aluminum deposited physically by practical processes developed by John Strong. or chromium followed by aluminum developed by Robley C. Williams. Scraps of the metal are attached to tungsten wires a few inches or feet from the mirror. and the whole is enclosed in a chamber from which the air is pumped out to an almost perfect vacuum. An electrical circuit is closed. the tungsten wires become highly heated and the bits of metal. less refractory than the tungsten, are quickly vaporized. Unobstructed by air molecules, the atoms of vaporized metal fly across to the glass and condense in a highly reflective coating about $\frac{1}{250,000}$ in. thick.

These processes afford tougher, more resistant, longer-lasting coatings than does silver. They also reflect more of the actinic rays that affect the photographic plates used by the modern astronomer in place of visual observation. While the familiar aluminum surfaces are not mirrorlike. those formed by this method may easily be mistaken for a silvered mirror.

When aluminum is deposited on a glass surface which is not adequately cleaned, the adhesion will be inferior to that exhibited by a deposit on a properly cleaned surface. In most cases the mirror will appear to be good at first but will develop countless tiny blisters after standing for a day or so.

3. Plane Mirrors.—These mirrors, plane within $\frac{1}{400,000}$ in, or even $\frac{1}{800,000}$ in. and used as accessories with some astronomical instruments, are much more difficult to make than paraboloidal mirrors of equal diameter. A modification of Foucault's test or a test with Newton s fringes against a plane of known precision governs the figuring process, which consists of local polishing with small pitch laps. The finished plane is vacuum coated with reflecting metal. Since about 1913 glass or fused quartz planes called optical flats, made to the same precision by the same methods but not coated. have been in use throughout the mechanical industries for optically checking the accuracy of the precision gauges that make possible the manufacture of identical, inter-

changeable parts. In the United States from time to time these flats, as they wear out of true, are checked at the national bureau of standards against a still more precise master flat, plane within $\frac{1}{4,000,000}$ in.

See also SEXTANT; MICROSCOPE; TELESCOPE.

IV. ASTRONOMICAL MIRROR MAKING AS A HOBBY

Astronomical mirror making is a hobby for thousands of amateur astronomers who have made their own telescopes. In the 19th century amateurs discovered a scarcity of prepared instructions, partly because secrecy concerning the working methods had long been a tradition among professional makers, even though many of these had themselves begun as amateurs. This hindrance to the hobbyist was removed largely by the writings of W. F. A. Ellison. Russell W. Porter, Albert G. Ingalls and Allyn J. Thompson, beginning about 1920. Within the next decades tens of thousands of astronomical telescopes, principally of the relatively inexpensive reflecting type. were made in home workshops by amateurs, mostly adult.

In the reflecting telescope the mirror is at once the most important, the most difficult and the most interesting part to make. Thus, mirror making is itself a hobby within a hobby. The amateurs' mirrors, usually from 6 to 12½ in. in diameter. are made by modifications of the methods already described and usually by hand. The amateur's mirror disk. instead of being placed face up on a slowly rotating turntable and ground with a metal tool of lesser diameter, is placed face down on another glass disk of equal diameter, attached to the top of a barrel. and stroked with the hands back and forth across the lower disk with coarse, wet abrasive grains placed between the two. (The lower disk. called the tool, is later discarded.) The worker simulates the motions of the professional mirror maker's machine by keeping the mirror in gradual rotation with his fingers between the strokes, at the same time slowly walking sidewise around and around the barrel. The three combined motions keep the near-spherical curve from becoming lopsided.

The longer the grinding is continued the more concave the upper or mirror disk is ground out, the tool becoming convex to match its curvature. The concaving and corresponding convexing occur, instead of a uniform wearing down of the two flat faces, because the pressures automatically increase toward the ends of the strokes when the central areas of the upper disk press on the outer areas of the lower disk.

After a few hours of this preliminary roughing out, the mirror concavity approaches the desired depth ($\frac{1}{20}$ in. for a typical amateur's mirror 6 in. in diameter). Series of finer and finer grains are then substituted for the coarse abrasive to produce as smooth-ground a glass surface as can be had by grinding glass against glass. The tool is then covered with pitch and the mirror is polished five to ten hours against this medium with rouge; the process is essentially as described above for large mirrors made professionally, but the stroking is done by hand. The final figuring, or precise shaping within millionths of an inch. of the geometrically ideal paraboloid by eliminating local irregularities of surface such as zones that are high or low, is done by stroking the mirror in special patterns of motion against the same pitch lap on which it was polished. Foucault's all-revealing test is made every few minutes throughout the figuring, so that the worker may watch closely the new changes in curvature that spontaneously arise locally on the surface and decide on the next stratagem to steer the curve in the desired direction.

Because no two mirrors exhibit the same combinations of these deviations, the treatment cannot be standardized beyond a few general rules, which do not always apply. Within the limits of these general instructions the worker contributes from his own resourcefulness and imagination by devising methods, many of which prove fruitless or worse, forcing him to hours of effort to recover lost ground before he hits on a successful one.

Because the coating of the completed mirror with reflecting aluminum (superior to the more easily applied silver coating) requires too large an investment in high-vacuum apparatus, the amateur sends it to a laboratory to be coated, a brief procedure. He then plans and builds a telescope tube and a mechanical mounting with axes, so that his telescope may be easily pointed at different celestial objects. (A. G. I.)

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MIRROR WRITING: *see* HANDWRITING.

MIRZAPUR, a city, *tehsil* and district in Uttar Pradesh, India. The city is on the right bank of the Ganges, 30 mi. S.W. of Varanasi; pop. (1951) 86,528. The river front is lined with stone ghats (bathing and crematory stairs), mosques, Hindu temples and dwelling houses of the wealthier merchants. Formerly it was the emporium of trade between central India and Bengal, which has now been diverted to the railways. It has lac factories and manufactures brassware and woollen carpets.

The municipality (Mirzapur-cum-Vindhyachal City) includes the town of Vindhyachal (Bindhachal), an important centre of pilgrimage, with the shrine of the mountain goddess Vindhyeshwari.

MIRZAPUR TEHSIL (1,186 sq.mi.) had a population in 1951 of 432,098.

MIRZAPUR DISTRICT extends southward across the Son valley. Area 4,372 sq.mi. It is crossed from east to west by the Kaimur range. the eastern extension of the Vindhyas. A central jungle plateau separates the valley of the Ganges from that of the Son. The part north of the Son is highly cultivated and thickly populated, but the rest of the district consists largely of ravines and forests with a sparse population. The population in 1951 was 1,017,289.

MISAMIS OCCIDENTAL, a coastal province on the northeastern part of the Zamboanga peninsula, Mindanao, Republic of the Philippines. Pop. (1959) 254,290.

Only 802 sq.mi., it is a small province facing Iligan bay. A narrow coastal plain gives way to rolling hills which partially encircle a mountainous mass centring on Mt. Malindang (7,964 ft.). A provincial highway follows the roughly semicircular shoreline. There are no roads into the rugged interior area. Coconuts and corn are the principal crops. The principal towns are Oroquieta, the capital, and Ozamiz, a chartered city and the principal port. (AN. C.)

MISAMIS ORIENTAL, a coastal province on northern Mindanao and including nearby Camiguin Island. Republic of the Philippines. Pop. (1959) 452,870. Area 1,512 sq.mi.

The area includes a narrow coastal plain and rolling to rough hill lands (disected plateau). Some of the river valleys contain deep deposits of coarse alluvium. The principal products are coconuts, corn, rice and lumber. There is a large modern pineapple cannery at Bugo, but the fruit is grown in Bukidnon province, to the south. Cagayan, the capital and only city (pop. [1959] 56,679) is a secondary port and the principal air centre of Mindanao.

Hibok-Hibok, a volcanic peak on Camiguin Island, was active in 1948 and again intermittently from Sept. 1950 until 1952. (AN. C.)

MISCARRIAGE, a folk term for spontaneous abortion, the death and expulsion of a human fetus during the first 24 weeks of life. Expulsion of a dead fetus later in pregnancy is termed stillbirth.

See ABORTION; STILLBIRTH.

MISDEMEANOUR, the generic term used in English law to include all those offenses against the criminal law which are not by common law or statute made treason or felony. In *Russell* on Crimes it is defined as a crime for which the law has not provided a particular name.

The term misdemeanour includes not only all indictable offenses below the degree of felony, some of them grave crimes, such as sedition, riot and perjury, but also the petty misdemeanours, which may be dealt with summarily by justices of the peace, and the most trifling breaches of local by-laws.

As a matter of legal history, many misdemeanours represent

what were originally described as trespasses against the peace, a phrase which is equivalent to a tort or delict, accompanied by circumstances calling for prosecution in the interest of the crown and the public as well as for civil proceedings by the injured parties. Such acts as riot, public nuisance, sedition and the different forms of libel naturally came to be regarded as wrongs against the peace.

Many of the early statutes anent justices are particularly concerned with the punishment of rioters and some offenses now treated as misdemeanours belonged to the spiritual and not to the temporal courts (*i.e.*, perjury).

Numerous acts or omissions are punishable as "misdemeanours by interpretation." In other words, disobedience to the command or prohibition of a statute as a matter of public concern is indictable as a misdemeanour, even if the statute does not so describe it, unless the terms of the statute indicate that some other remedy alone is to be pursued. For some misdemeanours penal servitude may be imposed by statute; but as a rule the appropriate punishment is by fine or imprisonment without hard labour, or both, at the discretion of the court unless limited by a particular statute. The offender may also be put under recognizance to keep the peace and be of good behaviour.

At the present time the practical difference in English law between misdemeanour and felony lies in some matters of procedure; for instance, an arrest for misdemeanour may not be made without judicial authority, except under specific statutory authority.

MISE, an Anglo-French term denoting originally a payment. The *Rotuli Misae* of John's reign, for example, record the king's current disbursements from day to day.

In a more technical sense, the word is applied to the payments made by the county palatine of Chester to each new earl, and by the Welsh to each new lord of the Marches, or to a prince or king on his entry into the country. By transference of idea the word came early to mean the settlement of a dispute by arbitration or agreement and in this sense is familiar in English history in the "Mise of Amiens," in January, and that of Lewes, in May 1264.

MISENUM, ancient port, Campania, Italy, about 3 mi. S. of Baiae (*q.v.*) at the west end of the Gulf of Puteoli (Pozzuoli). Until the end of the Republic it was a favourite villa resort dependent on Cumae. Agrippa made the fine natural harbour into the main naval station of the Mediterranean fleet (31 B.C.). In 890 it was destroyed by the Saracens. The harbour consisted of the outer basin, or Porto di Miseno, protected by moles, of which remains still exist, and the present Mare Morto, separated from it by a comparatively modern embankment.

The town lay on the south side of the outer harbour, near the village of Miseno, nhere remains of a theatre and baths have been found. Remains of villas can also be traced; the largest of these, which occupied the summit of the promontory, belonged first to Marius, then to Lucullus and then to the imperial house. Tiberius died there.

MISHAWAKA, a city of St. Joseph county in northern Indiana, U.S.. on the St. Joseph river 90 mi E. of Chicago and adjacent on the west to South Bend (*q.v.*). Major industries produce rubber footwear, cushions, mattresses, automobile mats, raincoats, foundry supplies, packing products, electric power, sheet metal products and missiles. Bog iron discoveries in 1833 brought industry to the site, building blast furnaces and housing for workers; in 1839 the settlement was incorporated as Mishawaka, named for an Indian princess who lived in the area. In 1899 it was chartered as a city. It has a large Belgian population.

For comparative population figures see table in INDIANA: Population. (J. J. D.)

MISHMI, a hill tribe north of the Brahmaputra in Assam, India, divided into four groups, said to be endogamous, called Chulikata (crop-haired), Bebejiya, Taroan and Miju, the customs of the two last differing a little from those of the two former. These groups are divided into patrilineal exogamous septs. They claim to have reached their present habitat from the north, except one sept, which came from the south. Polygamy is allowed and a man's widows go to his heir, Headmen are chosen by heredity, qualified by wealth and personality. Offenses within the sept are punished by the kindred, otherwise the blood feud is resorted to and revenge obtained by killing or enslaving some member of the offender's sept. All use arrows poisoned with aconite, but, while the first two groups use the simple bow and cane helmets, the two latter use the crossbow and no helmets.

All believe in a home of the dead underground, and all bury, but the Taroan and Miju dig up their dead after five days and burn them.

See O'Callaghan, The *Mishmis,* Appendix B. II (Assam Census Report, 1921).

MISHNAH: see TALMUD.

MIŠIĆ, ZIVOJIN (1855–1921), Serbian statesman, was born July 7, 1855, at Struganik near Valievo, the son of well-to-do peasant parents. He passed through the old artillery school in Belgrade and served in the Serbo-Turkish War of 1877 and the Serbo-Bulgarian War of 1885.

During the Bosnian annexation crisis he became assistant chief-of-staff to Gen. Radomir Putnik; he also fought in the first and second Balkan wars. When the Austrians invaded Serbia in Nov. 1914, Mišić was appointed to the command of the 1st army. His simple and unaffected heroism inspired his soldiers with confidence; and after the decisive victory of Rudnik early in December the Austrians were driven out of Serbia.

Mišić, who had been created voivode (marshal) after Rudnik, again served with distinction during the retreat of the Serbian army in the winter of 1915. He resumed command of the 1st army on the Salonika front in Aug. 1917, and in June 1918 was made chief of staff. A convinced believer in the idea of Yugoslav unity, he promoted the efforts of the exiled Yugoslav committee to organize Yugoslav legions on every front. He died on Jan. 20, 1921.

MISIONES, the extreme northeastern province of Argentina, bounded by Paraguay, Brazil and the Argentine province of Corrientes. Area, 11,506 sq.mi. Pop. (1957 est.) 345,053; (1947) 246,396. The province is characterized by abundant rainfall (70 in. per year) and a hot climate (mean annual temperature 73°). The rough terrain is accented by canyons. rivers and low ranges of the Sierra Victoria, Sierra Iman and Sierra Grande, largely covered with pine and broadleaf trees. The area was part of the region occupied by the famous Jesuit Guarani missions in the 17th and 18th centuries (see GUARANIS and PARAGUAY: *History*). It became an Argentine territory after several decades of dispute with Paraguay and Brazil and the bloody Paraguayan war of the 1860s.

The principal product is mate (Paraguay tea), followed by lumber and forest products, cotton, corn and tobacco.

The capital, Posadas, pop. (1956) 52,200, established in 1865, is located on the upper Paraná river in the western corner of the province.

River steamboats and a railroad from Asunción, Parag., to Buenos Aires link the city with the coast. The spectacular Iguazú falls on the Brazilian border at the northern tip of the province is perhaps the best-known landmark. (Js. R. S.)

MISIONES, a department of southern Paraguay, lies between the Tebicuary and Paraná rivers. Area 3,025 sq.mi. Pop. (1960 est.) 54,567. It was settled, as its name implies, by the Jesuit missionaries of the 17th and 18th centuries. Consisting almost entirely of a great lowland, much of it marshy, its chief economic importance is for cattle raising, although crops of rice, maize and sugar are also significant, and some mate is gathered.

San Juan Bautista (pop. [1960 est.] 6,488) is the capital, and San Ignacio, founded in 1609, an important centre for processing agricultural produce.

Both are on a major highway between Asunción and Encarnación, which bisected Misiones department and increased its importance and settlement. (G. J. B.)

MISIONES, SIERRA DE, an undissected piece of the Paraná plateau which forms the divide between the Paraná and Uruguay rivers (*qq.v.*) in the Argentine province of Misiones. It is incorrectly translated as "mountain" since actually it is only the height of land between two valleys, an interfluve, The top

of the plateau in this area is about 1,500 ft. above sea level.
(P. E. J.)

MISKITO COAST: *see* MOSQUITO COAST.

MISKOLCZ (MISKOLC), a Hungarian town situated on the eastern slope of the Bükk mountains, in the fertile valley of the Szinva. It is an old but thriving town that clearly reflects its position on the frontiers of several forms of religious expression in its Gothic, Roman Catholic, Eastern Catholic, Lutheran and Calvinistic churches. This aspect is closely connected with its function as a centre of contact for hill and plain, an activity further apparent in the four large annual fairs at which there is a large trade in cereals and flour, wine and fruit, cattle and hides and other agricultural products; in addition there are flour mills, tanneries, boot factories and porcelain works. Like many of the towns on or near the Hungarian plain it has sufferedgreatly at the hands of invaders, notably the Mongols in 1241–43, who killed about 85,000 Hungarians on the Mohi heath, southwest of the town, and during the Turkish wars in the 16th and 17th centuries, and has been devastated by fire three times, in 1781, 1843 and 1847. About 4 mi. S.W. of the town are the warm springs and baths of Tapolcza. The population of Miskolcz (1960) was 143,364 (mun.).

MISPICKEL or ARSENOPYRITE: *see* ARSENOPYRITE.

MISPRISION, a term in English law, almost obsolete, used to describe certain kinds of offense. Thus we have misprision of treason and misprision of felony. But there is no misprision of misdemeanour.

Misprision of Treason is the concealment or keeping secret of high treason, and the punishment is loss of the profit of the lands of the offender during life, forfeiture of all his goods and imprisonment for life.

Misprision of Felony is the concealment or procurement of the concealment of a felony committed by another person, punishable on indictment by fine and imprisonment.

In the United States, misprision of treason is defined to be the crime committed by a person oning allegiance to the United States and having knowledge of the commission of any crime against them. who conceals and does not, as soon as may be, disclose and make known the same to the president or to some judge of the United States, or to the governor or to some judge or justice of a particular state.

MISRULE, LORD OF, in mediaeval times the master of the Christmas revels. Probably J. G. Frazer *(Golden Bough* III) is right in suggesting that the lord or abbot of misrule is the successor of the king of the Roman Saturnalia. who personated Saturn. Stow *(Survey)* writes: "In the feast of Christmas there was in the King's House . . . a Lord of Misrule . . . and the like had ye in the house of every nobleman of honour or good worship. were he spiritual or temporal." The mayor and sheriffs of London also had lords of misrule but by an act of common council (1jj5) their expenses were severely curtailed. These mock monarchs began their reign on Allhallows Eve and misruled till Candlemas. In Scotland they were known as "Abbots of Unreason," and in 1555 a special act suppressing them was passed. In Tudor times their reign was marked by much expense.

MISSAL, the book containing the liturgy, or office of the mass *(missa),* of the Roman Catholic Church. The earlier *Sacramentary,* the book used by the celebrant at the altar, contained merely the fixed canon of the mass or consecration prayer and the variable collects, *secretae* or *orationes super oblata,* prefaces and post-communions for each fast, vigil, festival or feria of the ecclesiastical year; for a due celebration of the Eucharist other books were required for use by the choir, deacon and subdeacon, viz., the *Antiphonarium Missae,* afterwards called the *Graduale,* containing the proper antiphons (introits), responsories (graduals), tracts, sequences, offertories, communions and other portions of the communion service designed to be sung by the schola or choir, and the *Lectionarium* (or *Evangeliarium* and *Epistolarium)* with the proper lessons. But as the custom grew, from the 8th century onwards, of private celebrations in which the priest had to say the whole service, the contents of these separate books came by degrees to be combined in a single volume, the *Missale plenum.* All modern missals are of this last description. The *Missale romanum ex decreto ss concilii tridentini restitutum,* now in almost exclusive use throughout the Latin obedience, owes its present form to the council of Trent. which undertook the preparation of a correct and uniform liturgy and entrusted the work to a committee of its members. This committee had not completed its labours when the council rose, but the pope was instructed to receive its report when ready and to act upon it. The "reformed missal" was promulgated by Pius V on July 14. 1570, and its universal use enjoined, the only exceptions being churches having local liturgies which had been in unbroken use for at least two centuries. It has subsequently undergone slight revisions under Clement VIII (1604). Urban VIII (1634) and Leo XIII (1884), and various new masses, both obligatory and permissive, universal and local, have been added. The Roman, like all the western liturgies, is distinguished from those of the Eastern Church by its flexibility. A distinctive character has been given to the office for each ecclesiastical season, for each fast or festival of the year, almost for each day of the meek; and provision has also been made of a suitable communion service for many of the special occasions both of public and of private life.

The meagre liturgical details furnished by the *Sacramentarium gregorianum* are supplemented by the texts of the *Ordo romanus,* the first of which dates from about the year 770. The ritual they enjoin is that for a pontifical high mass in Rome itself; but the differences to be observed by a priest *quando in statione facit missas* are comparatively slight. The Gregorian *Antiphonarius sive gradualis liber ordinatus per circulum anni,* as its name implies, contains those variable portions of the mass which were intended to be sung by the schola or choir. It gives for each day for which a proper mass is provided: (1) the *Antiphona* (Antiphona ad Introitum) and *Psalmus; (2)* the *Responsorium* and *Versus,* with its *Alleluia* and *Versus;* (3) the *Offertorium* and *Versus;* (4) the *Communio* and *Psalmus.* The word *Antiphon* (ἀντίφωνον, English, *anthem)* in its ecclesiastical use had reference to the very ancient practice of relieving the voices of the singers by dividing the work between alternate choirs. In one of its most usual meanings it has the special signification of a sentence (usually scriptural) constantly sung by one choir between the verses of a psalm or hymn sung by another. According to the Roman liturgiologists it was Pope Celestine who enjoined that the Psalms of David should be sung (in rotation presumably) antiphonally before mass. In process of time the antiphon came to be sung at the beginning and end only and the psalm itself was reduced to a single verse. In the days of Gregory the Great the introit appears to have been sung precisely as at present—that is to say after the antiphon proper. the *Psalmus* with its *Gloria,* then the antiphon again. The *Responsorium,* introduced between the epistle and gospel, was probably at first an entire psalm or canticle, originally given out by the cantor from the steps from which the epistle had been read (hence the later name *Graduale*), the response being taken up by the whole choir. The *Offertorium* and *Communio* correspond to the "hymn from the book of Psalms" mentioned by early authorities *(see,* for example, Augustine, *Retr.* ii, 11; *Ap. Const.* viii, 13) as sung before the oblation and also while that which had been offered was being distributed to the people. A very intimate connection between these four parts of the choral service can generally be observed; thus, taking the first Sunday in the ecclesiastical year, we find both in the *Antiphonary* and in the modern *Missal* that the antiphon is Psalms xxv, 1–3, the psalmus Psalms xxv, 4, the responsorium (graduale) and versus Psalms xxv, 3 and xxv, 4, the offertorium and versus Psalms xxv, 1–3 and xxv, 5. The communio is Psalms lxxxv, 12, one of the verses of the responsorium being Psalms lxxxv, 7. In the selection of the introits there are also traces of a certain rotation of the psalms in the Psalter having been observed.

The first pages of the modern Roman missal are occupied with the *Calendar* and a variety of explanations relating to the year and its parts and the manner of determining the movable feasts. The general rubrics *(Rubricae generales missalis)* follow, explaining what are the various kinds of mass which may be celebrated, prescribing the hours of celebration, the kind and colour of vest-

ments to be used, and the ritual to be followed (ritus *celebrandi missam*), and giving directions as to what is to be done in case of various defects or imperfections which may arise. The *Praeparatio ad missam* and Gratiarum actio post *missam,* which comes next, are in a short manual of devotion to be used as opportunity may occur before and after celebration. Next comes the proper of the season (Proprium *missarum* de tempore), occupying more than half of the entire volume. It contains the proper introit, collect (one or more), epistle, gradual (tract or sequence), gospel, offertory, secreta (one or more), communion and postcommunion for every Sunday of the year, and also for the festivals and ferias connected with the ecclesiastical seasons, as well as the offices peculiar to the ember days, Holy Week, Easter and Whitsuntide. Between the office for Holy Saturday and that for Easter Sunday the ordinary of the mass (*Ordo* missae), with the solemn and proper prefaces for the year, and the canon of the mass are inserted. The proper of the season is followed by the proper of the saints (Proprium sanctorum), containing what is special to each saint's day in the order of the calendar, and by the Commune sanctorum, containing such offices as the common of one martyr and bishop, the common of one martyr not a bishop, the common of many martyrs in paschal time, the common of many martyrs out of paschal time and the like. A variety of masses to be used at the feast of the dedication of a church, of masses for the dead and of votive masses (as for the sick, for persons journeying, for bridegroom and bride) follow, and also certain benedictions. Most missals have an appendix also containing certain local masses of saints to be celebrated ex indulto apostolico. See MASS; VESTMENTS.

MISSI DOMINICI, the name given to the officials commissioned by the Frankish kings and emperors to supervise the administration of their dominions. Their institution dates from Charles Martel and Pippin the Short, who sent out officials to see their orders executed. When Pippin became king in 754 he sent out missi in a desultory fashion; but Charlemagne made them a regular part of his administration, and a capitulary issued about 802 gives a detailed account of their duties. They were to execute justice, to enforce respect for the royal rights, to control the administration of the courts, to receive the oath of allegiance and to supervise the conduct and work of the clergy. They were to call together the officials of the district and explain to them their duties, and to remind the people of their civil and religious obligations. In short they were the direct representatives of the king or emperor. The inhabitants of the district they administered had to provide for their subsistence, and at times they led the host to battle. In addition special instructions were given to various missi, and many of these have been preserved. The missi were not permanent officials, but were generally selected from among persons at the court, and during the reign of Charlemagne personages of high standing undertook this work. They were sent out in twos, an ecclesiastic and a layman, and were generally complete strangers to the district which they administered.

Even under Charlemagne it was difficult to find men to discharge these duties impartially, and after his death in 814 it became almost impossible. Under Louis I the nobles interfered in the appointment of the missi, who, selected from the district in which their duties lay, were soon found watching their own interests rather than those of the central power. Their duties became merged in the ordinary work of the bishops and counts, and under Charles the Bald they took control of associations for the preservation of the peace. About the end of the 9th century they disappeared from France and Germany and during the 10th century from Italy.

See G. Waitz, *Deutsche Verjassungsgeschichte* (1844); *E.* Dobbert, *Ueber das Wesen und den Geschäftskreis der missi dominici* (1861); *L.* Beauchet, *Histoire de l'organisation judziciaire en France, époque jranque* (1865); V. Krause, *Geschzchte des Institutes der missi domznici* in the *Mitthezlungen der Instituts für österreichische Geschichtsforschung,* vol. xi (1880); E. Bourgeois, *Le Capztulaire de Kiersy-sur-Oue* (1885); *N.* D Fustel de Coulanges, *Histoire des Institutions politiques de l'ancienne France* (1889–90).

MISSILES, a general term for the family of weapons that radically changed warfare after World War II. It includes guided missiles, which may be defined as robot devices that can be directed to a target by commands originating from outside the weapons or by instruments built into them. The term also includes ballistic missiles, but does not include free-flight rockets. The latter are given only an initial direction of fire, are propelled in that direction by a rocket motor, and are then allowed to "coast" in free, unguided flight (see ROCKETS).

A ballistic missile is so called because its trajectory resembles that of a gun-fired projectile. The missile is given an initial controlled period of flight, during which the rocket motor burns, until the desired direction and velocity are reached. This propulsion period usually measured in seconds, may be compared to the time that a conventional artillery shell requires to pass through the gun tube. A period of unpowered flight then follows during which the missile follows essentially the same trajectory that an artillery shell would follow if given the same velocity and direction. This trajectory is shaped like a fraction of an ellipse, except for slight variations caused by the resistance of the atmosphere or by minor flight path corrections. As the speed of the missile increases, the length of its trajectory increases and the fraction of the ellipse described increases until, when the missile goes into orbit around the earth, a complete ellipse is described.

Guided missiles may have any type of trajectory and may operate in space, air or water. But, being weapons, they are by definition always intended for a target. Other forms of remotely controlled craft such as target and reconnaissance drones or space exploration vehicles are not guided missiles because they are not used to attack a target. Thus, the German V-I and V-2 missiles of World War II were guided missiles; their guidance systems were set before launching and could not be changed in midcourse.

The U.S. Honest John rocket, not guided, and the Soviet Sputnik satellite system, not target bound, were not guided missiles.

Guided missiles have been developed primarily because, since the beginning of armed conflict, the warrior has tried to improve his ability to strike deep within an enemy fortress with minimum danger to himself and his assaulting troops. A succession of catapults, rockets and guns led up to the famous German Paris gun of World War I which fired a projectile approximately 80 mi. But gun artillery was not practical at such a long range. (See ARTILLERY.)

Military aircraft soon proved to be a better means of extending the range of gun artillery. But the airplane could be intercepted in flight, for it did not have the high-speed ballistic trajectory of an artillery shell. It flew to the target at a relatively slow speed, normally followed a level course, and had an "air-breathing" engine. To cope with this new form of fire power, military men turned to antiaircraft artillery, interceptor aircraft, and radar detection devices that proved highly effective when properly employed.

Seeking an escape from antiaircraft artillery fire without loss of accuracy, military developers hit upon the idea of keeping the airplane beyond maximum gun range and guiding their bombs after dropping them. The controlled bombs that resulted were the first guided missiles to appear in warfare. They were followed by remotely controlled aircraft and by the German V-I of World War II. Then came a technological breakthrough with the appearance of a ballistic trajectory missile that was rocket-propelled and controlled by self-contained mechanisms. The German army revealed it first with the A-4 rocket, better known outside Germany as the V-2. It traveled at supersonic speed, had a range of 200 miles, and defied all attempts at interception.

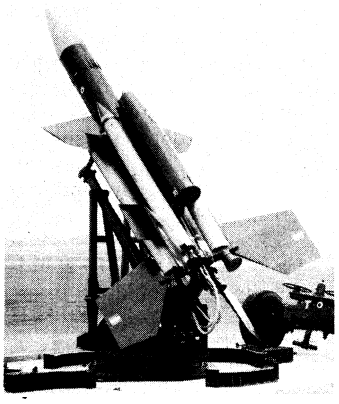
TYPES OF GUIDED MISSILES

A guided missile may be classified by type according to the location of its target and the location of the point from which the missile is fired. For example, a missile fired from the surface of the earth and destined for an aerial target is known as a surface-to-air missile (SAM). Similarly, other missiles are often designated as surface-to-surface (SSM), air-to-surface (ASM), and air-to-air missiles (AAM).

Surface-to-Air. — The surface-to-air missile (SAM) came into being because advances in bomber aircraft, bombing technique, and in surface-to-surface missiles rendered conventional antiaircraft artillery and interceptor aircraft obsolete. The former air defense weapons could not cope with the high altitude, speed and maneuverability of the targets. Even if artillery shells could have reached the high altitudes at which bombers flew, the time of flight of the projectiles was so long that the plane could easily have evaded the predicted impact point. Interceptor aircraft also became inadequate as air defense weapons when bombers and missiles reached supersonic speeds, for the inherent limitations of human pilots and fighter aircraft rendered them ineffective.

The fighter plane had an extremely short time to intercept an enemy bomber and lacked the necessary speed and altitude advantage over the bomber. The human pilot had great difficulty even seeing the target at such speeds. Even when guided to the target by electronic devices, the pilot might have to undergo accelerations to maneuver to the attack that would be beyond human endurance. Against a ballistic missile traveling at 15,000 m.p.h. the piloted interceptor plane was helpless.

It is from these facts that the importance of the SAM stems. The missile moves toward its target with great speed, at long range, and is able to maneuver. As the bomber attempts evasive action, the constantly changing interception point is computed; the missile. altering its course correspondingly, destroys the target. SAMs are propelled either by air-breathing jet engines or by rocket motors. Because it uses atmospheric oxygen, the jet-powered missile (*e.g.*, U.S. navy Talos and the British Bloodhound) does not need to carry an oxidizer to mix with its fuel; thus it can travel farther than a rocket for a given total weight. However. its speed and altitude are inherently limited by its propulsion system. Rocket-propelled SAMs, having neither altitude nor speed limitations, are generally considered preferable as air defense weapons. Against incoming ballistic missiles, very high altitude rocket-propelled bombers, and outer space vehicles, they are a necessity. The U.S. army Nike missiles are examples of rocket-propelled SAMs. The U.S. navy in 1959 launched its first destroyer designed for launching missiles, the U.S.S. "Henry B. Wilson" equipped with Tartar missiles and conventional guns.



BY COURTESY OF THE BRISTOL AEROPLANE CO LTD.

BRITISH BLOODHOUND. A SURFACE-TO-AIR MISSILE

SAMs may be guided by command signals from the ground, bv self-contained radar target seekers and trackers, by "homing" on electronic or heat radiations of the target, by automatically following a radar beam tracking the target, or by a combination of these means.

Surface-to-Surface. — The surface-to-surface missile (SSM) was also developed to overcome the inherent limitations of conventional artillery and of aircraft. The SSM offers improvement in range, lethality and accuracy, and most dramatically in range. Guns cannot be considered as practical mobile weapons at ranges greater than about 20 mi., but there is no limitation to the range of missiles.

The destructive power of SSM warheads can be made much greater than that of artillery shells because they can be made much larger. Missile warheads do not need to be as shock-resistant because they are not subject to the enormous accelerations of artillery shells. The accuracy of a conventional artillery projectile can be improved upon in certain cases by the guidance system of the SSM.

The SSM overcomes several serious limitations of aircraft as well as artillery. As an intercontinental artillery weapon with hypersonic ballistic trajectory, the SSM gives the enemy only minutes of warning, or perhaps no warning at all, and is far more difficult to intercept than an airplane. It is not vulnerable to adverse weather and it does not expose an aircrew to enemy countermeasures. At great range, however, it may not achieve the accuracy of aircraft bombing; nor can it compete with the ability of the human pilot to grasp a changing tactical situation and act according to good judgment.

At shorter ranges on the tactical battlefield SSMs appear as antitank weapons, highly accurate pillbox destroyers, and means of delivering atomic warheads. Smaller missiles may be only 4 ft. long and weigh less than 100 lb.; huge intercontinental ballistic missiles may weigh more than 100 tons. SSMs may be rocket-propelled or atmospheric jet-propelled but the extreme vulnerability of air-breathing systems to air defense missiles makes the use of rocket propulsion almost mandatory.

Air-to-Surface. — As noted above the air-to-surface missile (ASM) was the earliest form of guided missile. Controllable bombs dropped from aircraft were employed in World War I and World War II. The need for ASMs became urgent at the end of World War II because of the advanced state of development of air defense weapons. Any air-breathing vehicle, regardless of speed, is highly vulnerable to rocket-powered SAMs, but the use of ASMs of sufficient range enables launching aircraft to remain out of reach of an air defense system and attack a surface target with minimum risk.

ASMs may be divided into three basic types: controlled bombs, glide bombs and powered missiles. The first controlled bomb is one whose flight path can be varied by small amounts to improve accuracy. Control can be accomplished either by remotely steering the bomb into the target or by using a homing device which permits the missile to sense the target and head for it automatically. Controlled bombs are more accurate than uncontrolled bombs but they do not permit the launching aircraft to remain at a safe distance from the target. The second type of ASM, the glide bomb, permits the aircraft to bomb from a greater range. By the use of wings on the missile to produce aerodynamic lift a longer glide path can be used. Unpowered ASMs are obsolescent because they force the launching aircraft to operate within the effective range of air defense missiles. But powered ASMs can fly almost any desired distance after being launched. The major limitations to such weapons are the size of the aircraft required to carry large long-range ASMs and the potential inaccuracy of the system. The classic World War II example of the powered ASM was the air-launched version of the V-I. However, its own lack of accuracy was compounded by the difficulty of accurately locating the point of launch, an inherent problem in any XSM system.

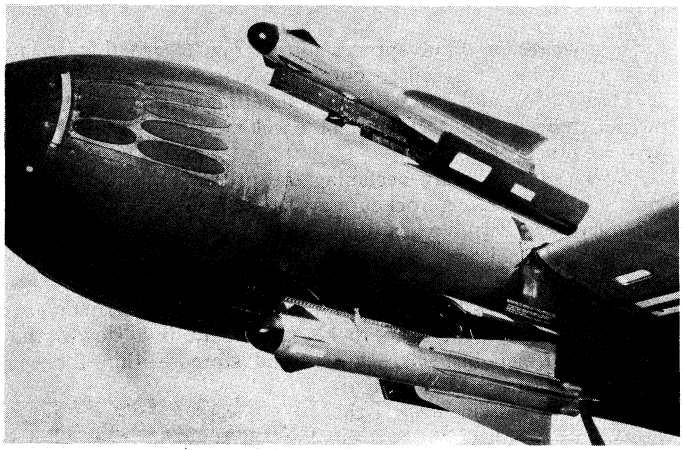
ASMs are most effective against targets easily distinguished from their backgrounds. Automatic target-seeking devices, which overcome in part the inaccuracy problem, may then be used.

Air-to-Air. — The air-to-air missile (AAM) was developed because aerial combat with conventional guns became almost impossible when planes exceeded the speed of sound. A fighter pilot on a head-on interception course with a bomber may not even see the target, much less fire on it, because he may be within visual range no more than one or t o seconds. A right angle approach is equally difficult because the target is in the line of fire only an instant. The only approach that can be effective is from the rear, but during such an approach the fighter is most vulnerable.

When employing the AAM the pilot does not have to close with the target or even aim accurately at it. If the missile has an automatic target-seeking guidance system the pilot needs only to make sure, by instruments, that the missile "sees" the target and is within range. The dramatic employment of the U.S. navy's Sidewinder missile by the Nationalist Chinese air force in 1958 against Chinese communist aircraft demonstrated the effectiveness of the AAM.

IMPACT OF GUIDED MISSILES ON WARFARE

The impact of guided missiles on warfare has been revolutionary. It may be argued that all changes in methods of warfare are evolutionary rather than revolutionary. However, if the rate of



BY COURTESY OF U.S. AIR FORCE

U S. AIR FORCE FALCONS. AIR-TO-AIR MISSILES RETRACTABLE INTO FUSELAGE OF AIRPLANE

change in warfare during the period of development of guided missiles and atomic fire power is compared to the rate of change in any previous period in military history, one must concede that revolution is a better term. Only aj years (1933–1958) elapsed from the beginning of serious military effort until operational missiles in every area of combat were effective and had altered the forms of war.

Missiles have made obsolete many of the classic symbols of air, naval and land warfare. Even the terms air, naval and land warfare are obsolete. for these forms are inseparable in modern war. When the threat of employment of missiles with atomic warheads hangs over the area of combat. the massed troop formations of World War II and the great assemblages of opposing planes and ships become as obsolete as the horse cavalry charge.

Modern warfare with guided missiles may be divided into three broad forms: operations for control of land areas, operations for control of sea areas, and strategic missile attack and defense. These forms of warfare cannot be separated clearly and each contains elements of the old forms of air, land and naval warfare. A fourth term is probable in time—military operations in outer space.

Tactical operations for controlling land areas have been radically affected by guided missiles. In the offensive role missiles have replaced and greatly extended the fire of most heavy artillery and have generally increased the power of the attack. Missiles with atomic warheads can destroy any defensive stronghold. Defensively, guided missiles have virtually eliminated the threat of enemy aircraft. The air space over any given area can be dominated by the force that holds the area. Guided missiles have gradually taken over many of the combat missions of manned aircraft. Missiles have forced armies to increase their mobility to avoid destruction; dispersion and mobility have become all-important. The airplane has become more important as a means of transport than as a weapon.

Small, agile, "ground-hugging" aircraft have appeared in increasing numbers in modern armies.

Land control warfare may be directly affected by strategic missile warfare. To protect its forces against strategic missiles, an army may employ anti-missile missile systems. It is probable that combat and supporting forces of the future will be constantly shifting to avoid presenting a fixed concentrated target, for to be fixed is to invite destruction by enemy missile artillery. Logistic instailations will be dispersed, temporary and as far back from the tactical battle as possible. The use of major ports and established lines of communications may be avoided because of the missile threat. Greater dependence upon undersea craft for supply and storage is visualized for areas near the oceans

The probable nature of operations for control of sea areas became a subject of controversy after World War II. The classic role of naval forces—control of sea communications—remained as critical as it ever was, but there were differences of opinion as to how this role was to be performed. Because of the advent of the automatic target-seeking, air-to-ship guided missile, the aircraft carrier and other surface combat vessels were thought by some to be obsolete.

On the other hand, the ability of naval vessels to protect themselves with SAM defenses grew steadily. The capabilities of undersea craft made spectacular advances. Many observers felt that in the future the task of keeping sea lanes open would consist primarily of antisubmarine and antiaircraft operations with guided missiles as the primary weapons.

In strategic missile warfare, huge intercontinental ballistic missiles (ICBM) and smaller intermediate range ballistic missiles (IRBM), both land based and ship based, play the major role. The ship based IRBM is particularly important. As a component of strategic missile operations the submarine-launched missile is difficult to intercept in flight and the mobile launcher is equally difficult to locate. A sea-based 1,700 nautical mile missile such as the U.S. navy's Polaris can reach any potential target on the surface of the earth. At the middle of the 20th century the commonly visualized war situation was something like this: one of two great hostile powers on separate continents would initiate a sudden overwhelming atomic attack on the other followed by retaliation in kind by the nation attacked. In the event of such a catastrophe, it was considered probable that both nations would undergo crippling losses that would far outweigh any possible gain. The ability of a nation to survive such an attack and continue with military operations would depend upon many factors: the quality of the attack, dispersion and protection of its population, the mobility of its military forces, its defensive weapons, and its will to continue the conflict. The chief targets of a strategic missile attack would be missile launching sites, other military forces, industrial centres, political and military centres. Elimination of the enemy's means to retaliate would have a high priority.

The ability of defensive missile systems to detect and stop a strategic missile attack would play a great part in determining the attacker's decision to attack at all. An effective anti-missile missile system would represent an advanced stage in missile sophistication. Such a system would detect the enemy attack within seconds after the launching, if possible, in order to give maximum time for countermeasures. The incoming missiles might be fired on the short great circle arcs directly toward distant targets or on long great circle arcs around the earth in orbital trajectories.

The possibility of orbital trajectories for intercontinental missiles raised the broader possibility of warfare in space itself. Military planners assumed that outer space would be used to support combat operations within the atmosphere. Huge rocket boosters similar to those used for guided missiles, but much larger, were expected to place satellites into orbits around the earth for several purposes. They could be used for communications relay, reconnaissance, mapping, weather forecasting, and other purposes.

In time, satellites and other space vehicles might become serious military threats which would have to be neutralized. Space vehicles, manned or unmanned, might attack targets on earth with guided missiles; space defense might become a necessity; and missile warfare in space between hostile space vehicles might result. An extension of this concept led some students of the problem to consider the moon as an area of military operations, reached by manned missiles and dominated by the force superior in missile technology.

MISSILE PROPULSION

As noted above, missiles may be powered either by jet engines or rocket motors. Both are forms of jet propulsion, the jet engine being ducted (air-breathing) and the rocket being non-ducted. These power plants give missiles tremendous speeds, which is the primary reason for their use. But they have other advantages, too. They can produce enormous amounts of power in a short time; jet engines have high altitude ceilings and rockets have no ceiling at

all; and both types are relatively simple.

A missile is jet-propelled by the same force that causes a toy balloon to fly about when it is inflated and then released. The thrust of the air escaping from the mouth of the balloon causes a reaction in the opposite direction and the balloon is propelled. Similarly, the thrust of a missile engine creates a force in the opposite direction equal to the magnitude of the thrust. Thrust is measured in pounds of force in English-speaking countries and in kilograms of force in most other nations. The exhaust gases do not "push" against the air to obtain thrust. A rocket can operate with a complete absence of air. The thrust of modern missiles varies from a few hundred pounds for the smaller missiles to hundreds of thousands of pounds for intercontinental ballistic missiles.

The thrust of space vehicle boosters, an outgrowth of large missile systems, is measured in millions of pounds.

Of the several forms of ducted jet engines the ramjet is most common. It is capable of supersonic speeds and yet it is potentially a simple and inexpensive engine. In all forms of ducted jet engines compression must be accomplished before combustion, usually by a power-consuming compressor. In the case of the ramjet, however, the "ramming" action of the air in the intake duct is sufficient to provide the needed compression. A combination of high speed and proper air intake duct design is necessary. Air is rammed into the duct around a cone-shaped diffuser, slows down and increases in pressure. Moving into the jet engine the air slows down still more in the ever-expanding cross section until it enters the combustion chamber and mixes with the injected fuel. The mixture is then ignited and the combustion gases are exhausted with greatly increased momentum compared to their momentum on entry into the ducts. The resultant thrust is sufficient to send ramjet missiles up to 70,000 ft. or more at supersonic speeds.

Data on Typical Missiles

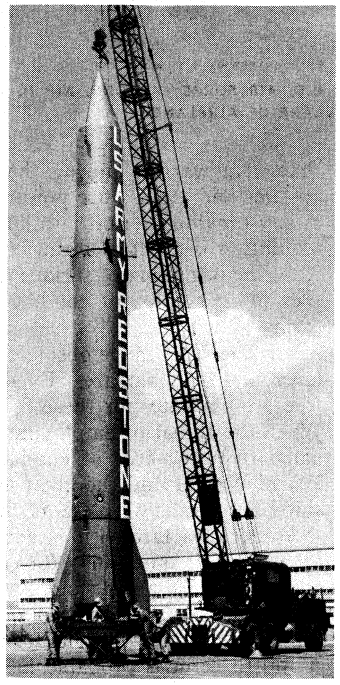
Name	Propulsion	Range (in mi.)	Guidance	Warhead	Approx. gross wt. (in lb.)
SAM					
Bomarc (U.S.)	ramjet	400	command homing	conventional or nuclear	15,000
Hawk (U.S.)	solid rocket	22	radar homing	conventional	1,200
Bloodhound (Brit.)	ramjets, solid rocket booster	--	semiactive homing	—	2,000
Nike-Hercules (U.S.; successor to Nike-Ajax)	solid rocket	75	command	conventional or nuclear	10,000
Talos (U.S.; shipbased)	ramjet, solid rocket booster	65	beam rider	conventional or nuclear	7,000
SSM					
Atlas (U.S.)	liquid rocket	6,300	inertial	nuclear	260,000
Blue Streak (Brit.)	liquid rocket	2,800	inertial	nuclear	175,000
Polaris (U.S.; submarine launched)	solid rocket	1,500	inertial	nuclear	28,000
Sergeant (U.S.; successor to Corporal)	solid rocket	75+	inertial	nuclear	20,000
Jupiter (U.S.)	liquid rocket	1,500	inertial	nuclear	110,000
Redstone (U.S.)	liquid rocket	200	inertial	nuclear	61,000
T-3 (U.S.S.R.)	liquid rocket	5,000	radio inertial	nuclear	175,000
Thor (U.S.)	liquid rocket	1,500	inertial	nuclear	110,000
AAM					
Falcon (U.S.)	solid rocket	5	radar and infrared homing	conventional	100
Sidewinder (U.S.)	solid rocket	6–7	infrared homing	conventional	155
Firestreak (Brit.; successor to Fireflash)	solid rocket	8	infrared homing	—	—
ASM					
Bullpup (U.S.)	solid rocket	5	radio command	conventional	570
Hound Dog (U.S.)	turbojet	500	inertial	nuclear	—

The combustion products have no tendency to exhaust forward out the open duct because the high pressure region in the diffuser section offers much higher resistance to motion in that direction than does the open exhaust nozzle. The inertia of the rearward-moving gases also tends to make them continue in that direction. There must be some means to sustain the flame in the combustion chamber. The air is moving so fast it would blow out any flame placed in it unless some device such as a perforated metal plate or grate provided small local regions where air velocity is low.

The two major disadvantages of the ramjet are that it must have atmospheric oxygen to operate, and is therefore limited to the atmosphere; and it must be moving at high speed to get proper ramming effect. Thus, it must be accelerated to operating speed by some other means.

The rocket is rapidly becoming the primary means of guided missile propulsion. A rocket may be described as a jet engine that carries its own oxygen along instead of depending upon the atmosphere. This makes the rocket completely independent of the medium in which it operates.

Rockets are classified, according to the type of propellant used, as solid or liquid. A solid rocket propellant is a slow-burning explosive formed into large grains and stored within the combustion chamber. Upon ignition, the exposed surfaces of the grains burn until all the propellant is consumed. The outstanding advantage of the solid propellant motor is its simplicity. Solid rockets have some performance disadvantages. but the advantage of simplicity is so overriding that great efforts are made to adopt solid fuels in all missile systems. *(See* PROPELLASTS.)



BY COURTESY OF U.S. ARMY

U.S. ARMY REDSTONE, A SURFACE-TO-SURFACE MISSILE

Rocket motors using liquid propellants such as kerosene, alcohol and aniline are particularly desirable when high efficiency, long burning time and high thrust are required. They also permit control of the missile by shutting off the flow of fuel at any moment. The German V-2 was a liquid fuel rocket and most of the long-range missiles that came into operational use during the 1950s were of this type. The U.S. army's Jupiter missile, a modified form of which hurled the free world's first earth satellite into orbit in 1958 was also a liquid fuel rocket, burning kerosene and liquid oxygen.

Most military observers believe that in time virtually all propulsion systems for guided missiles will be solid fuel rockets. Liquid fuel missiles are extremely complicated and require a long time for fuelling, while solid fuel rockets may be kept in a state of instant readiness. Liquid propellants must be injected into the combustion chamber from storage tanks within the missile, along with an oxidizer such as liquid oxygen or nitric acid, a process that requires many pipes, valves, pumps and regulators. Atmospheric jets do not have sufficient velocity or altitude for missile requirements.

Neither atmospheric jets nor liquid fuel rockets are suitable for rugged field use. Solid fuel missiles are preferred for installation on shipboard where the storage and handling of liquid fuels poses serious problems.

MISSILE GUIDANCE

Missiles must be controlled in two basic ways: trajectory control and attitude control. In simplest terms, trajectory control means making the missile follow the desired path to the target. Attitude control means keeping the missile pointing in the right direction without pitching or rolling. If the missile's attitude is not controlled, signals directing it to turn or dive result in the wrong maneuver.

Trajectory control can be accomplished by having the missile react to some natural phenomena about it, to self-contained internal controls, or by the use of electromagnetic control. In order to send a missile to its target, natural phenomena such as the earth's

magnetic field, variations in pressure with altitude, appearance of the earth's surface or location of the stars can be used. The guidance system can be designed to detect such phenomena, compute changes in course desired and steer the missile accordingly. The German V-I missile of World War II depended upon natural phenomena for trajectory control. It maintained a constant course by the use of a compass and a constant altitude by means of an altimeter. The distance was measured by means of a small impeller turning in the windstream. The impeller was calibrated so that a certain number of rotations represented a unit of distance. If all went according to plan, the V-I dropped on its target after traveling the proper distance in the right direction.

The most common self-contained internal controls are preset and inertial. Preset guidance permits a course to be set into the missile before firing; once the missile is fired it must follow the prescribed course.

The German V-2 rocket of World War II had a preset guidance system. It rose vertically for a few seconds and then turned into a specified angle of climb until the rocket motor automatically shut off. It had no ability to correct for unexpected conditions in flight.

Inertial guidance is a much more advanced version of preset guidance. The course to be followed is set before firing; by the use of accelerometers, the inertial system detects deviations from the desired trajectory, computes the corrections necessary to return to the desired trajectory and causes the missile to correct itself. Such self-contained controls have the advantage of being immune to enemy countermeasures.

The electromagnetic systems most commonly used are known as command control, radio navigation, beam rider and target seeking. Command control, as the name implies, permits a human or mechanical operator remote from the missile to command it. The command signals may be sent to the missile by radio or by trailing wires in the case of very short range missiles.

Radio navigation is another system that can be used for longer range missiles. By constantly locating itself with respect to radio stations of known location the missile can steer itself to the desired target. The beam rider is a system that follows a radar beam. It knows only to stay within the beam and will go wherever the beam is pointed.

The most "intelligent" guidance system of all is the target seeker, because it is the only system that actually perceives the target and automatically goes toward it. This is an electromagnetic form of guidance because the missile seeker detects some form of electromagnetic radiation such as infrared or radio propagation. The target may be "illuminated" by radar so that the missile may see it. Such guidance systems may be used in combination for controlling the missile during different portions of its flight.

MISSILE WARHEADS

Guided missiles may have any type of warhead that a bomb or artillery shell may have. Depending upon its application, the warhead may be atomic or conventional high explosive; or it may be some special purpose type for a particular target. A missile can carry a large aircraft bomb and deliver it with the speed of an artillery shell, thus combining the best features of both aircraft and artillery. The use of such a relatively expensive delivery system is considered justifiable considering the capability of the warhead.

Conventional high explosive warheads are used with short range missiles when the purpose is to destroy a heavily armoured or protected target such as a tank or pillbox.

HISTORICAL BACKGROUND

The use of air weapons in World War I aroused an interest in remote control aircraft. Germany produced a bomb that could be controlled by electrical signals sent through trailing wires which connected the bomb with the controller in an airship. In 1916 the United States army and navy began a joint study of pilotless aircraft. Improved means of propulsion were being sought as well. In the United States and in Germany rocket enthusiasts began to experiment with controlled rockets. Robert H. Goddard, U.S. scientist, developed theories of rocket propulsion and conducted tests as early as 1915. He developed the first automatic gyroscopic missile stabilization and jet vane control; he also fired the first supersonic rocket.

In Europe, Hermann Oberth, a German professor primarily interested in space travel, developed similar theories. Oberth's work aroused considerable enthusiasm for rockets and space travel in Europe.

A spaceship travel club was formed in Germany in 1927. The German army soon recognized the military potential of guided missiles and in 1933 began construction of a guided missile research centre at Peenemunde on the Baltic sea. This was the first serious military effort to develop military missiles and may be considered the beginning of practical weapons development.

Some work was done on remote controlled weapons in the United States before World War II, but it was not until 1940 that a guided missile program was seriously considered. The German advantage of six years of development effort before 1939 resulted in that country's being able to employ missiles extensively during World War 11.

Two approaches to long-range offensive missiles were explored in Germany, the pilotless aircraft concept and the guided artillery projectile concept. The FZG-26, or V-I buzz bomb was the aircraft approach. It was a preset control monoplane powered by a crude but inexpensive jet motor. Carrying a one-ton warhead, it flew a low-level, powered flight path at about 400 m.p.h. for a maximum range of about 160 mi. The weapon was doomed to failure, however, because of its fixed launching sites, which were bombed repeatedly, and its vulnerability to destruction in flight by air defense weapons. Less than half of the V-1 missiles launched arrived at target areas and at times interception rate exceeded 90%.

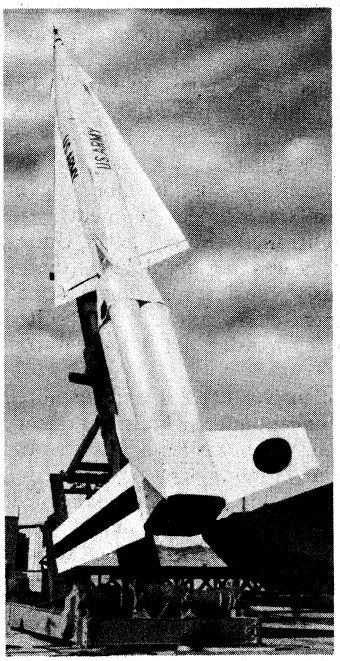
The artillery approach was the A-4 rocket, more commonly known as the V-2. It, too, delivered a one-ton warhead but in the supersonic trajectory of an artillery shell. An important feature of the V-2 system was its mobility, but Hitler did not want to use it. Overriding the German army concept of mobility, Hitler insisted on building elaborate concrete launching sites for the V-2. The British soon located the permanent V-2 fortresses and bombed them until useless. At last the Germany artillerymen won their point, and the firing units became mobile. Thereafter the Allies were never able to counter the weapon. Interception of the huge projectile in flight was impossible and the frequently changed launching sites were never found. Despite Allied superiority in the air, more than 4,000 V-2 missiles were fired before ground troops finally overran Germany. Here are perhaps the two greatest lessons learned about long-range missile warfare in World War II: (1) the superiority of the rocket concept over the pilotless aircraft concept; and (2) the superiority of mobile launching sites over fixed emplacements. Modern technological developments have further emphasized the validity of these lessons.

After World War II, guided missile research and development was accelerated by many nations. Technological "breakthroughs" in atomic rnarheads, electronics, and rocket propulsion, and a growing hostility between the Lnited States and the Soviet Union all contributed to a race for missile superiority. Great Britain, France, Sneden and Switzerland also developed some guided missiles, mostly of short-range defensive type.

Both air defense missiles to counter the jet bomber threat and offensive missiles received emphasis. Beginning with the first intercept of an aircraft by a missile (U.S. army Nike-Ajax, 1951) the capability of air defense weapons increased until by 1958 a L.S army, Nike-Hercules had demonstrated that any missile or craft limited to the atmosphere could be successfully countered. The Nike-Hercules destroyed a target more than 70,000 ft. high, traveling at more than three times the speed of sound. Similar successes were scored against lorn-flying aircraft. These developments, coupled with the advent of ballistic missiles for virtually every type of surface target previously attacked by aircraft, foreshadoned the end of air warfare in the minds of many military authorities.

Replacing fighter aircraft in the air defense role were such

weapons as the U.S. Nike and Bomarc, the British Bloodhound, and the Soviet T-6. Except for ground-hugging aircraft (that followed the terrain like ground vehicles) tactical support aircraft were being replaced by many surface-to-surface missiles of short and medium range. Replacing the bomber aircraft were such intermediate range missiles as the U.S. Jupiter, Polaris and Thor, the British Blue Streak, and 5,000-mi. missiles such as the U.S. Atlas and the Soviet T-3.



BY COURTESY OF U.S. ARMY

U.S. ARMY NIKE-HERCULES, A SURFACE-TO-AIR MISSILE

The postwar policy of the Soviet Union to release little or no information on its guided missile program was no indication that progress was not being made. On the contrary, by 1960 it was evident that artillery units of the Soviet army mere armed with intercontinental missiles. In 1957 Russia placed the first earth satellite into orbit and in 1958 successfully achieved sufficient velocity with a missile to escape the gravitational attraction of the earth entirely.

A by-product of guided missile development, space exploration, gradually became a separate technical and experimental field of its own, distinct from guided missiles.

The first space vehicles, boosted into earth orbit or to escape velocity by modified SSMs, weighed from 30 to 185 lb., but by the early 1960s huge rocket boosters such as the 1,500,000-lb. thrust Saturn (capable of orbiting 50,000 lb.) were under development. (See SPACE EXPLORATION.)

Thus in the short period of about 25 years, from 1933 when the German army began guided missile research until 1958 when the U.S. Atlas demonstrated intercontinental range, guided missiles revolutionized the art of warfare.

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MISSIONARY RIDGE: see CHATTANOOGA.

MISSIONS is the term used to denote organized efforts for the propagation of a religion. The agents of propagation have been known as missionaries. Though this article deals with the history of Christian missions, Buddhism and Islam are also missionary religions. Some schools of Hinduism began missionary activities in modern times.

Zoroastrianism and to some extent Judaism were missionary religions in ancient times.

Christian missions in the modern period have been divided into "foreign" and "home" categories. Foreign missions indicates evangelistic efforts directed to regions and peoples beyond the boundaries of the nation in which the sending agency is located, but does not normally include pastoral ministry to emigrants from that country. Home, domestic or inner missions indicates church extension and ministry to special groups within the national boundaries.

Younger churches have arisen in almost all countries of Asia, Africa, Latin America and Oceania as a result of former missionary endeavours and they also are beginning to undertake evangelism abroad. Western churches have at the same time come to recognize that their own secularized countries are now properly mission fields. Consequently the term foreign missions is becoming obsolete and is being replaced by world mission. Missions is increasingly being used to denote the agencies of propagation and the academic study of the subject, also known as missiology.

The traditional organization of the history of missions has undergone considerable change, largely as a result of the studies of Kenneth Scott Latourette. Edward Caldwell Moore demonstrated that expansion had not been continuous but rather characterized by periodicity. Eras of expansion were followed by periods of arrest.

Latourette interpreted this periodicity as a pattern of advance and recession in an ascending spiral. Each major wave of expansion has been followed by one of recession. However, each new wave of advance has set a new high mark, has lasted longer and has ascended more rapidly, while each succeeding recession has been briefer in its duration and less severe in its losses. The seeds of each new advance have been planted in the preceding time of retreat. This pattern eventually works out in the future in an almost steadily ascending line of advance. The periods as defined by Latourette were: (1) the first great advance, to about A.D. 500; (2) the first great recession, from 500 to about 950; (3) the second advance, roughly from 950 to 1350; (4) the second major recession, from about 1350 to 1500; (5) the third advance, from 1500 to 1750; (6) the third recession, from about 1750 to 1815; and (7) the "Great Century" of expansion, from about 1815 to 1914. The contemporary period is too close at hand to estimate accurately, but the definite advent of a new period in missionary theory and practice after World War II would indicate that the intervening years are best treated with the preceding century. Even those who on historical or theological grounds cannot accept Latourette's theory about a definite pattern of expansion and his prophecy of the future nevertheless find his periods, or a modification of them, useful for the organization of the history of missions.

EARLY HISTORY

First Advance to A.D. 500.—The Christian world mission arises out of the life and ministry of Jesus Christ, but it has antecedents in universalistic prophetic Judaism, which combined ethical monotheism with the vision of a world community of men, equal as individual creatures before their Creator and sovereign God. Ultimately the origin of the mission is found in the idea of God acting in history for the salvation of mankind. Prophetic universalism culminated in the conviction of the early church that God was in Christ reconciling the world unto Himself. The Gospel, being both the message of Jesus and the message of the early Christians about Jesus, was directed to all men and was free from any national and racial limitation. The heart of this Gospel is the affirmation that Jesus Christ is Saviour and Lord. The church appropriated to itself the Hebrew prophets' concept of the true Israel as a faithful remnant saved to save the world. An evangelistic obligation was recognized as being inherent in discipleship.

From the beginning until modern times, although there have been many subordinate motives from time to time, the chief motivation of the mission has been the church's obedience to the Great Commission given by the risen Lord: "Go therefore and make disciples of all nations, baptizing them in the name of the Father and of the Son and of the Holy Spirit, teaching them to observe all that I have commanded you; and lo, I am with you always, to the close of the age." This obedient witnessing by the church then becomes the agency through which the Holy Spirit convinces men that Jesus Christ is Lord and Saviour.

The Christian faith first expanded through the communities of the Jewish dispersion. After a brief struggle with a Judaizing element within the church, the universal character of the Christian faith and practice was acknowledged and freed from the requirements of Hebrew law and ceremonial. The church spontaneously embarked on its task of winning the nations, a total commitment reflected in the tradition that the 12 apostles each took responsibility for a definite geographic area. There was an officially commissioned roving missionary ministry, of which Paul and Barnabas are examples. However, extensive evangelism was done by ordi-

nary laymen in day-to-day contacts and especially as they traveled. Paul, the greatest and the prototype of all missionaries, evangelized much of Asia Minor and the chief Greek cities and was active in Rome, despite his status as a prisoner. The new religion spread rapidly along the trade routes into all the great centres of population. By the 2nd century the roving missionaries appear to have ceased to exist, and evangelistic responsibility came to rest upon the bishops.

Christianity had spread to all parts of the Roman empire by the time of Constantine, aided by the prevailing peace, easy communication, the use of Greek as a universal medium of communication, a growing identification of the faith with Hellenism, and the widespread spiritual hunger of the time. Estimates of its numerical strength vary from one-twentieth to one-half of the population. It was strongest in Asia Minor and weakest in the northern and eastern European provinces, Palestine, Phoenicia and Arabia. Persecution by the state aided Christianity's expansion, because "the blood of the martyrs became the seed of the Church." The first totally Christian states arose east of the Roman empire. The city-state of Edessa was first, and became the base for further eastward and northern expansion. Armenia at the end of the 3rd century became the first large country to undergo mass conversion at the command of its king. Gregory the Illuminator was the apostle to this nation. East of the Roman empire, however. the growing alliance of Christianity with Rome and with Hellenistic culture hindered the spread of the faith just as much as it favoured it within the empire.

Mass movements within the Roman empire became increasingly to prevail after Constantine granted toleration and his successors gradually adopted Christianity as the state religion, suppressed paganism with increasing severity and sought religious uniformity. Although paganism lingered long, by A.D. 500 the population of the Roman empire was almost solidly Christian. During this period the real missionary endeavour had moved to the borders of the empire and beyond them. The Germanic tribes were mostly converted before they invaded the empire, and this lessened the destruction and brutality which accompanied the invasions. The outstanding missionaries of the period were: Ulfilas, who evangelized the Goths; Martin of Tours, the great missionary of central Gaul; and Patrick, the apostle to Ireland. Outside the empire permanent Christian communities were established in Ethiopia by Frumentius of Tyre and in India, where the Syrian Christians of Malabar still claim the Apostle Thomas as their founder and where the church had certainly been established by the 3rd century. Nestorian episcopal sees were established as far into central Asia as Merv and Herat in the jth century.

Losses and Gains to A.D. 950.—Losses.—The church had won the Roman empire, but the disintegration of that empire with which it had become identified threatened the existence of Christianity. Such losses as resulted from the invasions of the Germanic peoples and others out of eastern Europe and central Asia were only temporary, but the Arab invasion of the 7th and 8th centuries established Islam as the dominant religion in about half the area where Christianity had previously claimed all or a majority of the population. The older faith was completely eliminated in north Africa and Arabia and in the territories from Egypt eastward it was slowly strangled. There the churches remained as minority enclaves usually associated with a particular nationality, always under pressure and slowly dwindling.

Celtic Missionaries.—Many of the Germanic tribes which invaded western and central Europe held to the Arian form of Christianity and Catholic Christianity was faced with the twofold task of healing the breach of heretical schism and of converting the pagans. The conversion of the pagan Franks to Catholic Christianity, symbolized by the baptism of their king Clovis in 496, marks the turning point toward success in both efforts. While losses were occurring in the Mediterranean area, there was steady advance into northern and central Europe. The missionaries in the initial advance, however, did not come from the older centres of the faith, but from its remote northern outpost. They were the Celts, first from Ireland and then from Scotland. These Celts were monks, as all the chief agents of missionary expansion were now to be until the rise of Protestant missions. Their motive seems to have been as much ascetic discipline and renunciation as evangelism, for the self-imposed exile from the beloved homeland plays a part in their actions. A leader who had taken such a vow would frequently associate nith him a band of 12 companions in imitation of Christ and the Twelve. Columba (b. 521) established Iona as a centre for the conversion of Scotland, and then brother Celts of that land were recruited for the mission. They went from Ireland and Scotland into England. the Orkneys and Faroes, the Frankish kingdoms, the Low Countries, the Alpine region, the Danubian lands, and even into Italy. The greatest names after Columba are Columban (b. 543), who after heroic labours in the Vosges and the Burgundian kingdom, established the monastery of Bobbio in northern Italy and died there in 61j; his companion, Gall or Caillech; Aidan, the first bishop of Lindisfarne; and Cuthbert, who evangelized Northumbria from Lindisfarne.

The southward penetratign made by the Celtic missionaries brought them into conflict with the growing hegemony of Rome over the western church, because they did not acknowledge Roman claims to special authority, their spontaneity and individualism clashed with the Roman sense of order, they followed a different calendar than Rome, and their rite was also considerably different. Just as Celtic leadership in the mission came to an end, it was taken up by the Englishmen whom they had brought to Christianity.

English *Missionaries.*—It was in England that Celtic and Roman claims were resolved in favour of the latter and the two streams merged in a new missionary force. Pope Gregory I sent a mission under Augustine to England in 596, the first instance of such papal initiative. Canterbury, the capital of Kent, was the base of the mission. Theodore of Tarsus completed Augustine's work, and then largely through the efforts of Wilfrid royal support uas won for Roman control and customs. The English missionaries to Europe. therefore, extended Roman hegemony in the areas where they laboured. Wilfrid, Willibrord, and the great apostle to the Germans, Winfred, renamed Boniface, firmly planted the faith in the Low Countries, East Frisia, Saxony and Bavaria.

Boniface, who began his missionary career in 716, received a papal commission to the Germans east of the Rhine in 719. He converted the pagans. established ecclesiastical order, fostered civilization and established Benedictine monasteries as bases for evangelism and Christian nurture. He was martyred by pagan Frisians in 754. The base of the English mission was sadly weakened by Viking raids and invasions, but Frankish missionaries joined in the work of their teachers. Anskar (Ansgar or Ansgarius) (801–865) is an example. Visions had called him to a missionary apostolate from the time of his youth. Established as bishop of Hamburg, he initiated a mission to all the Scandinavian peoples.

After the death of Boniface a reaction in Sweden and Denmark wiped out most of the gains. Under Charlemagne the coercive poner of the state had been used to complete the conversion of the Saxons.

Byzantine and *Nestorian Missionaries.*—Agents of the Greek church in Constantinople pressed northward into the Balkans. The Bulgars were won by the 9th century. The brothers Cyril and Methodius were sent to Moravia by the patriarch at the request of the ruler, Rastislav, about 863. Their methods and their translation of the Bible and the liturgy into Slavonic were not only successful in Moravia but assisted in the conversion of other eastern Slavs. The western Slavs aere simultaneously being evangelized by Roman Catholic agents, and Saxon military pressure favoured their work among the Czechs. Methodius allied with the Latin church. A mission to the Russians was begun about the 9th century. Farther east the Jacobites and especially the Nestorians mere active. The Islamic conquest of Persia inflicted a setback of great severity. but the Nestorian penetration of central Asia continued. The Turks were given a patriarch in the latter part of the 8th century, and churches were established in Sinkiang. Alopen introduced the faith in the capital of China, Ch'ang-an,

in 635.

The mission flourished under imperial favour, and a patriarchate for China was established early in the 8th century. However, the church was crippled by persecution under the emperor Wu Tsung in 845 and thereafter speedily disappeared, although Christianity lingered on west of the frontiers of China.

Later Middle *Ages.--Advance* in Europe *and* Asia.—The flowering of medieval European culture was accompanied by four centuries of missionary expansion, and during this period the conversion of Europe mas completed, the Russians were won, missions to Islamic areas were begun, and the faith was taken once more to China. The most spectacular advance of Christendom against Islam was in the reconquest of the Iberian peninsula and Mediterranean islands and in the crusades. These military ventures were not the products of missionary motivation, however, and they erected a permanent barrier of bitterness between Islamdom and Christendom.

Contrasted with the militant crusades are the methods of loving persuasion attempted by Francis of Assisi and Raimon Lull (martyred in 1315 or 1316). Both the Franciscan and Dominican orders created special missionary organs, and sent their friars throughout the Islamic world. They endeavoured to win the ancient churches of the orient to obedience to Rome in the hope of making them potent missionary agencies to Moslems.

The conversion of the Scandinavian peoples begun by Anskar went forward under the active direction of the Viking kings. Canute left Denmark thoroughly Christianized when he-died in 1035. Haakon, Olaf Tryggvason and Olaf Haraldson during the second half of the 11th and first half of the 11th centuries completed the Christian conquest of Norway, the islands to the north. Iceland and under the second the faith reached Greenland. Olof Skottkonung and his sons at the same time used less force and were just as successful in Sweden. The conversion of the remaining peoples of eastern Europe took place during the 10th and 11th centuries. The Magyars were converted fully by the end of Stephen I's reign in 1038, and the Poles had been won at the same time. Unfortunately much coercion by the state then entered the picture. The Saxons and Poles imposed Christianity on the Wends in the course of conquest, and the Knights of the Sword or Fratres *Militiae* Christi followed the same pattern in East Prussia and the Baltic states.

The Russian ruler Vladimir was converted to Orthodox Christianity in c. 987, and the progress of national conversion went steadily forward. the church contributing powerfully to the formation of Russian culture. The Mongol invasion of the 13th century temporarily weakened the church in some areas but speeded up its efforts to convert the northern regions of the country beyond Mongol control. Stephen of Prem (1330–1390) was an outstanding figure in this northward movement and was a missionary to the Finns.

The Mongol invasion devastated the Christian communities of central Asia, but once the Mongols settled down to rule their conquests the prevailing peace favoured missionary endeavour. Nestorian, Franciscan and Dominican missionaries penetrated the Mongol territories, and the first two reached China. The court favoured both the numerous Nestorian agents and the Franciscan mission under Giovanni di Monte Corvino, who arrived in the capital in 1294. However, both forms of Christianity were too closely identified in the popular view with the Mongol rule and were swept away in the Ming restoration. The rise of the Seljuk Turks, newly converted to Islam, and the disintegration of the Mongol power in the region turned the tide against Christianity in central Asia.

Losses From *1350* to 1500.—The setback in China and central Asia was the beginning of a serious recession. The Ottoman Turks came to the fore as the dynamic force in Islam, replaced the Arab state with a new empire, destroyed the Byzantine empire, captured Constantinople in 1453, conquered the Balkans, and were turned back only at the gates of Vienna.

Although the Christian churches in the Balkans were not destroyed, Islam became the state religion there and large Islamic elements were introduced into the population. Elsewhere under Turkish rule the old Eastern churches declined still further. The Black Death carried off hundreds of missionaries who were not replaced. There was little concern about evangelism for more than a hundred years.

Roman Catholic Advance, 1500–1750.—In this period Christianity first became a world religion. The voyages of discovery resulted in a new world view and expanded the horizons of Europeans. Three new Roman Catholic empires arose and their courts were burdened with a sense of obligation for the evangelism of their subjects—Spain, Portugal and France. The pope divided the dominion of the newly discovered territories between the monarchs of Spain and Portugal and imposed upon them responsibility for sending and maintaining missionaries and for building churches and protecting Christians.

Unfortunately the agreement included awarding ecclesiastical patronage in both areas to the crown, and this was to become a stumbling block to adequate deployment of the missionary force. However, it was not so much the colonial policy of the states as a new spiritual vigour within the Latin church which reformed it internally following the Protestant revolt and recalled it to its missionary obedience. The Franciscans, Dominicans, Augustinians and other older orders took up the mission work again with increased zeal, and a new order, the Society of Jesus, became a major factor in the advance.

The foundation in 1663 of La Société des Missions Étrangères de Paris (the Foreign Missionary Society of Paris) demonstrates that in some parts of the church zeal was not confined to the monastic orders. The object of this organization was—through the work of secular priests, not monks—to raise up quickly a secular indigenous clergy in mission lands. Central direction to the whole vast enterprise was provided by the establishment at Rome in 1622 of the Sacred Congregation for the Propagation of the Faith (Sacra Congregatio de propaganda *fide*), by which papal responsibility for the mission was acknowledged and papal control effected. It was concerned with the assignment of territory. ecclesiastical relationships and the support, training and direction of missionaries. Its value was soon demonstrated not only in the expansion of the mission but also in protecting the local missions from domination by colonial officers.

Evangelization went hand-in-hand with the military conquest of Central and South America, the islands of the Caribbean, and the Philippines, where neither primitive society nor religion could withstand the invaders. The missionaries and their supporters among the Spanish colonists strove valiantly to mitigate the horrors of conquest and to protect the natives against exploitation. Bartolomé de las Casas. appointed protector general of the West Indies, is the best-known missionary. Conversion was superficial but at least nominally complete before the end of the period. French colonial policy in North America was the opposite of the Spanish and sought to interfere with Indian life as little as possible. Conversion. therefore, was not coerced. Missionary work was perhaps in consequence even more heroic than in Spanish territories. but missionary martyrs were more the victims of involvement in intertribal hostilities than of religious persecution or antagonism.

Portuguese colonial expansion was directed to India and the far east. with the major exception of Brazil. Africa was chiefly regarded as an obstacle to be circumnavigated. although there mere some minor colonial and missionary ventures there. A Christian kingdom of the Congo existed in the first half of the 16th century. Although numerous orders served in the east. it was the Jesuits pre-eminently who are associated with major developments. Francis Xavier (1506–1552) was the great apostle to these peoples. Commissioned as papal nuncio to India and the east, he arrived in Goa in 1542. He laboured among the Parava pearl fishermen near Cape Cormorin, in Travancore, Ceylon and Malacca. and established at Goa a training college for youths from many lands who would return as missionaries. Then he founded a mission in Japan, and seeking to enter China died on an island near Macao. The mission in Japan flourished, and in 160; there were about 300,000 Christians. However. a series of persecutions of extreme severity began in 1587 and lasted for a half a century. Christianity was proscribed, thousands were martyred and Japan isolated

itself from the western world. Great success attended the mission in China under the able leadership of the great Jesuit Matteo Ricci and his successors. The court favoured the mission, and an edict of toleration was proclaimed in 1692. Interorder quarrels. climaxing in the rites controversy, however, incurred the anger of the emperor and brought disfavour and repression on the Christians. Despite the exclusion of missionaries, persecution and isolation, a community of about 250,000 remained at the end of the 18th century. The Dutch drove the Portuguese from Indonesia and Ceylon and excluded Roman Catholic missionaries. Little was accomplished in Malaya, Burma and Siam (Thailand). except that the last of these became the base for a large-scale operation in Indochina. A large membership was raised up in the states of Cambodia, Cochin, Laos and Annam. The Foreign Missionary Society of Paris was the chief agency there. Through intervention for the protection of the missionaries. French influence became predominant in the area. Throughout the whole of south and east Asia Spanish and Portuguese claims to control ecclesiastical appointments interfered with effective missionary work. Partly to overcome this difficulty and partly to insure direct oversight of the missions. the Propaganda created few new sees and appointed vicars apostolic instead of diocesan bishops with full episcopal powers. The vicar apostolic was consecrated as the titular bishop of some extinct see and was invested with the personal privileges and powers of a bishop and was assigned to a region where he exercised episcopal powers. not in his own right, but as the personal representative of the bishop of Rome.

1750 **to 1815.**—Latourette regards the period from 1750 to 1815 as a time of recession. Missionary interest declined, contact with China was cut off, some Indians in South America reverted to paganism; but there was no great loss of territory. This was a time of wars which disrupted the home base, and the disintegration of the Portuguese and Spanish empires adversely affected missions. Another cause of diminished activity was the dissolution of the Society of Jesus.

PROTESTANT MISSIONS

The Protestant churches were slow to undertake missions. In the 16th. 17th and 18th centuries the expansion of Protestantism outside of Europe was through emigration, especially to North America. Efforts were made to provide pastoral care for such emigrants and for soldiers, officials and merchants in far off colonial outposts. Two British foundations, the Society for Promoting Christian Knowledge (1698) and the Society for the Propagation of the Gospel in Foreign Parts (1701), were established for this purpose. Protestant monarchs and their governments in general were not as zealous as the Roman Catholic monarchs in evangelizing their new subjects. However, the Virginia and Massachusetts charters mentioned the propagation of religion, and the chaplains of the Dutch East India company were required to instruct and baptize natives. Contacts with subject peoples or aborigines in the colonies did inspire some missionary efforts. Thus John Eliot's mission to the Indians in Massachusetts drew support from persons in the colony and in the homeland and led to the creation of the Society for the Propagation of the Gospel in New England in 1649, the first genuine missionary society. The Mayhew family began, in 1641, 150 years of service to the Indians of Martha's Vineyard and Nantucket, and there were other ventures! such as the Stockbridge mission. Added to the influence of such examples as these, the voices of Adrianus Savaria (1590), Justus van Heurn (1618), and Justinianus von Weltz (1621–1668), and a few other prophets called the churches to their missionary obedience.

It was German Pietism which brought forth continuing missionary activity on a large scale. Philipp Jakob Spener, the father of Pietism. advocated missions, and his successor as leader of the movement. August Hermann Francke, made the University of Halle the centre of missionary zeal and training. The missionaries recruited and trained by Francke were sent to Tranquebar in India by King Frederick IV of Denmark beginning in 1705, this monarch having more zeal for missions than his fellow Protestant rulers. The first two missionaries were Bartholomaus Ziegenbalg and Heinrich Plütschau. A lively correspondence between Francke, the missionaries, persons in England associated with the S.P.C.K., and Cotton Mather and others in America diffused knowledge about the enterprise and stimulated interest. Out of the same Pietist circle came Count Nicolaus Ludwig von Zinzendorf. Under his leadership the Moravian refugees on his estate recovered the apostolic vision and purpose, and the reborn Moravian Church made the mission the chief reason of its existence. The first missionaries went from Herrnhut to St. Thomas in the West Indies in 1731, and within a decade Moravian missionaries were to be found from Greenland to the Cape of Good Hope. The example and spirit of their work influenced John Wesley, William Carey, and the founding fathers of the British missionary societies.

Seeing no hope of persuading the churches officially to accept responsibility, the advocates of missions moved to establish voluntary societies. The publication in 1792 of William Carey's *Enquiry into the Obligations of Christians to use Means for the Conversion of the Heathens* crystallized sentiment and brought action. Carey and a dozen fellow ministers organized the Baptist Missionary society in Oct. 1792, and the following year Carey and John Thomas went to India as the first agents of the society. The London Missionary society was founded in 1795 by ministers and laymen of several denominations; and the Evangelicals in the Church of England organized the Church Missionary society in 1799. The Netherlands Missionary society began in 1797. Thus by the close of the 18th century continuing organs for missions had been established by Protestants.

PROTESTANT MISSIONARY ADVANCE, 19TH AND 20TH CENTURIES

The upsurge of missionary interest so apparent among Protestants during the last decade of the 18th century continued steadily to gain momentum throughout the 19th century. which Latourette called the "Great Century" of Christian expansion. The colonial outreach of Protestant European powers broadened the horizons of their people just as the age of discovery had done for the Roman Catholic portions of Europe. The political and cultural prestige of Europe aided missionaries in penetrating all parts of the globe, as did also the development of communications and the relative prevalence of peace. The Industrial Revolution provided rank and file church members with the means of supporting missionaries in increasing numbers. The chief motive was once again obedience to the Great Commission. The aim was the proclamation of the Gospel, and the program mas developed experimentally as need and opportunity demanded.

There was no generally accepted theoretical basis and little attempt to provide it until Gustav Warneck founded the study of *Missionswissenschaft* in Germany in the late decades of the 19th century. Looking at needy humanity through the eyes of Christ, the missionaries reached out hands of compassion and proclaimed the Gospel by deed as well as by word and life example. They gave the people the Bible in their own language, after first reducing many languages to writing; they instructed them in modern knowledge as well as in Christian life and doctrine; they taught them to read and write; and they healed their diseases. The vernacular Bible, the schoolbook, and the medicine bag soon became the constant companions of the missionary. The printing press, the school, and the hospital alongside the church became identifying marks of Protestant mission stations. Ignorance, illiteracy and physical sufiering were regarded as belonging to the realm of Satan and to be vigorously assaulted. Converts were gathered into churches, but it remained a weakness of Protestant missions in general that until the fourth decade of the 20th century there was much more stress on winning individual allegiance to a "Christian movement" than on building the corporate community. the church. However, by the middle of the 19th century the aim of the missionary enterprise was, in the terms of Henry Venn in England and Rufus Anderson in the United States. the fostering of "self-governing, self-supporting. self-propagating churches."

Missionary agencies increased with each new decade. In Great Britain the Wesleyan Methodist Missionary society was founded in 1813; it embarked on genuine missionary work as well as pastoral service to colonists; and the Glasgow and Edinburgh societies were

replaced by an official Committee on Foreign Missions of the Church of Scotland, an exception to the usual pattern of voluntary societies. The interdenominational Basel Mission society for Switzerland and Germany was established in 1815, and the Leipzig, Berlin, Rhenish and other societies followed.

The foreign missionary enterprise of U.S. churches is popularly held to begin with the foundation of a mission band at Williams college in 1806. When some of these men appealed to the Congregational churches of Massachusetts to be commissioned and supported in missionary service, the American Board of Commissioners for Foreign Missions was founded in 1810. It served several Presbyterian and Reformed denominations also for more than half a century and then became principally a Congregationalist organ. The American Baptist Missionary union came into being in 1814. The Methodist Episcopal Church created its Board of Foreign Missions in 1819, and other denominations soon took a similar step. The U.S. pattern was to be that of denominational boards of missions through which the denomination officially discharged its missionary responsibility in contrast with the voluntary and unofficial societies of Europe. As the decades passed mission boards and societies, either officially or unofficially representing nearly all the churches came to exist in Europe wherever there was a sufficient body of Protestants, in the United States and Canada, in Australia and New Zealand, and in South Africa. By 1900 there were more than 300 such boards and societies, and 50 years later there were more than that number in the United States alone.

Because of the reluctance of the societies to commission women with equal status with men and to give sufficient emphasis to special work for women and children, women organized both denominational and nondenominational boards and societies. Examples are the Woman's Union Missionary Society of America (1860), the Zenana Bible and Medical mission (1861), and the Church of England Zenana Missionary society (1880). After general missionary societies gave attention to such work, the women's societies merged with the general agencies or became auxiliary to them.

Nondenominational faith missions, with personnel and funds drawn from individuals and congregations across denominational lines, arose in the second half of the 19th century and became more numerous in the 20th. Unlike the denominational agencies, they promise neither salaries nor fixed allowances to their missionaries, but distribute to them the funds received. There was little difference in theological viewpoint between these societies and the church missions originally, but in the 20th century these faith missions might be characterized as fundamentalist. The prototype and model for faith missions was the China Inland mission, which later changed its name to Overseas Missionary Fellowship. It was founded by J. Hudson Taylor in 1865 in order to carry the Gospel into remote interior regions of China where the older missions had not yet been able to establish new stations.

Wars in Europe and America and economic depressions, such as the great one of the 1930s, might at times curtail missionary support, and local disturbances and major catastrophes like the Boxer Uprising might occasionally cause a regional setback; but there was a steady expansion of the missionary force up to mid-20th century. Potent forces in recruitment were the Student Volunteer Movement for Foreign Missions, organized in 1886 in the United States, and the Student Volunteer Missionary union, organized in 1892 in Great Britain.

Growth of the Churches

The labours of the Protestant missionaries resulted in the gathering of meager first fruits through much of the 19th century, but toward the end of that century the churches began to grow rapidly. The extent to which mature churches had developed in the 20th century was manifested at the Madras conference in 1938, where half of those present represented younger churches.

Far East.—India and China competed for major attention, British societies predominating in the former and U.S. in the latter, and more of the resources of the mission went into India than any other country. William Carey and his associates, Joshua Marshman and William Ward, known as the Serampore Trio, set the pattern for mission work in that country, with an emphasis upon the translation of the Bible, the preparation and printing of Christian literature, schools, and the training of a native ministry.

Alexander Duff pioneered in higher education, and college education became an important medium for introducing Christian principles. A vast system of schools from kindergarten to university was developed. Mass movements from outcaste and low caste groups were notable.

Ceylon and Burma were closely associated with India in missionary developments, and the types of work were the same. The British societies worked with the Singhalese and the American Board of Commissioners for Foreign Missions among the Tamils of the Jaffna peninsula. The pioneer in Burma was the U.S. missionary Adoniram Judson, who began work in 1813. The Society for the Propagation of the Gospel came later. Only a small group was drawn from the Burman Buddhist background but large churches were built up among the animistic Karens, Kachins and others. The great Karen Baptist Church proved self-supporting and evangelistic to a remarkable degree from the beginning.

Early missionary ventures in southeast Asia were associated with the Dutch East India company, whose chaplains founded many congregations now more than 300 years old. The Dutch missionary societies made Indonesia the exclusive field of their operations, excepting the Moravian mission in Surinam. The German Rhenish mission also entered and developed the renowned Batak church in Sumatra, the community on Nias, and the church among the Dyaks of Borneo. Many missions worked among the Chinese of the area as long as the Chinese ports were closed to foreigners, but withdrew when the ports were opened. The American Methodists remained to work among the Chinese and also among the animists of British Borneo. In Malaya access to the Malays was denied, and missionary efforts were confined to the Chinese and the later Indian immigrants. The Presbyterian Church in the U.S. maintained the chief work in Thailand and the Christian and Missionary alliance was almost alone in Indochina.

In the Philippines the work was carried on entirely by U.S. agencies. When the islands passed under control of the United States, seven boards conferred on the obligation which appeared to rest upon the U.S. churches. Six entered into a comity agreement. During half a century a Protestant community of about 710,000 members and adherents arose. The Philippine Independent Church, with about 1,000,000 communicant members, joined in communion with the Episcopal Church.

China was not open to missionary work until the treaties of 1842–44, and it was a quarter of a century more until toleration was granted. However, Robert Morrison had begun work in Canton in 1807, and he and others like the pioneer Karl F. A. Gützlaff managed to lay the foundation for the vast work to come later. The "protection" afforded missionaries and native Christians by foreign powers did much harm, and local antiforeign movements often caused setbacks. Several hundred westerners and thousands of Chinese Christians died for their faith in the Boxer Uprising of 1899–1900.

Protestant schools, literature and hospitals mediated western knowledge; and youths interested in national reform and wanting contact with western culture turned in increasing numbers to these institutions as the revolution gathered momentum. Thus Protestant Christianity exerted an influence far greater than its numbers would have indicated. The churches grew rapidly in the 20th century, and during the war years from 1937 to 1945 indigenous sects not related to the missions began to flourish, such as the True Jesus Church.

As a consequence of Communist government in China all missionaries, except a few in prison or under other forms of arrest, were expelled, and the churches isolated. The church was stripped of all functions but worship and fellowship, and the institutions were taken over by the government. However, there remained considerable evangelistic activity. Much of the leadership of the churches was purged on political grounds, and the churches were put under the corporate direction of a "Three-Self Patriotic Movement" which co-ordinated their activities, marshalled them

in support of government policy, and served as their liaison agent with the government.

Following the reopening of Japan and the signing of treaties permitting the residence of foreigners, three U.S. missions working in China simultaneously sent representatives into the country in 1859. Early enthusiastic acceptance of Christianity along with other aspects of western culture ended by 1900 as a strong nationalism began to assert itself. Christianity in Japan is predominantly found among urban and middle classes. Government pressure during World War II resulted in the merger of all denominations into the United Church of Christ in Japan (Kyodan), but after the war some of the churches withdrew. The Kyodan remained the largest ecclesiastical body. Higher education has always been a chief feature of the missionary program, and the formation of the Japan International Christian university at Tokyo was a notable event after the war.

After several heroic attempts to introduce Christianity into Korea had ended in martyrdom, continuing mission work was begun in 1884 by Henry Appenzeller, Horace N. Newton, and Horace G. Underwood. The Korean churches became renowned for self-support, Bible study and evangelistic zeal. Christianity became under Japanese rule something of a vehicle for the preservation of Korean national aspirations and Christians were often under great pressure. The Korean War and division of the country multiplied difficulties, but the churches continued to grow.

Pacific Islands. — The islands of the Pacific early attracted missionaries, beginning with the London Missionary society's party to Tahiti in 1797. The vast distances, the thousands of islands and the hostilities of many natives presented formidable obstacles. The roll of heroic martyrs is long, including John Williams and Bishop John Patteson. The story of the mission ships is of peculiar interest. The missionaries protected the natives against exploitation. Entire populations became Christians, but in some islands, such as Fiji, large numbers of non-Christian Indian labourers were brought in.

Near East and North Africa. — Protestant efforts in the near east and north Africa were originally directed toward the Jews and to the revival of the ancient Eastern churches. Separate congregations arose when the evangelicals were expelled from their old communions. Education, medicine and literature were emphasized. There were few converts from Islam. The Armenian and Nestorian Evangelicals in Turkey and Iran were destroyed or expelled after World War I. In the 1950s the largest Protestant community was in Egypt.

Latin America. — The Evangelical churches in Latin America were started largely from the United States, although large immigrant groups went from Europe to several countries. Faith missions played a large role. Pentecostals formed the largest group in Chile. Two important British missions are the South American Missionary society and the Evangelical Union of South America. Brazil has the largest number of Evangelicals.

Africa. — It is impossible to write anything of consequence in a few lines about the vast continent of Africa south of the Sahara. Although the Moravians began work in south Africa in 1737 and some west Africa missions are more than a century old, in many parts of east Africa and elsewhere some of the first converts were still living in the latter 1950s. Missions had to face the problems peculiar to work under a colonial government and later met new problems arising from African aspirations for freedom or self-government and a higher standard of living. Education has been largely in the hands of the missions, but unlike the case in the orient there no university education was introduced. Relatively little was done in raising an adequate ministry for what amounted in many places to a mass movement church. Africa missions contributed largely to inspiration and support of the whole missionary cause through men like the explorer-missionary David Livingstone and his father-in-law, Robert Moffat.

Missionary Co-operation

A remarkable degree of co-operation characterized the Protestant missionary enterprise from its beginning. One manifestation of this was the foundation of auxiliary services needed by all across denominational lines, including the Bible societies (British and Foreign, 1804; American, 1816) and the Tract societies (Scotland, 1793; London, 1799; American, 1823). Informal missionary fellowships, of which the earliest was the Bombay Missionary fellowship of 1825, soon became regional and national organizations. India set the example for other areas, and there the regional associations merged into the Decennial Missionary conferences, the first of which was held in Dec. 1872–Jan. 1873. These conferences dealt with recognition, transfer and discipline of members and agents; with common policies; and with the division of territory, which became known as comity. Comity became the general rule except in Japan and it resulted in "denominationalism by geography." Beginning with the negative purpose of guaranteeing noninterference in the affairs of a mission within a recognized area, comity became the basis for positive co-operation and ultimately for the maintenance of union institutions.

Parallel with the conferences in the various fields was a series of international popular conferences in Europe and America. These were New York, 1854; London, 1854; Liverpool, 1860; London, 1878; London, 1888; and the Ecumenical Missionary conference in New York in 1900. Regional conferences were also held in the Scandinavian countries, and a Continental Missions conference met at intervals beginning in 1866. Standing organs for continuous consultation and co-operation among the home base administrators began with the German Ausschuss in 188; and the Foreign Missions Conference of North America in 1893. These experiments in the field and at the home base led to the World Missionary conference at Edinburgh, Scot., in 1910. John R. Mott traveled around the world on behalf of its continuation committee in order to seek acceptance of the conference's findings and to bring into being national conferences of missionary societies, such as the Conference of Missionary Societies of Great Britain and Ireland, and National Christian councils, in which churches and missions co-operated for common action. These two types of councils and conferences were then brought as daughter councils into the International Missionary council, formally organized at Lake Mohonk, N.Y., in 1921 after a delay caused by World War I. Influential World Missionary conferences were held at intervals by the I.M.C., the first at Jerusalem in 1928. These conferences were occasions for survey, study, shaping policy, devising new strategy, and strengthening co-operation. After the formation of the World Council of Churches, this body and the International Missionary council entered into formal "association," and in 1958 it was announced that the two bodies would merge in 1961.

Orthodox Missions

Missionary efforts by Orthodox Eastern churches during the 19th and 20th centuries were limited to those of the Russian church. Missions were established in Siberia, the Aleutian Islands, Alaska and Japan. The last was founded in 1863 by Bishop Nicolai. Archbishop Innocent founded the Orthodox Missionary society at Moscow to forward these efforts.

Missionary activity ceased with the establishment of Communist control in Russia. Because of its origin, the Orthodox church in Japan suffered severely during World Wars I and II, especially World War II, and was greatly reduced in strength. Assistance was given after World War II by the Russian Orthodox Church in the United States.

Later Roman Catholic Missions

Roman Catholic missionary efforts had never ceased, although they had reached a low ebb by 1800. They were slow in reviving, but eventually became once more a vast enterprise. The Sacred Congregation for the Propagation of the Faith vigorously directed a world-wide mission, and a new organization came to its support. An Institute for the Propagation of the Faith was formed in Lyons in 1822 for the purpose of raising money for the total work. Eventually a National Society for the Propagation of the Faith, often with diocesan branches. came to be established in most countries where the church is strong. As the result of the crippling effect of World War I on certain European countries, and also because

of the growth and power of the Catholic community in the United States, the U.S. churches moved suddenly from the status of a mission field themselves to that of supplying the greatest part of the resources for the world-wide mission. After World War II the pre-eminent position of the U.S. church was still further enhanced. U.S. missionary personnel was still disproportionately small in comparison with the total body in the 1950s, but U.S. branches of the important missionary orders were organized, and purely U.S. agencies, such as the Catholic Foreign Mission Society of America (Maryknoll, N.Y.), were formed.

The outstanding new development in Roman 'Catholic missions in the 20th century was the promotion of a native clergy and episcopate, strongly supported by the Roman pontiff (Benedict XV, encyclical *Maximum Illud,* Nov. 30, 1919; Pius XI. encyclical *Rerum Ecclesiae,* Feb. 18, 1926; Pius XII, encyclical *Evangelii Praecones,* June 21, 1951).

The movement was given dramatic expression when Pius XI in 1926 consecrated six Chinese bishops. There were more than 100 native bishops, vicars apostolic. and prefects apostolic by the early 1960s. A Chinese and an Indian, moreover, had been elevated to the dignity of cardinal.

See articles on various denominations and biographies of missionaries: also references under "Missions" in the Index volume.

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MISSISSIPPI, often called the "Magnolia state" after its official flower, is a south central state of the U.S. The state is bounded on the north by Tennessee. on the east by Alabama, on the south by the Gulf of Mexico and Louisiana, and on the west by Louisiana and Arkansas from which it is separated by the Mississippi and Pearl rivers. The total area is 47,716 sq.mi., of which 493 sq.mi. are water surface. It is the 32nd state of the union in size. The state capital is Jackson and the state entered the union Dec. 10. 1817. as the 20th state. The mockingbird has been adopted as the state's official bird. The state flag has a red background upon which, in the upper right corner, there is one blue and one white horizontal stripe and, in the left corner, a St. Andrew's cross emblazoned with 13 stars which represent the original colonies.

PHYSICAL GEOGRAPHY

Topography. — ?*lost of Mississippi, nhich is situated between approximately 30° 13' and 35° N., and 88° 7' and 91° 41' W., lies within the Gulf coastal plain. Rolling hills cover the greater part of the state except for a narron strip along the Gulf coast and an area in the northwestern section lying betneen the Yazoo and hlississippi rivers. 'These two sections are low and poorly drained. The highest elevation, about 800 ft., is in the northeastern part of the state in Tishomingo county.

Climate. — Its latitude, low elevation and proximity to the Gulf of Mexico produce, in southern Mississippi, a rather mild and equable climate, but to the northnard the climate is more subject to extremes. The normal mean annual temperature for the state is 64°, on the coast it is 6*i*° and on the northern border 61°. Annual precipitation for the state is about 51 in. (southern half, 54 in.; northern half, 49 in.). Nearly one-third of the rain falls in January, February and March, but July is also a wet month. The driest months are September and October. The prevailing ninds are from the southeast.

Soil. — The soils along the Gulf coast are generally unsuited to agriculture because of their lack of fertility and poor drainage. A few miles from the coast, however, the soils support tung-oil groves and some vegetable and truck crops.

The loess uplands include an area in the western part of the state that stretches from Tennessee to Louisiana between the delta on the west and the sandy-clay hills to the east. These uplands are made from fine, wind-blown soils that erode easily but are very fertile and productive if cultivated properly.

The delta soils to the west of the loess uplands are rich alluvial soils. Where the problem of flooding has been solved by levees, this is the most fertile area in the state and is noted for its cotton, hybrid corn and rice production. Native hardwoods, such as cypress, red gum and swamp hickories also grow there.

The section lying east of the loess uplands. and north of the coastal meadows is known as the "piney woods." This includes most of the southern half of the state. Pine forests predominate in this region and furnish raw materials for the lumber and pulpwood industries.

In the northeastern part of the state, there are two very different types of soil. The so-called "prairie section" is a rich agricultural area which formerly produced cotton. but which now produces livestock and dairy products. Native Bermuda grass is the basis for most of the pastures. The other section in northeast Mississippi is that of the sandy-clay hills. There, the soil is of low fertility and subject to erosion. There are small areas, however, where the soil supports cotton and dairy production.

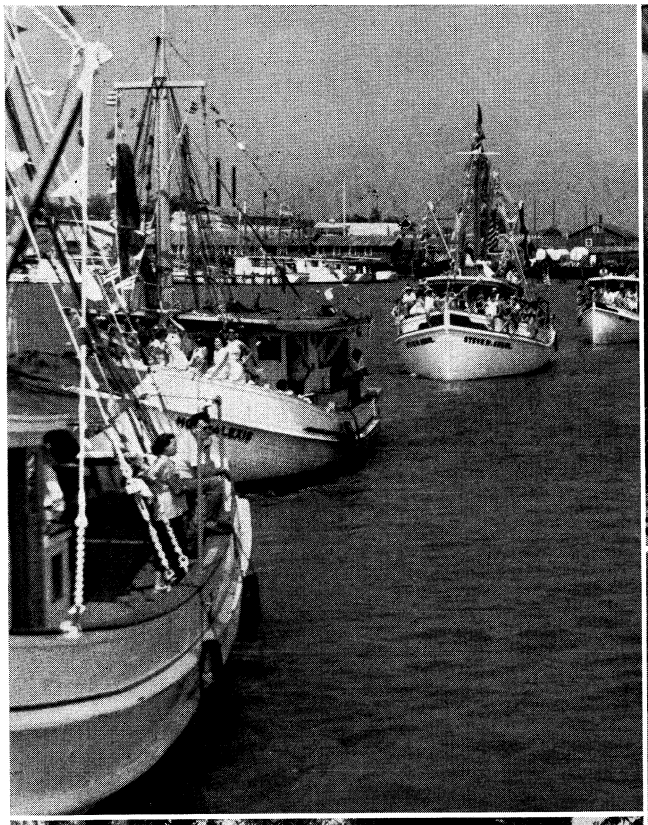
Coast Line.—The coast line, about 85 mi. long, is bordered by a beach of white sand and is broken by several small and shallow indentations, among which are St. Louis, Biloxi, Pascagoula and Point Aux Chênes bays. Separated from it by the shallow Mississippi sound is a chain of low, long, narrow sand islands, the largest of which are Petit Bois, Horn, Ship and Cat. Channels have been dredged so that Gulfport and Pascagoula have become ports for ocean vessels.

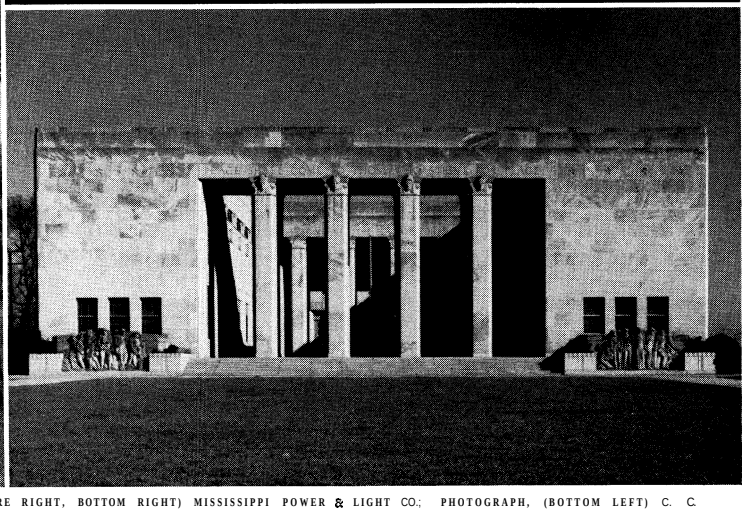
Drainage. — There are five major drainage basins within the state. The Tombigbee river basin drains the northeastern section. The Pascagoula river, formed bv the iunction of the Leaf and Chickasawhay rivers, drains the southeastern part. The Pearl river drains the south central section. The Mississippi river and its tributaries drain the western section. The Yazoo river, made by the junction of several small rivers; flows into the Mississippi near Yicksburg thus draining northwest blississippi. The Big Black river, also a tributary of the blississippi, drains the west central section.

Plants and Animals. — More than half of the total acreage of Mississippi is covered with forests. In the piney woods section of the state the longleaf pine is the most outstanding type of tree. Other types of trees found in the state include the live oaks (often hung with Spanish mossj, willow, bald cypress, black and sweet gum, white oak. hickory, honey locust, poplar, maple, sycamore and magnolia. There are six national forests in blississippi. They are the Homochitto in the southwestern corner of the state, Holly Springs in the north, De Soto in the southeast, and also the Chickasawhay, Bienville and Delta.

Mississippi woodlands abound in a large variety of flowering trees: shrubs and plants. Magnolias, dogwood, redbud and wild azaleas, commonly called honeysuckle, are among the commonest varieties of the flowering trees and shrubs. Other native flowers include roses, Virginia creeper, black-eyed Susans, violets, wistaria, papaws and primroses. Improved varieties of azaleas and camellias are grown in gardens in the southern part of the state. Roses, iris and all kinds of flowering bulbs thrive in flower gardens. In March many communities set aside days when gardens are open to the public. The city of Natchez observes the whole month.

Formerly, many wild game animals were native to Mississippi, but uncontrolled hunting eliminated most of them. Game animals now hunted include rabbits, foxes, squirrels, raccoons, opossums and deer. Alligators abound in the swampy bayous. Almost all kinds of fresh-water fish are abundant. The most commonly caught are black bass. speckled trout, carp, channel and mud cat, bream and perch; in the Gulf-coast area there are





BY COURTESY OF (TOP LEFT) BILOXI CHAMBER OF COMMERCE, (TOP RIGHT, CENTRE RIGHT, BOTTOM RIGHT) MISSISSIPPI POWER & LIGHT CO.; PHOTOGRAPH, (BOTTOM LEFT) C. C. HAMILL

SCENES IN MISSISSIPPI

Top left: Bay of Biloxi during the annual Shrimp festival. Biloxi is a leading shipping centre for shrimp and oysters

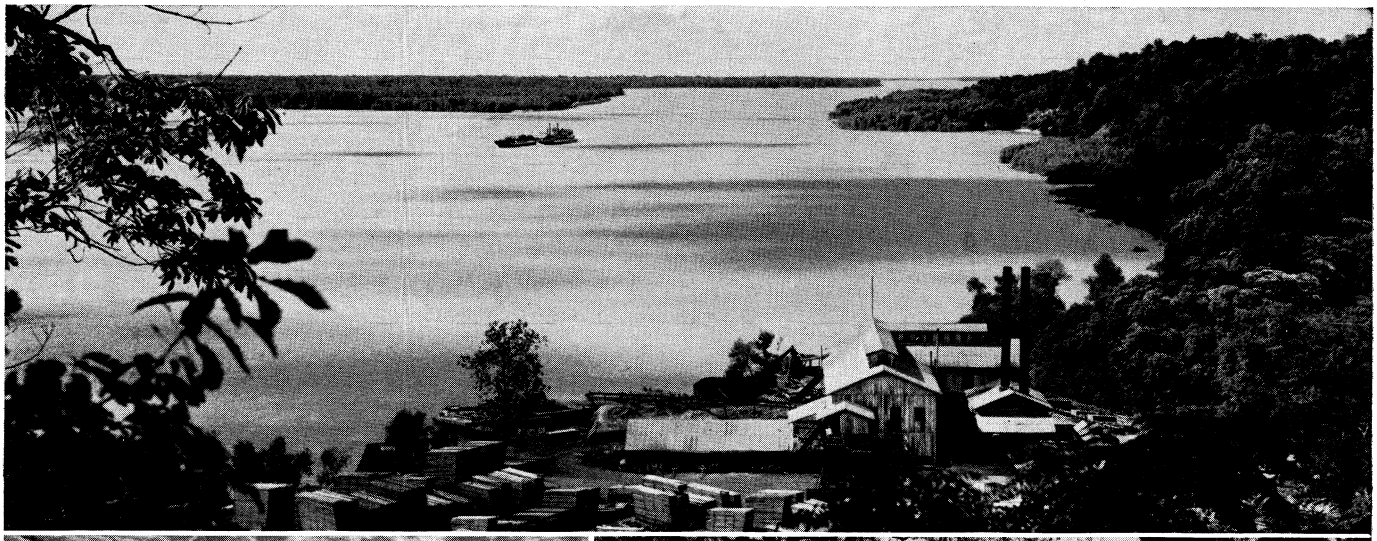
Top right: The state capitol building in Jackson, dedicated in 1903, is similar in design to the national capitol

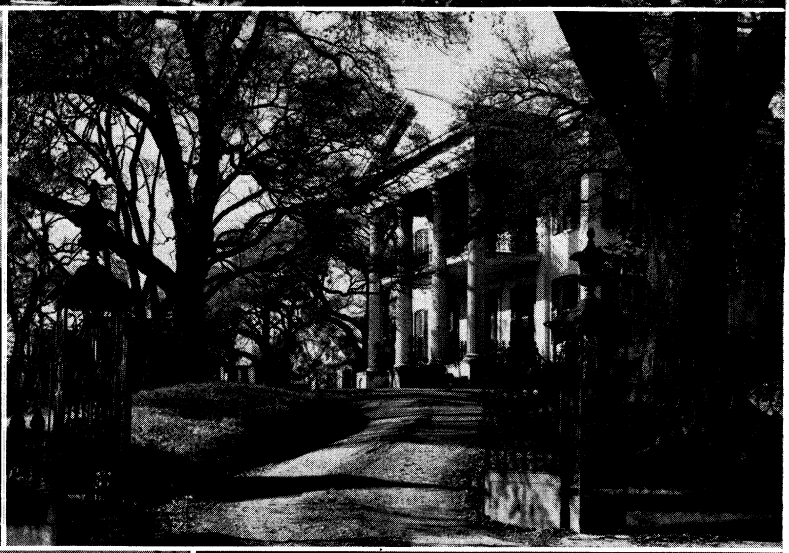
Centre right: Ft. Massachusetts, on the western end of Ship Island in the Gulf of Mexico, was erected in the mid-19th century to protect the entrance of the waterway to New Orleans

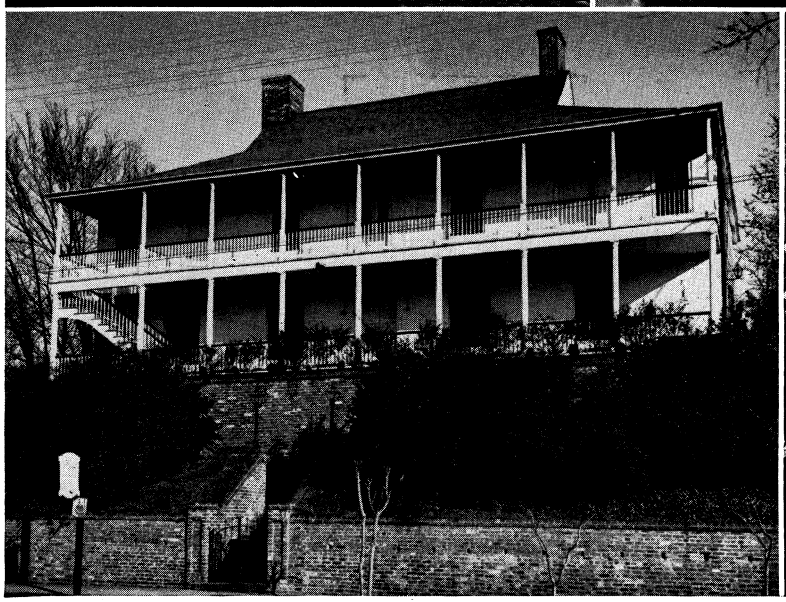
Bottom left: Picking Spanish moss which hangs in festoons from giant oaks along the Gulf coast

Bottom right: War Memorial building, Jackson, a monument to Mississippi servicemen who died for their country

MISSISSIPPI







BY COURTESY OF (TOP, BOTTOM RIGHT) STANDARD OIL CO. (N.J.), (CENTRE RIGHT, BOTTOM LEFT) MISSISSIPPI AGRICULTURAL & INDUSTRIAL BOARD; PHOTOGRAPH (CENTRE LEFT) C. C. HAMILL

VIEWS OF MISSISSIPPI

Top: The Mississippi river at Natchez. At the foot of the bluffs is the first lumber mill opened in the state (1809)

Centre left: Oystermen at daybreak off the shore of Pass Christian, where there are about 30 sq.mi. of shell-fishing banks

Centre right: Stanton hall, one of more than 40 historic homes in Natchez, was built in the classic style typical of ante-beilum architecture in Mississippi

Bottom left: Connelly's tavern or Ellicott's inn, Natchez, built in 1795 in the Spanish Provincial style

Bottom right: Cotton pickers near Belzoni in the fertile Mississippi delta country. Cotton is the chief product of the state

also sheepshead, mullet and drum. Chief among the game birds are bobwhite quail, migratory waterfowl, mourning doves and wild turkeys Coastal birds include the brown pelican, various types of terns sandpipers and plovers. Among the songbirds are the state's official bird. the mockingbird, bluebirds, brown thrashers. robins, cardinals, blue jays, warblers and sparrows. In the coastal regions and in the delta the egret is fairly common.

Parks and Monuments. — The state has developed a system of public parks most of which have facilities for picnicking, water sports and fishing. There are also accommodations for overnight guests and lodges for assemblies. The state parks contain approximately 14,000 ac. of woodland.

National-park areas in the state are the Vicksburg Military National park and the Natchez Trace parkway. The former was established to commemorate the siege of the city in 1863 during the Civil War. In the park are the remains of trenches and gun emplacements that made up the battle lines (see VICKSBURG). The Piatchez trace is a road that was developed from an Indian trail nhich followed the natershed from Natchez northeastnard between the Big Black and Pearl rivers to the foothills of the Pontotoc ridge There it left the divide and struck more eastwardly across the Tombigbee river, meeting the Tennessee river near Muscle shoals. Brice's Cross Roads national battlefield commemorates the battle fought June 10, 1864, near the town of Baldnyn. Another national battlefield site is at Tupelo where the last major battle of the Civil War to be fought in Mississippi took place in July 1864. The Ackia battleground, nhere the Chickasaw Indians defeated the French in 1736 and thus opened up the country to English settlers, is a national monument. Around Natchez are grouped approximately 30 ante-bellum mansions nhich are open to visitors in the spring of each year Other places of historical interest include Beauvoir, the last home of Jefferson Davis, near Biloxi, and Friendship cemetery at Columbus where Memorial day is believed to have had its origin in 1866. The old Spanish fort in Pascagoula. now a museum, is considered the oldest building in Mississippi; the old state capitol in Jackson, built in 1839, has been restored and is used as a museum.

HISTORY

The Indians. — The principal Indian tribes living in Mississippi when the nhite men came were the Chickasaws, the Choctaws and the Natchez. The Chickasaws lived in the northern part of the state, the Natchez in the southnestern portion and the Choctans in the remainder. It has been estimated that there were 20.000 or 30.000 Indians living within the present boundaries of Mississippi. At first, the white men were most interested in trade and in converting the Indians to Christianity. but later, they became interested in settling the area for permanent homes, which brought on conflict.

In the second half of the 20th century, a few Indians still lived in Mississippi on reservations provided by the federal government. Physical remains of the prehistoric Indians, such as arrowheads, pottery and mounds, are still frequently seen One of the best-known mounds is Nanih Waiya, the sacred mound of the Choctans, which is located in the southern part of Winston county. Mounds in the western part of the state have furnished artifacts for archaeologists. A group of four mounds near the site of old Selsertown in Adams county has been especially productive in supplying relics.

Exploration and Settlement. — In the first half of the 16th century the Spanish began the exploration of Mississippi. The most important expedition was led by Hernando de Soto in 1540. He entered Mississippi near the present site of Columbus and spent the ainter near Pontotoc. Early in March 1541 hostility between the Spaniards and the Indians flared into open warfare in which the Spanish defeated the Indians and moved westward to make the great discovery of the Mississippi river in May. Successfully crossing the river, the Spanish passed through parts of Arkansas Louisiana and Texas. In 1542 the expedition returned to the Mississippi river at a point near Natchez, where De Soto died. Later the remainder of the expedition made its way to the Spanish settlements in Mexico, but their failure to find any precious metals caused the Spanish to lose interest in the area.

More than 100 years later, explorers went down the Mississippi river from the French colony in Canada. Father Jacques Marquette and Louis Jolliet, a trader, explored the river as far south as the Arkansas river The accounts given of this trip fired the imagination of Robert Cavelier, Sieur de La Salle, who received permission from Louis XIV. king of France, to explore the Mississippi river valley and to build forts. In 1682 La Salle explored the Mississippi river to its mouth and named the territory Louisiana in honour of his sovereign. The explorer met his death in an attempt to establish a colony at the mouth of the river. His death and the involvement of France in a European war caused a postponement of attempts at colonization.

A successful French colonizing expedition led by Pierre le Moyne, Sieur d'Iberville arrived off the coast of Mississippi in 1699 After the exploration of the loner reaches of the Mississippi river and the coast line, Le Moyne decided to settle on Biloxi bay There the colonists built a fort and named it Fort Maurepas. In 1702 Fort Louis on Mobile bay, was established and ten years later Mobile was founded. Soon other settlements were begun near the mouth of the Pascagoula river. The oldest house now standing in Mississippi, called Old Spanish Fort, dates from this period. Fort Rosalie, non known as Natchez, was established in 1716.

The development of French Louisiana passed into the hands of the Mississippi company which nas promoted by John Law (*q* v). Law's vigorous policies and the transfer of the colony's capital to New Orleans brought about a rapid development. Trouble arose between the French and the Natchez Indians over ownership of the land, hon ever and on Nov. 29, 1729, the Indians attacked Fort Rosalie and killed or took prisoner the entire population whereupon the French made preparations to punish the Natchez and their allies the Chickasans. The French forces attacked the Chickasaws at Ackia, a village near Tupelo, but were defeated. Continued difficulties with the Indians and unwise administration made the colony unprofitable. When the English won the French and Indian War (1754–63), the French were forced to cede all of their territorial claims east of the Mississippi river. except New Orleans, to England.

The British colony of West Florida included the lands west of the Apalachicola river and those south of the 31st parallel, but later the northern boundary was extended to 32° 28′. Pensacola was the capital, but Mobile the principal settlement. Fort Rosalie, renamed Fort Panmure. was not important until a new wave of immigrants came into the area in the 1770s to escape the unrest on the eastern seaboard. West Florida prospered under British rule. but it was occupied by the Spanish during the American Revolution. When the British signed the treaty of peace with the 13 colonies in 1783, the southern boundary mas fixed at 31° though Spain did not recognize this boundary. The area was in dispute until the Treaty of San Lorenzo between the United States and Spain was signed in 1795.

Statehood.—Mississippi territory, organized in 1798, included land between the Chattahoochee and Mississippi rivers on the east and west and between 32" 28' and 31° on the north and south. The Indians held the land to the north. About 5,000 people lived in Mississippi territory at that time. The Cnited States set up a territorial government with Winthrop Sargent as governor and Piatchez as the first capital. In 1802 the capital was moved to Washington, a small town near Natchez, and it remained the seat of government throughout the territorial period. An important event that affected the people of Mississippi territory was the Yazoo land fraud by which the Georgia legislature sold to speculators most of the land non making up the state of Mississippi (then a part of Georgia's western claims) in 1795. The following year a new legislature rescinded the sale of the land and in 1802 Georgia ceded the land to the federal government. Other important events of the period were the Louisiana Purchase in 1803 and the War of 1812.

Troubles with the Indians increased during the War of 1812 and Gen. Andrew Jackson was sent to subdue them. By the

Treaty of Fort Jackson Aug. 9, 1814, the Indians were forced to cede valuable lands to the federal government. Mississippi territory was then expanded but congress decided that the area was too large for one state and divided the territory to make the states of Mississippi (1817) and Alabama (1819).

David Holmes, who had served as territorial governor from 1809, became the first governor of the new state of Mississippi. The early years of statehood brought many changes. In 1822 a new capital, located on the Pearl river near the centre of the state, was named for Andrew Jackson. The United States signed several cession treaties with the Indians: the first, Doak's Stand, in 1820, with the Choctaws; the second, Dancing Rabbit Creek, in 1830, with the Choctaws; and the third, Treaty of Pontotoc, in 1832, with the Chickasaws. By 1840 Mississippi had 60 counties, and the entire state was in the hands of white settlers. The state had grown so much that a new capitol building was built and occupied in 1839.

This period of development brought prosperity. Roads and railroads were built, and steamboat navigation played an important part in getting the ever increasing cotton crop to market. The settlement of new lands and the growing demand for cotton made that crop the most important factor in the economy of the state. Negro slaves were brought in to produce the cotton, and by 1840 they outnumbered the white people.

Civil War and Reconstruction. — The period between 1850 and 1860 was marked by an intensive discussion of the slavery question. The Whigs and the Democrats united in support of slavery and its extension into the territories. In 1859 the Democratic state convention adopted a resolution favouring immediate secession if a Republican were elected to the presidency. The Democratic candidate for governor was John J. Pettus, who was elected by a large majority. In the presidential election of 1860 blississippi voted for John C. Breckinridge, the nominee of the southern wing of the Democratic party.

After Lincoln's election Mississippi took immediate steps to withdraw from the union. A convention which met in Jackson on Jan. 7, 1861. passed two days later an ordinance of secession by a vote of 84 to 15. Mississippi was the second state to pass such an ordinance, and it joined other southern states to form the Confederate States of America. The legislature took immediate steps to prepare for defense, and Earl Van Dorn became commander of the Mississippi troops. Jefferson Davis, one of bfississippi's most distinguished citizens, became the president of the Confederacy.

Many battles and skirmishes of the American Civil War were fought on Mississippi soil, but the most important campaign was the fight for Vicksburg, which involved many months of planning and three campaigns. Gen. U. S. Grant led the third campaign which culminated in the siege and capture of the city (July 4, 1863). (For details of the campaign see VICKSBURG.) Federal troops, under the command of Gen. B. H. Grierson, moved across the state from Tennessee to Baton Rouge, La. During this raid, the Federals burned public buildings, destroyed factories and wrecked railroads. Other Federal troops, under the command of Gen. William Tecumseh Sherman, moved across Mississippi from Vicksburg to Meridian destroying property and confiscating livestock and provisions. The war ended in Mississippi when Gen. Richard Taylor surrendered his command on May 4, 1865.

In the summer of 1865 a convention met in Jackson to change the constitution. This convention abolished slavery, but refused to ratify the 13th amendment to the constitution of the United States or to make any changes in the state's voting laws uhich would enable Negroes to vote. Gov. Charles Clark had already been arrested by federal government troops, and the legislature stayed in session only a few hours because of fear that its members would be arrested. However, there was a political campaign in the fall of 1865. Gen. Benjamin G. Humphreys was inaugurated as governor in Oct. 1865 and served until he was removed by federal troops in 1868. Political conditions were chaotic because the federal congress refused to recognize the government of the state. In 1867 congress put into effect its plan of reconstruction, and Mississippi was placed in the fourth military district. The federal soldiers registered voters who took the oath of allegiance to the union and especially encouraged the Negroes to register. Delegates selected by the newly registered voters framed the constitution of 1869. James L. Alcorn. a Republican, was elected governor in 1869, and Mississippi, after meeting all of the requirements of the reconstruction act, was readmitted into the union. The same year the 14th and 15th amendments to the federal constitution were ratified. From 1870 to 1875 the government was under control of the unscrupulous carpetbaggers, Negroes and that part of the white population that was without political experience. Taxes were increased — expenditures had increased nearly threefold between 1869 and 1871 — and there was much official corruption. but the state escaped the heavy burden of debt imposed on some of the other Southern states, by reason of constitutional inhibitions.

Political and economic conditions were very unsettled, and race riots broke out in a few communities. By 1875, however, the Democrats had reorganized themselves and were able to win control of the state legislature.

When the legislature assembled in Jackson in Jan. 1876 impeachment proceedings were begun against the governor, Adelbert Ames, the lieutenant governor, A. K. Davis, a Negro, and the superintendent of education, T. W. Cardoza. also a Negro. Davis was convicted and removed from office, and Cardoza and Governor Ames were allowed to resign. John M. Stone, acting president of the senate, became governor. The Democratic legislature instituted a program of economy and reorganized the government. A constitutional convention drew up a new constitution in 1890 which insured the control of the state to the white people.

The 20th Century. — The history of Mississippi in the 20th century has been characterized by progressive legislation. The passage of the direct-primary election lam in 1902 placed in the hands of the electorate the nomination of public officials. Reforms were effected in the management of the penitentiary; in care of the ill, the handicapped and the indigent; in transportation; and in the provision of educational opportunities. Politically blississippi has supported the Democratic party in every national election since 1890 except in 1918. when the electoral vote went to the States' Rights party. Mississippi governor Fielding L. Wright was the nominee for vice-president on the States' Rights ticket.

In 1960 Mississippi elected a slate of unpledged presidential electors who voted for Senator Harry F. Byrd of Virginia for president of the United States.

GOVERNMENT

Mississippi has had four constitutions in its history. The first was drawn up in 1817 when the state was admitted to the union. The constitution of 1832 was more democratic than the first in that it provided for the election of most of the executive and judicial officers. The third constitution was drawn up in 1869 to make it possible for Mississippi to be readmitted into the union after the Civil War. A fourth constitution was written in 1890.

The 1890 constitution has been amended many times. but it continues to serve as the basic law of the state. One of its principal objectives was the establishment of qualifications for voting. The new requirements provided that a person must live in the state at least two years and in his election district a-minimum of one year before becoming eligible to vote. The prospective voter must also be able to read any part of the constitution or be able to understand it when it is read to him. Voters were further required to register four months prior to an election and to pay a poll tax for two years preceding the election.

The 1890 constitution also provides that the responsibility for state government should be divided among legislative, judicial and executive departments. The legislature consists of two houses, the senate and house of representatives, both elected for four-year terms. The senate has 49 members elected from 42 senatorial districts, and the house of representatives has 140 members. The legislature meets biennially in even-numbered years for regular sessions and in special session at the call of the

The judicial system consists of justice of the peace courts, county courts, circuit courts, chancery courts and a supreme court. There is at least one justice of the peace in each of the five supervisors' districts in every county. Some counties that exceed a specified population have county courts, which have exclusive jurisdiction over eminent domain and juvenile cases as well as civil cases of less importance. The circuit courts are the courts of intermediate or general jurisdiction. They serve as appellate courts for cases from justice of the peace and county courts and hear both civil and criminal cases. The chancery courts are specialized courts which deal with divorce cases, deeds, wills, estates and the guardianship of minors. The number of circuit and chancery courts is fixed by statute. The judges of all these courts are elected for four-year terms.

There are nine judges on the supreme court, which is the highest tribunal in the state and hears cases appealed from the chancery and circuit courts. The state has been divided into three supreme court districts, each with three judges, serving eight-year terms. The member with the greatest seniority is the chief justice.

The members of the executive department who are elected by the people are the governor, the lieutenant governor, the secretary of state, the attorney general, the treasurer. the superintendent of public education, the auditor of public accounts, the commissioner of agriculture and commerce. the tax collector, the commissioner of insurance and the land commissioner. All serve four-year terms and all may immediately succeed themselves except the governor, the treasurer and the auditor. There are more than 100 boards and commissions which administer the state's business. Some of these are elected while others are appointed by the governor with the consent of the senate.

Finance and Taxation. — In its early history the state received most of its income from the property tax, but in the 20th century there began a decline in the importance of that tax as a source of state income, though it was still important in financing local governments. Rfissisippi has a homestead exemption law which exempts homes, not to exceed $5.000 and 160 ac., from taxation. Personal and excise taxes have increased in importance as sources of revenue. Personal taxes include income and estate taxes. Business taxes include franchise taxes, licences, corporation net income taxes and the sales tax. The sales tax provides nearly one-half of the revenue for the general fund.

A state tax commission, composed of three members, has important financial responsibilities. It equalizes tax assessments among the counties, assesses all public utility property, administers the homestead exemption law and collects revenue under tax laws designated by the legislature. These taxes provide 90% of the revenue for the general fund. However, the administration of the revenue system is divided among many agencies.

In the second half of the 20th century, the state's general revenue amounted to more than $225,000.000 annually. Of this sum, slightly more than one-fifth was derived from the federal government. The state's expenditures totaled about $225 000.000 annually, and the gross debt stood at more than $100,000,000. In the late 1950s, approximately 33⅓% of the state's revenue was being spent on education, about 23% on highways, approximately 16% on public welfare and slightly more than 5% on health and hospitals. The state's income at this time was nearly four times as great as it had been prior to World War II. State expenditures had increased about the same amount. Though Mississippi had the lowest per capita income of any of the states, such income was, nevertheless, about four and one-half times as great as it had been prior to World War II.

*Mississippi: Places of 5,000 or More Population (1960 Census)**

Place	Population				
	1960	1950	1940	1920	1900
Total state	2,178,141	2,178,914	2,183,796	1,790,618	1,551,270
Aberdeen	6,450	5,290	4,746	4,071	3,434
Amory	6,474	4,990	3,727	2,861	1,211
Bay St. Louis	5,073	4,621	4,138	3,033	2,872
Biloxi	44,053	37,425	17,475	10,937	5,467
Brookhaven	9,885	7,801	6,232	4,706	2,678
Canton	9,707	7,048	6,011	3,252	3,404
Clarksdale	21,105	16,539	12,168	7,552	1,773
Cleveland	10,172	6,747	4,189	1,674	479
Columbia	7,117	6,124	6,064	2,826	507
Columbus	24,771	17,172	13,645	10,501	6,484
Corinth	11,453	9,785	7,818	5,498	3,661
Greenville	41,502	29,936	20,892	11,560	7,642
Greenwood	20,436	18,061	14,767	7,793	3,026
Grenada	7,914	7,388	5,831	3,402	2,568
Gulfport	30,204	22,659	15,195	8,157	1,060
Hattiesburg	34,989	29,474	21,026	13,270	4,175
Holly Springs	5,621	3,276	2,750	2,113	2,815
Indianola	6,714	4,369	3,604	2,112	630
Jackson	144,422	98,271	62,107	22,817	7,816
Kosciusko	6,800	6,753	4,291	2,258	2,078
Laurel	27,889	25,038	20,598	13,037	3,193
Leland	6,295	4,736	3,700	2,003	762
Louisville	5,066	5,282	3,451	1,777	505
McComb	12,020	10,401	9,898	7,775	4,477
Meridian	49,374	41,893	35,481	23,399	14,050
Moss Point	6,631	3,782	3,042	3,340	—
Natchez	23,791	22,740	15,296	12,608	12,210
New Albany	5,151	3,680	3,602	2,531	1,033
Ocean Springs	5,025	3,058	1,881	1,732	1,255
Oxford	5,283	3,956	3,433	2,150	1,825
Pascagoula	17,139	10,805	5,900	6,082	708
Pearl	5,081	—	—	—	—
Philadelphia	5,017	4,472	3,711	1,669	—
Picayune	7,834	6,707	5,129	2,479	—
Starkville	9,041	7,107	4,900	2,596	1,986
Tupelo	17,221	11,527	8,212	5,055	2,118
Vicksburg	29,130	27,948	24,460	18,072	14,834
West Point	8,550	6,432	5,627	4,400	3,193
Yazoo City	11,236	9,746	7,258	5,244	4,944

*Populations are reported as constituted at date of each census.
Note: Dash indicates place did not exist during reported census, or data not available

POPULATION

The population of Mississippi in 1820, three years after it had obtained statehood, was 75,448. Its population ranked 22nd among the 27 states and territories that then composed the union, and was classified as 100% rural. The decade between 1830 and 1840 was the period of most rapid growth after achieving statehood—the population increased 175% during that ten-year span. Immediately before the Civil War, in 1860. the state had a population of 791,305 and was 14th in population size among the 42 units of the government at that time; it was about 97% rural in character. At the beginning of the 20th century, the state had slipped to 20th in rank of population (out of 48 units) with a total of 1,551,270 by the 1900 census. It was still largely rural as 92.3% of the people were classified as nonurban dwellers. From 1910 to 1920 the. population declined 0.4% and from 1940 to 1950, 0.2%. The trend continued between 1950 and 1960, there being a 0.04% decline in that ten-year period. In 1940, for the first time in a 100 years, the white population (1,106,327) of the state outnumbered the Negro population (1,074,578); in 1950, the preponderance of whites over Negroes had grown larger (54.2% native white; 45.4% nonwhite, practically all Negro).

The 1950 total population showed 2,178,914 persons living within the state making Mississippi the 26th in size of population among the states. The rural population had declined to about 72% of the total at that time. There was one standard metropolitan statistical area (Jackson, including Hinds county) in 1950 and it had a total population of 142.164 persons. By 1960 the Jackson standard metropolitan statistical area had a population of 187,045 or 8.6% of the total population. In 1960 Mississippi had a population of 2,178,141 persons, a decrease of 773 from 1950; it ranked 29th in population size among the states.

The population per square mile in 1960 was 45.6 as compared with 49.6 for the U.S. as a whole. The 1960 urban population was 820,805, or 37.7% of the total, continuing the trend toward increasing urban residence. In line with the rest of the U.S. the percentage of persons 65 years old or more was 7.0% in 1950. The percentage of the population 14 years old and over that was in the labour force (34.7% in 1950) mas steadily increasing.

EDUCATION

Historical. — Public education was almost entirely neglected during the colonial and territorial periods. The first school to be established in the state was Jefferson college, later Jefferson Military college, near Natchez; it was incorporated in 1802. Charters were granted to schools in Claiborne, Wilkinson and Amite counties between 1809 and 1815, and to Port Gibson academy and Mississippi college at Clinton in 1826. The state established in 1819 what is believed to be the first educational

institution to grant diplomas to women. The first free high school, Franklin academy, was opened in Columbus in 1821. The public-school system was established in 1846, but the schools established at that time had no uniformity in quality or funds. Before the Civil War, more than 150 special charters were granted by the legislature to institutions of learning, and from the close of the war until 1891 there were about 125 additional charters granted. These schools did not include those operating under the general laws of the state.

In 1870 a uniform system of public education was organized. At that time, each county in the state and each city of 5,000 population was made a district in which free public schools were to be maintained for at least four months of the year under the supervision of a board of school directors. Prior to the Civil War there were no public schools for Negroes, but by 1869 there were more than 80.

With the coming of the 20th century there were many changes in the development of public education. In 1910 the consolidation of schools was begun. At first, wagons, and later, school buses, transported students to school. Colleges began to offer courses in education and two teachers' colleges were established. Schools were graded and standards for teachers mere raised. A textbook commission was appointed to select uniform textbooks. In the 1940s the state began buying textbooks for children in grammar and high school. School buildings were improved and school terms were lengthened.

The legislature of Mississippi embarked upon a new chapter in educational history in 1952. It appointed a recess committee on education whose purpose was to study the public-school system and to make recommendations for equalizing and improving educational opportunities. As a result of its study the committee recommended, and the legislature passed, the necessary legislation for a complete reorganization. A state educational finance commission was created with the purpose of receiving and reviewing plans for the consolidation or reorganization of Mississippi's school districts. The commission could also disburse funds made available by the legislature for school construction and equipment. The plans submitted to the finance commission were drawn up after surveys had been made by experts in school administration. When the reorganization plan was complete, Mississippi had only 151 school districts compared with the more than 4,000 it had had formerly. Negro and white children were in the same districts, but in separate schools. Each county's board of education is elected by the popular vote of the qualified electors of each supervisor's district. The county superintendent of education serves as executive secretary of the county school board.

A system of publicly supported junior colleges grew out of the agricultural high schools which had been started in 1908 to improve educational facilities for rural children. The first agricultural high schools to add junior-college work were Pearl River county and Hinds county in 1922. The popularity of the program led to rapid expansion and in the second half of the 20th century there were 17 junior colleges (14 for white students and 3 for Negroes) to provide educational opportunities beyond the high school. In addition there were four private junior colleges for white students and six for Negroes.

Colleges **and** Universities. — Of the many colleges established in Mississippi before 1860. two were still in existence in the second half of the 20th century: Mississippi college at Clinton (affiliated with the Baptist Church), established as Hampstead academy in 1826; and the state University of Mississippi, chartered in 1844 and opened in 1848 at Oxford. Other state-supported schools for white students are Mississippi State university (1878) at Starkville, Mississippi State College for Women (1884) at Columbus, Mississippi Southern college (1910) at Hattiesburg and Delta State college (1924) at Cleveland. For Negroes there are Alcorn Agricultural and Mechanical college (1871) at Lorman, Jackson State college (1877), which became a four-year degree-granting tax-supported institution in 1940, at Jackson and Mississippi Vocational college (1946) at Itta Bena. Among the privately supported four-year colleges for white students are Belhaven college (Jackson. Presbyterian, 1894), Millsaps college (Jackson, Methodist, 1891), William Carey college (Hattiesburg, Baptist, 1906) and Blue Mountain college (Blue Mountain, Baptist, 1873). A private senior college for Negroes is Tougaloo college (Tougaloo, Congregational Christian and Disciples of Christ, 1869). A scholarship program is financed by the state for Negro students who need to go outside of the state for additional training which the state does not provide.

HEALTH AND WELFARE

The Mississippi state board of health was organized in 1877, but it did not become an important factor in public health until the 20th century, when the legislature increased its support and expanded its facilities and duties. The board's educational program has been effective in the control and eradication of communicable diseases.

The state's hospital program includes hospital licencing, the allocation of funds to, and the inspection of, hospitals that care for charity patients. and hospital planning as well as construction. The state also provides hospitals at Laurel, Meridian, Natchez and Vicksburg for the care of the indigent. The University hospital, at Jackson, also provides care for such patients. The state sanitorium near Magee provides treatment for tuberculosis patients.

After the Hill-Burton act was adopted by the federal congress in 1946, the Mississippi commission on hospital care had the responsibility of formulating a complete plan for hospital construction in the state. These new hospitals and health centres were financed by federal, state and local funds. Within ten years the number of available beds had increased 55% and hospital admissions 117%.

The state legislature established the state department of public welfare in 1936 with funds provided by the federal and state governments. The department, operating through the county welfare departments, provides assistance to the indigent aged, the physically disabled, dependent children and the indigent blind. Blind children can be sent to state schools for the blind and there is also a college fund for the aid of the blind. The state also maintains schools for the deaf.

The department of public welfare supervises probationers; that is, children who have appeared before juvenile courts but were not sent to a training school. Mississippi maintains two training schools for delinquent children, one at Columbia for white children and the Oakley training school, near Raymond, for Negro children.

The state cares for its mentally retarded at the Ellisville state school and for the mentally ill at hospitals in Meridian and Whitfield.

The Mississippi state penitentiary at Parchman operates farms and shops to provide for the needs of the penitentiary. It also provides vocational training as part of its rehabilitation program as well as an elementary education for those who need and want it.

THE ECONOMY

Agriculture. — Throughout its history Mississippi's economy has been based upon agriculture. Although the percentage of agricultural workers was decreasing, about one-half of the total working population was still employed on the farm in the second half of the 20th century. Cotton has always been the most important single crop, but in the 20th century the boll weevil threatened to destroy the cotton economy. This threat was met by the development of improved varieties of cotton seed and the use of insecticides. The increased use of machines. such as tractors and cotton pickers, and improved agricultural practices also helped cotton maintain its dominance. The value of the cotton crop has been materially increased by the use of the seeds for the manufacture of cottonseed oil and feed. Nevertheless. in spite of these improvements the harvested acreage of cotton has gradually decreased over the years. The production of livestock and livestock products has increased so that they rank next to cotton in cash income. Other important crops are hay, soybeans, rice, oats, corn and other vegetables.

Industry.— In the 1930s the state started the "Balance Agriculture With Industry" (B.A.W.I.) plan to promote the development of industry. Under this plan communities gave financial aid to new industries. Such industries were so located that approximately a third of the nonagricultural workers were employed in manufacturing. Since more than one-half of the area of the state is classified as forest lands, it is natural that the manufacture of wood and wood products is the most important industry. After World War II the manufacture of clothing became one of the fastest growing industries. Other important manufacturing industries include food processing, chemicals and textiles. An increase in personal income came with the development of industry. There was a 39% per capita increase within ten years after World War II.

Electricity furnished by the Tennessee Valley authority has been an asset in the industrial development of northeast Mississippi.

Minerals.—Oil and gas are the principal minerals found in Mississippi. In addition to the gas wells within the state, gas pipelines from Louisiana and Texas cross Mississippi making natural gas easily available to a large percentage of the population. Gas extraction plants located in the Canfield and Brookhaven fields produce gasoline and butane and propane gas.

The oil industry had its beginning in 1939 when the Tinsley field in Yazoo county was discovered, and within 20 years there were more than 2,000 producing wells in the state. More than one-third of the land is under lease for oil and gas development. Refineries located in Mississippi produce gasoline, kerosene, gas oil, fuel oil, lubricants and asphalt.

Other natural resources include sand, gravel and limestone suitable for the manufacture of cement; and clay and clay minerals, including deposits usable in the manufacture of brick, tile and pottery, bentonite and fuller's earth.

Transportation.— The Mississippi river is one of the most important routes of transportation within the state. The United States government improved navigation on the river by dredging the channel, by providing navigation aids and by flood control. The tonnage of freight carried on the river doubled during a five-year period after World War II. Coal, steel, grain, automobiles, sugar and oil are the principal commodities carried by river freight. Greenville, Vicksburg and Natchez are the leading river ports.

Railroad constructiori began in Mississippi in 1831 when the first line connected U'oodville with St. Francisville, La. At the time of the Civil War, there were two east-west lines and two north-south lines across the state. There was little new construction after the war until the rise of the lumber industry in the early part of the 20th century stimulated the construction of additional lines. The coming of motor transportation and improved highways, however, caused some rail lines to be abandoned.

In 1930 the state highway system was placed under the control of a highway commission composed of three members with one elected from each of the supreme court districts. The state built and maintains a primary system of highways which includes the main highways across the state. There is also a secondary system of hard-surfaced roads, called farm-to-market roads, which afford good transportation to the rural areas.

Commercial airplane transportation first came to Mississippi in 1929 when the Delta air lines began passenger service from Dallas, Tex., to Atlanta, Ga., via Jackson. Later, another route from Chicago to New Orleans also stopped in Jackson. These flights made Jackson an important airport. The Gulf-coast area is served by flights from New Orleans to Jacksonville, Fla. Local service lines operate within the state and provide travel by air between principal cities.

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MISSISSIPPI RIVER, the "Father of Waters," was named Misisipi by the Ojibway Indians (*Mis,* "great"; *sipi,* "river"). On some of the early French maps it was so named, and it is eminently deserving of the name. The source of the river was not known until 1832. when Henry Rowe Schoolcraft discovered its origin in a lake he named Itasca (Lat. *veritas,* "true"; *caput,* "head"). (See ITASCA, LAKE.) In this northern Minnesota lake district, 1,475 ft. above sea level, three great river systems, the Red, St. Lawrence and Mississippi, have their origin.

The length of this great river can only be approximated due to imperfect drainage in the north and meanders in the south; the U.S. department of the interior, geological survey, gives it as 2,348 mi. The least accurately measured portion is from the mouth of the Ohio to Head-of-Passes below New Orleans, where for 964 mi. the Mississippi flows over land of its own making. The greatest fall in the river is in the 500-mi. stretch upstream from Minneapolis-St. Paul. a drop of 700 ft.

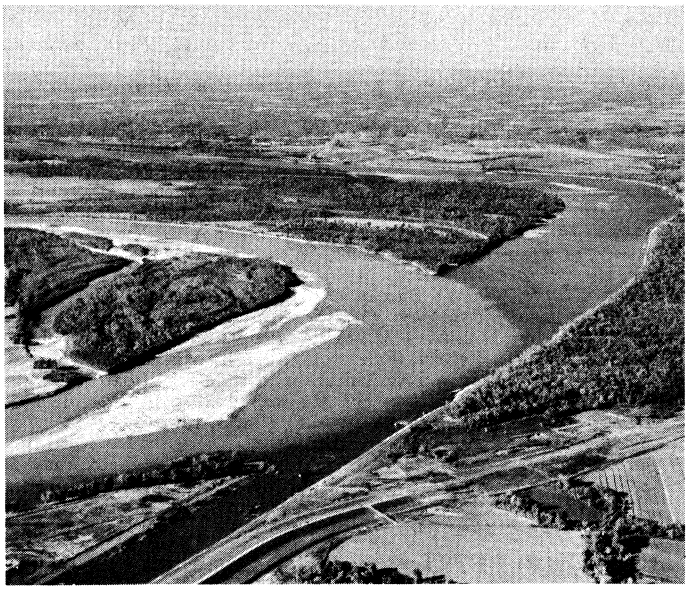
With its two great tributaries, the Ohio and the Missouri, the Mississippi drains an enormous area; water from 31 states and two Canadian provinces flows into the Gulf of Mexico by way of this system. This embraces approximately 1,243,700 sq.mi. or one-eighth of all North America. Expressed another way, its longitudinal expanse is 1,900 mi. and its latitudinal 1,400 mi.

Physiographically the Mississippi drainage basin embraces parts of the Laurentian, Central lowland, Great Plains, Appalachian and Central highlands. Rocky mountains and Gulf coastal plain provinces. Climatically it also includes a diverse group: from humid continental short summer in the north to humid subtropical in the south; from humid continental long summer in the east to steppe and mountain in the west. Mineral endowment and soils represent a similar diversity.

The Mississippi empties into the Gulf of Mexico an estimated 724,000,000,000cu.ft. of water each year. This is about $1\frac{1}{2}$ times the discharge of the St. Lawrence. 8 times that of the Rhine and 177 times that of the Thames. The Ohio is the greatest contributor to the water of the Mississippi, being about $3\frac{1}{2}$ times that of the Missouri, the next greatest. It is not necessary to view the waters from the air to see that the silt in the Missouri identifies its contribution for miles downstream.

Tributaries.— One way of evaluating the Mississippi's contribution to American life is to examine its tributaries. The Mississippi may be resolved into three major regions—headwaters and northern tributaries; the very large tributaries of the middle section; and the lower Mississippi—each region with its distinctive characteristics. For a time during the days of early settlement, the river was a bond that tended to unify these physical regions, but with the westward movement and an occupied continental heart-

land, the uniqueness of the three tributary regions asserted itself in the character of river use; the unifying effect of the river began to increase again after 1940.



BY COURTESY OF GERALD R MASSIE— MISSOURI DIVISION OF RESOURCES AND DEVELOPMENT

AERIAL VIEW SHOWING THE CONFLUENCE OF THE MISSOURI AND MISSISSIPPI RIVERS A FEW MILES NORTH OF ST. LOUIS. THE MISSOURI IS THE MUDDIER RIVER SHOWN ENTERING THE MISSISSIPPI RIVER FROM THE LEFT

Northern **Region.**—Except in southwestern Wisconsin, the headwaters and northern tributaries flow through an area of comparatively recent release from the continental ice sheet; much of the character of drainage and soil derives from this fact. Physiographically it is essentially the West lakes section of the Central lowland and the Superior upland portion of the Laurentian shield. The prevalence of lakes of all sizes and swamps, plus the fact of flow over a plain of alluvial fill, gives a meandering course to the headwater streams and even to the upper Mississippi itself. The lakes and swamps also greatly reduce the number and stage of floods and limit the usefulness of streams to local commerce.

The larger tributaries from the east are the Wisconsin, Black, St. Croix and Chippewa, names redolent with memories of upper lakes' lumbering. There is but one major tributary from the west, the Minnesota. The better lands of the basin lie to the west, but there are none of the minerals that figure so prominently in the east. The level plains of old Lake Agassiz support an important grain-livestock economy. On the upper Mississippi and its northern tributaries are extensive areas of marshland that support a specialty crop, wild rice, the harvest of which is largely in the hands of Chippewa Indians (who serve as guides or lumbermen for the remainder of the year). Over much of the area there are the marks of three successive exploitations: lumbering, mining and generally subsistence farming.

Middle Region.— The middle section of the Mississippi drainage basin is the region that gives the basin its continentality. Two great river systems, the Ohio and Missouri, embrace very extensive areas to the east and west, respectively. This section of the Mississippi and the tributaries has virtually none of the youthful landscape characteristics noted in the headwaters. The river is more deeply entrenched, with the banks generally no more than a mile apart; the names of some of the towns and cities—Council Bluffs. for instance—suggest this.

Tributaries from the east include such important streams as the Rock, Illinois and Kaskaskia; from the west come the Cedar and Des Moines rivers. In considering the apparent paucity of tributaries in this section, it must be remembered that both the Ohio and the Missouri are great river systems, each with many important tributaries.

The middle section of the Mississippi is much more subject to flooding than the northern, owing in part to the absence of lakes but mostly to the rainfall distribution and percentage of runoff of its far-flung eastern and western tributaries. There the Rockies and the Appalachian and Central highlands introduce an entirely different reason for changes in the volume of water moved by the rivers; the timing of their floods can be disastrous to the lower Mississippi river plains. The accessibility of this portion of the Mississippi river valley is one of the three bases of its economic dominance. East of it lie the lower Great Lakes and St. Lawrence river, the only deep-water outlet to the Atlantic; to the east also are the important corridors through the north and Appalachian highlands that give access to the middle Atlantic port cities. Far to the west are the passes through the Rocky mountain barrier. South of it is the route to the Gulf of Mexico, oldest and most important of the water outlets for the heartland of the United States.

Southern Region.— The southern portion, below the confluence with the Ohio, has tributaries that differ markedly from those of either section of the river to the north. For almost a thousand miles, the Mississippi, swollen by the waters of the Ohio, pursues a meandering course over its flood plain built upon the underlying coastal plain. As in no other part of the river valley, it may be characterized by its tributary river basins, which tend to parallel the Mississippi itself. From the north they are the St. Francis, Yazoo and Tensas basins, with the Yazoo as the only major eastern tributary; and the Atchafalaya, which was made a distributary. The St. Francis, Yazoo and Tensas basins virtually monopolize the tributaries of the main stream; the major exceptions are, from the west, the Arkansas and Red, two of the longest tributaries to the lower Mississippi.

A third drainage feature is the series of short placid Louisiana streams, which, at least in times of high water, act as distributaries of the lower Mississippi. Among the larger ones are the Teche and La Fourche.

1. Yazoo Basin. In the southern region, longest of the three, the features common to the four parallel tributary basins are far greater than those that distinguish one from another. The only important tributary basin to the east of the Mississippi is the Yazoo, lying between Memphis and Vicksburg. The Yazoo river follows a very meandering course on this alluvial plain, with a fall of only $7\frac{1}{2}$ in. per mile or about twice that of the Mississippi a few miles to the west. Prior to the completion of the system of levees in 1886, the Yazoo basin was subject to overflow by the larger stream; after that time it became one of the major cotton-growing regions in the south.

2. St. Francis Basin. The St. Francis is the northernmost and largest of the alluvial basins on the west side of the Mississippi; the Black and St. Francis rivers follow nearly parallel courses along the major axis of this basin. The southern end of the basin is hard to determine since the Arkansas flows in from the Rockies and merges its alluvial plain with the St. Francis as it makes its difficult entry into the Mississippi. In most respects the St. Francis basin is similar to the Yazoo, although interrupted by Crowley's ridge.

3. Tensas Basin. The Tensas basin comprises the flood plain on the west side of the Mississippi from the Arkansas to the Red river. It, too, has a vaguely defined southern boundary where it merges with the flood plain of the Ouachita river coming in from the Ozark highlands. In all essential respects, this basin is similar to the Yazoo. The long Red river, which makes a doubtful entrance into the Mississippi, has a very low gradient, much silt and a number of meandering tributaries on both sides. Several of these tributaries long ago were dammed by logs to form lakes of varying sizes; its waters merge with the Atchafalaya river on the south.

4. Atchafalaya Basin. The fourth and final alluvial basin is that of the Atchafalaya, west of Baton Rouge and New Orleans. While similar to the other three alluvial basins of the lower Mississippi, this river was naturally an independent stream; engineers made it a distributary of the Mississippi to use when the need arises in times of flood.

Use.— Earliest to discover the low divide separating the Mississippi from the Great Lakes and to evaluate the usefulness of

the river were the French from the St. Lawrence valley, whose fur traders, traveling with a priest, started many Mississippi valley villages before the English appeared. Among them were: Peoria, 1680; Detroit, 1701; New Orleans, 1718; and St. Louis, 1764. Ohio was the only state in the old Northwest Territory with no French land claims at the time the public domain was established. In a sense the French were not true colonists since their economy never passed the fur-trading dominance: fur-trade tends to discourage the evolution of a permanent economy. To these French trappers, the river was the final link in the St. Lawrence-Great Lakes-Mississippi waterway to the warm Gulf of Mexico and the Caribbean. They recognized its geographical advantage and unifying influence in terms of continental development, but they were numerically and economically inadequate to secure and hold it. After the treaty of Paris in 1763, French settlements in the St. Lawrence valley became part of the British North American colonies.

The British tidewater colonies along the middle Atlantic coast were forbidden to expand westward across the Appalachian highlands into the Mississippi valley by the British North America act. To the American Continental Congress and its successors, the Mississippi river was at first a threat and then an invitation; the purchase in 1803 of the Louisiana territory ended the threat. Lacking the power to protect lives or land titles in the old Northwest Territory, the nation's first public domain, the Continental Congress forbade settlement in this part of the Mississippi valley; after enactment of the ordinance of 1787, however, settlement was permitted. This territory developed into the nation's first corn and wheat belt; it soon found a ready market for its surplus farm products in the old cotton-growing south. The Mississippi's big eastern tributary then gathered the commodities for shipment down the Mississippi; until the Civil War peak of steamboating, commerce on the Mississippi grew rapidly. By 1840 one-half of all commercial vessels under American registry were in use on the Mississippi river system. After the Civil War, steamboat traffic declined; the railroads gave better service.

The emergency in transportation incident to World War I resulted in such rail congestion that the federal government attempted to stimulate river transport; the cessation of hostilities did not end this effort. The Federal Barge Lines were established in 1918 to demonstrate the economy of barge traffic; 40 years later, river barge traffic had grown so spectacularly on all parts of the Mississippi system that the Federal Barge Lines were sold to a private carrier.

Improvements. — Factors accounting for the increase in traffic on the Mississippi are many and varied. Improvements in the river and in transportation equipment lagged prior to 1928, but thereafter, and especially after World War II, great strides were made. The process of levee maintenance, straightening of the channels, desilting, devices for flood alleviation (if not always control), and dredging of channels, especially below New Orleans, have always been in progress.

Most Mississippi locks, like those in its busiest tributary the Ohio, measure 600 ft. by 110 ft., making double locking necessary. The Falls of St. Anthony (Minneapolis-St. Paul) are bypassed by canals constructed by the corps of engineers. A lower lock, 1,200 ft. long and with a rise of 25 ft., is in use; an upper lock with a rise of 50 ft. (highest on the river) was scheduled for completion in 1962. This particular lock illustrates a significant change in river improvements, a change that attempts to integrate river transport with the recentralization of the nation's manufacturing. Above this upper lock a harbour 33 mi. long, under construction, will serve the commerce of and through the Twin Cities. Adjacent to the harbour is a 3,000-ac. tract of reclaimed land that will serve as an "industrial park" for newly located factories.

Farther south, New Orleans constructed an industrial canal linking Lake Pontchartrain with the river and offering planned industrial sites for new factories. St. Louis built a terminal for river traffic, with the result that tonnage handled nearly tripled between the late 1940s and late 1950s. Near Keokuk, Ia., the locks are 1,200 ft. long, 110 ft. wide and 38 ft. deep, a type planned for all locks subsequently constructed.

Improvements in towboats and barges proceeded more rapidly than did river facilities. Specialized barges were developed for certain commodities — molten sulfur, petroleum, new automobiles, acids and alkalis — and the size of barges, power of towboats and aids to navigation also increased. A barge 300 ft. long holds 1,000,000 gal. of petroleum; a railroad tank car holds 13,000 gal. An oil-fired, air-conditioned excursion steamer carries 4,000 passengers. A St. Louis firm built a towboat with diesel engines generating 8,500 h.p., ten rudders and five decks carrying a crew of 17; it could move 40-barge tows from St. Louis to New Orleans in ten days at rates, depending upon the commodity, from 12% to 50% lower than railroad rates. Such a tow moves more than twice the tonnage of most ocean freighters. Not many of the 4,200 modern diesel towboats on the Mississippi river system are as large, but the trend is upward. Approximately 8% of intercity freight is moved over these waters.

Manufacturing industries began to be attracted to Mississippi river sites, particularly after World War II. In this choice of location, though improvements in the river were influential, the prime factor was expanding markets and rising freight costs. These industries consume a diversity of raw materials and produce a variety of commodities, but the most important, perhaps, are those that require much power in processing. In the south the chemical industries have come to dominate the Intra-Coastal waterway, which contributes much tonnage to commerce on the Mississippi above New Orleans. St. Louis, Memphis, Baton Rouge and New Orleans have all become important manufacturing cities, each with a wide market area. Among the smaller cities that might be named are Dubuque, Davenport, Vicksburg and Chalmette.

Problems. — It is to be expected that there will be problems connected with the regular use of such a large river as the Mississippi. Some of these problems, in fact most of them, stem from the physical circumstances of the river; historically, there are the difficulties of using the Mississippi as a boundary between states. The changing course of the main channel is a periodic problem for counties and states, particularly in the southern third of the river, though some stabilization has been achieved.

Floods have always been a very serious problem, not only to navigation on the river, but to riparian occupance as well. Experience since the early 19th century, together with the findings of the Waterways Experiment station operated by the federal government near Vicksburg, resulted in a vast system of river controls and harbour improvements. Aside from the flood control measures established on tributary rivers (for instance: the Tennessee Valley authority, Miami Valley Conservancy district and Missouri Valley authority), the several Mississippi engineering districts constructed a complex pattern of reservoirs, floodways, spillways, distributary channels and levees in the lower third of the river system.

Despite these improvements, the regular commercial use of the Mississippi is attended by serious hazards. Ice and high water are perennial problems. Channels shift and bars are formed. The river functions as a commercial artery only if dredging is constantly underway at several points, notably in the channels below New Orleans. The devices for reducing flood damage in themselves give rise to risk of property damage.

The chief economic problem centres around financial support of river navigation, flood control measures, etc. The channel is maintained and lighted, levees are built, locks are operated and personnel are licensed at federal expense; only the transportation equipment is taxed. Even on the busiest river of the Mississippi system, the Ohio, if the hidden costs are considered, traffic is partly subsidized by the tax-paying public.

See separate articles on the chief tributaries, as OHIO RIVER; MISSOURI RIVER; etc.; *see* also RIVER AND RIVER ENGINEERING. *See* also Index references under "Mississippi River" in the Index volume.

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MISSISSIPPI RIVER STEAMBOAT. Few phases of 19th-century North American life had so wide and vivid an influence on the region and people around it as the Mississippi river steamboat. For 50 years, from about 1820 to 1870, this "swimming volcano," as one passenger called it, dominated the economy, agriculture, commerce and social customs of the middle area of the United States.

These "palaces on paddle wheels" made possible the golden age of the central south and Mississippi valley during the days before the Civil War. They gave its greatest growth to New Orleans, queen city of the Mississippi, and determined the direction of development of other cities, towns and rural areas. They made fortunes for their owners and for plantation masters; they brought much of the old south in touch with the world and aided in the growth of slavery and the cotton economy.

In a region still not far removed from its frontier period, the steamboats provided a primary contact with other people and other wavs of life for thousands of men and women. They gave to American tradition such figures as the waistcoated Mississippi gambler, the Negro roustabout who dragged cargoes on and off, and emotion-charged incidents such as the bizarre explosions on the river and the great Mississippi races.

Steamboat pioneering began in America in 1787 when John Fitch of Connecticut made a successful trial. Robert Fulton's profitable experimentation followed, but not until 1811 was a vessel built especially for the "western waters," the lower Mississippi—the "New Orleans," built at Pittsburgh, Pa., under the direction of Nicholas J. Roosevelt, agent for Fulton and Robert R. Livingston. Most observers predicted disaster when Roosevelt, with his wife, started down the Ohio. The way was dangerous and the Mississippi an especially hazardous stream, with eddies, rapids, hidden snags and sand bars.

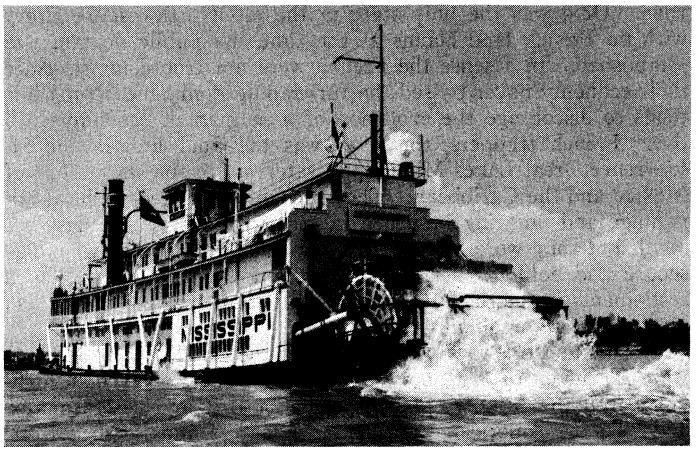
The trip began in May and did not end until Jan. 10, 1812. The vessel had many difficulties; again and again it tied up for repairs. After traversing the Ohio falls it continued downriver; at New Madrid, Mo., a violent earthquake made the earth open and river banks crumble away, but the "New Orleans" survived. After wild excitement at many points, it arrived at the Creole city.

There Fulton and Livingston began in early 1812 the operation of a service between New Orleans and Natchez, Miss., under a monopoly contract with the territory of Orleans, one of a number of such contracts obtained in various states. The vessel traveled eight miles an hour downstream, three miles up. Within two years the "New Orleans" sank, though her engine was rescued. Fulton and Livingston continued operations in this western area, but the former wrote soon afterward of his weariness and disgust at the expense and losses.

Nevertheless J. G. Fliigel, an observant passenger on a second "New Orleans" steamer of 1817, described the "elegance" of the boat, with "red bombazette curtains and fringes and mosquito bars," sofas, chairs and looking glasses. Despite Fulton's gloomy remarks, Fliigel claimed that on one such Natchez-New Orleans trip net proceeds reached $4,000. "There is within the bounds of knowledge," he asserted, "no business in any part of the globe which is more lucrative than this . . ." ("Diary of J. G. Fldgel," *Louisiana Historical Quarterly,* published by the Louisiana Historical Society, July 1924.)

Yet the Mississippi remained a treacherous stream. In 1816 Henry Miller Shreve of Shreveport, La., made history by launching his "Washington"; before long it made the trip from New Orleans to Louisville in a phenomenal time of 2j days. In so doing Shreve flouted the Fulton-Livingston claim to an exclusive right to navigate the river. For several years the two sides fought the matter in courts, and eventually the monopoly was rejected there.

Shreve's work has given him the title of father of Mississippi navigation. An engineer-boatman-inventor, he had realized that vessels planned for clear, deep eastern waters would never do well on the Mississippi. He made radical changes in design; drawing up the engine, he mounted it on a hull as shallow as that of a barge. The engine itself was high pressure, capable of making progress against the Mississippi's might.



BY COURTESY OF U.S CORPS OF ENGINEERS

PADDLE-WHEEL STEAMBOAT

A tall second deck was added and paddle wheels placed at the side. Though many hooted at the strange-looking thing, so tall in the air, so light in the water, Shreve's experiment became the prototype of all Mississippi steamboats.

From then on the people of the Mississippi valley and tributaries turned to the steam vessels. In 1814 New Orleans, near the mouth of the river, had counted hardly 20 steamboat arrivals. Within 20 years the figure had reached 1,200. Cotton was spreading over the south and southwest; sugar had become the major crop of the area below New Orleans. For the south a new day had begun.

About New Orleans the steamboat-cotton wealth was crystallizing. By the 1830s its banking capital exceeded that of New York city; its port competed with New York as the nation's largest, and in exports it frequently ran ahead of its eastern rival. In a single decade New Orleans' population doubled.

Upriver the steamboats brought soaring prosperity to Memphis, Tenn., St. Louis, Mo., Natchez and other points. Along the Mississippi and its tributaries the roads were short and undependable; the rivers were the highways of the day and they ran south to New Orleans and the ocean below it. "The master street of the world," one enthusiast called the New Orleans water front; nowhere else, it was said, could be found such a concentration of steamboats. They stretched for four or five miles, curving with the river itself, sometimes two and three deep.

Lady Emmeline Wortley described the procession of the river boats on the lower river: "By night the scene is one of startling interest and magical splendor. Hundreds of lights are glancing in different directions from the villages, towns, farms and plantations on shore, and from the magnificent 'floating palaces' of steamers, that frequently look like moving mountains of light and flame, so brilliantly are these enormous leviathans illuminated, outside and inside . . . steamer after steamer coming sweeping, sounding, thundering on. . . ." (Lady Emmeline Stuart Wortley, *Travels in the United States,* Harper & Brothers, New York, 1851.)

Vessels grew larger, engines more powerful, paddle wheels bigger. The double smokestack became the symbol of the steamboat, and between them many a boat carried a gilded ornament or a flamboyant design of some kind—a cotton bale, a star, an anchor. Paddle boxes had their own ornamentation. Inside all might be white "gingerbread," wood curlicued and gilded, knobbed and flowered. Eventually exteriors were similarly trimmed until, as more than one person noted, they looked like wedding cakes afloat.

All steamboats of any size ultimately had "lounges" or central cabins in the style of ornate hotel lobbies, with rich rugs, oil paintings and lines of chandeliers. Chefs were taktn from famous restaurants and had large staffs to assist them. A number of boats had large orchestras, and there were maids and butlers to assist

cabin passengers. Surviving menus show scores of dishes, nith choices of as many as 7 soups and 15 desserts. Now and then a vessel printed its own newspaper as it went up and down the river. For the men there were bars, long and mirrored and almost always jammed, barber shops and lounging quarters.

Eliza Ripley in her Social Life in Old New Orleans tells how one imaginative owner decorated stateroom doors (and flattered particularly good steamboat patrons) with views of some of the great plantation homes along the Mississippi. Nevertheless, Mrs. Ripley makes clear that, with all the display, such trips might be arduous. On the popular "Grey Eagle," berths were so narrow that, in trying to turn over, she fell out and landed in the wash-basin on the opposite side. Her sister, sitting on the lower berth to braid Eliza's pigtails, "then sent me forth so that she could braid her own." Service proved negligent, meals confused and disorganized.

Outside the cabins a simpler, rougher life went on. Roustabouts and crew stretched on the decks, and with them deck passengers who might be poor traders trying to sell wares in the hinterlands, new'settlers and their wives, immigrants from Europe or flatboatmen going upriver. (The latter continued to flourish for down-river trips, in spite of the arrival of steam power.) In the social caste system of the south such passengers received little heed and almost no care; they sat or lay wherever they could.

The captain became an omnipotent person, a man with vast authority over life, commerce or well-being. He could remove a passenger at a word, and tales are told of luckless ones dropped at marsh edges. He lived in splendour on land and water, often a man of many anecdotes, perhaps of prodigal hospitality when in good mood, but of sulfurous rages and thundering orders when others crossed him.

The steamboat pilot was a man deferred to by all on board, including the captain. He received top pay, and generally deserved it. On him depended the safety of passengers and crew, day and night. His was a rare ability, part long training, part detailed knowledge of an unbelievably complicated subject, part a quality approaching instinct.

The Mississippi remained treacherous, filled with snags, with driftwood, with shoal points just below the surface. Perched high above the steamboat, the pilot operated in darkness, depending on memory, on years of accumulated skills and on informed guesswork, for the river changed constantly and the pilot had to take chances at every point.

Mark Twain (Samuel Clemens) in his Life on the Mississippi has an inspired, often-quoted description of his interview with a pilot, while a cub on the river. Clemens was told he must "get this entire river by heart . . . know it just like ABC. . . . It is all there is left to steer by on a very dark night. Everything else is blotted out and gone." (Life on the Mississippi, Hillcrest ed., The Writings of Mark Twain, vol. ix, Harper & Brothers, New York, 1904.) Moreover, the cub had to learn that on a clear starlit night black shadows had special qualities that must be understood and that a certain line on the surface meant an obstruction, while another only a wind. But how could he know the difference? His teacher could not explain precisely; Clemens must watch and learn. It was no wonder that the cub said, at one point, that he wished he were dead. He later became an expert, however.

The blowing of the steamboat whistle, signaling an approach to a town, could electrify a river community. Hundreds would race to the riverbank to watch the excitement, to see who arrived, what news the crew brought, how high the cotton bales towered on the deck. (Sometimes the cotton filled every foot of space, blotting out light from cabin windows, so that candles had to be used by day.) The steamer carried foodstuffs and manufactured goods; it took produce and materials for transshipment.

At other points hundreds watched the procession of the steamboats. Since the engines swallowed fuel hungrily, men cut down vast supplies of cordwood and stacked them for quick pickups when needed. At isolated spots, tiny settlement points or the edges of plantations, individuals or clusters also stood on the banks for hours with flares to await the next vessel. Most steamboats would halt anywhere for business, even performing casual errands.

Smaller vessels, the showboats, were also moving along the Mississippi and tributaries with plays and vaudeville, little companies of entertainers with a staple line of melodramatic favourites. The showboats made their greatest successes at towns which had no other theatre. About them, as about the steamboats, went colonels, ministers, lawyers, prostitutes, thieves, schoolgirls, housewives—a cross section of the population of the day.

Repeatedly stories were whispered of well-dressed individuals, soft-mannered, hard-eyed, who struck up acquaintances with young travelers or others new to the river. After a few minutes at the bar the conversation went to cards; a game followed and in the morning the river gambler might leave with $10,000, a year's plantation profits. Other accounts describe games that went on for 36 or more hours, whole estates being lost by the lift of a card. Some gamblers operated singly, others in pairs, many maintaining that they operated "fairly and honestly."

The average life span of a vessel was four to five years. Not built to last long, the vessels' engines sometimes were poorly constructed and maintained, and the steamboats fell victim to obstructions in the river, to exploded boilers or mishandling in the engine room—or simply the yearning for speed. Time schedules constantly quickened. In Shreve's day the New Orleans-Louisville run was 25 days; in 1853 the "Eclipse" shortened it to less than $4\frac{1}{2}$.

From 1810 to 1850 an estimated 4,000 persons died in steamboat disasters. Classic accounts describe the drowning of scores, the hurling of bodies across banks; many lingered on, horribly burned, others were never found. A large proportion of such disasters could be traced to the custom of races on the river. Captains of two vessels, leaving a city about the same time or meeting in the river, would frown and shout at one another; from crew and passengers a cry would go up: "Beat 'm!" From then on hysteria would seize men and women. Shouting, waving, they would stare intently as one. then the other took the lead.

Safety precautions would be flouted, engines pushed beyond capacity, and then tragedy sometimes followed. Again, however, such races were also carefully prearranged, with thousands learning of them in advance and looking on from shore. The winning vessel would gain a new popularity, a great commercial advantage, if it survived.

Meanwhile, little heeded by the proud steamboat interests, two potent rivals were in the making. Railroad construction began early at Baltimore, Md., in the upper south, with the launching of the Baltimore and Ohio railroad in 1828. Bad times of 1839, however, deterred other large-scale southern railways, and along the Mississippi leaders scoffed at the new medium. Canal construction also started in 1828, between Baltimore and Cumberland, Md., yet few river people saw a reason for concern. Nothing could be faster or cheaper than the steamboats, they insisted.

Nevertheless by the 1850s patterns were changing. The new methods of transport were tapping the old steamboat market. River trade continued to thrive, often reaching new high totals; at the same time, however, railroads and canals took an ever greater share. The Civil War of 1861–65 played havoc with river transportation; for many miles gunboats replaced steamboats and the railroads proved their growing efficiency.

The postuar period saw a revival of steamboating, with new vessels and new spurts of prosperity. After dark years of neglect, the streams were improved, levees built higher; transportation became safer. and for a time many felt that old times had come back. The year 1870 witnessed a steamboat excitement such as the nation had never known, the greatest race of all.

Almost annually the time upriver had been reduced in successive competitions. The distance from New Orleans to Natchez had taken Henry Shreve five and one-half days: by 1835 it required only a day and 21 hours. In 1853 the "Natchez" (one of many bearing the name) cut the time to $17\frac{1}{2}$ hours. On June 30, 1870, another "Natchez" under Capt. T. P. Leathers, faced the "Robert E. Lee," Capt. John W. Cannon commanding. The two would race up to Natchez and beyond to St. Louis.

Along the river tens of thousands planned to watch; newspapers printed elaborate details and telegraph wires carried information to the world. Men bet unprecedented sums; reputations and for-

tunes were in the balance. The result was a raging contest and also a bitter controversy. Cannon stripped down his "Lee.!' rejecting freight, ripping out rigging, upper works, even doors and shutters to cut wind resistance, carrying pine knots and fat side meat to feed the fires. Leathers, more confident for his "Natchez," quietly took on some small freight; otherwise everything would be as usual, he said.

The race hegan at New Orleans at 5 P.M. A short way upriver at Baton Rouge, La.. Cannon made a surprise maneuver; he had arranged to have a fast boat loaded with additional fuel. The "Lee" did not stop to load as expected! but slowed up while the other vessel lay alongside under full steam, and the transfer mas thus made. The "Natchez" had to use the usual method. Yet thousands were certain that the latter boat would make up the gap. At Memphis, Vicksburg, Miss., Cairo. Ill. and other points the interest boiled high. but the "Lee" won, reaching St. Louis in 3 days, 18 hours and 14 minutes.

Slowly the old-time steamboats retired from the river. Today towboats and barges move in a heavy stream along the Mississippi and its tributaries: inland waterways development has brought a new prosperity, but of a different sort. The days of glamorous passenger service, of arrogant "palaces," colourful crews and roustabouts live on only in story and song.

BIBLIOGRAPHY.—E. W. Gould, *Fifty Years on the Mississippi* (1889); Samuel Clemens (Mark Twain), *Life on the Mississippi* (1883); Harnett T. Kane, *Natchez on the Mississippi* (1947). (H. T. K.)

MISSISSIPPI v. JOHNSON (4 Wallace 475, 1867), a suit brought by the state of Mississippi before the U.S. supreme court asking permission to file a plea "to enjoin and restrain Andrew Johnson. President of the United States . . . from executing . . . the Reconstruction Acts." Although the radical congress in March 1867 had passed the Reconstruction acts over his presidential veto, Johnson directed his attorney general to oppose the Mississippi plea.

The court held that the action was not within its jurisdiction. Chief Justice Salmon P. Chase said that the case fell under "the general principles which forbid judicial interference with the exercise of executive discretion."

MPSSOLONGHI or MESOLONGION (Mesologgion), the chief town of the department of Acarnania and Aetolia. Greece; in the Central Greece and Euboea region on the north side of the Gulf of Patras. about 7 mi. from the coast; pop. (1951) 12,179. The town is notable for the siege which Mavrocordato and Botzaris sustained in 1822 and 1823 against a Turkish army 11.000 strong, and for the more famous defense of 1825–26. Lord Byron died there in 1824, and is commemorated by a cenotaph.

MISSOULA, a city of western Montana. U.S., on the Clark fork of the Columbia river, at the mouth of the Bitterroot; the seat of Missoula county and the seat of the state university, opened in 1895. The city lies at the foot of the mountains in a broad valley which is the bed of a glacial lake, at an elevation of 3,223 ft. Missoula valley is the huh of five great western valleys —lower Flathead. Bitterroot, Hellgate, Blackfoot and St. Regis. The city is a regional headquarters for the U.S. forest service and is the training centre for the famous smoke jumping crews of forest fire fighters. Ft. Missoula. a pioneer fort now inactive, is located near the city. The Flathead Indian reservation is about 30 mi. N.W. The federal laboratory for the study and control of Rocky mountain spotted fever and similar diseases is at Hamilton, 35 mi. S.

The lumber industry is represented by a large mill at Bonner, 10 mi. E., and a paper pulp mill west of the city. A large beet sugar refinery is located in the city. Dairy products are also important.

The first settlement in the region was made in 1841, when Father Pierre Jean de Smet founded St. Mary's mission at the present Stevensville, 30 mi. S. of Missoula. The area now included by Missoula county was successively a part of Oregon, Washington and Idaho territories before Montana territory was formed in 1864. The city was founded in 1865 and incorporated in 1885; the name is from an Indian word of uncertain meaning. Missoula adopted a commission-manager form of government in 1954. but returned to the mayor-council form in 1958. For comparative population figures see table in MONTANA: *Population.*

(M. G. BU)

MISSOURI, popularly known as the "Show Me" state, one of the west north-central states of the United States. Its area is 69 686 sq.mi, making it 19th in size among the states. Its greatest width is 282 mi., length 304 mi. On the east the Mississippi river separates it from Illinois, Kentucky and Tennessee; on the north is Iowa and a short stretch of the Des Moines river: on the south is Arkansas; and on the west are Oklahoma, Kansas and Nebraska, with the Missouri river bend on the northwest. The state takes its name from the Missouri river, called by explorers after a neighbouring Indian tribe; the meaning of the word is not known. Missouri was admitted to the union in 1821 as the 24th state; its capital is at Jefferson City. The state flower is the downy han thorn (*Crataegus mollis*), the tree the dogwood and the bird the bluebird. The state motto is a quotation from Cicero, Salus *populi* suprema lex esto ("Let the Welfare of the People Be the Supreme Law"); there is no official state song. The state flag, adopted in 1913, has three horizontal bars of red, white and blue, on which is a circular device enclosing the state coat of arms surrounded by 24 stars.

PHYSICAL GEOGRAPHY

Physical Features.—The area that is now Missouri (between 36° and 40° 35' N. lat. and 89° 5' and 95° 45' 11'. long.) was alternately sea bottom and dry land at many times during its geologic history. Only large bodies of water could have deposited such huge and uniform areas of rock. Ripple marks are common in the sandstone of the Ozarks, and fossils in the rock show remains of coral and other sea organisms. Marine sediments probably covered even the ancient granite and porphyry hills, though later erosion has removed some overlying rock, exposing the igneous strata. At one time molten rocks formed the entire surface of the state; as these cooled, stream erosion created a vast plain interrupted by occasional knobs, mountains and valleys. Into the primeval sea rivers emptied mud and clay which became shale; sand turned into sandstone; gravel became conglomerate; and the remains of sea organisms helped form limestone (calcium carbonate) and dolomite (calcium magnesium carbonate). Factors in the formation of the state's four geologic regions were glaciation, uneven arching of bedrock: and erosion and weathering of various types of rocks.

Glaciated *Plains.*—Two major glaciers covered most of north Missouri; a third glacier entered from Illinois. affecting St. Louis and St. Charles counties. To the west of Jefferson City glaciation crossed the Missouri river to the northern edge of Pettis county; to the east it stopped a few miles short of the present river bed. Glaciers forced streams out of their valleys in the bedrock with deposits of clay, sand, gravel and boulders.

Ozarks.—Great springs, caves and sinkholes are common in the Ozarks and bordering areas where ground water has dissolved soluble dolomites or limestone. Springs also flow from beds of permeable material, such as sandstone. The Missouri Geological survey defines this region of hills, plateaus and deep valleys as extending to the north bluffs of the Missouri river valley as far west as Glasgow. The eastern margin spills over into Illinois from St. Charles county, returning to hlissouri at Cape Girardeau and running southwest through Poplar Bluff and into Arkansas. The western edge stops short of Sedalia, Osceola and Springfield, which are in the western plains region, thence extends southwest to the tip of Oklahoma. Some streams follow courses cut thousands of years ago through sediments, occasionally encountering hard knobs of granite or porphyry, with a consequent narrowing of the valley to form what are called locally shut-ins. In the course of time the Ozarks were worn down to a plain, on which sluggish streams meandered in crooked channels similar to those of the present Mississippi. When the Ozarks were again uplifted, the streams stayed in their old channels, cutting deep valleys, some as much as 400 ft. below the adjacent uplands. The state's highest point is Taum Sauk mountain in Iron county, 1,772 ft. While large areas of the Ozarks reach 1,400 ft. in altitude. parts are less than 1,000 ft. above sea level; elsewhere in the state elevations above 1,200

ft. are not unusual. (See also OZARKS.)

Western Plains.—The bedrock of the plains adjacent to the Ozarks is cherty or flinty limestone with lower layers of shale. Large limestone quarries are common around Springfield, Osceola and Sedalia; pure. brittle limestone that takes a marblelike finish is found in the vicinity of Carthage and Joplin. The bedrock is younger west of a line through Jasper, Cedar, St. Clair, Benton, Pettis and Saline counties; in these sediments are deposits of coal, oil and gas.

Southeastern Lowlands.—Long after the seas had permanently withdrawn from the rest of Missouri, an arm of the last sea to reach the state extended from the present Gulf of Mexico, covering the lowlands that were in the process of sinking. This sea deposited a thick accumulation of sand, clay and shale, later easily eroded by the hlississippi river. This area includes Stoddard, Dunklin, New Madrid, Mississippi, Pemiscot and parts of Butler, Bollinger. Scott and Cape Girardeau counties; altitude 230 ft.

Climate.—The weather in general is changeable, but there are many periods when it is settled and moderate; winters are fairly brisk, with occasional short periods of extreme cold; excessively warm summers are the exception. Average number of days with temperatures below 32° F. ranges from about 105 in the north to about 65 in the extreme southeast. Average annual precipitation ranges from about 50 in. in the southeastern lowlands to 32 in. in the extreme northwest, about 42% falling in the crop-growing months, May through August. Occasionally, summer thundershowers are accompanied by hail and high winds. Tornadoes, usually with narrow paths, dip down once or twice a year, often disintegrating after a few miles. Extremes of heat, cold, drought and moisture occur. Winters in the Ozarks are milder than in the upland plain and prairie section, largely due to differences in latitude, but summers average cooler because of the higher altitude.

Soil.—A blanket of wind-blown dust or loess spread over much of the state during the glacial period. This thick yellow silt caps the bluffs on the Missouri and the Mississippi upstream from the central part of the state, in the northwest, to depths of 50 to 75 ft. Bands of alluvium in the bottom lands of the larger streams form another area of productive soils. Glacial till, clay with a small mixture of sand and gravel, found in the north, varies in fertility, depending on plant organic material. In the Ozarks bedrock is mainly cherty limestone and dolomite. which tends to gravelly or stony soils low in fertility. Shales are the most important soil-forming materials in the prairie region of the southwest. Most upland areas have a heavy or claylike subsoil, favourable to retention of water in ponds but reducing absorption and increasing runoff and erosion. Depth of surface or topsoil ranges from one to three feet for most alluvial or bottom-land soils to four inches or less on severely eroded hillsides. Loess soils in the northwest are 18 in. or more deep. Approximately ten inches is normal throughout the northeastern, central and southwestern sections, and six to eight inches in most of the Ozarks. Deepest soils are in the drainage area of the southeast lowlands and in the Missouri and Mississippi bottoms.

Vegetation.—Forests (mostly oak-hickory type) once covered more than two-thirds of Missouri, although the prairie lands of the north and west had trees only in the valleys. Most of this was cut over during the period of ruinous lumbering in the 19th and early 20th centuries (see Lumbering, below), and the lush grass of the original prairies has disappeared. Even today, however, black willow, sycamore, red cedar, American elm, oak, hickory, ash, walnut, hazelnut, linden and maple trees may be found throughout the state, as well as honey locust, dogwood, redbud, sumac, hackberry, persimmon, papaw, wild plum, cherry and crab apple. Many kinds of berries grow wild, as do wild flowers; from spring to late autumn, forests and pastures are bright with goldenrod. milkweed, spiderwort, sweet William, roses, bloodroot, columbine, verbena, shooting star, jack-in-the pulpit, trumpet vine, bittersweet, asters and many others. The swamp regions that remain have characteristic vegetation, including bald cypress, corkwood. water locust, swamp cottonwood, etc.

Animal Life.—The large game animals—buffalo, elk, black bear, panther, antelope, badger—that once were numerous in Missouri have all disappeared past recall. Others, such as water turkey, deer and beaver, whose numbers were reduced by hunting, lumbering and land cultivation, are being brought back by conservation efforts. A nonpartisan conservation commission, first provided for in 1936 and financed largely from sale of hunting and fishing permits, has co-operated in habitat development, restoring food, cover and water for animal life. Encouragement of farm pond construction, erosion control plantings of shrubs and a program of education have increased the numbers of principal small species—quail, rabbits, squirrel and doves. Live trapping and redistribution multiplied beaver from a few colonies to populations permitting an annual open season on all major streams. Deers were similarly increased to an estimated 250,000 animals, distributed state-wide, with a legal harvest of about 14.000 annually. The commission developed over 30 areas for waterfowl shooting, warm-water fishing, trout fishing, general hunting and natural production of wildlife for trapping and redistribution. Lying in the heart of the great Mississippi flyway. Missouri is visited by more than 400 kinds of birds. and waterfowl hunting opportunities have been increased by public shooting areas.

State Parks.—The state park board of the department of conservation maintains cabins, camping grounds and dining lodges in many of the 30 state parks, approximating 70,000 ac. The most popular of these are around the large springs in the Ozarks. Alley Spring State park, in Shannon county, has an old mill and a pool fed by an average flow of 80,800,000 gal. of water a day. Bennett spring, near Lebanon, is larger, and Big spring, the largest single spring in the U.S., near Van Buren, pours 252,000,000 gal. daily into Current river. Similarly picturesque parks are Montauk, in Dent county; Roaring River, in Barry county; and Round Spring, in Shannon county.

Lake of the Ozarks State park, near Osage beach, the largest of the parks, has 89 mi. of shore line and about 4,000 ac. of water. The lake itself, formed by a hydroelectric power dam on the Osage river, is the largest lake in Missouri, with a shore line totaling 1,372 mi. Several streams flowing in deep valleys have been dammed, providing extensive multiple-purpose reservoirs combining facilities for water recreation with flood control, municipal water supply and electric power production: Taneycomo and Bull Shoals lakes (White river); Clearwater reservoir (Black river); Wappapello reservoir (St. Francis river). Preservation of the swift-flowing Current, Jack's Fork and Eleven Point rivers in their natural state has been the objective of conservationists and the national park service.

Tourism is an important business in Missouri. The $500,000,000 spent annually by tourists places it 11th among the states in this regard. Points of interest are the Truman library, at Grandview; the Harry S. Truman Birthplace Memorial shrine. at Lamar; the George Washington Carver National memorial, near Diamond, and the boyhood home of Gen. John J. Pershing at Laclede.

HISTORY

Numerous Indian mounds scattered about the state and discoveries of almost every type of arrowhead and spear point indicate an early and varied prehistoric population. Perhaps the largest mound is one found in Pemiscot county that is 400 ft. long, 250 ft. wide and 35 ft. high, surfaced with a sort of soft brick.

Early French explorers, Louis Jolliet and Jacques Marquette, opened communication from Canada by way of the Great Lakes and the Mississippi river in 1673. Although the Spanish Hernando De Soto discovered the Mississippi in 1541, René Robert Cavelier, Sieur de La Salle, who reached the Gulf of Mexico from upstream in 1682, claimed formal possession of the entire valley for France. Though some early historians credited both De Soto and Francisco Vasquez de Coronado with reaching the Missouri country. it is now considered that both stopped short of this.

In a two-day period, March 9–10, 1804, upper Louisiana, which in 1812 became the territory of Missouri, was successively under three flags, Spanish, French and American. The Louisiana Purchase of 1803 did not end the power struggle over the mid-continent. Spanish policy thereafter was directed toward dismemberment of the United States or at least prevention of

southwestward expansion toward Mexico, or New Spain. Large Spanish land grants west of the Mississippi had been given to American settlers in a mistaken effort to encourage disaffection, and some Americans in high places were on the pension list of the Spanish king. During the earlier period of French control fabulous reports of silver deposits near the Meramec river resulted by 1720 in mining operations by the Company of the Indies, a part of John Law's Mississippi bubble (see LAW, JOHN), in what became the world's greatest lead field.

Under the same speculative auspices Ft. Orleans was built on the Missouri river in what now is Carroll county. This trading post was designed to cultivate Indian relations as a countermove to a Spanish advance that had met disaster in what now is Nebraska. This farthest west outpost was abandoned by 1728 or 1729. Missouri's first permanent settlement, Ste. Genevieve, dates from about 1735, when French-Canadian habitants of Kaskaskia crossed the Mississippi from the Illinois country to work the lead mines.

Founding of St. Louis (*q.v.*) as a fur-trading post by Pierre Laclede Liguest came in 1764. Nearby, at the mouth of Des Pères river, as early as 1700, French Roman Catholic missionaries had set up a short-lived station with a large Indian population. A trading post that became St. Charles was established 25 mi. N.W. of St. Louis in 1780; this was the first state capital, 1821–26

American Migration.— Encouraged by the Spanish ambassador to the United States, Col. George Morgan, of Virginia. in 1789 gathered a party of 70 Americans to found a model city. New Madrid, across from the mouth of the Ohio, mhcre two French-Canadians had a trading post. Failing to receive concessions, including self-government, from the governor general at New Orleans, Morgan returned east, though many of his associates remained. Development of this southeastern area was impeded for years by the severe earthquake of 1811–12, which turned much land into swamp. Upriver, on higher ground, Louis Lorimier in 1795 received a grant to what became Cape Girardeau, where a small post had been established several years before. Most of the newcomers were Americans.

A landmark near Defiance, in St. Charles county, is the house built by Nathan Boone, in which his father, the frontiersman Daniel Boone, died in 1820. The elder Boone having lost his Kentucky land claims welcomed the offer (1798) of Spanish Lieut. Gov. Zenon Trudeau to provide 845 ac. in Femme Osage district, where Daniel Morgan Boone, his eldest son, previously had settled A party of settlers, including his youngest son, Nathan Boone, came with the famous pioneer, who was given a magistrate's office. That central Missouri district popularly called the Boonslick country was connected with St. Charles by Boonslick road, a main trail for settlers by 1822. At the terminus of Boonslick road was the town of Franklin, long since washed into the hlissouri river, an early outfitting point for the Santa Fe trail and boyhood home of the scout Kit Carson. There a government land office had first year sales (1818–19) exceeding 662,000 ac., valued at $1,894,000, less than $3 an acre. By 1830 the Boonslick country had a population of 43,394 out of the state total of 140.455.

Moses Austin in 1797, with a background in lead mining in Connecticut and Virginia, obtained a Spanish grant to Mine a Breton (or Burton), where the town of Potosi developed, in Washington county. Improving on older methods, Austin sank the first mine shaft, built furnaces, a shot tower and sheet lead plant in the woods, as well as a sawmill, flour mill, roads and bridges. Involvement in failure of the Bank of St. Louis in the panic of 1819 led him to attempt to recoup his fortunes in Texas, then a part of New Spain, where he was to settle 300 families. His death there in 1821 left his son. Stephen F. Austin, to carry on as the "Father of Texas," one of the long line of Missourians whose further migrations gave the state the name "Mother of the West."

Indian **Relations.**—When the white man came. the Osage and the Missouri were the main Indian tribes, apparently numbering about 15,000. Sauk and Fox war parties had almost destroyed the Missouri by 1789. Early exploration of the upper reaches of the Missouri by Meriwether Lewis and William Clark (1804–06) and two expeditions by Zebulon M. Pike, sent by Gov. James Wilkinson to the north and the southwest, encouraged trade relations, as well as added to geographic knowledge. During the War of 1812 Indian unrest stirred by the British and the Tories who had fled to Canada menaced outlying settlements. The governorship of Clark (1813–20) and his later administration of Indian affairs developed confidence among the chiefs, who often visited him in St. Louis, the administrative centre. Friction with remaining tribes was lessened by giving them lands farther to the west before settlers swarmed in.

In a final treaty with the Big and Little Osage nations in 1825, Clark awarded them a 50-mi. square tract in Kansas; a $7,000 annuity for 20 years, in money, merchandise, provisions or domestic animals, as desired; 600 head of cattle, 600 hogs, 1.000 domestic fowls, 10 yoke of oxen and 6 carts, farming implements and a blacksmith paid by the government to keep the tools fit; and comfortable and commodious houses for the principal chiefs. The proceeds of 54 sections of land were to support an Osage school, and reservations were to be established for mixed Indians-whites.

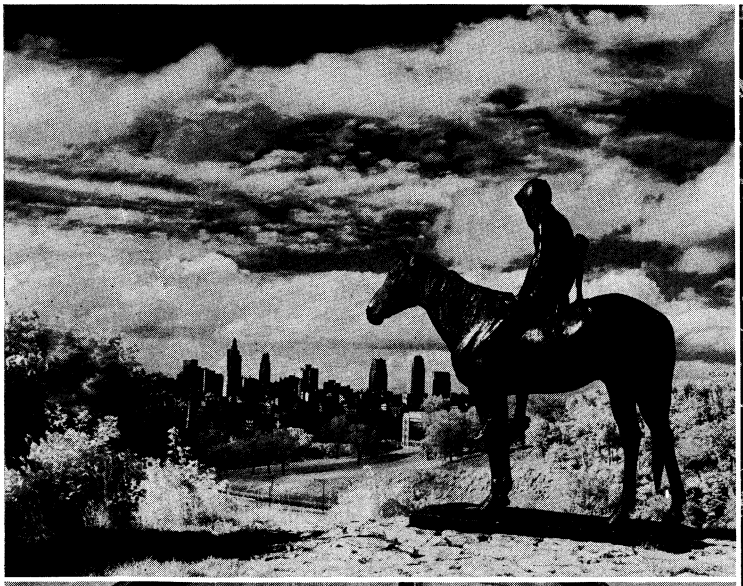
Building a State.— Desire for self-government was realized on Aug. 10, 1821, when Missouri was admitted to the union as the 24th state. (The struggle that took place in congress before the state's admission is described in the article MISSOURI COMPROMISE.) The population was 70,000. Southerners, comprising the first wave of settlers after statehood, took over fertile bottom lands as farmers, unlike their French predecessors, who had gathered in communities and tilled only small common fields. living mainly on the fur trade. No taxes had been collected by France or Spain; by 1805 U.S. authorities announced that taxes could be paid in shaven deerskins at the rate of three pounds to the dollar before a certain date. A shortage of currency made lead. as well as pelts, a medium of exchange.

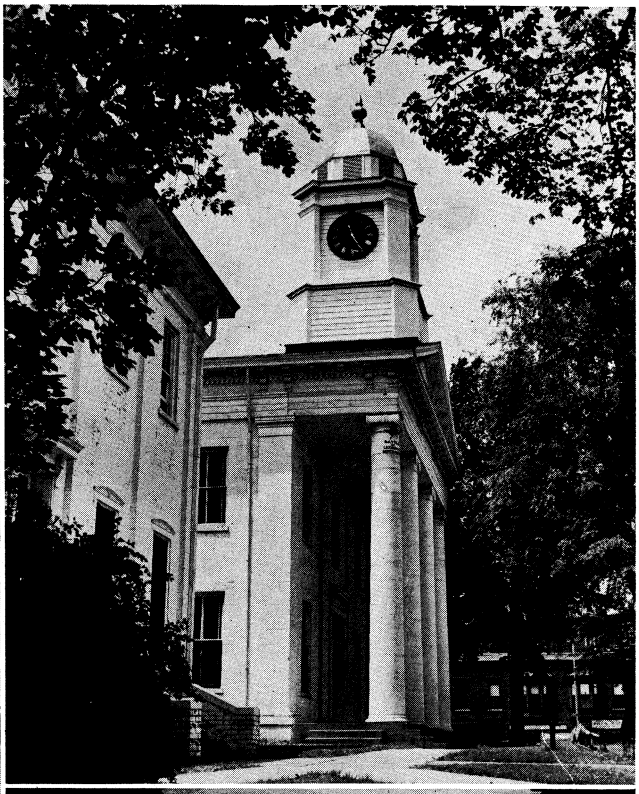
Opening of steamboat transportation on the Mississippi in 1817 (two years later on the Missouri) quickened and expanded the fur trade. Trappers worked more than 1,000 mi. up the Missouri, also reaching the Green river, and perhaps Great Salt lake, and opening South pass to California and Oregon. It was estimated that 250,000 buffalo were killed in 1848, and 25,000 buffalo tongues were shipped to St. Louis. The western branch of John Jacob Astor's American Fur company brought back 67,000 buffalo robes in 1840. Cargoes of tallow from bear and buffalo, a substitute for lard, sometimes were poured into hollowed-out boats and towed to market. Finally the development of the silk hat and an accompanying fashion for other furs diminished the market. much of which had been for manufacture of felt or beaver hats.

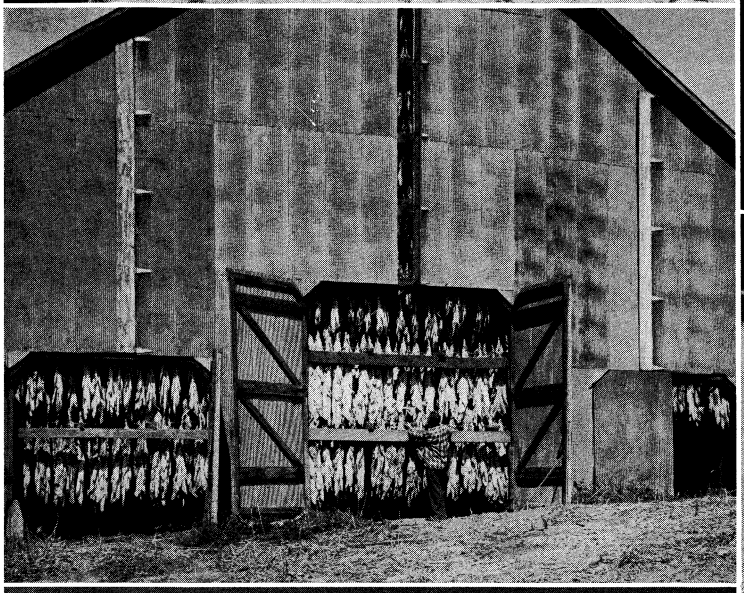
In much the same way the day of the steamboat passed. The first steamboat reached St. Louis in 1817, and the traffic expanded rapidly. In 1860 more than 5,000 vessels arrived at St Louis. But the American Civil War played havoc with river traffic, and after the nar the frantic interest in railroading also led to the decline of the steamboat. (See also MISSISSIPPI RIVER STEAMBOAT.)

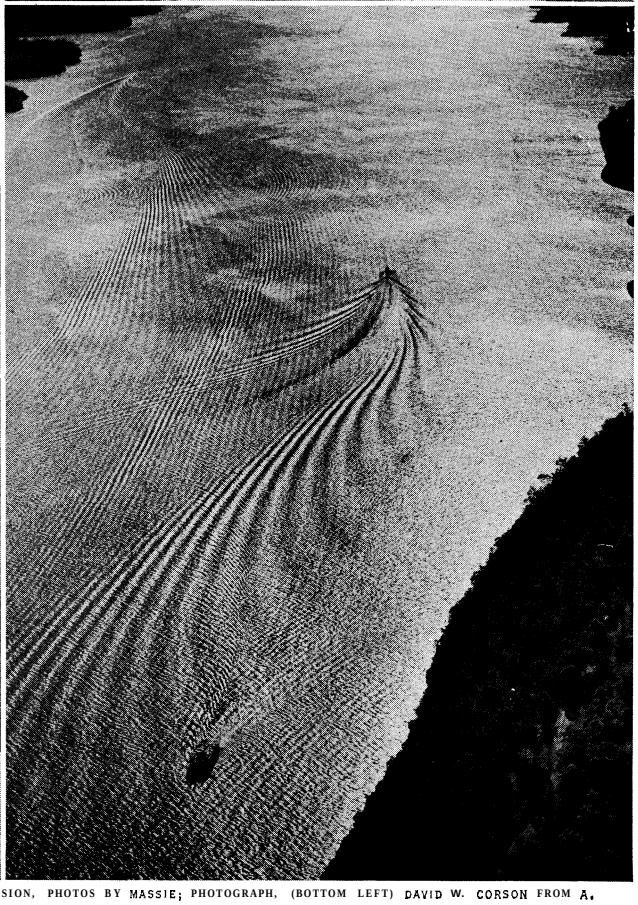
Bonds issued to promote rail lines during the period of intensive speculation cost the state treasury $25,000,000; many towns and counties bonded themselves for lines never built. The first railroad across the state, the Hannibal & St. Joseph (1859), short-cut Missouri river traffic and was connected with St. Louis by the North Missouri line at Macon. Four years earlier the Pacific railroad had been extended from St. Louis to the capital, Jefferson City; by 1865 this reached Kansas City on the western border. By 1858 the St. Louis & Iron Mountain railroad had an 86-mi. line to the Pilot Knob mining district; another line had reached Rolla by 1861. The great Eads bridge across the Mississippi at St. Louis was completed in 1874, a lower deck for rail traffic competing with the ferries: since 1857 a railroad from Cincinnati had disembarked passengers on the east bank of the river.

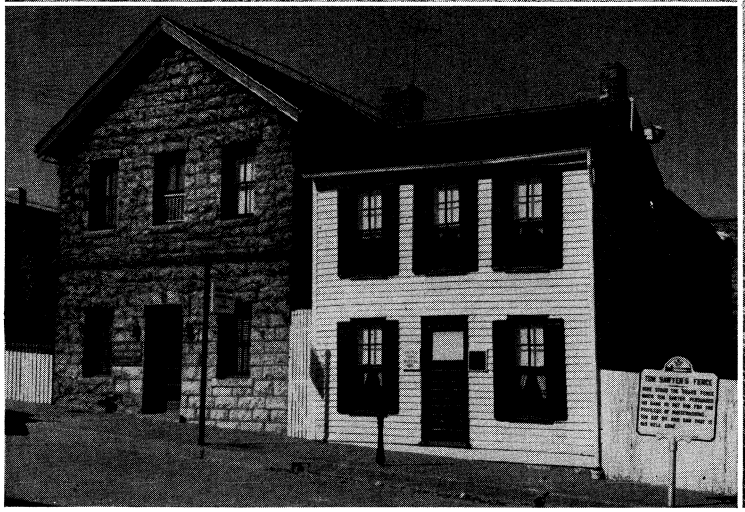
In the meantime overland trade with Santa Fe, N.M., had boomed from its opening in 1821, when Mexico had freed itself from Spain. The first expedition, by William Becknell and 21 men, started from Franklin. By 1827 the take-off had shifted west to Independence, and in the '40s to Westport, later a part of Kansas City. Traffic in cotton goods, cutlery and easily freighted products reached a value of $250,000 by 1831. A good part of this was in Mexican silver dollars, which were cut into halves, quarters and











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VIEWS OF MISSOURI

Top left: "The Scout," a bronze statue of a Sioux Indian by C. E. Dallin (1917) in Penn Valley park overlooking Kansas City

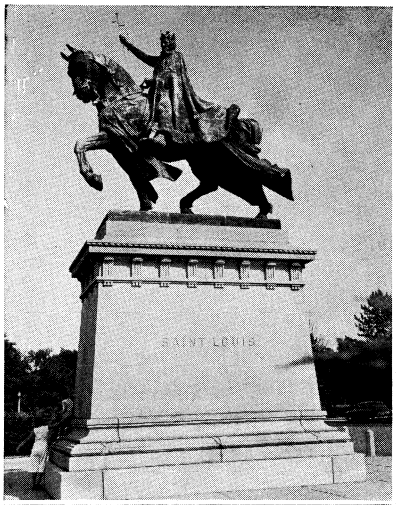
Top *right:* Lafayette county courthouse, Lexington. A cannon ball fired during the Civil War in the battle of Lexington (1861) is lodged in the pillar in the foreground

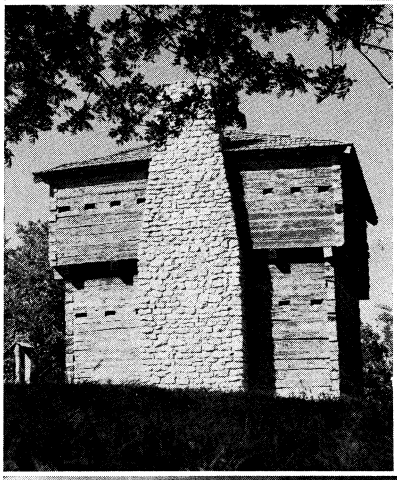
Centre left: Tobacco storage barn near the village of Weston, an important Missouri tobacco market

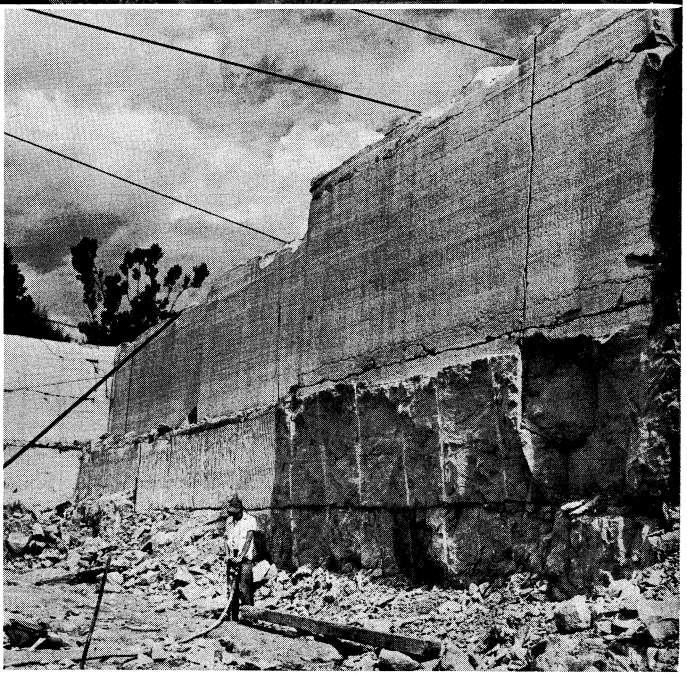
Bottom left: Mark Twain's (Samuel Clemens) house and museum, Hannibal. At the right is the fence of the whitewashing episode in "The Adventures of Tom Sawyer"

Bottom right: Boats on the Lake of the Ozarks, one of the largest artificial lakes in the U.S., formed by damming the Osage river

MISSOURI







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SCENES IN MISSOURI

Top left: Bronze equestrian statue of St. Louis the Crusader, in front of the City Art museum, Forest park. St. Louis

Top right: The state capitol, Jefferson City. In the right foreground is the governor's mansion

Centre left: Blockhouse of Fort Osage, Sibley, established in 1808 as a military and trading post by William Clark of the Lewis and Clark expedition

Bottom left: Picking cotton near Kennett, business centre of Dunklin county. Cotton is a major agricultural product of the state

Bottom right: Marble quarry, Carthage, an area rich in marble, zinc and lead

half-quarters, or bits, as preferable to wildcat paper. The exchange also laid the foundation of Missouri's extensive mule trade; in 1832 the caravans brought back 1.300 mules, jacks and jennets, or female burros. (See also SANTA FE TRAIL.)

Slavery and Politics.—Well-to-do southerners moving west for cheap land chose Missouri in preference to the Northwest territory, where slavery was forbidden. Slave labour also had been used extensively in French lead mining. At the outbreak of the American Civil War there were 144.000 slaves and 29,000 masters in a total Missouri population of 1,182,000; these Negroes mere taxed as property, assessed at $44,000.000 in 1860. The traditional southern institution came under question by later arrivals from the north and by the German immigrants who began to arrive in the 1830s. To a certain extent free labour was discouraged by slave competition, but the growing abolition movement was based on moral rather than economic grounds, while defense of slavery was involved in the emotional issue of states' rights.

The controversy mounted after statehood was granted under the Missouri Compromise (*q.v.*). Sen. Thomas Hart Benton as early as 1828 sought backing for gradual emancipation allied with an educational program. Elijah P. Lovejoy in 1837 was forced to leave St. Louis by a mob that pillaged the print shop from which his abolitionist *The* Observer was issued; five weeks later he nas killed across the river, in Alton, Ill. The difficulties experienced by the Mormons in Independence and later in Daviess and Caldwell counties (1831–39) were based partly on the fact that the Mormons, mostly northerners and easterners, were abolitionists while their neighbours, many from southern states, were not. (See also LATTER-DAY SAINTS, CHURCH OF JESUS CHRIST OF.) The legislature in 1847 established penalties for teaching any Negro to read or write and forbade any free Negro to enter the state. Benton's refusal to push the slavery cause ended his 30 years in the senate in 1851.

The Dred Scott case, originating in St. Louis in 1847 and calling into question the constitutionality of the Missouri Compromise limitation on slavery, sharpened the issues. Annexation of Texas, war nith Mexico and the Kansas-Nebraska act of 1854 found Missouri officially on the slavery side. The Kansas-Nebraska act, leaving the question of free soil or slavery to residents of the territories, led to persistent border troubles between Missouri and Kansas (*q.v.*), in which peaceful citizens suffered. Emancipation was advocated by the Free-Soil movement in 1856, led by Francis P. Blair, Jr., and B. Gratz Brown. In the first summer of the mar Gen. John C. Fremont from headquarters in St. Louis proclaimed the freedom of all slaves owned by active secessionists in the state. This was reversed by President Lincoln's policy, which sought to compensate border-state slaveowners in advance of unpaid emancipation in the Confederate states. Nothing coming of this, the state legislature in 1863 voted for gradual emancipation and abolition by 1870. The new state constitution, proclaimed by Gov. Thomas C. Fletcher, a radical Republican, on Jan. 11, 1865, abolished slavery.

Civil War and Reconstruction.—Of all Missourians of military age 60% served in the war, 109,000 in the Union army and 30,000 in the Confederate. Federal casualties reached 14,600 dead. While many engagements were fought in the state, that of greatest magnitude was the battle of Wilson's Creek, Aug. 10, 1861, in which Gen. Nathaniel Lyon was killed and his outnumbered Federal troops forced back toward Springfield. Governor Jackson, who advocated secession, had fled from Jefferson City before Lyon's advance, and a provisional government, headed by Judge Hamilton R. Gamble as governor, was established through action by a delegate convention that had voted against secession. Efforts to take St. Louis, stronghold of Union strategy. were defeated by Gen. U. S. Grant at Belmont, Mississippi county, and by Gen. Thomas Ewing at the battle of Pilot Knob in Sept. 1864. In the latter attack Gen. Sterling Price lost 1.000 men out of the Confederate force of 12,000; Union losses were 200. Ruins of the earthworks of Ft. Davidson, the Federal stand, are visible along the Iron county highway. Swerving back across the state, Price finally mas defeated in the battle of Westport, three days' losses amounting to 1,000 on each side, putting an end to Confederate hopes in Missouri.

Guerrilla warfare ravaged Missouri throughout the war, particularly along the Kansas border. Gen. Thomas Ewing, of the 11th Kansas volunteers, by his drastic order no. 11 in 1863 compelled all residents of several Missouri border counties except those within a mile of principal towns to leave their homes within 15 days. Those proving loyalty could stay at any military station or move to the interior of Kansas. All grain and hay not delivered to the nearest post was destroyed. A famous painting by the Missouri artist George Caleb Bingham depicts a family leaving their looted and burning home, a picture indicating the reaction to the deportations even by Union sympathizers.

Similar revulsion arose at the end of the war to a new state constitution listing 86 acts that a citizen must deny under oath in order to vote. No person who had aided or sympathized with the Confederacy could function as a lawyer, teacher or minister. The constitutional convention also ordered all court officers removed in order to forestall legal obstruction. The radical Republicans could not realize that the war was over, and it was 1870 before Sen. Carl Schurz, supported by conservative Republicans among his fellow Germans and with the aid of the reorganized Democratic party, elected B. Gratz Brown governor and obtained repeal of the loyalty test (its clause disqualifying professional men from practice had previously, in 1866, been declared unconstitutional by the U.S. supreme court). In 1872 Democrats assumed control of the state and in the ensuing 88 years were interrupted by only five Republican governors. The period closed with a new constitution drawn up in 1875, putting a limit on taxes, requiring a two-thirds majority in bond elections and limiting state debt to $250,000 in any one year, a reference to heavy losses in railroad financing.

Mid-20th-century sessions of the general assembly authorized watershed conservation districts; tightened regulation of nursing homes for the aged (after loss of 72 lives in a fire); and widened the powers of the Bi-State Development agency to own and operate facilities, from bridges to airports and transportation, in the metropolitan area adjacent to St. Louis in Missouri and Illinois.

GOVERNMENT

Under the constitution adopted in 1945 six executive officers are elected for four-year terms: governor, lieutenant governor, secretary of state, state auditor, state treasurer and attorney general. Election of the auditor is held independently, at mid-term. All other heads of departments are appointed by the governor. There are 114 counties, plus the city of St. Louis, which ranks as a county in itself. Each county is entitled to at least one member in the house of representatives, the more populous counties having more, all elected for two-year terms. There are 34 senatorial districts; each elects one senator for four years, half of the body coming up for election every two years. The general assembly meets in the capital, Jefferson City, in odd-numbered years.

Under a nonpartisan court plan the governor appoints one of three persons named by a special commission to fill vacancies in the supreme court and courts of appeals. The chairman of this nonpartisan commission is the chief justice of the state supreme court; members of the bar in each appeals district elect one member, and the governor selects one citizen, not a member of the bar, from each of the three appeals districts. At the next general election after the appointee has been on the bench for at least one year the people vote on a special ballot as to whether he shall be retained in office. Vacancies in circuit courts of the city of St. Louis and in Jackson county (Kansas City) are filled similarly. Upon expiration of a judicial term an incumbent wishing to succeed himself is listed on a ballot without party designation, and voters vote yes or no on the question as to whether he shall be retained in office.

The per capita debt of the state as computed in 1938 stood at $6.17, the total being $24,398,839. Assessed valuation of all tangible property was about $7,000,000,000. Sales tax receipts provided about 61% of general revenue, income tax 23%, liquor taxes 4.44% and general property tax 1.257,. A gasoline tax was earmarked for highway use.

POPULATION

The 1960 census gave Missouri a population of 4,319,813, an increase of 9.2% over the 1950 population of 3,954,653. Population in 1810 was 19,783; in 1860, 1,182,012; and in 1900, 3,106.-665. The state in 1960 had four standard metropolitan statistical areas, which are Kansas City, St. Joseph, St. Louis and Springfield. These areas had a total population of 2,893,536, or 67.0% of the total population of the state. Only 33.456 of those enumerated constituted the rural population.

*Missouri: Places of 5,000 or More Population (1960 Census)**

Place	Population				
	1960	1950	1940	1920	1900
Total state	4,319,813	3,954,653	3,784,664	3,404,055	3,106,665
Ballwin	5,710	—	—	—	—
Bellefontaine Neighbors	13,650	—	—	—	—
Berkeley	18,676	5,268	2,577	—	—
Boonville	7,090	6,686	6,089	4,665	4,377
Breckenridge Hills	6,299	4,063	—	—	—
Brentwood	12,250	7,504	4,383	—	—
Bridgeton	7,820	202	169	121	178
Brookfield	5,694	5,810	6,174	6,304	5,484
Cape Girardeau	24,947	21,578	19,426	10,252	4,815
Carthage	11,264	11,188	10,585	10,068	9,416
Caruthersville	8,643	8,614	6,612	4,750	2,315
Charleston	5,911	5,501	5,182	3,410	1,893
Chillicothe	9,236	8,694	8,012	6,772	6,905
Clayton	15,245	16,035	13,069	3,028	76
Clinton	6,925	6,075	6,041	5,098	5,061
Columbia	36,650	31,974	18,399	10,392	5,651
Crestwood	11,106	1,645	—	—	—
Creve Coeur	5,122	2,040	—	—	—
De Soto	5,804	5,357	5,121	5,003	5,611
Dexter	5,519	4,624	3,108	2,635	1,862
Excelsior Springs	6,473	5,888	4,864	4,165	1,881
Farmington	5,618	4,490	3,738	2,685	1,778
Ferguson	22,149	11,573	5,724	1,874	1,015
Festus	7,021	5,199	4,620	3,348	1,256
Florissant†	38,166	3,737	1,369	682	732
Fulton	11,131	10,052	8,297	5,595	4,883
Gladstone	14,508	—	—	—	—
Glendale	7,048	4,930	2,526	749	—
Grandview	6,027	1,556	596	410	—
Hannibal	20,028	20,444	20,865	19,306	12,780
Hazelwood	6,045	336	—	—	—
Independence	62,348	36,963	16,066	11,686	6,974
Jefferson City	28,228	25,099	24,268	14,490	9,664
Jennings	19,965	15,282	—	—	—
Joplin	38,958	38,711	37,144	29,902	26,023
Kansas City	475,539	456,622	399,178	324,410	163,752
Kennett	9,098	8,685	6,335	3,622	1,509
Kinloch	6,501	5,957	—	—	—
Kirksville	13,123	11,110	10,080	7,213	5,966
Kirkwood	29,421	18,640	12,132	4,422	2,825
Ladue	9,466	5,386	3,981	—	—
Lebanon	8,220	6,808	5,025	2,848	2,125
Lees Summit	8,267	2,554	2,263	1,467	1,453
Liberty	8,909	4,709	3,598	3,097	2,407
Malden	5,007	3,396	2,673	2,098	1,462
Maplewood	12,552	13,416	12,875	7,431	—
Marshall	9,572	8,850	8,533	5,200	5,086
Maryville	7,807	6,834	5,700	4,711	4,577
Mexico	12,889	11,623	9,053	6,013	5,099
Moberly	13,170	13,115	12,920	12,808	8,012
Monett	5,359	4,771	4,395	4,206	3,115
Neosho	7,452	5,790	5,318	3,968	2,725
Nevada	8,416	8,009	8,181	7,139	7,461
North Kansas City	5,657	3,886	2,688	—	—
Olivette	8,257	1,761	987	—	—
Overland	22,763	11,566	2,934	—	—
Pagedale	5,106	3,866	—	—	—
Perryville	5,117	4,591	3,907	1,763	1,275
Pine Lawn	5,943	6,425	—	—	—
Poplar Bluff	15,926	15,064	11,163	8,042	4,321
Raytown	17,083	—	—	—	—
Richmond Heights	15,622	15,045	12,802	2,136	—
Rock Hill	6,523	3,847	1,821	—	—
Rolla	11,132	9,354	5,141	2,077	1,600
St. Ann	12,155	4,557	—	—	—
St. Charles	21,189	14,314	10,803	8,503	7,982
St. John	7,342	2,499	—	—	—
St. Joseph	79,673	78,588	75,711	77,939	102,979
St. Louis	750,026	856,796	816,048	772,897	575,238
Sedalia	23,874	20,354	20,428	21,144	15,231
Sikeston	13,765	11,640	7,944	3,613	1,077
Springfield	95,865	66,731	61,238	39,631	23,267
Trenton	6,262	6,157	7,046	6,951	5,396
University City	51,249	39,892	33,023	6,792	—
Warrensburg	9,689	6,857	5,868	4,811	4,724
Washington	7,961	6,850	6,756	3,132	3,015
Webb City	6,740	6,919	7,033	7,807	9,201
Webster Groves	28,990	23,390	18,394	9,474	1,895
Wellston	7,979	9,396	—	—	—
West Plains	5,836	4,918	4,026	3,178	2,902
Woodson Terrace	6,048	616	—	—	—

*Populations are reported as constituted at date of each census. †Returned until 1910 as Florissant, from 1920 to 1940 as St. Ferdinand and from 1940 as Florissant.
Note: Dash indicates place did not exist during reported census, or data not available.

In 1950 nonwhites in the state were 7.6%, almost all Negro. Foreign-born white mere 2.3%, still mainly from Germany; Russia and Italy ranked next, and there were considerable numbers of British, Irish, Austrians and Poles.

The population per square mile in 1960 was 62.0, as compared with 57.1 in 1950 and with 49.6 for the U.S. in 1960.

The number of occupied dwelling units (or households) in 1950 was approximately 1,190,000, as compared with 1,069.000 in 1940. The average population per household had declined from 3.5 in 1940 to 3.3 in 1950.

There mere 96.4 males per 100 females in the 1950 population, as compared with 98.8 in 1940. Of the population 14 years old and over, 52.2% was in the labour force; 22.4% of employed males were engaged in agriculture, 7.5% in construction. 21.6% in manufacturing. 8.1% in transportation, 17.7% in wholesale and retail trade and 11.1% in service activities of all kinds.

The most conspicuous population trend is that toward increase in urban and comparative decline in rural population. but the latter is real as well as comparative. In 1950, with 748 places of less than 2.500 population, offering little employment opportunity, a heavy migration, particularly of younger people, to industrial centres, some outside the state, was under way. Most counties have experienced a population decline, and many of them had fewer people in 1960 than they did in 1890; in the northwestern half of the state all counties without major cities had fewer people than they had in 1890. The six southeastern counties are the only rural counties to show upward trends. The percentage of persons 65 years of age and older was 2.256, higher than the national average, explainable largely by the emigration of younger persons.

EDUCATION

Efforts to obtain a standard level of educational opportunity in both urban and rural schools led to the establishment of a foundation program of equalization in 1955. It was successful in reducing the number of school districts, which numbered 8,400 in 1947, to fewer than 3,000 in the late 1950s. In addition to consolidation, the foundation program offered incentives and means for improved teaching. The state constitution requires that at least one-fourth of general revenue be apportioned for support of public schools; to this a cigarette tax was added under the foundation program. Legal limitations prevent use of state school funds for children under 6 years of age and for persons 21 or over, and this interferes with kindergarten and adult educational activities. A state board of education composed of lay members appointed by the governor performs routine functions, with an administrator in charge.

Special schools include the State School for the Deaf, at Fulton, and the State School for the Blind, at St, Louis.

University of Missouri.—The University of Missouri, first state university west of the Mississippi, was established in 1839. It later became the first land-grant college in the west through its school of agriculture and mechanical arts on the main campus at Columbia and the school of mines and metallurgy at Rolla. In the early 1960s there were 14 schools and colleges on the 900-ac. main campus. with an enrollment of more than 11,000 full-time resident students, and 3,000 additional students at Rolla, a centre of scientific research and engineering. More than 10,000 correspondence students were enrolled annually, and 1,160 mere in extension courses for college credit. The agricultural extension service reached thousands of persons for farm and home programs, and the agricultural experiment station conducted research, teaching and field work on more than 23,000 ac. of farm lands and timberlands, as well as in laboratories.

The school of journalism, established in 1908, was the first of its kind; it operates a newspaper and provides a staff for the radio and television stations. The college of arts and science includes the school of social work. The schools of forestry and of home economics are allied with the college of agriculture. There are also colleges of education and of engineering; a graduate school; a school of business and public administration; a school of law; a school of medicine, including a school of nursing and a separate school of veterinary medicine.

The university library contains nearly 1.000.000 volumes.

Other Institutions of Higher Education.—Broadening of the curriculum of state normal schools led to renaming these. each under its regional board of regents. Northeast Missouri State Teachers college (founded 1867), Kirksville; Southeast Missouri

State college (1873), Cape Girardeau; Central Missouri State college (1870), Warrensburg; Northwest Missouri State college (1905), Maryville; and Southwest Missouri State college (1906), Springfield. Lincoln university, established for Negroes in 1866 at Jefferson City, has been integrated racially, as have other state schools. In 1808 Ste. Genevieve academy was chartered, and such private or church-related schools reached 204 by 1850. Ten denominational colleges, chiefly Protestant. belonged to the Missouri College union in the early 1960s. These were included among 19 senior colleges, of which St. Louis university (Roman Catholic; 1818) and Washington university (nonsectarian; 1853), both of St. Louis, were the largest (see ST. LOUIS). The University of Kansas City (nonsectarian), chartered in 1929, enrolls nearly 2.000 students annually and has a library of approximately 200,000 volumes. There were also 14 junior colleges, including several operated as part of the public-school system of some communities, and a number of religious seminaries.

HEALTH AND WELFARE

Missouri has pioneered in the mothers' pension plan (aid to dependent children originated in Jackson county in 1911); in special education for handicapped children; and in harmonizing its juvenile court code with modern conditions. It also integrated its schools in prompt and orderly fashion after the supreme court decision of 1954 declared racial segregation in public schools to be unconstitutional. Such progress seldom has come suddenly by passing laws—Roman Catholic parochial schools ended segregation before the public-school system did—reform originating, instead, in the responsible concern of large groups of citizens. Among such factors are the Missouri Association for Social Welfare, the League of Women Voters and religious agencies, such as the Metropolitan Church Federation of St. Louis. with its counseling service, training programs and interpretation of current needs through radio, television, press and pulpit.

Although hospital facilities have been poorly distributed about the state, St. Louis and Kansas City provide outstanding medical centres. The department of health and welfare, set up under the state constitution of 1945, operates a cancer hospital at Columbia and a tuberculosis sanatorium at Mount Vernon. Its division of mental diseases has hospitals at Fulton. St. Joseph, Nevada, Farmington and St. Louis, in addition to the Missouri State school at Marshall for the care and training of mentally retarded and epileptic children, and the St. Louis Training school for mental defectives between 5 and 20 years of age. The division of welfare assists persons over 65, dependent children, victims of calamity, the disabled and the blind and also administers direct relief and child welfare service. The state department of correction controls a penitentiary for men at Jefferson City and an auxiliary for women at Tipton and the Intermediate Reformatory for Young hfen at Algoa Farms, near the capital. There are also several prison farms. with two canneries, two dairies, a pickle factory. a slaughterhouse and tno quarries. In 1957 the site for the medium security prison was acquired near Moberly. A training school for boys is at Boonville, that for girls at Chillicothe.

ECONOMY

Nearly half the counties in 1959 had no village with a population as large as 2,500, and only 18 counties had towns larger than 10,000. Increasing farm mechanization had resulted in two-thirds of rural youth, mainly those of greater aptitude, both men and women, leaving to seek economic opportunity in larger centres. The result was a reservoir of unskilled labour at wages slightly below the national level. Four distinct rural areas stem from interacting economic, social, cultural and physical characteristics. Largest is that north of the Missouri river, extending south along the western border to Jasper and Lawrence counties; this has a relatively high level of living, with emphasis on education and commercialized farming. Another begins with Cole county, extending along the Missouri and Mississippi to Cape Girarcleau, including early French settlements but with a German background, dating to 1837. at Hermann. Here are Lutheran and Catholic parochial schools, less attendance at high school, lower relief expenditures and some off-farm employment. A third division is the Ozarks, populated by descendants of southern highlanders, with much subsistence and part-time farming and a higher birth rate, altogether reminiscent of early America. Six counties in southeast Missouri form the fourth area, nith a high percentage of Negro labour, tenant farming, with little permanent tenure, and fixed social classes.

Agriculture.— Fewer but larger farms have resulted from increasing mechanization. The bureau of the census in the second half of the 20th century reported a total of about 200 000 farms in Missouri, a decline of 17.5% during and after World War II. The census of 1930 listed 55,000 more farms and an average acre value of $53.23, as compared with $81.45 in the 1950s. Though total acreage in use remained approximately unchanged, average farm size increased in 25 years from 132.2 ac. to 169.6 (28%). Missouri ranks third in farm co-operative membership, following Minnesota and Illinois. The Missouri Farmers association, centred in Columbia, marketing crops and processing and distributing supplies ranging from seeds to tractor fuel, reported over 155,000 members in the second half of the 20th century, operating three feed mills, three fertilizer plants, two plants processing poultry, eight handling milk, and a packing house. The Consumers Co-operative association of Kansas City, a regional supply agency operating in 11 states, reported $130,000,000 of supplies distributed annually, mainly petroleum, fertilizer and feed. Loans from the Rural Electrification administration, chiefly to co-operatives, by the early 1960s had provided power to nearly all the state's farms. The number of tenants decreased from a peak of 91,000 in 1940 to 35,000 in a period of 15 years. Factors favourable to better rural living included the soil conservation service (through erosion control and water management) and the Farmers Home administration, both in the U.S. department of agriculture; the latter provided loans to family-sized operators to improve living and operating conditions and for purchase, enlargement or development of farms.

Cash farrn income from cattle, hogs, milk, poultry and eggs represents well over 60% of total farm income. Chief crops, in order of cash value, are corn, wheat, soybeans, cotton (lint; an excellent long-staple variety) and hay.

Industry.— Of states west of the Mississippi, Missouri ranks third in manufacturing, after California and Texas. A tendency toward decentralization, notably in the shoe and clothing industries, has supplemented the basic food processing and lumber operations usually seen outside metropolitan areas. Wide diversity is reflected in the more than 6,000 industrial establishments, with nearly 400.000 employees. an annual payroll of $1.600,000,000, and a $3,200,000,000 value added by manufacture annually in the second half of the 20th century, the latter sum having nearly doubled in the ten-year period following World War II. The leading industries, in order according to value added by manufacture, are transportation equipment, food and kindred products, chemicals and kindred products. machinery (excluding electrical), fabricated metal products and leather and leather products. Of the 448 classifications used by the federal census of manufactures nearly 400 are represented in Missouri.

Mining.— Mineral production by the early 1960s was valued at about $150,000,000 annually. Missouri leads the states in production of lead, as it has since 1906, and barite; it is the second largest producer of lime and the third of fire clay. Its five principal minerals, in order of value, are cement, stone, lead. lime and coal. Nonmetals account for 63% of the total mineral value, metals 29% and mineral fuels 8%. A notable increase in iron ore potential accompanied drilling discoveries in the Pea ridge district near Sullivan of high-grade deposits estimated at 100,000,000 tons, located at great depths. Government aid in financing exploration for strategic minerals led to discoveries of lead in the Vibernun: area of southeast Missouri. said to exceed the old lead belt, which it parallels at a lower level. Bituminous coal is produced in numerous small mines scattered over the state. the largest being found in Henry, Macon, Bates, Barton and St. Clair counties; 96% of the tonnage is supplied by strip mines. Metals in small production include cobalt, copper, nickel, manganese and

silver, with less amounts of cadmium, gallium, germanium and indium.

Forestry. — Through a system of reforestation, fire protection, and tax concessions to owners of well-managed forest croplands, much of the damage of earlier unrestricted lumbering has been offset. While most of the stands were immature in the early 1960s. trees grew on more than 15,000,000 ac., more than one-third of the state. In addition to state forests, comprising 170,000 ac., the Clark and Mark Twain National forests, in the southern Ozarks, protected 1,359,000 ac.

Damage created by open-range livestock in several counties was an obstacle to pulp mill establishment, although protected areas showed possibilities of increased growth. Replanting of 50,000 ac. mainly in shortleaf pine added a new wood to the commoner oak and hickory.

Trade and Finance. — Missouri is the only state with two federal reserve banks, one in St. Louis and another in Kansas City, reflecting the central geographic location, with large terminal farm markets and processing and distribution facilities. St. Louis also is a centre of farm credit agencies set up by the federal government but passing into farmer ownership — a land bank, a production credit association and a bank for co-operatives. Many communities have established industrial development corporations to attract new industries.

Transportation and Communication. — From the founding of the first newspaper, the *Missouri Gazette*, by Joseph Charless in 1808, at St. Louis, journalism has developed an aggressive tradition carried on by many noted editors. In the second half of the 20th century the press was supplemented by 18 television stations and about 80 radio broadcasting establishments. The two largest cities were main airline terminals, others being served by regional feeder lines. There were 23 trunk-line railroads, and federal and state highways crisscrossed the state, leaving no point more than a few miles from a modern highway. Many pipelines carrying natural gas, oil and gasoline crossed the state from the southwest. Waterways to the Gulf of Mexico from Kansas City and above had been supplemented by access to the St. Lawrence seaway through the Illinois river canal. Modern towboats made the round trip from St. Louis to New Orleans in 16 days, comparing favourably with schedules of river packets of old days. Whereas a modern tow consisted of 8,000 to 10,000 tons of freight, packets had been hard pressed to handle 600 tons, though some had carried 2,000.

See also Index references under "Missouri" in the Index volume.

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Current statistics on production, employment, industry, etc., may be obtained from the pertinent state departments; the principal figures, together with the current history, are summarized annually in the *Britannica Book of the Year*, American edition. (PL. G.)

MISSOURI COMPROMISE, a term referring to the compromise measures worked out in the U.S. congress that prepared the way for admission of Missouri as the 24th state. The immediate issue was whether slavery should be permanently legalized in the new state; a second issue was the policy of congress toward slavery in the territories west of the Mississippi river.

In Dec. 1818 congress received a petition to authorize Missouri to form a state government. When this was considered in the house of representatives on Feb. 13, 1819, James Tallmadge of New York introduced an amendment providing that no additional slaves should be admitted into Missouri and that children of slaves already there should be freed at the age of 25. Debates on this amendment revived the sectional controversies between north and south which had appeared periodically in the preceding 40 years. The amendment was accepted by the house, but rejected by the senate. Congress adjourned March 4, 1819, without acting on the Missouri bill.

The following summer a considerable body of public opinion in the north was rallied in support of the Tallmadge proposal. Much of this anti-Missouri sentiment, as it was called, arose from a genuine conviction that slavery was morally wrong. Political expediency was mixed with moral convictions. Many of the leading anti-Missouri men had been active in the Federalist party which seemed to be in the process of disintegration; it was charged that they were seeking an issue on which to rebuild their party. The Federalist leadership of the anti-Missouri group caused same northern Democrats to reconsider their support of the Tallmadge amendment and to favour a compromise that would thwart efforts to revive the Federalist party.

The 16th congress assembled in Dec. 1819 and on Jan. 3, 1820, the house voted to enable Maine to form a state government. The senate amended the bill to authorize both Maine and Missouri to frame state constitutions, the latter without restriction as to slavery. To this, the senate added an amendment offered by J. B. Thomas of Illinois to exclude slavery from all other parts of the Louisiana purchase north of the latitude 36° 30′, the southern boundary of Missouri. When the house refused to accept this compromise, Henry Clay took active leadership of the compromise group. Even with all his skill, the compromise proposals probably could not have passed the house as a single bill. A large majority of northern congressmen still were opposed to the unrestricted admission of Missouri while a larger proportion of southern congressmen opposed any limitation on the extension of slavery. Clay forced separate votes, however, and all the controversial measures passed by slender majorities and were signed by President James Monroe on March 3 and 6, 1820.

Final admission of Missouri faced one more hurdle. The constitution of the new state included a provision excluding free Negroes and mulattoes, and a majority in the house was unwilling to vote for the admission of Missouri until that clause was stricken from the constitution. Again Clay worked for compromise and won over enough votes by a proposal to make the admission of Missouri contingent on an act by its legislature agreeing never to impair the rights of the citizens of any state. This is sometimes known as the second Missouri Compromise.

Debates on the admission of Missouri raised constitutional as nell as political questions. In the final action congress accepted the southern contention that it could impose no restrictions on new states nhich did not apply equally to all states. It also accepted the argument of northerners that it did have the power to regulate slavery in the territories. More significant however was the impact upon attitudes toward slavery and sectional interests. The debate alerted extreme antislavery groups in the north to the implications of the extension of slavery, but northern Democrats preferred continued cooperation with southern Democrats to the espousal of a strictly sectional issue. In the south the attack on slavery solidified sectional determination to defend slavery. No southern leader thereafter could support any restriction on slavery and remain in public life; within a few years southern spokesmen were defending the thesis that slavery was essential to the welfare of the south and was indeed morally defensible. In 1854 the Missouri compromise was repealed.

See also UNITED STATES (OF AMERICA): History.

See Glover Moore, *The Missouri Controversy 1819–1821* (1953).

(*H.* W. BY.)

MISSOURI RIVER, longest of the tributaries of the Mississippi, is formed by the confluence of the Jefferson, Madison

and Gallatin rivers in the Rocky mountain area of southwestern Montana, 8,000 ft. above sea level. Flowing at first north onto the high plains, the Missouri then turns east before assuming its winding, unstable course to the Mississippi. For most of the way the river flows through its two major physiographic sections, the high and the low Great Plains, finally debouching into the Mississippi over its own alluvial plain,. 2,466 mi. from its source.

Basin. — The area drained by this great river system is about 529,400 sq.mi., of which 2,550 sq.mi. are in Canada. Elevations within the basin are extreme: from 14,000 ft. above sea level in the Rockies near the continental divide to 400 ft. where the Missouri joins the Mississippi.

In general, the northern plains are lower than the southern Great Plains. Four areas stand out in contrast with the prevailing surface of the Great Plains. In north central Nebraska are the Sand hills, a region of low sand hills, small enclosed basins and intermittent streams, principally affording pasture for cattle. A second area of rolling terrain with thin limestone soils fitted only for grazing is the Flint hills in east central Kansas. The third hill area is the concentration of erosional land forms in west-central South Dakota known as the Badlands, where, even under the most favourable climatic conditions, grazing is generally the highest use of the land. The most verdant of the hill or mountain areas on the plains is the Black hills of western South Dakota. Most of this area is national forest, and recreation is the source of most of its income. A final hill area is the Ozark highland in the far southeastern part of the Missouri basin. Although well-watered and once forested, the steep slopes and thin soils preclude crop agriculture except in the valley bottoms. Recreation is the major source of income over most of the highlands.

The apparent uniformity of the remainder of the Missouri basin is deceptive. The badland type of topography is found on a smaller scale in many places, particularly in the middle valley of the Little Missouri and along the upper courses of most of the longer rivers. Continental glaciation has also resulted in differentiating the land surface in the northern and northeastern portions of the basin where old glacial channels, that once were the beds of glacial lakes, plains, morainic deposits and till plains are found. (*See* also PLEISTOCENE EPOCH.) In east central Nebraska are rolling plains of wind deposition; this loess soil is productive when watered. Most extensive of all subdivisions of the basin are the high plains on the west formed by outwash from the cordilleran glaciation of the Rockies. In the main, soils are fairly deep and fertile. Their ability to absorb and hold water varies widely and is, perhaps, their most critical quality from the viewpoint of agriculture.

The climates prevailing over the basin are arid, with the extreme temperature ranges characteristic of a mid-latitude, continental interior. Most of the larger cities are in the drier western portion, including Denver, Colo., Laramie and Cheyenne, Wyo., and Great Falls and Helena, Mont. Tornadoes, blizzards, torrential rains, heavy snows, sustained high temperatures (perhaps three weeks) and searing droughts have done their worst to discourage permanent settlement. In no other part of the interior U.S. are average wind velocities so high as on the Great Plains. The high rate of air movement increases evaporation and promotes dust blowing on fields which are or have been cultivated. Hail insurance is commonly taken on about half of the wheat acreage on a representative farm or ranch on the western Great Plains.

The population of the Missouri basin is about 7,000,000; these states have shown a decline in population since 1939 whereas the nation has significantly increased.

Flow. — The flow of the Missouri and of most of its tributaries is exceedingly varied, with the lowest on the Missouri in winter and the greatest from April to June, the flood season. The average flow near the mouth is 64,000 cu.ft. per second; the minimum is 4,200 cu.ft., and the maximum is 900,000 cu.ft. With unprotected slopes and with such violent fluctuations in flow, erosion and silting are major problems.

Tributaries. — The tributaries of the Missouri are nearly all from the west, chief among them are the Yellowstone, Platte, Milk. Kansas, James, Little Missouri, Big Sioux, Niobrara, Osage and Grand; all but the last are essentially Great Plains rivers. Unlike the tributaries of the Ohio, those of the Missouri rarely afford natural corridors through hill or mountain terrain.

Navigation. — The mouth of the Missouri was discovered in 1673 by Jacques Marquette and Louis Jolliet, while they were coming down the Mississippi. Early in the 18th century French fur traders began to ascend the river, and in 1764 St. Louis was established as a depot; but the first exploration of the river, from its mouth to its headwaters, was made in 1804–05 by Meriwether Lewis and William Clark. Until many years later the commerce on the river was restricted to the fur trade, and was carried on with such primitive craft as the canoe, the pirogue, the bullboat and the keelboat. The river was little used during the early movement to the west; instead the central route over South pass in west central Wyoming, an important link in the Oregon trail, was followed until railroads were constructed farther south. The first attempt to navigate the Missouri with steamboats was made in 1819. The American Fur company began to use steamers in 1830 and flat-bottomed Mackinaw boats, keelboats and small steamboats were in use on the Missouri below Fort Benton, Mont., 2,285 mi. from the Mississippi, between 1840 and 1870. Steamboat traffic was at its height in 1858, when no fewer than 60 regular packets were engaged in it, but its decline began in the following year with the completion of the Hannibal and St. Joseph railway to St. Joseph, Mo., and by the end of the 19th century it had almost disappeared.

For the first 150 years after settlement along the river little was done to render the Missouri more useful as a waterway or as a source of water for agriculture or power. In 1944 congress authorized a comprehensive program for flood control and water resource development in the Missouri river basin. It embraced a system of more than 100 dams and reservoirs on the Missouri and certain of its tributaries. Local flood protection, involving levees and bank stabilization, and a deeper channel were provided for from Sioux City, Ia., to the Mississippi, a distance of 760 mi. By the time a more ambitious plan, the Missouri River Basin program, or simply the Pick-Sloan program, was presented early in the 1950's, a substantial part of the channel and regulatory reservoir undertaking had been completed or nearly so. Commercial barge lines began operations on the Missouri in 1953 and within a few years their tonnage amounted to more than 400,000 a year—about twice the total at the peak of the old steamboat days.

Irrigation.—Irrigation does not stand as a remedy for the drought probltm in Great Plains agriculture. In the eastern part of the basin many farmers are by no means certain that its cost is justified in the long run. Rainfall fluctuates so widely around a critical point for crop production that even a slight reduction in moisture affects crop yields seriously. In the larger, drier western portion, it is a physical rather than an economic problem generally. Nearly all of the functioning irrigation districts are on the upper reaches of rivers along the Rocky mountain front. Largest of these districts is the Colorado piedmont from Denver to Fort Collins. Others are in the Big Horn basin of Wyoming, along the larger rivers in Montana, on the North Platte near Scotts Bluff, and on the South Platte from Ogallala to Grand Island, Nebraska. These districts account for the greater part of the 5,000,000 ac. under irrigation in the Missouri basin. The 36 units of the Missouri River Basin program involve 2,500,000 ac. of newly-irrigated land and 250,000 ac. with a supplementary water supply. Most of these irrigated districts are on the eastern or low Great Plains, many of them on the shorter rivers which follow generally parallel courses to the Mississippi. On these streams the pattern of irrigated districts is similar to beads on a string. Three large areas of concentrated irrigation development are in eastern Nebraska and the Dakotas. In any such program for conservation in the harsh but relatively simple environment of the western Missouri basin, land use is subject to most of the physical and economic hazards of the humid east, plus others more or less restricted to the higher, drier lands of the west. Hay and sugar beets are most prevalent in irrigated areas. There are other crops important in several districts, including potatoes, fruits and vege-

tables. Prime requisite in these cash crops grown under irrigation is a high return per acre. Beets are grown in rotation with small grains, alfalfa, and sometimes corn, depending upon the elevation; they rarely are the major crop in any of the districts.

Livestock-feeding operations are integrated into the farm program, with beef cattle and lambs being fattened, in part on the feed crops. sugar beet tops and beet pulp.

Power.—In addition to irrigation, power development and flood protection are goals of the larger projects. There is no single. integrated power system to serve the entire basin, as in the TVA. At the beginning of the second half of the 20th century there were 9 federal hydroelectric installations and 17 operated by nonfederal and private agencies, with a total capacity of 500,548 kw. The basin program includes 36 federal installations, with a total capacity (including the 17) of 3,000,000 kw. By states their distribution is: Montana 8. North Dakota 6, Wyoming 5, South Dakota 3, Colorado 3 and Kansas 2.

Floods.—The paucity of large cities in the basin probably reduces the news value of Missouri basin floods to eastern newspapers. However, on the 6,000,000 ac. of agricultural land subject to flood, the federal government has reported damage of $200,000,000 in a single year. Visible manifestations of attempts to alleviate the flood problem are the huge dams and reservoirs which have been constructed, nearly all of them on the Missouri. Among them are Fort Peck, Garrison, Fort Randall, Oahe, Gavins Point, Harlan County (Republican River), and Lake of the Ozarks. (*See* also DAM.)

Mineral Resources.—Historically the mining centre of the Missouri basin has been the Black hills, where gold, silver and lead have been mined since 1874. Bituminous coal and lignite are mined at several places in North Dakota, Montana, and Wyoming. A relative newcomer to basin mining is in northern Montana and North Dakota where the big Beaver Lodge and Tioga fields are developing in the Williston basin lying athwart the international border.

Manufacturing.—Except for Denver, dominant manufacturing city in the Missouri basin, the industrialization of the region has been based upon the conversion of the agricultural surplus. The production of flour, beet sugar, stock feeds, meat, leather, canned fruit and dairy products are most widespread. The manufacture of cement is established at a few places. and a beginning has been made in petroleum refining and petro-chemical products. With the established manufacturing of the east north central states and the rising importance of Denver and Salt Lake City, the prospect for industrialization in the thinly populated Missouri basin is not great. *See* also UNITED STATES (OF AMERICA): *Physiography: Rivers and Harbours: Great Plains Province.*

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MIST, a term which is the official and vernacular British equivalent of what was defined by international meteorological convention in 1873 as "light fog" (a fog with visibility greater than 2,000 mi.). But in vernacular it is often incorrectly used as a synonym for drizzle, in the United States, or for haze (*q.v.*), in British countries. To avoid confusion, the weather services of the U.S. discontinued use of the term mist in official observations and reports after 1939. *See* FOG. (R. G. SE.)

MISTINGUETT (stage name of JEANNE MARIE BOURGEOIS) (1873–1956), the most famous and popular French comedienne of her time. The daughter of an upholsterer, she was born at the village of La Pointe-Raguet, near Montmorency, on April 5, 1873. The name Mistinguett (Miss Tinguiett), derived from a song in a musical show, *Miss Helyett,* was suggested by her allegedly English-looking, protruding front teeth. Her greatest fame was achieved in Paris in spectacular revues at the Moulin Rouge and the Casino de Paris. She often partnered Maurice Chevalier, and her best-remembered songs are "C'est mon homme" and "J'en ai marre." She wrote two books: *Mistinguett and* Her *Confessions* (1938) and *Mistinguett, Queen of the Paris Night* (1954). After a long career, during which she appeared in London and toured the Americas, she died at Bougival, near Paris, on Jan. 5, 1956.

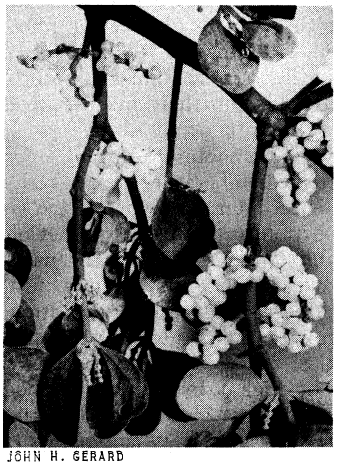
Mistinguett was not highly talented as a dancer, nor did she have a good voice, but she had vitality, conviction, a winning personality and a pair of legs celebrated for their beauty; even in old age she was able to play young parts.

MISTLETOE, common name for many species of semiparasitic green plants belonging to the Loranthaceae (*q.v.*) or mistletoe family. In Europe the commonly known species, the traditional mistletoe of literature, is *Viscum album,* found native from Great Britain to northern Asia. In England it is most abundant on the apple tree and is rarely found on the oak. Poplars, willows, lime, mountain ash and maples are its favourite habitats. Mistletoe forms a drooping yellowish evergreen bush, two to three feet long, particularly noticeable in winter when it contrasts with the naked limbs of deciduous trees or with the deep green of evergreen trees serving as hosts. The thickly crowded, forking branches bear opposite leaves about two inches long and obovate-lanceolate in shape. Small, dioecious flowers, yellower than the leaves, appear in late winter and soon give rise to white berries, which when ripe are filled with a viscous semitransparent pulp.

Most fruit-eating birds eat the berries and thereby distribute the seed; this is accomplished when the bird wipes its beak, to which seeds adhere, against the bark of a tree. The viscid pulp soon hardens, affording a protection to the seed; in germination the sucker root penetrates the bark of the susceptible host and establishes a connection through which nourishment and water are derived from the host (mistletoes, being green, supply some of their own food).

Mistletoes, one of the few groups of higher plants parasitic on both deciduous and evergreen trees and shrubs, are slow in growth but very persistent; their natural death is determined by the death of the host. Sometimes merely pests, they may, if abundant, kill desirable trees. They may be controlled by removing the brittle green growth as completely as possible.

In the U.S. the common mistletoes are in the genera *Phoradendron* and *Arceufhobium. Phoradendron flavescens* (the American mistletoe), very similar to the traditional mistletoe of Europe, occurs especially on deciduous trees from New Jersey to Florida and westward. The larger *P. macrophyllum* grows in bushy clumps two to eight feet in diameter and parasitizes chiefly poplar and willow from Texas to central California. Along the Pacific coast. *P. villosum* occurs chiefly on oak; *P. juniperinum,* with scalelike leaves, grows on junipers and incense cedar; *P. bolleana,* with pearllike berries, occurs on cypress; and the mesquite mistletoe, *P. californicum,* with slender pendulous branches, parasitizes mesquite, creosote bush and cat's-claw. In eastern North America *Arceuthobium pusillum* is a very small parasite on coniferous trees. Many species of the genus *Loranthzrs* inhabit the tropical regions of the eastern hemisphere.



JOHN H. GERARD

AMERICAN MISTLETOE (PHORADENDRON FLAVESCENS), PARASITIC ON VARIOUS DECIDUOUS TREES

Pliny is the authority for the reverence in which the mistletoe was held by the Druids. Prepared as a draft, it was used as a supposed cure for sterility and a remedy for poisons. Later, the mistletoe became esteemed as a traditional Christmas decoration. In the U.S., branches of *P. flavescens,* especially those with berries, are gathered for sale during the Christmas holidays. The traditional mistletoe, bound in a religious and sentimental aura, gave rise to the pleasant custom of'kissing under the mistletoe,

thought by some to lead to inevitable matrimony.

See also PARASITISM AND PARASITOLOGY.

MISTRAL, FRÉDÉRIC (1830–1914), Provençal poet, was born at Maillane (Bouches-du-Rhône) on Sept. 8, 1830. In his ninth year Mistral was sent to a small school at Avignon, where he read much in Homer and Virgil. Returning to Maillane (1847) he sketched a pastoral poem in four cantos (*Li Meissoun*). With all his love for the country, he soon realized that life on a farm did not satisfy his ambition. So he went to study law at Aix, where he contributed his first published poems to Roumanille's Li *Prouvençalo* (1852) (*see* PROVENCAL LITERATURE). He had become *licencié en droit* the year before, but now decided on a literary career.

The Félibrige was founded in 1854, and five years later appeared *Mirèio* (Avignon, 1859), the masterpiece not only of Mistral. but so far of the entire school. The tale itself was nothing—the old story of a rich girl and her poor lover. kept apart by the girl's parents: Mirèio. in despair. wanders along a tract of country to the church of the Trois-Maries, in the hope that the latter may aid her. But the effort was too great: she sinks exhausted and dies in the presence of her stricken parents and her frenzied lover. Into this simple web Mistral has woven descriptions of Provençal life, scenery, character. customs and legends that raise the poem to the dignity of a rustic epic that is unique in literature. There is no deep psychology in the characters. but then the people depicted are simple rustic folk. who wear their hearts on their sleeve. But *Calendau* (1867), the story of a princess held in bondage by a ruthless hrigand and eventually rescued by a youthful hero. is a comparative failure. The description of scenery is again masterly; but the old lore, which had charmed all readers in *Mirèio,* here becomes forced, not inevitable. The characters are mere symbols —indeed the whole poem is obviously an allegory, the princess standing for Provençe, the brigand for France and the young lover for the Félibrige. Mistral lavished enormous labour on this work, which probably accounts for its lack of spontaneity. as also for the love he bears it. In 1876 (the same year in which he married Mlle. Marie Rivière. of Dijon) was published *Lis Isclo d'or—a* collection of the shorter poems that Mistral had been composing from 1848 onward. Here he is again at his very best. Old legends. *sirventes* and lyrics—all are admirable. Even the *pièces d'occasion* may be reckoned with the best of their kind. Two pieces, the *Coupe* and the *Princesse*, aroused violent controversy on their first appearance. They reproduce, in effect, the theme of *Calendau*, and Mistral was accused of trying to sow discord between the north and south of France. He was altogether innocent of such a design. *Nerto* (1884) is a charming tale of Avignon in the olden days, in which a girl's purity triumphs over her Iover's base designs and leads him to nobler thoughts. The play *La Rèino Jano* (1890) is a complete failure. if judged from the dramatic standpoint; it is rather a brilliant panorama. a series of stage pictures. and the characters neither Iive nor arouse our sympathy. In the great epic on the Rhône (*Lou Pouèmo dou Rose,* 1897) the poet depicts the former barge life of that river and intertwines his narrative with the legends clustering round its banks and with a graceful love episode. For the first time he employs blank verse, which he uses with great mastery, hut again the ancient lore is overdone, A splendid piece of work is *Lou Tresor dou félibrige* (1886). In these two volumes Mistral has deposited with loving care every word and phrase. every proverb, every scrap of legend, that he had gathered during his many years' journeyings in the south of France. In 1904 he was awarded a Nobel prize for literature.

Mistral published a Provençal translation of the book of *Genesis* in 1906 and a collection of poems, *Lis Oulivado,* in 1912. His memoirs appeared in 1906 also. under the title *Moun Espelido* (*Mes origines*). After his death. which took place at Maillane on March 25, 1914, three volumes of his *Proso d'armana (Prose d'almanach*) were collected. The centenary of his birth was brilliantly celebrated, and the years 1930–31 saw the publication of an extraordinary number of books about him.

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MISTRAL, GABRIELA (1889–1957), pseudonym of Lucila Godoy Alcayaga, Chilean poet, was the first South American to be awarded a Nobel prize. winning it for literature in 1945. She was born in Vicuña, Chile. April 7, 1889. Her prize-winning "Sonetos de la Muerte" ("Sonnets of Death") made her poetic ability known in 1914. *Desolación* (New York, 1922), includes "Dolor"—the aftermath of a love affair tragically ended by the suicide of her lover. *Ternura* (1924; enlarged in 1945) and *Tala* (1938) evidence a broader interest in mankind; but love—of children. the down-trodden. nature and God—remained her principal theme. Her verse, more often virile than feminine and frequently coloured by figures and words peculiarly her own, is characterized by great warmth of feeling and strong emotional power; but in the poems for children there is a haunting, wistful strain of maternal tenderness. Her poetry has been translated into English. French, Italian, German and Swedish. Her prose is simple, sincere, and at times tense with emotion, but does not surpass her verse. A Chilean edition of her *Selected Works* reached i t seventh volume in 1954. She died on Jan. 10, 1957 at Hempstead, N.Y.

BIBLIOGRAPHY.—4. S. Blackwell, *Some Spanish-American Poets,* 2nd ed.. pp. 236–279 (1937); F. Onís, *Antologia de la poesia española e hispanoamericana (1882–1932),* (1934); and N. Pinilla, *Biografía* de G. *M.* (1946). (J. R. S.)

MISTRAL: *see* WINDS. MOUNTAIN AND LOCAL.

MISURATA, chief city of Tripolitania territory of Libya. 137 mi. E.S.E. of Tripoli by road and 122 by sea. Pop. (1954) 56,902 (district). It manufactures carpets and reed mats and has a few small industries. Its port, an open roadstead, lies 7 mi. E. at the north end of the salt marsh (Sebcha) of Tauorga, described by Strabo as about 40 mi. long and 9 mi. wide.

During World War I it was the capital of the ephemeral republic of Tripolitania. In World War II the British 8th army captured the city in Jan. 1943. (P. W. I.)

MITAU: *see* JELGAVA.

MITCHAM, a municipal borough (1934) in the Mitcham parliamentary division of Surrey, Eng., 8 mi. S. of Charing Cross, London, by road. Pop. (1951) 67,269. Area 4.6 sq.mi. On Mitcham common (440 ac.), a fair has been held every August for centuries. Mitcham, though mentioned in Domesday Book (Michelham), was built up as a residential area for Londoners. In the 18th and 19th centuries it was known for its cultivation of flowers. chiefly lavender and peppermint. There are now light industries.

MITCHELL, DONALD GRANT (1822–1908), U.S. author. won his greatest vogue by blending the moods of gentle fancy and tender sentiment which characterized popular taste in the 1850s, making his pseudonym, "Ik Marvel," a household name. Born in Norwich, Conn., April 12, 1822, he graduated from Yale in 1841, and was U.S. consul at Venice, Italy (1853–54). His best known books. *Reveries of a Bachelor* (1850) and *Dream Life* (1851), occupy the borderline between fiction and essay. Their evocation of rural delights, their treatment of youthful love and sorrow. and their escapism to a dream world have perennial charm. Most significant among his later works are *My Farm at Edgewood* (1863). recording his interest in agriculture, and Dr. *Johns* (1866), a novel reflecting his religious liberalism.

See Waldo *H.* Dunn, *The Life of Donald G. Mitchell* (New York, 1922). (H. R. Bx.)

MITCHELL, JOHN THOMAS WHITEHEAD (1828–1895), English Co-operator, was born at Rochdale on Oct. 18, 1828. He was an illegitimate child, greatly attached to his mother, who, to support them. kept a small beerhouse and later let lodgings to workmen. When he was 22 he became superintendent of the Milton Road Congregational Sunday school, an office he held throughout his life. At the Sunday school his interest in

co-operation was aroused; he joined the Rochdale Pioneers Co-operative society in 1853 and served on its management committee. In 1869 he was elected s director of the Co-operative Wholesale society — started in 1863 .and its future still uncertain.

Hitherto, the ideal of Co-operators had been that manufacture should be carried on in self-governing workshops, the profits being divided among the workers. But a new principle had been introduced by the device of "dividend on purchase." This brought success to the Rochdale Pioneers and a rapid increase in the number of retail co-operative societies, while productive workshops were continually failing. By this device. the surplus on trading was returned to the consumers. and profit-making was eliminated. A system was thus inaugurated in which the consumers organized distribution and production for use, to supply their own needs. Mitchell was the first to understand the possibilities of this system and something of its underlying theory (of which the full implications were first shown by Beatrice Webb in 1891), and he believed that it could become co-extensive with the nation. The success of this "Rochdale" system in England. largely due to Mitchell. has led. to its being copied in almost all civilized countries. Under Mitchell's chairmanship after 1874, the Co-operative Wholesale society built up a strong hnancial position.

For accounts of Mitchell see C.W.S. *Annual, 1896* (Manchester); P. Rediern, *John* T. W. *Mitchell* (Manchester, 1923) ; Beatrice Webb, *The Discovery of the Consumer* (1928).

MITCHELL, MARGARET (1900–1949), U.S. novelist, author of *Gone With the Wind,* was horn in Atlanta, Ga., in 1900. She attended Washington seminary in Atlanta and Smith college, Northampton. Mass. Called back from college by her mother's death, she wrote for the *Atlanta Journal* from 1922 until, in 1926, an ankle injury forced her retirement from the paper. It was then that she began to write her one book. *Gone With the Wind,* a novel about the American Civil War and the Reconstruction as seen from a southern point of view. She worked on the book for ten years, and it was published in June 1936 In 1937 Miss Mitchell received the Pulitzer prize for fiction. After the motion-picture rights were sold for $50,000, the picture made from the novel received an Academy award in 1940.

Gone With fhe Wind was almost certainly the largest selling novel in the history of U.S. publishing. A million copies were sold in the first six months after its publication. 50,000 of them in one day. Two million copies had been sold in the U.S. by 1939, and over 8,000,000, in 40 countries, before her death.

Margaret Mitchell married John R. Marsh in 1925. She died on Aug. 16, 1949, after having been struck by an automobile in Atlanta.

MITCHELL, MARIA (1818–1889), U.S. astronomer, who made photographs of the sun and a special study of Jupiter and Saturn, was born on Nantucket Island! Mass., Aug. 1, 1818. In 1865 she became professor of astronomy and director of the observatory at Vassar college; and in 1888 professor emeritus. She died at Lynn, Mass., on June 28, 1889.

See Phebe Mitchell Kendall, *Maria Mitchell: Life, Letters and Journals* (1896).

MITCHELL, REGINALD JOSEPH (1895–1937), British aircraft designer who produced the Spitfire fighter, was born at Talke, near Stoke-on-Trent, Staffordshire, on May 20, 1895. He was apprenticed to an engineering firm at Stoke and, after a period as assistant engineer there, joined the Supermarine Aviation works at Southampton in 1916, becoming chief engineer and designer in 1920. In 1922 he collaborated with Hubert Scott-Paine in producing a flying boat which won the Schneider trophy. Continuing this collaboration, he designed a number of marine craft ranging from large flying boats to small racing float seaplanes. In 1925 his S-4 floatplane raised the world speed record to 226.752 m.p.h. and in 1927, 1929 and 1931 his aircraft won the Schneider trophy on three successive occasions.

In 1931, Flight Lieutenant Stainforth raised the world speed record to 407.5 m.p.h. in Mitchell's S-6B. Mitchell's last aircraft was the famous eight-gun Spitfire fighter (1936) which contributed so much to victory in the battle of Britain and of which nearly 19.000 were built. He died at Southampton on June 11, 1937. (D. CR.)

MITCHELL, SILAS WEIR (1829–1914), U.S. physician and author, who excelled in novels of psychology and historical romance, was born in Philadelphia. Pa., Feb. 1j, 1829. He studied at the University of Pennsylvania and Jefferson Medical college (M.D., 1850), both in his native city. As an army surgeon during the American Civil War he became interested in nervous diseases, and was soon renowned for his "rest cure." In 1866 he published "The Case of George Dedlow," a story notable for its psychological insights and realistic war scenes. He wrote some 170 medical monographs on topics ranging from snake venom to neurasthenia, doing valuable pioneering work in several fields. *Wear and Tear* (1871) and *Fat and Blood* (1877), medical popularizations, were best sellers.

Mitchell also wrote juvenile stories, verse and prose fiction. Perhaps his most notable works are: *Roland Blake* (1886); *Hugh Wynne* (1898) ; *The Adventures of François* (1899) ; *Circumstance* (1901); *Constance Trescott* (1905); and *The Red City* (1907). His complete works were published as "The Author's Definitive Edition" in 16 volumes (1913–14). Mitchell died in Philadelphia, Jan. 4, 1914.

See Anna Burr, *Weir Mitchell: His Life and Letters* (1929); *E.* P. Earnest, *S. Weir Mitchell: Novelist and Physician* (1950); David Rein, *S. Weir Mitchell as a Psychiatric .Novelist* (1952).

MITCHELL, SIR THOMAS LIVINGSTONE (1792–1855), British explorer of Australia, was born at Craigend, Stirlingshire, Scot., on June 16, 1792. A distinguished surveyor in the Peninsular War, he was appointed surveyor general of New South Wales in 1828. Mitchell explored northern and western New South Wales (1831 and 1835); discovered "Australia Felix," the western district of Victoria (1836) ; and attempted to travel overland from Sydney to the Gulf of Carpentaria (1845–47). He published the journals of his explorations (1838). an Australian geography (1851), texts on surveying and military exercises and a translation of *Os Lusiadas* by L. de Camões (1854). He was knighted in 1839, and died in Sydney on Oct. 5, 1855. (T. M. PY.)

MITCHELL, WESLEY CLAIR (1874–1948), U.S. economist, who made pioneering studies of the money economy and became the world's foremost authority on business cycles, was born in Rushville, Ill., on Aug. 5. 1874. He attended The University of Chicago. where he came under the influence of Thorstein Veblen and John Dewey. Though his life was devoted primarily to economic research, he also taught economics at various universities, principally at Columbia.

In 1920 Mitchell helped to organize the National Bureau of Economic Research and was its director of research until 1945. He served as chief of the price section of the War Industries board during World War I, as chairman of Pres. Herbert Hoover's Research Committee on Social Trends, as a member of the National Planning board in 1933 and of the National Resources board in 1934–35. For many years Mitchell played a leading role in the Social Science Research council and the Bureau of Educational Experiments. Under his leadership quantitative studies of economic behaviour developed rapidly in the United States and abroad. Mitchell died in New York city on Oct. 29, 1948.

Among his publications are *Business Cycles* (1913), *Business Cycles: the Problem and Its Setting* (1927), *The Backward Art of Spending Money and Other Essays* (1937) and *Measuring Business Cycles,* with A. F. Burns (1946). (A. F. Bs.)

MITCHELL, WILLIAM (1879–1936), U.S. army officer, pioneer in military aviation, was born Dec. 29, 1879, in Nice, France, of American parents. His father, John Lendrum Mitchell, later became U.S. senator from Wisconsin. Young Mitchell attended Racine college in Wisconsin and Columbian (later George Washington) university in Washington, D.C. He left college to enlist as a private in the infantry at the outbreak of the Spanish-American War in 1898. Shortly after, he received a commission as a second lieutenant in the signal corps and embarked on a military career that lasted for more than a quarter of a century.

Mitchell served in Cuba, the Philippines and Alaska and in 1909 he graduated from the Army Staff college at Ft. Leavenworth. In

1917 he was assigned to the aviation section of the signal corps. He learned to fly during the winter of 1917–18 at a school located in Newport News, Va., to which he commuted on week ends from Washington. When the U.S. entered World War I, Mitchell was already in Europe as an observer. By the time Gen. John J. Pershing arrived in France as commander of the American expeditionary forces on July 4, 1917, Mitchell had become the best-informed American aviation officer in Europe.

Always a man of action, Mitcheli became the outstanding U.S. combat air commander of the war. In Sept. 1918 he commanded a French-U.S. air armada of almost 1,500 planes, the largest concentration of air power up to that time. This powerful force helped the U.S. 1st army wipe out the St. Mihiel salient. In the subsequent Meuse-Argonne campaign, Mitchell, promoted to brigadier general in Oct. 1918, used formations of up to 200 planes for mass bombing of enemy targets. His aggressive tactics reflected not only his character but also his ideas on the use of air power. In the latter, he was influenced by the great British air commander Maj. Gen. Hugh Trenchard, the foremost advocate and practitioner of strategic air bombardment during World War I.

Mitchell returned to Washington after the war to be appointed assistant chief. of the air service in 1919. He became a strong proponent of an independent U.S. air force and of unified control of air power, both of which were opposed by the army general staff and the navy. Mitchell challenged the concept of the navy as the first line of defense and mobilized congressional and public opinion to induce the navy to permit him to carry out bombing tests against old battleships. In July 1921 he commanded air service bombers that sank the former German dreadnought "Ostfriesland" in 21½ minutes off the Virginia coast. When air service bombers sank two obsolete U.S. ships in tests off Cape Hatteras in Sept. 1923, the navy took the lesson to heart and began to build its forces around the aircraft carrier.

As Mitchell's hopes for recognition and appreciation of the future of air power failed to materialize, he became increasingly outspoken in his criticism of the military hierarchy that did not accept his views. At the expiration of his term as assistant chief of air service in April 1925 he was sent to San Antonio, Tex., in his permanent grade of colonel, as air officer of the 8th corps area. But this departure from the seat of government did not silence him; he continued to write and speak in behalf of his views. The climax came in Sept. 1925 when the loss of the navy dirigible "Shenandoah" in a storm inspired Mitchell to publicly accuse the war and navy departments of "incompetency, criminal negligence and almost treasonable administration of the National Defense." In Dec. 1925 an army court-martial convicted him of insubordination. Sentenced to suspension from rank and duty for five years, he resigned from the army as of Feb. 1, 1926, and devoted the remaining ten years of his life to propagating his gospel of air power.

Mitchell died Feb. 19, 1936. He did not witness the vindication of much that he stood for. Had Mitchell lived through World War II he would have seen the fulfillment of many of his prophecies of air warfare: strategic bombardment, mass air-borne operations, the strategic importance of Alaska and the polar areas and the eclipse of the battleship by the airplane. During his life he was awarded many decorations and honours both by his own and other countries. In 1946 congress authorized a special medal in his honour; it was presented to Mitchell's son in 1948 by the chief of staff of the newly created U.S. air force.

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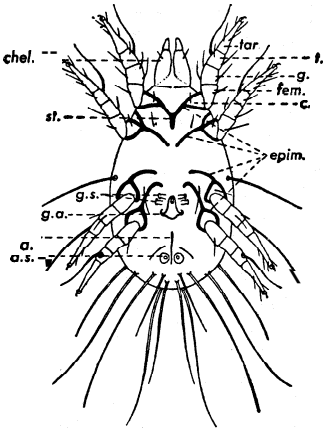
MITCHELL, MOUNT, a peak of the Black mountains, a short cross range extending north from the Blue Ridge through Yancey county, North Carolina, in 35° 45′ 53″ N. and 82° 15′ 11″ W. It is the highest (6,684 ft. above sea level) peak in the United States east of the Mississippi river. In the same region there are about a dozen summits above 6,000 ft., the noblest of them being Blackstock Knob (6,359 ft.), Big Craggy Mount (6,105 ft.) and Balsam Cone (6,611 ft.). The mountains of North Carolina were not subject to glaciation and are, therefore, covered with a mantle of soil to the top, except for rocky precipices. They are covered with hardwood and pine forests in the lower elevations, and in the upper parts with an unbroken mantle of spruce and balsam.

For elevation in North Carolina see *Precise Triangulation, Traverse and Leveling in North Carolina* (1924), which is special publication No. 101 of the U.S. Coast and Geodetic Survey.

MITE, a name applied to an order of small Arachnida, and to a coin of slight value. The coin was originally a Flemish copper coin worth one-third or a smaller fraction of the Flemish penning, penny. It is an expression in English for a coin of the smallest value, from its use in Mark xii, 43.

In zoology, "mite" is the name for minute members of the class Arachnida (*q.v.*), which, with the ticks (*q.v.*), constitute the order Acari. The word "mite," however, is merely a popular term and does not connote a natural assemblage. Mites are spread from the arctic to the antarctic regions, and inhabit land, freshwater and the sea. Many are permanent parasites; others, for part of their life only. The largest species reach half an inch in length; while the smallest, the most diminutive Arthropoda, are invisible to the naked eye.

Mites are divided into a number of families. The Bdellidae (Bdalla) are free-living with long antenniform palpi. The large tropical forms above mentioned belong to the genus *Trombidium* of the family Trombidiidae. They are covered with crimson velvety hairs. The legs are adapted for crawling and the palpi are raptorial. Tney are non-parasitic in the adult; but immature individuals of several genera and species are parasitic. (*See* HARVEST BUG.) The Tetranychidae are related to the last. A well-known example, Tetranychus *telarius*, spins webs and is sometimes called the money spider while other species of that genus, found in the U.S., are called "red spiders." Of special interest are the so-called louse-mites, Pediculoides ventricosus belonging to the family Tarsonemidae. They feed normally on grain-moth caterpillars, but often attack workmen in mills and cause severe dermatitis. Males and unfertilized females are only 0.2 mm. long, but the gravid females become so distended under the pressure of growing eggs that the posterior portion of their body assumes a globular shape of 1½ mm. in diameter. In an allied species, *Pediculopsis* graminum the sexes are dimorphic and may be recognized already in the egg. The freshwater Hydrachnidae are generally red or green and globular in shape. Their legs are furnished with long hairs for swimming. The marine Halacaridae creep on seaweeds and zoophytes. The Gamasidae are free-living with a thick exoskeleton and allied to the ticks (*q.v.*). The Oribatidae or beetle-mites are nonparasitic, and go through remarkable metamorphoses. It was shown by Horace Stunkard that common, so-called anoplocephaline tapeworms of sheep, rabbits and monkeys have oribatid mites for intermediary hosts. The Sarcoptidae are mostly parasitic. Some, however, live in decaying substances, the best known being the cheese-mite (Tyroglyphus *siro*) An allied species (T. *entomophagus*) damages collections of insects by destroying the specimens. They may be exterminated by benzine.



COURTESY H. E. EWING

Tyroglyphus lintneri, after Ewing. a., anus; a.s., anal suckers; c., coxa; chel., chelicera; epim., or epimera; f., femur; g., genital, or patella; g.a., genital armature; st., sternum; t., tibia; tar., tarsus

Some mites are parasitic upon mammals and birds. They belong to the four families, Gamasidae, Trombidiidae (vide supra), Sarcoptidae and Demodicidae. Most of the Gamasidae are free-living. The family, however, contains an aberrant genus, *Dermanyssus*, of which one species, "red-mite," D. gallinae, is found in fowl-houses, dovecotes and bird-cages. During the day they lurk in cracks and emerge at night. They do much damage to the birds by sucking their blood and by depriv-

ing them of rest. Birds are also attacked by many species of Sarcoptidae (*Pterolichus* and *Analges*) living on and between the barbules of the feathers. They are apparently harmless. *Epidermoptes* occur on diseased fowls and live on the skin at the base of the feathers where they cause an accumulation of yellowish scales. *Cytolechus* lives in the connective tissue round the respiratory organs, or in the air sacs. They also penetrate to certain internal organs, and give rise to tubercle-like nodules.

The cutaneous mites, mentioned above, merely suck the blood or feed upon the feathers, scurf and desquamating epidermis. Some species, however, give rise to a contagious disease known as scabies or mange. These mites belong to the Sarcoptidae and Demodicidae. A variety of species are responsible for Sarcoptic mange, *Sarcoptes mutans* producing it in the feet of birds. Another scabies of poultry is caused by S. *laevis*. Three genera of Sarcoptidae, namely *Sarcoptes*, *Chorioptes* and *Psoroptes* cause mange or scabies in mammals, the mange produced by ***Sarcoptes*** being the most serious, because the females of the species *scabiei*, burrow beneath the skin and are more difficult to kill. Their multiplication is very rapid. The numerous forms described from different mammals are probably all merely temporary varieties of a single species. Mange, if treated in time, can be cured by applications of sulphur ointment. *Demodex folliculorum* gives rise to "Demodecic or follicular mange," which is difficult to cure on account of the deep situation of the parasites. These infest the hair follicles and sebaceous glands in man and other animals. They differ from those previously noticed in the reduction of their legs and the elongation of the abdomen. They occur on domesticated animals, as well as on mice and bats.

The family Eriophyidae or gall-mites produce in plants results analogous to those produced in animals by Sarcoptidae and Demodicidae. As in the Demodicidae the abdomen is elongate, but the Eriophyidae differ from all other mites in having lost the last two pairs of legs. The best known of the excrescences or galls which they produce are the nail-galls of the lime caused by *Eriophyes tiliae*. Many species have been described. They inflict considerable loss upon fruit-growers by destroying the buds of the trees.

Well-preserved fossil mites were found in the Old Red Sandstone belonging to the Devonian, proving that mites belong to a very old group of arthropods.

MITFORD, MARY RUSSELL (1787–1855), English novelist and dramatist, only daughter of Dr. George Mitford, or Midford, was born at Alresford, Hampshire, on Dec. 16, 1787. She retains an honourable place in literature as the authoress of *Our Village* (1824–32), a series of sketches of village scenes and characters unsurpassed in their kind, and as fresh as if they had been written yesterday. Miss Mitford lived in close attendance on an eccentric father, refused all holiday invitations because he could not live without her, and worked incessantly for him except when she broke off her work to read him the sporting newspapers. Her writing has the charm of perfectly unaffected spontaneous humour, combined with quick wit and real literary skill. Miss Mitford met Elizabeth Barrett (Mrs. Browning) in 1836, and the acquaintance ripened into a warm friendship. The strain of poverty began to tell on her work, for although her books sold at high prices, her income did not keep pace with her father's extravagances. In 1837, however, she received a civil list pension, and five years later her father died. A subscription was raised to pay his debts, and the surplus increased the daughter's income. She died at Swallowfield. near Reading, on Jan. 10, 1855. Her father was a curious character. He first spent his wife's fortune then the greater part of £20,000 which his daughter won in a lottery at the age of ten.

Miss Mitford wrote poems in the manner of Coleridge and Scott (*Miscellaneous Verses*, 1810, reviewed by Scott in the *Quarterly; Christine*, a metrical tale, 1811; *Blanche*, 1813). Several of her plays were produced with success, notably *Julian* (1823), *The Foscari* (1826), *Rienzi* (1828), and *Charles I.* (1834). *Belford Regis*, a novel idealizing Reading, was published in 1835.

Her *Recollections of a Literary Life* (1852) is a series of *causeries* about her favourite books. Her talk was said by her friends, Mrs. Browning and Hengist Horne, to have been even more amusing than her books, and five volumes of her *Life and Letters*, published in 1870 and 1872, show her to have been a delightful letter-writer; *see* L'Estrange, *Life of Miss M. Russell Mitford* with letters (3 vols., 1869); W. Roberts, *Mary Russell Mitford, Her Life and Friendship* (1913).

MITFORD, WILLIAM (1744–1827), English historian, born at Beaulieu, Hants, on Feb. 10, 1744, the son of a barrister. He was educated under William Gilpin at Cheam and at Queen's College, Oxford. He then read at the Middle Temple. After his marriage (1766) with Fanny Molloy he retired to Exbury, where he occupied himself with Greek language and literature. After his wife's death in 1776 he spent much time abroad. He sat in the House of Commons with intervals, from 1785 to 1818. Mitford died at Exbury on Feb. 10, 1827. In addition to his *History of Greece*, he published a few smaller works, the most important of which was an *Essay on the Harmony of Language*, 1774. The style of Mitford is natural and lucid, but without the rich colour of Gibbon. Mitford was an impassioned anti-Jacobin, and his partiality for a monarchy led him to be unjust to the Athenians, and the appearance of Grote's work eclipsed Mitford's *History*. Clinton, in his *Fasti hellenici*, charged Mitford with "a general negligence of dates," though admitting that in his philosophical range "he is far superior to any former writer" on Greek history.

MITHILA, an ancient kingdom of India, corresponding to that portion of Behar lying N. of the Ganges, with an extension into Nepal, where was the capital of Janakpur. Its early history is obscure, but it has always been noted for its peculiar conservatism and the learning of its Brahmans. Maithili is a dialect of Bihari, with an archaic grammar and literature of its own.

MITHRADATES, less correctly MITHRIDATES, a Persian name derived from Mithras *(see* MITHRAISM), the sun god, and the Indo-European root *da*, "to give"; *i.e.*, "given by Mithras." The name occurs also in the forms Mitradates and Meherdates. It was borne by a large number of oriental kings, soldiers and statesmen. The earliest are Mithradates. the eunuch who helped Artabanus to assassinate Xerxes I, and the Mithradates who fought first with Cyrus the Younger and after his death with Xrtaxerxes against the Greeks. The most important are three kings of Parthia of the Arsacid dynasty and six kings of Pontus. There were also two kings of Commagene, two of the Bosporus and one of Armenia (A.D. 35–51).

Kings of Parthia.—MITHRADATES I (Arsaces VI), successor of his brother, Phraates I, came to the Parthian throne about 171 B.C. The first historic event of his reign was a war with Eucratides of Bactria, who tried to create a great Greek empire in the east. At last, after Eucratides was murdered by his son about 155, Mithradates was able to occupy some districts on the border of Bactria; to conquer Arachosia (Kandahar) and even, it is said, to cross the Indus. Meanwhile the Seleucid kingdom was torn by internal dissensions, fostered by Roman intrigues. Phraates I had already conquered eastern Media, about Rhagae (Rai), and subjected the Mardi on the border of the Caspian. Mithradates I conquered the rest of Media and advanced toward the Zagros chains and the Babylonian plain. In a war against the Elymaeans (in Susiana) he took the Greek town Seleucia on the Hedyphon and forced their king to become a vassal of the Parthians. About 141 he must have become master of Babylonia. Diodorus praised him as a mild ruler; and the fact that from 140 his coins carry the epithet *Philhellen*, "Greek loving," (till then he only called himself "the great king Arsaces") shows that he tried to conciliate his Greek subjects. The Greeks, however, on Mithradates' departure to Hyrcania (probably to check the raiding Sacae), induced Demetrius II Nicator, despite his previous defeat, to attempt their deliverance. At first victorious, Demetrius was taken prisoner in 138 and sent to Hyrcania, where Mithradates gave him his daughter Rhodogune in marriage and maintained him in royal state. In the same year Mithradates died and was succeeded by his son Phraates II.

MITHRADATES II, THE GREAT, king of Parthia *(c.* 120–88 B.C.), saved the kingdom from the Sacae (Tochari). who had occupied Bactria and eastern Iran, and is said to have extended the limits of the empire. He defeated King Artavasdes of Armenia and conquered 70 valleys; and the prince Tigranes came as hostage to the

Parthians. In an inscription from Delos he is called "the great king of kings Arsaces." He also interfered in the wars of the dynasts of Syria. He mas the first Parthian king who entered into negotiations with Rome, then represented by Sulla, praetor of Cilicia (92 B.C.).

MITHRADATES III murdered his father Phraates III about 57 B.C., with the assistance of his brother Orodes. He was made king of Media and waged war against his brother. but was soon deposed on account of his cruelty. He took refuge with Gabinius, the Roman proconsul of Syria.. He advanced into Mesopotamia, but was beaten at Seleucia by Surenas, fled into Babylon and after a long siege was taken prisoner and killed in 54 by Orodes I.

See N. C. Debevoise, *A Political History of Parthia* (Chicago, Cambridge, 1938).

A Parthian king Mithradates. who must have occupied the throne for a short time during the reign of Phraates IV. is mentioned by Jos. *Ant.* xvi, 8, 4, in 10 B.c.; another Meherdates, a pretender, was brought from Rome in A.D. 49 by the opponents of Gotarzes. but was defeated (Tac. *Ann.* xi. 10, xii, 10 ff.). The name of another pretender Mithradates (often called Mithradates IV) occurs on a coin of the first half of the 2nd century. written in Aramaic accompanied by the Arsacid titles in Greek (W. Wroth, *Catalogue of the Coins of Parthia,* London, 1903). A certain Meherdotes was one of the rival kings of Parthia who fought against Trajan in 116. Before he died in an attack on Commagene he appointed his son Sanatruces successor, who fell in a battle against the Romans (Joannes Malalas, *Chron.* xi, after Arrian).

(ED. M.; T. C. Y.)

Kings **of Pontus.**—The Mithradatidae of Pontus were descendants of an ancient Persian noble family. The details of their origin and the system of numbering them have been involved in some obscurity since the loss of the historical works of Hieronymus of Cardia, on which classical writers relied. The folloming account, which conforms to the view of M. Rostovtzeff (1932), has the advantage over those of E. Meyer and T. Reinach in so far as it preserves the reckoning. in accordance with ancient sources, of Mithradates Eupator as Mithradates VI without requiring either Meyer's substitution of two kings for one between Ariobarzanes of Pontus and Pharnaces or Reinach's contraction of Mithradates Philopator-Philadelphus and Mithradates Euergetes into a single king. It requires only that the last ruler of Cius should have been counted as the first prince or "founder" of the dynasty; and an inscription of Pharnaces, located in the Crimea, supplied Rostovtzeff with evidence. overlooked by earlier scholars, on which to argue the case for this.

MITHRADATES I, to whom (rather than to his son) the epithet CTISTES (Greek Κτίστης, "founder") seems to belong, was ruler of Cius on the Propontis (in succession, it is said, to two of his kinsmen, an earlier Mithradates and Ariobarzanes) from 337 or 336 B.C. till his death in 302 or 301. Suspected of treachery by Antigonus I, he may have been escaping to the east with his son when he was killed.

MITHRADATES II, to whom scholars before Rostovtzeff commonly assigned the title Mithradates I Ctistes, was the son of the foregoing. Warned by his friend Demetrius Poliorcetes, the son of Antigonus. that he had incurred the same disfavour as his father, he fled to Paphlagonia, where he seized Cimiata, a fort at the foot of the Olgassys range. Joined by the Macedonian garrison and by neighbouring populations. he conquered Cappadocian and Paphlagonian territories on both sides of the Halys to form the nucleus of his kingdom of Pontic Cappadocia or Pontus (*q.v.*). He died in 266/265 B.C.. leaving the kingdom to his son Ariobarzanes.

MITHRADATES III was very young when he succeeded his father, Ariobarzanes, c. 255 B.C. Early in his reign the Gauls (*see* GALATIA) invaded Pontus. Mithradates was at the battle of Ancyra (*c.* 240), in which he assisted Antiochus Hierax against his brother Seleucus Callinicus. His wife, their sister Laodice, had brought him Greater Phrygia as her dowry; and his daughter, also named Laodice. married Antiochus the Great. He attacked Sinope (c. 220), but it was not taken until after his death (c. 185). His son and successor Pharnaces I took Sinope (which he made the capital of the kingdom instead of Amasia) and tried also to extend his power into the Chersonesus Taurica (the Crimea).

MITHRADATES IV PHILOPATOR PHILADELPHUS. a younger son of Mithradates III. may have reigned for a time conjointly with his brother Pharnaces and then occupied the throne in a form of regency (*c.* 170–*c.* 150) for the latter's son. He assisted Attalus II of Pergamum to resist Prusias II of Bithynia.

MITHRADATES V EUERGETES. the son of Pharnaces, appears to have become sole ruler of Pontus c. 150. At first a friend of the Romans. he sent them a contingent during the Third Punic War and helped them to get possession of Pergamum (bequeathed to them by Attalus III, but claimed by Aristonicus, a natural son of Eumenes II). Nicomedes II of Bithynia also helped the Romans in the affair; and both he and Mithradates expected to be rewarded with Phrygia. A commission awarded it to Mithradates, but the Roman senate refused to ratify the bargain on the ground of bribery, Mithradates appears to have taken Phrygia without waiting for a new award. He likewise invaded Cappadocia and married his daughter to the young king Ariarathes VI Epiphanes. He acquired the succession of Paphlagonia from its last king, Pylaemenes, and obtained a kind of protectorate over Galatia. At the height of his power, in 121 or 120 B.c., he was assassinated by his courtiers during a banquet in his palace at Sinope.

MITHRADATES VI EUPATOR, called THE GREAT, succeeded his father Mithradates Euergetes at the age of 11. For a few years his mother ruled in his place; then she was deposed and thrown into prison. Securing himself by the elimination of his younger brother Mithradates Chrestus. Mithradates Eupator turned his attention to conquest. An expedition was sent to the northern shore of the Black sea, where the Greeks of the Chersonesus Taurica and of the Cimmerian Bosporus recognized Mithradates as suzerain in return for protection against the Scyths (*see* CRIMEA); and on the eastern shore Colchis was added to the Pontic kingdom. In Anatolia, however, the royal dominions had been considerably diminished after the death of Mithradates V: Paphlagonia had freed itself, and Phrygia (c. 116 B.c.) had been linked to the Roman province of Asia. The king's first move here was to partition Paphlagonia and Galatia between himself and Nicomedes II of Bithynia; but next he quarreled with Nicomedes over Cappadocia. Successful at first on two occasions, he was on both deprived of his advantage by Roman intervention (c. 95 and 92). Apparently acquiescing. he resolved to expel the Romans from Asia. A first attempt to depose Nicomedes III of Bithynia. the Roman's nominee, was frustrated (c. 90 B.C.). Then Nicomedes. instigated by Rome, attacked Pontic territory, and Mithradates, after protesting in vain to the Romans, finally declared war (88). He rapidly overran Galatia, Phrygia and Asia, defeated the Roman armies and ordered a general massacre of the Romans in Asia. He sent large armies into European Greece, and his generals occupied Athens. But L. Cornelius Sulla in Greece and C. Flavius Fimbria in Asia defeated his armies in several battles; the Greek cities mere disgusted by his severity, and in 85 he concluded peace. abandoning all his conquests, surrendering his fleet and paying a fine of 2.000 talents. In what is called the Second Rlithradatic War, L. Licinius Murena invaded Pontus without any good reason in 83, but was defeated in 82. Hostilities were suspended, but disputes constantly occurred. and in 74 a general war broke out. Mithradates defeated M. Aurelius Cotta, the Roman consul, at Chalcedon; but Lucullus worsted him outside Cyzicus (73) and drove him in 72 to take refuge in Armenia with his son-in-law Tigranes. After two great victories at Tigranocerta (69) and Artaxata (68), Lucullus was disconcerted by the defeat of his lieutenants and by mutiny. (See LUCULLUS, LUCIUS LICINIUS.) In 66 he was superseded by Pompey. who completely defeated both Mithradates and Tigranes. Mithradates established himself in 64 at Panticapaeum on the Cimmerian Bosporus and was planning an invasion of Italy by way of the Danube when his own troops, led by his son Pharnaces II, revolted. After vainly trying to poison himself, Mithradates ordered a Gallic mercenary to kill him. So perished (63 B.c.) Rome's greatest enemy in Asia Minor. His body was sent to Pompey, who buried it in the royal sepulchre at Sinope.

Ancient authorities have invested Mithradates with a halo of romance. His courage, his bodily strength and size. his skill in

the use of weapons, in riding and in the chase. his speed of foot, his capacity for eating and drinking, his penetrating intellect and his mastery of 22 languages are celebrated to a degree which is almost incredible. With a surface gloss of Greek education. he united the subtlety, the superstition and the obstinate endurance of an oriental. He collected curiosities and works of art; he assembled Greek men of letters round him; he gave prizes to the greatest poets and the best eaters. He spent much of his time in practising magic and it was believed that he had so saturated his body with poisons that none could injure him He trusted no one; he murdered his mother, his sons, the sister whom he had married; to prevent his harem from falling to his enemies he murdered his concubines, and his followers were never safe.

MITHRAISM, the worship of the Indo-Iranian god of light Mithra (Sanskrit Mitra), which spread from Persia to Asia Minor and thence to Rome and many parts of the Roman empire One of the last of the oriental mystery cults to reach the west. Mithraism was also one of the most vigorous, and in the final death struggle of paganism it emerged as a chief rival and opponent of Christianity.

History.- he position of Mithra in Iran. though greater than that of Mitra in Vedic India, held little promise of the god's future career in the west. He is not mentioned in the *Gathas* (*q.v.*), which suggests that he was deliberately ignored in the monotheistic reforms of Zoroaster. Later Zoroastrianism found room for him, though only as subordinate to the supreme god Ormazd (Ahura Mazda). He appears with Ormazd and Anahita, the goddess of waters, in royal inscriptions of the 4th century B.C., and Achaemenid kings of the period seem to have regarded him as their special patron. The Avestan hymns, notably *Ynsht x,* depict him as the god of heavenly light, all-seeing. the guardian of-oaths, protector of the righteous in this world and the next. and above all as archfoe of the powers of evil and darkness and hence god of battles.

It was not, however, this national cult of Mithra that was to attract the west, but rather an amalgam, in effect a new creation, that sprang up abroad in the wake of the Persian conquests The scanty information available does not make it possible to trace the development in detail, but it was almost certainly in eastern Anatolia, where Persian traditions survived longest, that the new religion took its definitive form. Babylonia contributed. as it did to most forms of late paganism, the fatal allure of its pseudo science, Chaldaean astrology, while Greek artists and Greek religion and philosophy provided the models, at least indirectly, for Mithraic iconography and the Mithraic mysteries. Yet despite its veneer of Hellenization, the cult had little appeal for Greeks, and only scattered traces are found in Greece and the Greek east.

A passage of Plutarch (*Pompey,* 24) may imply that the rites were first brought to the attention of the west by Cilician pirates captured in 67 B.C , but it was not until late in the 1st century AD. that Mithraism took firm root in the west, and it began to expand rapidly only in the following century. Rome itself, and its seaport Ostia, always remained a great centre of the cult, nhich reached to Numidia in the south and as far north as the Roman wall in Britain. It was. however, in the Danubian provinces and along the Rhine that Mithra nas most popular. apart from Rome; in western Gaul and the Spanish peninsula he seldom appears.

The new religion owed its diffusion primarily to the army, many of whose recruits were drawn from the Anatolian centres of Mithraic worship, and also to the traffic in oriental slaves; trade routes too played a part, since the stern probity of the god was attractive to the mercantile classes. The cult's chief appeal was at all times to the lowly and humble. and the influence and extent of imperial interest probably has been overemphasized by some scholars. The initiation of the emperor Commodus (A.D 180–192) was a passing fancy without lasting effect. The institution by Aurelian (A.D. 274) of a state cult of the "unconquerable Sun." *Sol invictus,* may have contributed incidentally to the prestige of Mithra, who also bore this proud title. but Mithra never achieved a place in the public cults of the state, and it is not until *c.* 307, under Diocletian, that an imperial dedication to Sol Invictus Mithra. acclaiming him as "a protector of the empire." is found. Yet in fact Dacia, long a stronghold of Mithraism, had already been abandoned to the barbarians (*c.* 270)—the first Roman province to suffer this fate.

With the advent of the Christian emperors, imperial favour gave nay to hostility and even to persecution. The victory of Theodosius in 394 effectively put an end to the cult. but not before the pagan revival under Julian the Apostate (360–363) and the final rally of the pagan aristocracy at Rome had for a few decades made the Persian god a principal symbol of the dying past.

Monuments, Myth and Ritual.— In the absence of liturgical norks or extensive literary accounts. the interpretation of Mithraism depends chiefly on archaeological evidence, above all the sculptures that adorned the sanctuaries Dedicatory inscriptions, in Latin or Greek. provide some significant details. and the polemic of Christian nriters is often suggestive.

The Mithraic chapels referred to as *spelaea* ("grottoes"), were sometimes actual caves more often small underground crypts. A narrow aisle was flanked on both sides by a broad raised bench. on nhich the worshipers, rarely more than 50 in number. could kneel or recline. At one end, often apselike, stood the representation of Mithra slaying the bull, evidently the crowning episode in Mithraic myth and perhaps in the ritual. The scene normally includes a pair of torch bearers flanking the central figures, a scorpion attacking the genitals of the bull. a serpent drinking its blood and a dog springing toward the wound in its side. Sun-god, raven (perhaps the messenger of the sun-god), tree. lion and ener are sometimes added. and, framing the scene, the signs of the zodiac. Finally, this nhole unit may be surrounded by a series of smaller panels, filled nith mythical scenes or symbolic figures.

On the basis of the sculptures, eked out with references from the literature, attempts have been made to reconstruct the Mithraic theology and legend. Though probably subordinate both to the first principle. Zervan Akarana (Infinite Time), and to Ahura Mazda. Mithra. as the creator and as mediator between man and the higher gods, nas clearly the chief deity of the cult as practised. A curious lion-headed human figure, about nhich a serpent coils, has usually been identified as Zervan Akarana, but it seems more likely that he is instead Ahriman, the power of death and darkness, who was perhaps regarded as the prince of this world. Mithra's own legend is depicted in detail, though the interpretation neces-

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"MITHRA SLAYING THE BULL," A ROMAN BAS-RELIEF IN THE LOUVRE. PARIS

sarily remains dubious. Franz Cumont's reconstruction, though ingenious and attractive. is open to some criticism and need not be outlined here. Among the events that appear certain are the birth of Mithra from a rock, his shooting an arrow at a cliff to bring forth water, his adventures in pursuit of the sacred bull, ending with his reluctant (?) sacrifice of the animal, his alliance with the sun-god. the banquet shared with him and his ascent to heaven in the chariot of the Sun. According to Persian sources the bull, apparently in origin a vegetation spirit. by its death gave birth to all living things; thus Mithra became the creator of life, as by his other exploits he was its protector against evil.

As to the organization of the mysteries, it is known that there were seven degrees of initiation open to the adept, perhaps corresponding to the seven planetary spheres to be traversed by the soul in its upward progress: *Corax,* Raven; *Nymph(i)us,* Bridegroom; *Miles,* Soldier; *Leo,* Lion; *Perses,* Persian; *Heliodromus,* Courier of the Sun; *Pater,* Father. (Except that *Pater* is the highest and *Leo* somewhere in the middle, there is no certainty as to the order.) Those in the lowest ranks were called servants, those in the ranks of *Leo* and above. participants, perhaps with reference to the sacred meal of bread and water, which Christian writers likened to the Eucharist.

Initiation was open to men of all ages, even boys; women were excluded. Intensive purifications, including perhaps a sort of baptism, mere prerequisite to initiation, and at each degree the initiate underwent certain ordeals, which however crude or fearsome were charged for him with symbolic meaning: thus the *Miles* was branded on the forehead, to mark him henceforth as a recruit in the army of Mithra, sworn to combat all evil. At the head of each group was either a *Pater* or priest. The latter was designated, in usual Roman fashion as *sacerdos* or *antistes;* there is no hint of the Persian *magus* or anything resembling a priestly caste. Despite the fixity of the iconography and, presumably. of the doctrines, there was no ecumenical organization or hierarchy; at most in each large centre there was a *pater patrum,* as it were, an overseer or bishop. Since Mithraism never became, officially, a recognized cult of the Roman empire, the separate groups of worship remained, like other nonpublic cults, private associations; administered by their own nonclerical officials and supported by private contributions. The numerous dedications. together with the simplicity of the sanctuaries, attest the fervid piety of the worshipers and no less their prevailingly modest circumstances. In fact the cult knew no social distinctions; and slave, freeman, rich, poor, labourer and noble met here as equals.

Like the other oriental mystery religions, but perhaps with more cause, Mithraism offered the appeal of an exotic and ancient wisdom. It professed to explain the origins of the universe and also its end; and Mithra, who had created once and was now man's defender and helper, would in those final days inaugurate a new order in which the faithful would enjoy forever a blessed immortality. Mithra, like the other oriental gods, offered man deliverance, but unlike such others as Attis or Osiris he could also serve as an ideal! a heroic leader for man to follow and emulate in the struggle against evil. A vigorous and positive morality characterized Mithraism throughout its career and constituted one of its chief attractions.

Relations to Christianity. — The oft-quoted opinion of Ernest Renan, that if the growth of Christianity had been stopped early in its history the world mould have been Mithraic, has less value, perhaps, as a historical judgment than for its evocation of how the religious conflict might have seemed to a 3rd-century Christian or Mithraist. Superficially, at least, the two religions had much in common: a divine Lord by whose deeds, performed once (unlike the annual passion of an Attis or an Osiris), man was assured of salvation; a sacramental meal; a ritual of baptism; a concept of religion that could liken the religious life to enlistment and service under a divine commander, *militia Christi* or *militia Mithrae* (though in the case of Mithraism this perhaps did not imply the cosmic struggle between good and evil that appears in both Christianity and Zoroastrianism); not dissimilar ideas of heaven and hell and of a Last Judgment; and a moral code considerably higher and more rigid than that found in contemporary society or required by most other cults. It is not surprising that pious Christians regarded these traits of the rival religion as satanic inventions, parodies of the rites and beliefs of the true church. The last stages of paganism did indeed witness some conscious borrowing of Christian religious patterns. but the more deeply rooted similarities are best explained in terms of a common oriental background.

The similarities were in any case outweighed by the differences, and in these Christianity generally had the advantage. In a period when philosophic and popular thought was increasingly tending to monotheism, Mithraism, for all its exaltation of Mithra, was securely bound to its polytheistic traditions. Mithraism suffered, too, in comparison by having as its redeemer a mythical figure, whose appeal could never match that of the historical Jesus worshiped by Christians as God incarnate. And Mithraism was fatally weak in its exclusion of women. Its distribution, except in the metropolitan centres, is significant: it flourished chiefly where particular conditions, military or mercantile, created a "man's world," and it was weakest where ordinary civilian patterns prevailed. Mithraism failed to use the family as a source of religious strength and continuity. This failure may help to explain why, when the circumstances favourable to its growth at last changed, the imposing edifice of Mithraism collapsed so suddenly and disappeared with such surprising rapidity.

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MITO, historic Japanese city and capital of Ibaraki prefecture. A commercial and railroad centre, it is about 60 mi. N.E. of Tokyo on the northern edge of the Tokyo plain. Between 1940 and 1958 its area increased from 13 sq.km. (5 sq.mi.) to 113 sq.km. (43.6 sq.mi.) and the population from 66,300 and 112,000. An ancient castle town, Mito became the seat of one of the three main branches of the Tokugawa family in 1606. (C. A. MR.)

MITRE, BARTOLOME (1821–1906), Argentine statesman, soldier, author, journalist and president of the republic, was born in Buenos Aires on July 26, 1821, the son of an Argentine army officer. While still a youth his political views caused him to seek refuge in Montevideo, and he spent the next 15 years in exile, serving in the sieges of Montevideo in 1838 and 1843–46 as captain and lieutenant colonel. commanding the government artillery in Bolivia, 1847–48, and editing *El Mercurio* in Valparaiso, Chile. 1848–49, until his opposition to the government compelled him to leave that country. In 1852 he returned to Argentina and commanded the Uruguayan artillery in the battle of Caseros (Feb. 3. 1852), nhere General Urquiza overthren the dictator Rosas. Elected deputy to the provincial legislature of Buenos Aires, he led the opposition to Urquiza's federal plan of government, was appointed provincial minister of war in 1853 and in 1860, governor of the province. In 1859 the estrangement between Buenos Aires and the confederation resulted in war. Mitre, commanding the provincial forces. was beaten in the battle of Cépeda (Oct. 22, 1859) and Buenos Aires was incorporated into the confederation, but in 1861 he defeated Urquiza in the battle of Pavón (Sept. 17), definitively establishing the hegemony of Buenos Aires; and after a short period as president *ad interim,* he became constitutional president on Oct. 7, 1862. Under his leadership Argentina made great progress. He impressed the authority of the national government upon the provincial *caudil-*

los, reorganized the finances. improved international relations and fostered public works, means of communication, immigration and industries.

When, in 1865, Argentina joined Brazil and Uruguay in the War of the Triple Alliance against Paraguay (1865–70), Mitre, then a general, was for a time in command of the allied troops. Soon after the conclusion of his presidential term in 1868, he was elected to the senate, and in 1872–73 filled a special diplomatic mission to Brazil and Paraguay. **A** candidate for the presidency in 1874, upon his defeat he headed an unsuccessful revolt, but he continued to have great political influence and in 1891 was a third time candidate for the presidency; he withdrew his name, however, and not long after retired from political life. He died in Buenos Aires on Jan. 18, 1906.

Mitre's activities were never restricted to those of soldier and statesman. Aside from his journalistic career. which included the ownership of *La Nación,* one of the most important nenspapers in Latin America, his contributions to philology and history proved him one of the outstanding intellectual men of the continent. His works include: *Rimas* (1854); *Historia de Belgrano* (1887); *Historia de San Martin* (1890), *Lenguas americanas* (1894). His private library, at the time the finest in Latin America, he presented as a gift to the state.

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MITRE, a liturgical headdress of the historic churches, generally proper to bishops. The word is derived through the Latin from the Greek *mitra,* a headband or headdress.

In the Roman Catholic Church its actual form is that of a sort of folding cap consisting of two halves which. when not worn. lie flat upon each other. These sides are stiffened. and when the mitre is worn, they rise in front and behind like two horns pointed at the tips. From the lower rim of the mitre at the back hang two bands (*infulae*), terminating in fringes In the Roman Catholic Church mitres are divided into three classes: (1) *Mitra pretiosa,* decorated nith jewels, gold plates, etc.; (2) *Mitra auriphrygiata,* of white silk. sometimes embroidered with gold and silver thread or small pearls, or of cloth of gold plain; (3) *Mitra simplex,* of white silk damask. silk or linen, with the two falling bands behind terminating in red fringes Mitres are the distinctive headdress of bishops; but the right to wear them as in the case of the other episcopal insignia, is granted by the popes to other dignitaries. Bishops alone, including of course the pope and his cardinals, are entitled to near the *pretiosa* and *auriphrygiata;* the others wear the *mitra simplex.*

Origin **and** Antiquity.— The origin and antiquity of the episcopal mitre have been the subject of much debate. Some have claimed for it apostolical sanction and found its origin in the liturgical headgear of the Jewish priesthood. Such proofs as have been adduced for this view are, however, based-on reading a special meaning into words (*mitra, infula,* etc.) used by early writers. With the episcopal mitre the Jewish *miznephet,* translated "mitre" in the King James version (Exod. xxviii, 4,36), has nothing to do. and there is no evidence for the use of the former before the middle of the 10th centurv even in Rome, while elsewhere it does not make its appearance until the 11th.

The first trustworthy notice of its use is under Pope Leo IX (1049–54). This pope invested Archbishop Eberhard of Trier, nho had accompanied him to Rome. aith the Roman *mitra,* telling him that he and his successors should wear it *in ecclesiastico officio* (*i.e.,* as a liturgical ornament) according to Roman custom, in order to remind him that he was a disciple of the Roman see (Jaffé, *Rrgesta pont. rom.,* ed. Leipzig. 1888, no. 4158).

From Leo XI's time papal grants of the mitre to eminent prelates became increasingly frequent, and by the 12th century it had been assumed by all bishops in the west, with or without papal sanction, as their proper liturgical headdress. From the 12th century, too dates the custom of investing the bishop nith the mitre at his consecration. It was not until the 12th century that the mitre came to be regarded as specifically episcopal, and meanwhile the custom had grown up of granting it *konoris causa* to other dignitaries besides bishops. *(See* **ABBOT.)**

Mitres were also sometimes bestowed by the popes on secular sovereigns. In the coronation of the emperor, more particularly, the mitre played a part. According to the 14th Roman *ordo,* of 1241, the pope places on the emperor's head first the *mitra clericalis,* then the imperial diadem.

Development of Form.—The original form of the mitre was that of the early papal tiara (*regnum*), *i.e.,* a somewhat high conical cap. The stages of its general development from this shape to the high double-horned modern mitre are clearly traceable though it is impossible exactly to distinguish them in point of date. The most characteristic modifications may be said to have taken place from the 11th to the middle of the 13th century. About 1100 the conical mitre begins to give place to a round one; a band of embroidery is next set over the top from back to front, which tends to bulge up the soft material on either side; and these bulges develop into points or horns. Mitres with horns on either side seem to have been worn until the end of the 12th century. The custom was, however, already growing of setting horns over the front and back of the head instead of the sides, and with this the essential character of the mitre during the middle ages was established.

In most of the reformed churches the use of mitres was abandoned with that of the other vestments. They have continued to be worn, however, by the bishops of the Scandinavian Lutheran Churches. In the Church of England the liturgical use of the mitre was discontinued at the Reformation but was revived in the latter part of the 19th century and is now fairly widespread.

In the Orthodox Eastern Church the mitre is proper only to bishops. Its form differs entirely from that of the Latin Church. In general it rather resembles a closed crown, surmounted by a cross. In Russia the cross usually lies flat, only certain metropolitans, and by prescription the bishops of the eparchy of Kiev, having the right to have the cross upright. In the Armenian Church priests and archdeacons, as well as the bishops, wear a mitre. That of the bishops is of the Latin form, a custom dating from a grant of Pope Innocent III; that of the priests, the *sagvahart,* is not unlike the Greek mitre. In the Syrian Church only the patriarch wears a mitre, which resembles that of the Greeks. The *biruna* of the Chaldaean Nestorians, on the other hand, worn by all bishops, is a sort of hood ornamented with a cross. Coptic priests and bishops wear the *ballin,* a long strip of stuff ornamented with crosses. etc., and wound turban-wise round the head; the patriarch of Alexandria has a helmetlike mitre, the origin of which is unknown, though it perhaps antedates the appearance of the *phrygium* at Rome. The Maronites, and the uniate Jacobites, Chaldaeans and Copts have adopted the Roman mitre.

The mitre was introduced into the Greek rite only after the capture of Constantinople by the Turks (1453).

See J. Braun, S.J.; *Die liturgische Gewandung,* pp. 424–498 (1907). The question of the use of the mitre in the Anglican Church is dealt with in the *Report of the Sub-committee of the Convocation of Canterbury on the Ornaments of the Church and its Ministers* (1908). *See* also the bibliography to the article VESTMENTS.

MITSCHER, MARC ANDREW (1887–1947), U.S. naval officer, who with consnicuous success commanded the aircraft carrier force, the famous task force 58, in the Pacific during World War II. He was born in Hillsboro, Wis., Jan. 26, 1887, and graduated from the United States Naval academy in 1910. On June 2, 1916, he qualified as the 33rd U.S. naval aviator. Mitscher had an important share in the development of naval aviation and in the integration of aviation into the U.S. fleet. Early in World War II he commanded the aircraft carrier "Hornet" in the battle of Midway. As a rear admiral. he commanded all aircraft in the Solomon Islands during bitter fighting there in 1943. As a vice-admiral he commanded the fast carriers from Jan. 6, 1944, leading this task force in air strikes on Truk, in the battle of the Philippine sea. the battle for Leyte gulf, and the captures of Iwo Jima and Okinawa.

Mitscher died on Feb. 3, 1947, while serving as commander in

chief of the U.S. Atlantic fleet, having held the rank of admiral from Sept. 13, 1946. (J. B. HN.)

MITTAG-LEFFLER, MAGNUS GOSTA (1846–1927), Swedish mathematician who founded *Acta Mathematica*, was born at Stockholm on March 16. 1846. He studied at Uppsala and later became lecturer at the University of Uppsala (1872–77), professor at Helsingfors (1877–81) and finally professor at Stockholm. being rector of the university in 1886, 1891 and 1893. Mittag-Leffler founded the journal *Acta Mathematica* in 1883, set up an editorial staff from the four Scandinavian countries, gained the patronage of Oscar II of Sweden and acted as chief editor for 45 years.

hfittag-Leffler made a number of contributions to analysis. He worked on the general theory of functions and gave a proof of Cauchy's theorem. He also dealt with the problem of the analytic representation of a one-valued function a result of which was the well-known Mittag-Leffler theorem. A good deal of his researches laid the foundation of later work of the Swedish school of function theoretical studies. He died at Stockholm on July 7, 1927, leaving his estate and mathematical library to the Mittag-Leffler Mathematical institute at Djursholm near Stockholm. (O. OE.)

MIVART, ST. GEORGE JACKSON (1827–1900), English biologist, known for his studies of comparative vertebrate anatomy, was born on Nov. 30, 1827, in London. In 1851 he was called to the bar, but devoting himself to scientific studies, he was appointed lecturer at St. Mary's Hospital medical school in 1862, and from 1874 to 1877 was professor of biology at the short-lived Catholic University College, London. In 1871 his essay *On the Genesis of Species* brought him into the controversy then raging round the theories of Darwin, and ultimately led to his estrangement from both Darwin and Huxley. Though admitting evolution in general, Mivart emphasized the distinction between organic and inorganic matter, minimized the importance of natural selection, and, especially in his *Nature and Thought* (1882) and his *The Origin of Human Reason* (1889), denied the evolution of the human intellect.

Among the scientific works of Mivart are: *Lessons in Elementary Anatomy* (1873), *Man and Apes* (1873), *The Common Frog* (1874) and *The Cat: an Introduction to the Study of Backboned Animals* (1881). Some articles published in the journal *Nineteenth Century*, while he was professor of the philosophy of natural history at Louvain, advocated the claims of science even where they seemed to conflict with religion, and were placed on the *Index*. Other articles in January 1900 led to his excommunication by Cardinal Vaughan, with whom he had a curious correspondence vindicating his claim to hold liberal opinions while remaining a Catholic. Shortly afterward he died, in London, on April 1, 1900.

MIXE-ZOQUE, a stock of Mexican Indians, in the region of the Isthmus of Tehuantepec, between longitude 92° and 96°, nowhere reaching the sea. The Mixe are to the west, the Zoque to the east. The two languages are related, but seem distinct from Zapotecan, Nahuan and Maya.

Mixe and Zoque were regarded as sturdy but backward people by their ancient neighbours. The Popoloco of Puebla and Tapachula of the Guatemalan frontier seem to belong to them linguistically. The 1950 census enumerated 58,000 Mixe and 10,000 Zoque.

MIXTEC, a people occupying much of the western half of the state of Oaxaca, Mex. With the Zapotec and several smaller groups, they are considered to form the Zapotecan linguistic family. They participated to some degree in the higher civilization of ancient Mexico. and made fine polychrome pottery. They were conquered by the Aztecs. In 1950, 154,000 Indians spoke hfixtec.

MIYAGI, prefecture (ken) in northeastern Japan, is the centre of communications and trade for the Tōhoku (northern Honshu) region. Area 2,813 sq.mi. Pop. (19jj) 1,727,065. Miyagi was formed from sections of Rikuzen and Iwaki provinces which were part of Mutsu province before the restoration of 1868.

Its western mountains are part of the Central range of Honshu. Its coastal range is broken by Matsushima bay, a beauty spot famous since Tokugama times, and Sendai plain which contains Sendai, capital of the prefecture. Considerable effort has been made to develop sea trade by improving the harbours of Ishinomaki and Shiogama. (C. A. MR.)

MIYAZAKI, a Japanese prefecture (ken) in southeastern Kyushu. was formed from the province of Hyūga after the restoration of 1868. Area 2,986 sq.mi. Pop. (1955) 1,139,384. Miyazaki is mountainous with a small coastal plain. A long growing season and the presence of the Japan current along its coast make two crops of rice possible in one year. The chief products are chemicals. wood pulp. bamboo goods and charcoal.

Miyazaki city (pop. [1955] 140,782), communications centre and capital of Miyazaki prefecture, is located on the largest agricultural plain of southeastern Kyushu. Miyazaki shrine commemorates the legend that the travels of the first emperor of Japan, Jimmu Tennō, started there. (C. A. MR.)

MIZPAH. There are several places of this name in the Old Testament. (1) Mizpah of Gilead, where Jacob was reconciled to Laban, and Jepthah encamped before attacking the Ammonites. It is supposed to be identical with Ramoth Gilead. (2) Mizpah of Benjamin, where the Hebrews assembled preliminary to the annihilation of the Benjamites (Judg. xx, 1); Samuel made it his headquarters (1 Sam. vii. 5). Fortified by Asa it became the seat of the viceroy Gedaliah and the scene of his murder. Although recently an identification with Tell-en-Nasbeh has been suggested, Nebi Samwil is the traditional and generally accepted site. A crusaders' church (1151), later converted into a mosque, is built over the traditional tomb of Samuel. It was destroyed by the shelling of the Turkish army in their efforts to drive from it the British troops (Nov. 27–30, 1917). (3) A territory near Mt. Hermon (Josh. xi. 3). (4) A town in the tribe of Judah (Josh. xv. 38). (5) Mizpah of Moab, where David interviewed the king of Moab and found a place of refuge for his parents (1 Sam. xxii. 3).

See W. J. Phythian-Adams, "The Mizpah of 1 Sam. vii, 5" (=Tell-en-Nasbch), *Journ. Pal. Orient. Soc.* 3:13 ff. (1923); W. F. Albright, "The Site of Mizpah in Benjamin" (Nebi Samwil), *Revue Biblique* 33:637 ff. (1924).

MIZRAIM, the biblical name for Egypt (Gen. x, 6. 13). The apparently dual termination (Heb. *Misrayim*) may be due to a misunderstanding or may refer to upper and lower Egypt as two entities in one. There is an alternative poetical form Masor (11 Kings xix. 24, etc.). In Isa. xi, 11 the name is distinct from Pathros or upper Egypt, and includes some of lower Egypt.

C. T. Beke. as long ago as 1834, in his *Origines biblicae* concluded that "Egypt" in the Old Testament sometimes denotes a district near Midian and the Gulf of Xqaba; and this view, restated quite independently by Hugo Winckler on later evidence (1893), has been the subject of continued debate. Egypt is known to have laid claim to the southern half of Palestine from early times. and consequently the extension of the name of Egypt beyond the limits of Egypt is inherently probable (so especially Ezek. xx. 36). For example. Hagar, as the ancestress of Ishmaelite tribes, may not have been an "Egyptian" in the strict ethnical sense.

Besides this hlizraim the Old Testament knows of another. In 1874 E. Schrader pointed out that the Assyrians locate a Musri (*i.e.*, Mizraim) to the north of Palestine and this land presumably is referred to in II Kings vii, 6 (mentioned with the Hittites) and again in I Kings x, 28 ff.. II Chron. i, 16 ff., where the word for "droves" (Heb. *m-k-v-h*) conceals the land of Kuë (Cilicia). The situation of this Musri is disputed. some authorities even placing it east of the Tigris.

M.K.S. (GIORGI) **SYSTEM:** *see* PHYSICAL UNITS.

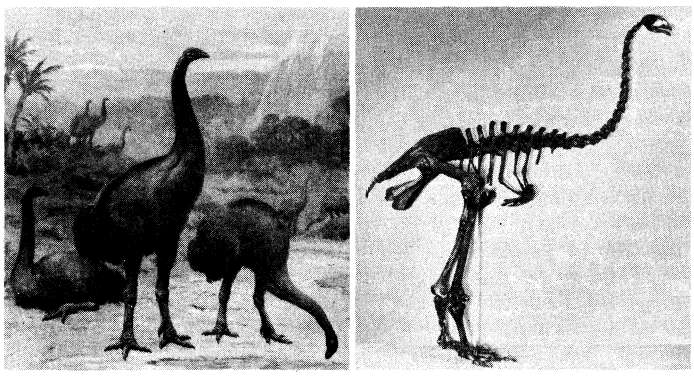
MNEMONICS, or *memoria technica*, the general name applied to devices for aiding the memory. The principle is to enable the mind to reproduce a relatively unfamiliar idea, and especially a series of dissociated ideas. by connecting it, or them. in some artificial whole. the parts of which are mutually suggestive. Among the most famous examples of metrical mnemonics are the "gender rhymes" of the Latin grammars, the hexameter lines (especially that beginning "Barbara Celarent") invented by logicians and the verse for remembering the number of days in the months ("Thirty

days hath September, April, June and November"). See also MEMORY.

See A. E. Middleton, *Memory Systems,* Old *and New,* 3rd *ed (1888).*

MNESICLES, the architect of the great Propylaea of the Athenian Acropolis, set up by Pericles about 437 B.C.

MOA, the Maori name of the extinct, flightless, ostrichlike birds comprising the New Zealand order Dinornithiformes (see BIRD). In the North Island the moas seem to have died out about 500–700 years ago, probably before the arrival of the Maoris. In the South Island they lingered much longer, possibly in the unexplored interior even down to the time that Capt. James Cook visited New Zealand (1769).



BY COURTESY OF CHICAGO NATURAL HISTORY MUSEUM, (LEFT) FROM A MURAL BY CHARLES R KNIGHT

MOA (DINORNIS ROBUSTUS), EXTINCT FLIGHTLESS BIRD. AT LEFT. RESTORATION DRAWING. AT RIGHT. SKELETAL CAST OF RECENTLY EXTINCT NEW ZEALAND MOA (EMEUS)

Numerous bones of the moa have been found in caves. swamps and kitchen middens. and some pieces of bodies with skin and feathers. The wings and shoulder girdle, except for a few vestiges in one species (Anomalopteryx *dromaeoides*), had entirely disappeared. There is no trace of a keel on the sternum. The bind limbs were very strong and ended in four toes. The bill was short and stout and the feathers had a large aftershaft. The moas varied from the 12-it.-high Dinornis *robustus* to the size of a turkey (Anomalopteryx *parva*). Their affinities are with the kiwis. Moas are known only as far back as the Pliocene, and seem to have been herbivorous. See KIWI.

MOAB, the name of an ancient people of Palestine who inhabited a district east of the Jordan and the Dead sea, lying north of Edom and south of Ammon.

The national traditions of the Israelites (see JEWS) recognize a close relationship between Moab and Ammon, "sons" of Lot, and the "brothers" Esau (Edom) and Jacob (Israel), and Moab is represented as already a powerful people when Israel fled from Egypt (Ex. xv, 15).

It was supposed that Moab, having expelled the aboriginal giants, was in turn displaced by the Amorite king Sihon, who forced Moab south of the Arnon (Wadi Mojib, a natural boundary) and drove Ammon beyond the Jabbok. The Israelites at Kadesh, almost at the gate of the promised land, incurred the wrath of Yahweh, and, deterred by a defeat at Hormah from pursuing their journey northward. chose another route (Num. xiv, 40–45; contrast xxi, 1–3).

A great detour was made round by the south of Edom (Num. xiv. 25; xxi, 4; Judg. xi, 18), and the people reached Pisgah in Moab (Num. xxi, 16–20; *cf.* Deut. iii. 27, xxxiv, 1), or, according to another view, passed outside Moab until they reached the border of Sihon's kingdom (Num. xxi, 13, 26; Judg. xi. 17 ff.). The late list in Num. xxxiii even seems to assume that the journey was made from Kadesh across the northern end of Edom. Apparently no fixed or distinct tradition existed regarding the journeys; and it is extremely probable that some of the most characteristic features of the narratives belong to much later periods than the latter half of the 2nd millennium B C., the age to which they are ascribed (*e.g.,* the poem on the fall of Heshbon, Num. xxi, 27–30).

The history of the "brothers" Moab and Ammon was bound up with that of Judah and Israel respectively and depended, to a considerable extent, upon these two and their mutual relations. Jephthah (*q.v.*), one of the Israelite "judges," delivered Gilead from Ammon, who resumed the attack under its king Nahash. only to be repulsed by Saul (*q.v.*). Ehud (*q.v.*) of Benjamin or Ephraim freed Israel from the Moabite oppression. To the first great kings, Saul and David, are ascribed conquests over Moab, Ammon and Edom. The Judaean David, for his part, sought to cultivate friendly relations with Ammon, and tradition connects him closely with Moab. His son Solomon contracted marriages with women of both states (I Kings xi. 5, 7), thus introducing into Jerusalem cults which were not put down until almost at the close of the monarchy (II Rings xxiii. 13). In the 9th century B.C. the two states appear in a more historical light, thanks to the Assyrian records and a lengthy Moabite inscription.

This latter inscription, now in the Louvre, was found at Dhiban, the biblical Dibon. in 1868. It contains a record of the successes gained by the Moabite king Mesha against Israel. Omri (*q.v.*) had previously seized a number of Moabite cities north of the Arnon, and for 40 years the Moabite national god Chemosh was angry with his land. At length he roused Mesha; and Moab, who had evidently retreated southward toward Edom, now began to take reprisals. "The men of Gad had dwelt in the land of Ataroth from of old; and the king of Israel built Ataroth for himself." Mesha took the city, slew its people in honour of Chemosh, and dragged before the god the altar hearth (or the priests?) of D-v-d-h (apparently a divine name: but curiously similar to David). Chemosh next roused Mesha against the city of Nebo. It fell with its thousands. for the king had "devoted" it to the deity 'Ashtar-Chemosh. Yahweh had been worshiped there, and his . . (?vessels, or perhaps the same doubtful word as above) were dragged before the victorious Chemosh. With the help of these and other victories (at Jahaz, Aroer, etc.), Moab recovered its territory, fortified its cities, supplied them with cisterns, and Mesha built a great sanctuary to his god. The inscription enumerates many places known elsewhere. (Isa. xv; Jer. xlviii), but, although it mentions the "men of Gad," makes no allusion to the Israelite tribe Reuben, whose seat lay in the district (Num. xxxii; Josh. xiii, 15–23; see REUBEN). The revolt will have followed Ahab's death (see II Kings i, 1) and apparently led to the unsuccessful attempt by Jehoram to recover the lost ground (ibid. iii).

Moab thus retained its independence, even harrying Israel with marauding bands (II Kings xiii, 20), while Ammon was perpetrating cruelties upon Gilead (Am. i, 13 ff.). But under Jeroboam II (*q.v.*) Israelite territory was extended to the Wadi of the 'Arabah or wilderness (probably south end of the Dead sea), and again Moab suffered. If Isa. xv ff. is to be referred to this age, its people fled southward and appealed for protection to the overlord of Edom (see UZZIAH). During the Assyrian supremacy its king Salamannu paid tribute to Tiglath-pileser III, but joined the short-lived revolt with Judah and Philistia in 712. When Sennacherib besieged Jerusalem in 700, Kamus (Chemosh)-nadab also submitted; and subsequently both Esarhaddon and Assurbanipal received tribute from the Moabite king Musuri ("the Egyptian"). During the reign of Assurbanipal Moab helped to repulse the invasion of the Nabayati and nomads of Kedar, a movement which made itself felt from Edom nearly as far as Damascus. It had its root in the revolt of Shamash-shum-ukin of Babylonia. and, coming at a time immediately preceding the disintegration of the Assyrian empire, had important consequences for Judah and the east of the Jordan.

Later, Moab joined the coalition against Babylonia (Jer. xxvii, 3), and if it is condemned for its joy at the fall of Jerusalem (Isa. xxv, 9 ff.; Jer. xlviii; Ezek. xxv, 8–11; Zeph. ii, 8–10), it harboured fugitive Jews (Jer. xl, 11): the dates of the most significant passages are unfortunately uncertain. If Sanballat the Horonite was really a native of the Moabite Horonaim, he finds an appropriate place by the side of Tobiah the Ammonite and Gashmu the Arabian among the strenuous opponents of Nehemiah. Still later we find Moab part of the province of Arabia in the

hands of fresh tribes from the Arabian desert (Jos *Ant.* xiii, 13, **j)**; and. with the loss of its former independent power. the name survives merely as a type (Dan. xi, 41).

As Mesha's inscription proves. Moab had reached a high state of civilization by the 9th century B C. Its language differed only dialectically from Hebrew; its religion and culture were very closely akin to the Israelite. The relation of Chemosh, the national god, to his "children" (Num. xxi, 29) was that of Yahweh to Israel (Judg. xi, 24). Apart from the religious cult suggested in the name Mt. Nebo, there mere local cults of the Baal of Peor and the Baal of Meon; and Mesha's allusion to 'Ashtar-Chemosh, a compound deity, has been taken to point to a corresponding consort whose existence might naturally be expected upon other grounds (see ASTARTE). The fertility of Moab, the wealth of wine and corn, the temperate climate and the enervating heat supply conditions which directed the form of cult. Nature worship, as in Israel, prevailed, and the impure rites of Shittim and Baal-Peor (Num. xxxi. 16; Ps. cvi. 28) would not materially differ from practices which Israelite prophets condemn. The kinship of Israel with the external states (Moab, Edom. and Ammon) is entirely justified. It extends intermittently throughout the history. But Israel remained a great power while Moab disappeared. It is true that Moab was continuously hard pressed by desert hordes; the exposed condition of the land is emphasized by the chains of ruined forts and castles nhich even the Romans were compelled to construct. But the explanation is to be found nithin Israel itself, and especially in the work of the prophets.

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MOAT, a depression surrounding a castle, city wall or other fortification, usually. but not always. filled with water. The existence of a moat was a natural result of early methods of fortification by earthworks, for the ditch produced by the removal of earth to form a rampart made a valuable part of the defense system. When. in the middle ages. earthworks gave way to masonry walls, the moat was retained, and became even more valuable than before as it prevented moving towers or battering rams from being brought up to the ramparts until the moat had been filled. With the development of firearms the moat lost much of its importance, but was occasionally retained into the 18th century as an obstacle against infantry attacks. Dry moats or ditches. as parts of modern earthworks, still occur spasmodically. *See* also CASTLE; FORTIFICATION.

For a thorough consideration of medieval moats, *see* E Viollet-le-Duc, *Dictionnaire Raisonné,* articles "Architecture Militaire" and "Château"

MOBILE, a city of southwestern Alabama, U.S., at the head of Mobile bay on the Gulf of Mexico; a river port and the state's only seaport; the seat of Mobile county. Maritime industry is extensive, including five shipyards in Mobile and the immediate vicinity; Brookley air force base is a major logistic installation of the U S air force and is one of the chief employers of labour in Mobile. Pop. (1960) city 202,779; standard metropolitan statistical area (Mobile county) 314,301. (For comparative population figures see table in ALABAMA: Population.)

History.— The Mobile area was explored by Spaniards under Alonso Alvarez de Piñeda (1519), Pánfilo de Narváez (1528, with Cabeza de Vaca), Francisco Maldonado (1540). Guido de las Bazares (1558) and Tristan de Luna (1559). French colonists under Bienville established Mobile at its present site in 1711, the first permanent European settlement in Alabama; and Mobile was the capital of French Louisiana (1711–20). Its name is a French adaptation of the name of an Indian tribe in the area.

French rule was followed in 1763 by British rule. During the American Revolution, Spanish forces under Bernardo de Gálvez captured Mobile. The United States occupied the city in 1813 and clarified its title by the Florida purchase (1819). In ante-bellum times Mobile became one of the leading ports in the export of cotton, and the Mobile and Ohio railroad was of major commercial importance in supplementing the river system.

During the American Civil War, trade with the West Indies and Europe was kept up despite a Federal blockade begun in 1861. In 1864 Adm. David G. Farragut entered the channel, captured the Confederate ironclad ram "Tennessee," destroyed one gunboat and drove another aground; in the engagement he lost the Federal monitor "Tecumseh." Fort Gaines, on Dauphin Island, surrendered on Aug. 7, 1864; Fort Morgan, on Mobile point, on Aug. 23. In the spring of 1865 Gen. E. R. S. Canby laid siege to Ft. Blakely and Spanish Fort, on the east side of the bay. After 25 days the forts. and then the city, were evacuated, and the Federal forces entered the city on April 12, 1865. In 1879 the municipality went bankrupt and in 1887 Mobile was again chartered as a city.

Banana importing commenced in 1893, supplementing the old export trade in lumber and cotton. Foreign and coasting trade was especially stimulated by the opening of the Panama canal. The opening of the system of locks and dams on the Warrior-Tombigbee rivers in 1915 proved to be a major event in the history of Mobile, as did the development of the Intercoastal Waterway and the Federal Barge Lines and the construction of the Alabama state docks, commenced in 1923. Cochrane bridge across Mobile bay (extending 10½ mi.) was completed in 1927 and Bankhead tunnel under the Mobile river in 1941. Bridge and tunnel together added materially to the trade area of Mobile by improving access to Baldwin county, which has the largest area of all Alabama counties.

Controlling depth of the ship channel has been a vital factor in the commerce and history of the city. Originally the minimum depth was only 5½ ft. In 1839 the channel had a minimum depth of 10 ft. but by 1867 the controlling depth was only 7 ft. A 13-ft. channel was opened in 1876. By 1888 the depth was 17 ft. and by World War I the channel was 27 ft. After World War II the channel's minimum depth was 36 ft. and width 400 ft.

Population characteristics.— The population of Mobile in 1950 was 63.1% native-born white, 1.3% foreign-born white and 35.6% coloured, almost all Negro. From 1820 through 1900 Mobile was the most populous city in Alabama, but since 1910 each census has shown Birmingham in first place. For a time during World War II Mobile was the fastest-growing city in the nation.

Commerce and Industry.— Manufacturing was less important than commerce during most of the history of Mobile but this ceased to be true in the 20th century. Textiles and food industries have long been significant. During World War I shipbuilding and other manufactures received considerable impetus. This was even more marked during World War II, when 196 ships were built in Mobile yards. One shipyard pioneered in welded hull construction, a process which proved of world-wide significance. Among the varied industries of Mobile are the manufacture of paper, aluminum, transportation equipment, lumber, food, textiles, chemicals, iron and steel. Factors in the growth of manufactures include the availability of electricity, water and petroleum; an adequate labour supply; and excellent transportation facilities. The principal oil field in Alabama is that at Citronelle in Mobile county. Manufacturing establishments in the county number over 200. In 1956 the total income in Mobile county was $229,072,000, as compared with $55,743,000 in 1939. These statistics summarize much of the economic history of the area during and after World War II.

Education.— Mobile is the site of Spring Hill college, a Roman Catholic coeducational college, established in 1830 and chartered in 1836. There is also an extension centre of the University of Alabama.

Parks and Recreation.— Mobile has a number of city parks, including Bienville square in the business section. Other points of interest in Mobile and the immediate vicinity include Bellingrath gardens, an estate a few miles south of the city, noted for its collection of azaleas and japonicas; a statue of Adm. Raphael Semmes, the Confederate naval hero; numerous ante-bellum homes and churches; the U.S. Marine hospital building; waterfront scenes including the oyster dock, the banana wharf and shipyards

located on Pinto Island, Blakely Island and at Chickasaw; Fort Morgan at Mobile Point (a state park); Fort Gaines and other scenes on Dauphin Island, 23 mi. S. of Mobile; and the U.S. quarantine station on Sand Island. Meaher and Gulf state parks are also nearby.

BIBLIOGRAPHY.—P. J. Hamilton, *Mobile of the* Five *Flags* (1913) and *Colonial Mobile,* new ed. (1952); C. G. Summersell, *Mobile: History of a Seaport Town* (1949) and *Alabama History for Schools* (1957); Caldwell Delaney, *The Story of Mobile* (1953) and *Remember Mobile* (1948). For economic history in the 20th century, see *Alabama Business,* published by the Bureau of Business Research, University of Alabama. (C. G. SL.)

MOBILIZATION, ECONOMIC. Economic mobilization is the vast and complex process by which all the productive resources of a nation are organized and directed in support of a major war effort. It is the transformation of the economic system into a supporting base for the armed forces of the nation. It is far more than the nation in arms in the traditional sense (*see* CONSCRIPTION; MOBILIZATION AND DEMOBILIZATION, MILITARY). It is the redirection of the entire productive effort of a nation in support of a maximum and sustained war effort. Considered within the context of military science it is logistics writ large. In the older meaning of the term, logistics (*q.v.*) related simply to the transport, quartering and supply of troops. It was usually limited to supply operations in the field. taking for granted not only the production but also the procurement of munitions, equipment and supplies. More recently the concept of logistics has expanded to the point where some authorities define it so comprehensively as to include the entire industrial and economic base of military operations.

Economic mobilization is essentially a 20th-century phenomenon. although anticipations of it may be found in earlier wars The experience of the Confederacy in the U.S Civil War, for example, represents a groping, incomplete and largely ineffective effort to mobilize the economy of the South in the struggle against the Sorth with its far greater wealth and resources. The Confederacy was greatly inferior in manpower, in finances, in transportation and shipping facilities and, above all, in productive capacity for turning out the munitions, supplies and equipment required by the armed forces. In the effort to make the most of these limited resources, Confederate and state governments resorted to a variety of extraordinary measures, which eventually included some degree of control over manpower, materials, transportation. foreign trade and prices as well as numerous government-owned and government-managed manufacturing establishments. Jealousy and friction between state and central governments. the poverty of administrative resources in a region where the role of government had extended little beyond the maintenance of order and, most importantly. the understandable failure adequately to grasp the nature and requirements of the situation combined to defeat the efforts to mobilize and manage a war economy.

20th-CENTURY MILITARY REVOLUTION

Both as concept and as process. economic mobilization is an outgrowth of the radical changes in the character and magnitude of warfare that have taken place since 1900. In all ages war has affected and been influenced by the prevailing economic system. Armed forces must be raised, trained, equipped. supplied and paid. The costs of war must be met in one may or another. Part of the product of the economy must be diverted from peacetime uses to the destructive purposes of war. The extent of such diversion rests at bottom on the ability of the economic system to produce a surplus beyond the bedrock requirements of the civilian population and the economy itself, and upon the ability of the government to capture this surplus by taxation. borrowing or requisitioning. Paradoxically, the usual effect of war has been to stimulate rather than depress the economy. Business improves, prices rise, production and employment increase and opportunities for profit making multiply. War periods in modern times have typically been periods of high production and relative prosperity. however unfortunate the consequences for particular segments of the economy, such as foreign trade, and however distorted the pattern of normal production and of business relationships. Yet with all this stimulation, disturbance and distortion, prior to the 20th century the capitalist economy of the western world continued to function during war substantially as in peacetime.

The reasons for this are clear. The scale and intensity of military operations in earlier wars were very limited, however prolonged and burdensome the conflict. Armies moved on foot and fought with hand weapons; engagements were infrequent and of brief duration; firepower was low; food and forage presented the major problems of supply. The demands of the military were correspondingly small in relation to the total output of the typically agricultural economy. Military requirements were added to those of the civilian population without any significant change in the organization and functioning of the economy as a whole. Under such conditions, military supplies were obtained largely by an intensification of normal procurement procedures, operating within the free market, although often greatly hampered by the widening gap between supply and demand, by multiplying shortages and by spiraling prices. Occasionally there would be resort to the more drastic methods of forced requisitions of supplies but such measures, except in enemy territory, were exceptional. There was no direct intervention by government in the functioning of the economy, as such, by the control of prices, wages, profits and rent, distribution of scarce materials through systems of priorities and allocations or rationing and the control of credit and investment.

All this was changed as the result of the impact upon warfare of the extraordinary technological and industrial developments culminating in the generation before 1914. Industrialization was the keynote of economic advance in all the great powers. Large-scale organization and mass production were the characteristic features of the new industry. Mechanization proceeded rapidly in all branches of economic life, stimulated by new sources of power such as electricity and the internal-combustion engine. new fuels such as petroleum and natural gas, new materials such as steel, rubber and aluminum. Combined with new methods of organization and direction. the new technology brought great increases in productive capacity and efficiency. Applied to the art of war, the new means of production made possible the equipment of large military forces with weapons hitherto available only in small quantities and introduced novel weapons and matériel that gave new dimensions to combat. The result was a new kind of warfare, based on the mechanization of combat and the industrialization of supply. The breech-loading rifle and metallic cartridge, the machine gun, the rapid-fire, breech-loading field gun and comparable weapons in the naval field, especially the submarine and the self-propelled torpedo, raised warfare to an unprecedented level of intensity. Military operations were further mechanized by the introduction of the airplane and the tank, both made possible by the internal-combustion engine. The railroad and steamship were supplemented for the first time by motor truck and the older methods of communication by motor vehicles and field telephones. The superior efficiency of the new industrial to the traditional agricultural economy made possible a greatly increased diversion of materials and manpower to the purposes of war.

WORLD WAR I

The attempt of Germany in 1914 to force a quick decision was frustrated in the first battle of the Marne and the conflict soon settled down to a stalemate of trench warfare on fronts hundreds of miles long with the opposed forces numbered in the millions. The huge numbers engaged, the long sustained actions rising to periodic climaxes in great offensives, and the high rates of fire of mechanized weapons resulted in enormous expenditure of ammunition and correspondingly heavy consumption of other supplies. The scale of the resulting supply problem far exceeded anything anticipated by any of the great powers. Not one of the belligerent nations had plans for any such contingency. Efforts to cope with the emergency produced a disorganization not only of antiquated military supply systems that soon verged on chaos, but of the supporting economies as well. National production declined rather than rose. The armed services competed with each other in the market as also did allies, compounding the confusion. The tradi-

tional methods of producing and procuring munitions within the framework of the free market, price incentives, private enterprise and competitive bidding. proved hopelessly inadequate. The gap between skyrocketing military requirements and limited sources of supply could not possibly be bridged. Spiraling prices were more productive of inflation than of badly needed goods.

Faced with supply crises that became worse with each passing week. the belligerent governments reluctantly accepted the necessity of extraordinary action. In the absence of both experience and plans and handicapped by the deeply embedded doctrines of individualism and *laissez faire,* the necessary directive action and controls came slowly and only under the compelling pressure of successive crises. The overriding need mas to channel scarce materials, goods, manpower and productive capacity where they were most needed to advance the war effort, reducing or cutting off the flow to less essential or nonessential uses. Beginning usually with controls over the distribution of critically short supplies of raw materials. governments gradually brought under their direct management or regulatory control transportation. food. fuels, manpower, foreign trade. prices, wages, credit and profits.

Price inflation was a major threat to the entire war effort. Spiraling prices interfered with getting desperately needed production by introducing elements of uncertainty, risk and speculation in business activities at all levels. Inflation favoured the speculator as against the producer, seriously affected fixed-income groups and lowered the take-home pay of workers and soldiers alike faster than adjustments could be made in wage and pay rates. Profit appeared to take precedence over patriotism; public indignation was aroused and national unity and morale undermined. Price stabilization was the key to the stability and productive efficiency of the economy.

The compelling need for munitions in ever-larger quantities focused attention upon the manufacturing industries producing them and upon the measures for channeling industry into military production. The task was twofold: the conversion of plants making civilian-type products to the production of the far more exacting specifications and very different articles of war matériel; and the large-scale expansion of production of all goods and services required to meet the tremendous needs of the military added to civilian requirements. Conversion and expansion alike were difficult, time consuming and costly in scarce labour and materials. The term "industrial mobilization" was shortly coined to describe this industry-centred process. *(See* INDUSTRY AND TRADE, WAR CONTROL OF.) Adapted from the familiar military phrase for assembling and readying conscript armies for action, the term was apposite. for, as it seemed to manufacturers and businessmen generally, the extraordinary measures adopted by government amounted to scarcely less than the militarization of industrial production. Actually, not only production but the entire economic system became quickly and deeply involved in the nar effort. Since industrial production takes place nithin the economic framework of such institutions as money. credit. prices and wages. the market. risks and investment. the mobilization of the one inevitably entails the mobilization of the rest.

COMPARISON OF PEACE AND WAR ECONOMIES

Broadly considered, economic mobilization is the process by which the normal economy of peacetime is transformed into the war economy. The distinctive character of the war economy can best be understood by noting the effects of this transformation upon certain basic institutions of the private enterprise economy which. prior to World War II at least. was the ruling economic system among the great powers. In the typical nar economy. private property is kept but loses something of its privacy since the owner's freedom to use it is restricted in numerous ways. The pursuit of self-interest and profit continues as the driving force of the economy but it becomes subject to many restraints and restrictions, as, for example. the multiplying regulatory controls. Property is made to bear a greatly increased burden of taxation, some of which is avowedly aimed at the recapture of the excessive profits usually accompanying wartime prosperity.

In two major respects, however, the war economy differs significantly from that of peacetime in nations where private enterprise prevails. In peacetime the basic decisions in the economy, that is. the decisions as to what goods and services are provided, of what quality. in what amounts and at what prices sold and bought, are made by private individuals or private business organizations, whether as producers, consumers, investors, workers or middlemen. In a war economy, on the other hand, these basic decisions and many other closely related ones are made by government agencies and government officials. They determine what is and what is not to be produced, in what quantities and for whom. and in what order of priority. Government takes the driving seat in the war economy and directs the operation of the vast and complicated productive machine of the nation so as best to support the national military effort. Businessmen and business organizations, workers and consumers still make decisions in a great many matters but they do so within the framework and limits of policies established and high-level decisions made by government.

Secondly, because the normally automatic stabilization of the economic system through the mechanism of prices and the free market breaks down as a result of the wide and continuing divergence between supply and demand in wartime, the government must step in and provide artificially the stability (or equilibrium) which the economic system no longer affords. It is significant that prices, the controlling and directing mechanism in peacetime, become themselves a primary object of control in the economy mobilized for war.

WORLD WAR II

Economic mobilization from 1914 to 1918 was simply a prelude to the vaster and more complex mobilization of resources set in motion by the outbreak in 1939 of World War II. Blitzkrieg as conducted by Germany in Poland. the Low Countries and France was carried out with a surprisingly small commitment of military forces and with no mobilization of resources in the proper sense of the term. The fall of France and the evacuation of Dunkirk marked the beginning of the full-scale military effort. Thereafter the mobilization of the economies of the belligerents proceeded at a pace directly proportioned to the gravity of their military situations.

Mobilization and management of the war economy in World War II were in fundamental respects very similar to the experience of World War I. The differences resulted in the main from the far greater scale and intensity and the somewhat longer duration of the second war. In contrast with the continental scale of the first war, the second was global in extent, with military operations carried on in two major and a number of lesser theatres. Total direct war costs rose tenfold and more above those of the first mar against increases of national product and income that were far less. The more fully committed nations, especially Britain, Germany and the U.S.S.R., devoted close to half their national incomes to the prosecution of the war, and the United States was not far behind.

On the technical side, World War II marked advances beyond World War I almost as striking as those that separated World War I from the wars of the 19th century. A highly mobile warfare on land and sea and in the air employed weapons and matériel of rapidly accelerating complexity and cost. The scientific and technological resources of the great powers that had played but a minor role in the first war were in the second as systematically and fully mobilized as industry. The resulting achievements greatly increased military effectiveness but at a cost both in the productive resources allocated to research and development and in the strain which producing the new devices placed upon the economy. Air warfare both figuratively and literally added a new dimension to warfare. Mass bombing of population and production centres carried the war directly to the source of the enemy's military strength and compelled the diversion of scarce resources to the work of repair, rehabilitation and civil defense.

With the benefit of World War I experience and with advances in the understanding of the economy and the arts of government and administration, the belligerents began the mobilization of resources in 1939–40 in a far better position than 25 years earlier.

However fumbling and haphazard some of the early efforts toward mobilization, governments in World War II had a far clearer grasp of the nature and requirements of a planned and managed war economy That mobilization of industry was only part of the larger task of mobilizing the economy for war was understood from the outset. In the democratic nations there was at first a reluctance on the part of both businessmen and the general public to face up to the demands of total war, but informed men in industry and government alike clearly envisaged the general character and problems if not the magnitude of the task ahead. The general extension of governmental activities in the interwar years, especially in response to the crisis of the great depression, had both increased the understanding of the economy and its management and enlarged greatly the administrative machinery and skills of government. Governments were thus far better equipped to deal with the war emergency

While the mobilization tasks of World War II were fundamentally much the same as in the earlier war, the greater scale and intensity of the war placed a far greater load on the supporting economies It was necessary to develop tighter, more elaborate and more highly refined systems of controls, adding tremendously to the administrative burdens of the central authorities. In respect to such vital materials as steel, copper and aluminum, a system of priorities — preferential paper claims on materials — proved quite inadequate. Priorities had to be largely replaced by systems of allocations in which specific quantities of each material were allocated to specific production programs and uses. Eventually, shortages of materials and goods tended to resolve themselves into shortages of labour. Such shortages had to be met by new and more stringent manpower controls.

Stabilization of prices presented unusually difficult problems caused by the wide and growing gap between the purchasing poner of a labour force enjoying full employment, with high wages increased by overtime and the greatly diminished quantity of consumer goods. Systems of direct controls over prices, including wages, profits and rents, were supplemented by a variety of measures for absorbing purchasing power, including taxation, forced loans and government savings bond campaigns. Great ingenuity was shown in devising fiscal measures for supporting stabilization and meeting the problems of war financing.

"COLD WAR" ERA

In the years after 1945, continuing international tensions, kept high by local wars and the unrelieved pressure of the "cold war" between the western and Soviet blocs. resulted in a new and greater emphasis upon civil defense and upon measures of economic readiness. The latter included government stock-piling of scarce materials, the establishment of reserves of production facilities and equipment and the building up of productive capacity in essential industries to serve as a mobilization base. Some beginnings were made in the dispersion of industrial capacity and the establishment of underground facilities as means for reducing vulnerability to aerial attack in future wars.

All such planning and preparedness measures were overshadowed by the advent of nuclear weapons. The relation of economic strength to military potential entered a phase in which only those nations with the capability of producing and delivering nuclear weapons in numbers could hope to qualify as great powers. The two leading nuclear powers were presumed to have the capability of delivering in a single massive attack on enemy population and production centres thousands of miles distant scores and possibly hundreds of nuclear bombs with a destructive power reckoned in millions of tons of TNT equivalent per bomb. Attacks of this magnitude could cause casualties numbered in tens of millions, destroy a substantial segment of a nation's productive capacity and seriously disorganize its entire economy for many months. Full recovery of the economy would require years.

Such massive nuclear strikes and counterstrikes. whether by manned bombers cr by missiles, might bring the active phase of the war to an end in a matter of weeks if not days. The outcome would depend primarily upon the state of mobilized readiness of the striking and defensive forces of the combatant powers. Under such conditions, economic mobilization could hardly get started before the war would be over, let alone contribute to its outcome, however indispensable it would prove in the massive and prolonged task of rehabilitation and recovery.

The concept of mobilized readiness in the 1960s envisaged not only substantial military forces in being, with primary emphasis upon the strategic air arm, but also a level of military production capable of continuously replacing obsolescent weapons and weapons systems with new and more effective ones, with the possibility of continuing a limited output of key military items in the wake of a nuclear strike. Increasing attention was given to the possibility that general nuclear war with its catastrophic destructiveness might be avoided by mutual forbearance if not mutual consent. If wars should be in fact limited, either in the weapons used. in the manner of their use or in the extent of national and territorial involvement, some degree and form of economic mobilization for war in the future was considered probable.

See R. Elberton Smith, *The Army and Economic Mobilization (1958)*; W. K. Hancock and *M. M.* Gowing, *British War Economy* (1949).

(L. C. H)

MOBILIZATION AND DEMOBILIZATION, MILITARY. In a military sense mobilization is the assembling and organizing of the armed forces of a nation for active military service in time of war or other national emergency. In its full scope, mobilization includes the organization of all the resources of a nation for active military service or for support of the military effort. Mobilization is one of the basic factors on which the successful prosecution of any war depends. The technological advances of the 20th century that have vastly increased the destructiveness of warfare have made rapid and efficient mobilization imperative A confused, disorganized and slow mobilization can result in the destruction of a nation's war-making potential and the defeat of its armed forces during the initial onslaught by an efficiently mobilized aggressor. What a nation can accomplish within the first 60 days of a war may well decide the outcome.

In planning and operation, mobilization must be a fully integrated effort that includes both a military phase and an economic or industrial phase. Mobilization may be limited in scope to provide for small wars, but even limited or partial mobilizations must be well planned, cohesive and integrated operations.

Military mobilization includes the procurement and training of manpower for military purposes; the selection of areas for training camps; the construction of training camps and other military facilities; and the procurement and issuance of arms, ammunition, uniforms, equipment, vehicles and stores to the using units. The procurement of military manpower is in itself a tremendously complex task that includes the calling up of reserves; the induction of raw recruits in great numbers; the allocation of manpower to the army, navy, air force and, within these major components, to the respective arms and services.

The classification and assignment of military manpower, in a full mobilization wherein manpower can be expected to be scarce, should provide for the utilization of even physically handicapped personnel in assignments for which they are physically qualified. The proper allocation of manpomer involves the determination of intelligence, physical stamina, leadership aptitudes and mechanical skills of personnel and the assignment of men (or women) to the services in accordance with predetermined needs. The expansion of the armed forces by vast numbers of untrained men and women requires an intensive training program to qualify each individual to do a job in an already existing military unit or in one of the host of new units that are formed. This rapid expansion of the armed forces also requires special promotions, new appointments and the assumption of new and larger responsibilities by trained personnel.

The procurement of military manpower does not take place in a vacuum. but is timed and correlated with the procurement of arms and equipment necessary for training and for combat. It is obviously wasteful and inefficient to procure manpower faster than it can be trained or equipped. Further, the expansion of the armed forces during mobilization must not only be geared to the equip-

ment production and training timetables, but must also be synchronized with a strategic timetable for deployment of military forces wherever they are needed. Mobilization, to be effective. must not only be well organized but must have "everything in step." The detailed schedules showing size, type and composition of military units to be organized during mobilization are sometimes referred to as the troop basis.

The complexities of all phases of mobilization and the necessity for organization, synchronization and efficient speed in the accomplishment of mobilization have made it necessary for nations to prepare detailed, comprehensive mobilization plans which are constantly under study and revision to keep them in current readiness. Such plans include the implementing details to accomplish mobilization and also may embody drafts of stand-by legislation for enactment when necessary. They may provide for new governmental agencies required for mobilization and nartime purposes, and may indicate how these new agencies will be co-ordinated with existing governmental agencies.

DEMOBILIZATION

Demobilization is the process of restoring a nation fully or partially mobilized for war back to a peacetime status. Just as a faulty. ineffective mobilization may result in a nation's military defeat, so a poor demobilization may result in the loss of objectives obtained by victory on the battlefield.

All the military and economic factors that make mobilization so complex are also involved in demobilization. and for many reasons the problems may be even more difficult. Public opinion, which usually supports mobilization as a means of winning a mar, may well clamour only for speed in demobilization, even though such speed may jeopardize "winning the peace." Allies who have had unanimity of purposes and objectives during mobilization and war may differ in their objectives following victory. Transportation facilities that have deployed military manpower progressively during mobilization and war may not be adequate to redeploy that manpower as rapidly as public opinion demands.

During demobilization, these are the main military tasks: (1) Manpower no longer needed in the armed services must be brought home and separated from the service. (2) War surplus material must be disposed of. War material required for reserve purposes must be properly stored to prevent its deterioration. (3) Requirements for military material for peace must be determined. (4) Missions of the armed services must be redefined to include occupation, military government and rehabilitation of defeated countries. These factors, together with the economic factors of demobilization, are all related, but each one contains within itself complex problems that require careful advance planning.

Determination must be made concerning what strength the armed forces require following the conclusion of war, so that only those in excess of the requirements are demobilized. The demobilization of military personnel requires co-ordination with the availability of transportation and, even more important. with the return of serviceable military supplies and equipment to areas where they can be militarily utilized or economically disposed of. The military requirements for manpower releases and disposal of excess military material must also be closely co-ordinated with the requirements of the nation's economy. The factors in demobilization, it is apparent, involve and affect the entire resources of a nation, just as they do in mobilization.

Mobilization and demobilization both require meticulous, coordinated advance planning by all elements of a nation: the government. the military, business, industry, agriculture, the professions. There is one essential difference: mobilization, to be fully successful, must be fast, with all elements in step; demobilization, to be successful, must be deliberate, with all elements in step. *See* also ARMY; CONSCRIPTION; MILITIA.

See Marvin A. Kreidberg and Merton G. Henry, *History of Military Mobilization in the U.S. Army, 1775–1945* (1955); John C. Sparrow, *History of Personnel Demobilization in the U.S. Army* (1952).

(M. A. Kc.)

MOBIUS, AUGUST FERDINAND (1790–1868), an outstanding German theoretical astronomer and mathematician, was born at Schulpforta, Prussia, on Nov. 17, 1790, and studied at Leipzig, Gottingen and Halle. In 1815 he became professor of astronomy at Leipzig, being chosen director of the university observatory, which mas erected (1818–21) under his superintendence. He died in Leipzig on Sept. 26, 1868. *De computandis occultationibus fixarum per planetas* (1815) established his reputation as a theoretical astronomer. *Die Hauptsätze der Astronomie* (1836) and *Die Elemente der Mechanik des Himmels* (1843) may be noted among his other purely astronomical publications. His labours in pure mathematics appear for the most part in *Crelle's Journal* from 1828 to 1858. These papers are chiefly geometrical, many of them being developments and applications of the methods laid down in his great work *Der barycentrische Calkul* (1827), which introduces homogeneous co-ordinates into analytical geometry. This treatise also deals with geometrical transformations, in particular projective transformations (collineations), and discusses the configuration known as the Mobius net, which later played an essential part in the systematic development of projective geometry. In the *Lehrbuch der Statik* (1837) Mobius gives a geometrical treatment of statics: leading to the null system of points and planes and thence to the study of systems of lines in space. Mobius was also a pioneer in the field of topology; in a memoir presented to the French Academy and discovered only after his death, he discusses the properties of one-sided surfaces. including the now celebrated Mobius strip. His *Gesammelten Werke* (4 vol.) were published in 1885–87.

His son THEODOR, an authority on Scandinavian letters, was born at Leipzig on June 22, 1821. His *Catalogus librorum islandicorum et Norvegicorum aetatis mediae* (1856) and *Verzeichnis der auf dent Gebiet der altnordischen Sprache und Literatur 1855 bis 1879 erschienenen Schriften* (1880) as keys to Scandinavian bibliography and his *Edda-Ausgabe* as a textbook are perhaps the most valuable to students. He died in Leipzig on April 25, 1890.

MOCATTA, FREDERICK DAVID (1828–1905), English Jewish philanthropist and historian, was born in London on Jan. 15, 1828, a member of a distinguished financial family. His grandfather. Abraham Lumbrozo-Mocatta, had founded in 1790 the firm of Mocatta and Goldsmid *(see* also GOLDSMID), of which Frederick Mocatta was a member until his retirement in 1874 to devote himself to works of public and private benevolence.

He first began to give his attention to the better housing of the working classes and the administration of charity in such a manner as not to demoralize the poor. He supported almost every hospital in London, and did much to promote education, especially that of the Jewish poor. Mocatta encouraged Jewish literature and research, and in addition was a patron of learning and himself an author. The chief of his historical works was *The Jews of Spain and Portugal and the Inquisition* (1877). On the occasion of his 70th birthday, he was presented with a testimonial from more than 200 philanthropic and literary institutions.

Mocatta died on Jan. 16, 1905, bequeathing his fine library and art collection to the University College of London, in the library of which they are now housed.

MOCCASIN, a one-piece shoe made of deerskin or other soft leather; the sole is soft and flexible and the upper part is often adorned with embroidery, beading or other ornament. It was from earliest times the footwear of the North American Indian tribes and was also worn by hunters, traders and settlers. In the second half of the 20th century it became a popular sport and casual shoe.

MOCCASIN, common name for certain poisonous, semiaquatic snakes, genus *Agkistrodon,* found in North and Central America, especially the water moccasin or cottonmouth, *Agkistrodon piscivorus.* It belongs to the pit vipers (*q.v.*), family Crotalidae, which includes also rattlesnakes, copperheads (*q.v.*) or highland moccasins, and many venomous serpents of Asia and one of southeastern Europe. Unfortunately! the term has been used also for various nonpoisonous water snakes. *Natrix,* because of their resemblance to the venomous cottonmouth. The harmless water snake, though it bites as readily as does the cottonmouth, has short solid teeth and no venom. The cottonmouth, on the other hand, has fangs and a powerful venom. Its bite, especially that

of a large adult, is usually immediately followed by a sharp, stinging pain at the site of puncture. Antivenins are available and recovery from the bite, if prompt first aid and early medical attention are given, is almost assured.

Cottonmouths, divided into eastern and western subspecies, *A. p.* piscivorus (eastern and southeastern lowlands) and *A. p.* leucostoma (southern central states), are so called because of the cotton-white interior of the mouth. Their habit of threatening an intruder with open mouth, an uncommon reaction among venomous snakes, is a distinguishing characteristic of the cottonmouths. They are found in marshes and along or in streams or ponds where their preferred prey of frogs and fishes abound. Although some individuals exceed 5 ft., adults are more often 3 to 33 ft. The pattern is dull and inconspicuous, consisting of dark-brown bars or blotches on a somewhat lighter background; in some cases, however, adults may be almost a uniform blackish. The females give birth to five to ten young in late summer. In captivity cottonmouths have lived as long as 18 years. A relative, the Mexican moccasin or *cantil* (*Agkistrodon bilineatus*), replaces *A. p.* leucostoma south of the Rio Grande. It is a more brightly coloured form that inhabits both coasts of Mexico and parts of Central America.

BY COURTESY OF SAN DIEGO ZOO

COTTONMOUTH MOCCASIN (AGKISTRODON PISCIVORUS)

See SNAKES; VENOM. (L. M. KR.)

MOCENIGO, the name of a noble and ancient Venetian family which included many doges, statesmen and soldiers. TOMMASO MOCENIGO (1343–1423) commanded the crusading fleet in the expedition to Nicopolis in 1396, and also won battles against the Genoese. While Venetian ambassador at Cremona he was elected doge (1414), and he escaped in secret, fearing that he might be held a prisoner by Gabrino Fondolo, tyrant of that city. He made peace with the Turkish sultan, but when hostilities broke out afresh his fleet defeated that of the Turks at Gallipoli. During his reign the patriarch of Aquileia was forced to cede his territories to the republic (1420), which also acquired Friuli and Dalmatia. Tommaso greatly encouraged commerce, reconstructed the ducal palace and commenced the library. PIETRO MOCENIGO, doge from 1474 to 1476, was one of the greatest Venetian admirals, and revived the fortunes of his country's navy after the defeat at Negropont in 1470. In 1472 he captured and destroyed Smyrna. He then defeated the Turks who were besieging Scutari and died of an illness contracted there. GIOVANNI MOCENIGO, Pietro's brother. doge from 1478 to 1485, fought against Mohammed II and Ercole I, duke of Ferrara, from whom he recaptured Kovigo and the Polesine. LUIGI MOCENIGO was doge from 1570 to 1577. During his reign Venice lost the fortresses Nicosia and Famagosta in Cyprus. He took part in the battle of Lepanto, but after the loss of Cyprus he was forced to make peace with the Turks and to hand them back his conquests. ANDREA MOCENIGO, who flourished in the 15th and 16th centuries, was a senator of the republic and a historian; he composed a work on the league of Cambrai entitled *Belli memorabilis Cameracensis adversus Venetos* historiae libvi *vi.* (1525). Another LUIGI MOCENIGO was doge from 1700 to 1709, and his brother SEBASTIANO from 1722 to 1732. ALVISE MOCENIGO (1701–78), who was doge from 1763 until his death, restricted the privileges of the clergy, and in consequence came into conflict with Pope Clement XIII.

MOCHA STONE (Moss AGATE), a grayish to milky white variety of chalcedony (cryptocrystalline quartz) containing opaque, dark-coloured inclusions whose branching forms resemble ferns, moss or other vegetable matter. The included materials, mainly manganese and iron oxides, are of inorganic origin. Most mocha stones are found as fragments weathered from volcanic rocks. Long used for ornamental purposes, they are obtained chiefly from India. Brazil. Uruguay, the U.S.S.R., central Europe and the western United States. The best stones are cut in flat or rounded form, and some are dyed to improve their colour. The Idar-Oberstein district in Germany is the principal cutting centre. See also AGATE (R. H. J.)

MOCKINGBIRD, a popular name of birds belonging to the American family hiimidae including also the thrashers (*q.v.*). The northern mockingbird (*Mimus* polyglottos) inhabits the southern part of U.S., visiting the north in summer and breeding, though rarely, in New England. West of the Alleghenies it is less numerous, though occurring in suitable localities across to the Pacific.

The mockingbird has a fine song of its own and. in addition, has a remarkable power of mimicry.

It is grayish-brown above and dull white below. The nest is often placed close to houses and is a careless structure. Three to six blue-green eggs, spotted with light brown, are laid. The great enemies of the mockingbird are snakes, which eat both eggs and young; but the parents show great courage in defense of their home and often drive off the intruder.

About 12 or 14 other species of *Mimus* occur, mostly in South America. The catbird (*Dumetella* carolinensis) is another ally; it too has both a fine song and the power of mimicry. It is sooty-gray and has a wide range on the continent and extends to Bermuda.

See CATBIRD.

MOCK ORANGE, the name given to species of *Philadelphus,* especially to those with highly fragrant flowers, and also to the Missouri gourd or calabazilla (*Cucurbita* foefidissima) of the southwestern U.S See CUCURBITACEAE; PHILADELPHUS.

MODELS AND MODELMAKING. The value of the model in various professions and industries, as well as its interest as a hobby, lies in its unique power to communicate the essential visual aspects of something planned or already existing Thus since early times men have made models, at scales ranging from miniature to full size, as the most direct approach to exploring the special relationships of new constructions and of demonstrating the three-dimensional qualities of known ones. The Egyptians used realistic models of chattels in tombs to serve the deceased in the next world; in China similar tomb models became schematized into paper cutouts. Witches used models incorporating some fragment of the original in magic rites to effect good or evil. Renaissance artists used models to study the lighting and composition of elaborate groupings. Models of clothing and of architecture have been used frequently from the 16th century on. Today modelmaking is a highly developed profession in the service of education. architecture industry, the armed forces and other fields, as well as a very popular hobby.

As an educational aid. the model has no peer in its ability to give the student an immediate grasp of certain kinds of material. The actions of opposing forces in the battle of Waterloo, the operation of moving parts in a reciprocating engine. the anatomical functions of the kidney system are examples of the myriad subjects which lend themselves to the medium of the model.

Science museums and exhibitions incorporate models into the presentation of various kinds of material. In natural history exhibits, for example, the habitat of fauna and flora can be recreated for thorough ecological study of environment by the observer. The methods of reproducing full-size landscape vignettes have been developed to a high degree of perfection. Material of vegetable nature is collected, from which molds and casts are made of plastic or other material with absolute fidelity. In these "habitat groups" the three-dimensional foreground is made to merge imperceptibly into a painted two-dimensional background.

In contrast to these models where complete faithfulness in all details is essential. schematic models may be desirable in certain instances where a principle is to be explained or a certain aspect is to be emphasized. For clarity in communicating an idea it is sometimes necessary to distort nature, select some of its elements and omit others and create new forms and colours. The initial stages in the design of exhibits are worked out by rough models for study purposes.

The materials and techniques employed in making scale models are unlimited. The success of the illusion depends to a great extent on the choice of material, according to the ability of its texture to suggest structures of a different size—for example, certain kinds of moss give a convincing suggestion of trees in foliage at a scale of 1:16. This is very useful for architects in rendering landscape for buildings that are being planned. The use of material designed for one purpose to convey the impression of another kind of material. seen at a different scale. is basic to modelmaking. It is part of the fascination for the one who makes the model (as well as a satisfactory illusion for the viewer) to discover a means of suggesting, for example, the cloud of insecticide being sprayed by an airplane.

Problems of architectural design can best be studied by means of models, since the element of three-dimensional space is vital in this field. The scope of the study may range from an entire city area to the interior of a single room; it may emphasize the outdoor space between buildings on a site, the flow of space from one room to another in one building or the colour scheme of an interior. Scale can be made immediately apparent by the use of human figures proportional to the project under consideration. The model can also be photographed and the illusion of full scale very closely approximated by careful adjustment of lighting and background.

The plan for the redevelopment of downtown Philadelphia was implemented by a model showing the area as it then existed; the part representing the section of the area under consideration could be turned over mechanically to reveal the projected improvement of that area. A very successful use of models for publicity purposes was seen in the "Highway of Tomorrow" exhibit of the General Motors corporation at the New York World's fair in 1939–40. In this exhibit the visitor was carried on a belt of moving chairs through a landscape in which the highway of 1939 gradually evolved into the highway of the future.

Nearly all industries use models varying in scale and purpose; the greatest value, however, derives from experimentation. Scale models of entire proposed factories are made to check location of machines, stock rooms and other features and to determine efficiency of production-line assembly. The early stages of the design of nearly all manufactured products require study of small-scale models. Full-size models are then made to refine the details of the finished design and to determine tooling requirements in the case of automobiles, refrigerators or other mass-produced items. Models of various scales are used in the fields of shipbuilding and aerodynamics. In the latter, the models are tested in wind tunnels at speeds greatly exceeding that of sound. This testing ensures perfection of design without risking human life and expensive equipment.

Industry has its own educational programs and uses cutaway or clear plastic models to demonstrate working relationships of machine parts and problems of assembly or disassembly. It is here that oversize models most often are used to demonstrate the workings of small mechanical parts. although magnified models are used also as display devices by watchmakers or other manufacturers of tiny, intricate artifacts.

Some unusual models have resulted from the study of water flow. One of the largest of these is a complete working model of the Mississippi river basin which is used by the U.S. government for demonstrations and experiments in flood and channel control. Another interesting model which served a valuable purpose in this field was a scaled-down section of the Suez canal, the function of which was to determine precisely what pressures the banks must withstand. Installed in a hydraulic laboratory in Grenoble, France, it was 210 ft. long and 29½ ft. wide. In it a self-propelled model of the hull of a tanker made hundreds of round trips until the erosion of the banks reached a maximum. As a result of these studies, an asphalt mattress, poured over a framework of steel and wire mesh, was designed to slide over the banks of the canal, thus saving in part the endless job of dredging.

Another model showing water flow has been made of the St. Lawrence seaway project. This is a 40-ft. working model of a cutaway section (complete with flowing water), and hydraulic engineers from countries all over the world are able to study from it the interior workings of such a complex operation.

For recreational and hobby purposes, models are constructed and used by children and adults. Generally these are airplanes, boats, railway trains and equipment. automobiles, steam engines or buildings and structures of all sorts. These models may be for display only, or they may be powered by steam or electricity, by motors using gasoline, diesel oil or compressed gases or by jet engines using liquid fuel or compressed gas. The development of plastics and injection molding made possible mass production of model kits which have a quality of fine detail not previously possible at such low cost.

The motion-picture industry makes extensive use of scale-modeled sets in order to reduce the cost of photographing sea battles, panoramas or any long-range or altitude camera shots. The theatre uses models of stage settings as a means of testing workability cheaply.

In the armed forces during World War II and the Korean war, modelmaking was used extensively, scaled solid models of planes, ships, tanks and other vehicles being used for recognition training for gunners. Elaborate models were made for tactical purposes, and in several cases scale models were made of entire areas under attack. These models were complete even to the shipping in the harbours and all shore installations, and they were used to ensure co-ordination in joint operations. Models of terrain or manufacturing areas were used to ensure recognition by bombardiers in the various air forces. (G. R. RE.)

MODENA (anc. MUTINA), city, Emilia-Romagna, Italy, capital of the province of Modena and seat of an archbishop, 31 mi. E.S.E. of Parma by rail. Pop. (1957 est.) 123,631 (commune). It lies in a damp, low plain on the south side of the Po valley, between the Secchia to the west and the Panaro to the east. Some main streets follow lines of canals, which still (now covered) traverse the city. The observatory stands 135 ft. above sea level.

The fortifications, converted into promenades, give the city an irregular pentagonal contour. Within are various open areas—the spacious Ippodromo, the public gardens, the Piazza Grande and the Piazza Reale.

The Via Aemilia passes obliquely through the city, from east to west.

Begun by Countess Matilda of Tuscany (1099), after designs of Lanfranc, and consecrated in 1184, the Romanesque cathedral (S. Geminiano) has a lofty crypt under the choir, three eastern apses and a façade with sculptures of the 12th century. The graceful bell tower, erected in 1224–1319, named La Ghirlandina from the bronze garland surrounding the weathercock, is 282 ft. high; in the basement may be seen the wooden bucket captured by the Modenese from the Bolognese in the affray at Zappolino (1325) (see Tassoni, *Secchia Rapita*). S. Giovanni Decollato contains a Pieta in painted terra cotta by Guido Mazzoni (1450–1518).

The so-called Pantheon Estense (the church of S. Agostino), is a baroque building by Bibbiena. S. Pietro and S. Francesco have terra cottas by Begarelli (1498–1565).

The extensive ducal palace, from the designs of Avanzini (1651–79), and finished by Francis Ferdinand V, with a fine courtyard. contains the military school. The Albergo delle Arti, built by Duke Francis III, accommodates the Museo Lapidario (Roman inscriptions, etc.); the valuable archives, the Biblioteca Estense, the Museo Civico, with paleoethnological and archaeological collections; a collection of textile fabrics; and the picture gallery, presented to the city by Francis V and later augmented by the Campori collection The town hall dates from 1194.

The university is mainly medical and legal with a faculty of physical and mathematical science.

Commerce is chiefly agricultural. Modena is the point at which the railway to Mantua and Verona diverges from that between Milan and Bologna, and has several branches to neighbouring places. It is also the starting point of a once important road over the Apennines to Pistoia by the Abetone pass, and of a canal by the Panaro and Po to the sea.

The old abbey of Nonantola (752) about 6 mi. N. has a fine

Romanesque church and valuable treasury and archives.

Modena is the ancient Mutina in the territory of the Boii, which became Roman in 215–212 B.C. The Roman town lay southeast of the modern; its northwestern wall is marked by the Corso Cmberto I; but the Roman level is 15 to 20 ft. below the modern. Its territory was conterminous with that of Bononia and Regium, and to the south it extended to the summit of the Xpennines. Marcus Brutus, lieutenant of Lepidus, held it against Pompeius in 78 B.C., and in 44 B.C. the place was successfully defended by D. Brutus against Mark Antony. The ravages of Attila and Lombard attacks ruined it. but about the close of the 9th century it was restored by its bishop. Ludovicus.

In the wars between Frederick II and Gregory IX it sided with the emperor. In 1288 Obizzo d'Este became its lord. Constituted a duchy in 1452 in favour of Borso d'Este. and enlarged and strengthened by Hercules II, it became the ducal residence on the incorporation of Ferrara with the States of the Church (1598).

Francis III (1698–1780) gave the city many public buildings. Hercules III (1727–1803) saw his states transformed by the French into the Cispadane republic, and died at Treviso. In 1814 his eldest son, Francis IV, received back the Stati Estensi and ruled them despotically. Francis Ferdinand V succeeded in 1846, and on Aug. 20, 1859, the representatives of Modena declared their territory part of the kingdom of Italy, and their decision was confirmed by the plebiscite of 1860.

MODERATOR, a judge or umpire, one who acts the part of mediator, and so a term used of the person chosen to be president of a meeting (as in the U.S., of a town meeting). In the universities of Oxford and Cambridge it is still used of the officers appointed to preside over certain examinations; but the best-known use of the word is in the Presbyterian churches; the name is applied to the minister elected to preside over ecclesiastical meetings or assemblies, as the synod, presbytery or general assembly.

See also PRESBYTERIAN.

MODERN ARCHITECTURE. Architecture since 1800 has shared with earlier architectures three diverse requirements: to render good performance; to stand up and sustain loads; and to give aesthetic satisfaction. The buildings have necessarily reflected the society in which they were created; they especially reflected the acquisition of technological control over natural power and the application of technology to problems of manufacture, distribution, transportation, communication, climate and physical comfort.

The greatest amount of energy was expended upon housing modern entrepreneurial management. The characteristic building types were the powerhouse or dam, the factory, the research laboratory, the administrative office building, the transportation terminal and the market. Architecture became the badge of commercial prestige, an advertisement of the new centres of power which sought in height, size and quality the architectural eminence accorded to churches and places of political assembly.

Until about 1900 it was not clear that a new style of architecture would accompany the new institutions. Many architects and clients attempted to enshrine science and commerce, the new metropolis and its suburban fringe, within classical and medieval styles. Others subscribed to a cultural schism, allowing the factory and powerhouse to be bold, inartistic expressions of engineering while buildings at the top of the social hierarchy, the church and the college, were made to conform to Gothic, colonial or Roman antecedents.

Thus most 20th-century cities were cacophonies of architectural styles as clients and architects were guided by any of four contrasting ideas. There were proponents of (1) formalism, such as Charles Follen McKim, who believed that beauty was obtained through the manipulation of cylinders, hemispheres and other simple geometric forms after Greek or Roman models. Arranged upon axes these forms constituted impressive monumental buildings, Henry Bacon's Lincoln memorial in Washington, D.C. (dedicated 1922), being one example. John Ruskin and Ralph Adams Cram advocated (2) romanticism. The complex spaces and structures of Gothic cathedrals were recreated in St. Thomas' church in New Tork city (1913) by Bertram Goodhue and in the University museum by Thomas Deane and Benjamin Woodward at Oxford. Eng. (c. 1858). Two hypotheses about nature became popular bases for modern styles. An old one, (3) mechanism, by which the universe mas interpreted as a system of uniform laws governing inert masses, suggested an emphasis on structures and materials and on the efficient. economical adaptation of form to use. It gained support among such architects as Walter Gropius, who established the Bauhaus (*q.v.*) on principles compatible with those of science and industry. Still another point of view. (4) organicism, a composite of romantic and mechanistic philosophies, was espoused by the great architect Louis Sullivan, who insisted that living organisms provide the formal, structural and adaptational principles of architecture. "Fallingwater," Bear Run, Pa., was designed by Sullivan's pupil Frank Lloyd Wright.

However suggestive for style, the four philosophies offered little basis for quality, which is a function of architectural design rather than style. Too few clients and architects realized that quality in architecture derives from a rhythmical arrangement of spaces and masses, which states a geometric theme in light and shade, expresses its purpose and executes that purpose well. The style may express a building's site. materials, use, structure, client, designer, interior spaces, era or social environment, but such expressions have nothing whatever to do with the utility (emotional as well as physical), stability or beauty of the result. Failure to understand the differences between style and composition contributed to the poor architecture of modern communities in instances such as those in which a Georgian, classical or Gothic style was chosen as being appropriate to a town, church, college or office building, however unsatisfactory the architectural result might be. See ARCHITECTURE: ***Expression.***

Good modern designs might achieve unity through the use of interlocking, dynamically asymmetrical masses and spaces, as in the town hall at Hilversum, Neth. (1924), by W. M. Dudok (1888–) or Ludnig Mies van der Rohe's German pavilion at Barcelona (1929), or by balancing similar voids or masses symmetrically with respect to an axis, as in the Galleria Vittorio Emanuele at Milan by Giuseppe Mengoni (1829–77) or the railroad station at Tours by Victor Laloux (1850–1937). The former arrangement characterized programmatic buildings, in which interior spaces were extruded to create salient, exterior masses, as in the Graduate centre at Harvard university (1950) by the Architects' Collaborative or Le Corbusier's Notre Dame du Haut at Ronchamp (1955). The latter type of composition. sometimes called monumental, prevailed wherever regular geometric enclosures were practical, as in the intersecting barrel vaults of the Lambert-St. Louis (Mo.) air terminal (1950–56) by Minoru Tamasaki or the spherical triangle of the auditorium at the Massachusetts Institute of Technology, Cambridge (1955) by Eero Saarinen. In each case, the successful building marked a graceful transition from the ground, terminated at the corners decisively, came to a forceful conclusion at its sky line and formed successful interior and exterior spaces with amenable transitions betueen them. Usually, a single spatial theme was varied rhythmically throughout the building, as in Frank Lloyd Wright's Johnson Wax company administration building at Racine, Wis. (1936–39), where the theme was a cylinder of space. Modern architecture must be judged on both its style—the building's expressive content, particularly as it reflects the people and institutions that built it—and its design—the organization of masses and spaces to achieve both a useful and an aesthetic result. Not all modern buildings were successful by either of these criteria, and only a few by both.

19TH CENTURY

BACKGROUND

The architectural theories that were ascendant during the 19th and 20th centuries were already operative during the 18th century. Formalist theories, derived from Renaissance ideas, were reflected in the works of Jacques François Blondel (1705–1774), in buildings like the Petit Trianon (1762–66) by J. A. Gabriel and in James Gibbs's St. Martin-in-the-Fields (1722–26). There were mechanists, such as Francis Hutcheson, Carlo Lodoli and the

abbé Laugier. "Rationalist" architecture, exemplified by George Steuart's St. Chad's at Shrewsbury, Eng., Sir John Soane's Bank of England and C. N. Ledoux's plans for Chaux, an ideal village for France. was functional and programmatic in plan and classical in style. There were also utilitarian buildings: the factory at Soho. Eng., for instance. showed the intention of Matthew Boulton and James Watt to use iron and masonry economically in industrial buildings. Most evident were the romanticists. Archaeological investigations during the 1750s by R. Wood and J. Dawkins at Palmyra and Baalbek, by D. Leroy in Greece, by J. Stuart and N. Revett in Athens inspired a classical temple at Hagley, Eng., while C. L. Clérisseau's investigation of the Maison Carrée at Nimes allowed Thomas Jefferson to reproduce the major features of that Roman building for the state capitol at Richmond. Va. The far east was the inspiration for a "pagoda" at Kew gardens. Marie Antoinette's peasantlike Petit Hameau at Versailles occasioned delight among the lovers of the rustic. Horace Walpole's Strawberry Hill expressed the enchantment with the Gothic that made Sir Walter Scott's works so popular. Scott himself built a "Gothick" house at Abbotsford, Edinburgh, begun in 1812. (See also BAROQUE ARCHITECTURE.)

1800–60

Rationalism. — Throughout western Europe and the eastern U.S. in 1800, remnants of Renaissance architectural forms survived until architects consciously revived them wholesale. Two clubs in London. the Reform (1837) by Sir Charles Barry and the Athenaeum (1829–30) by Decimus Burton, the latter a reflection of Baldassare Peruzzi's Palazzo Massimo at Rome, established the setting for the cultured English gentleman as the Renaissance *palazzo.* Dorchester house, London. by Lewis Vulliamy was a frank copy of the Villa Farnesina at Rome. The fashion also prevailed for churches, as in Arthur Gilman's Unitarian church on Arlington street, Boston. which was modeled upon Italian examples, and for department stores. In J. P. Gaynor's Tiffany store at New York city, the *palazzo* form, however much prestige it conveyed, was stretched into an absurdity.

Rationalist architects recognized the incongruity of Renaissance enclosures for modern institutions. One of the most interesting designers, Sir John Soane (1753–1837), in a series of buildings including the Bank of England (remodeled 1792–1823), the Dulwich Art gallery (1812), the stables at Chelsea hospital (1810) and his own house at Lincoln's Inn Fields (1812–14), created exterior masses out of interior spaces, achieved dramatic and unusual combinations of parallelepipeds and hemispheres and established innovative proportions. In Germany K. F. Schinkel (1781–1841), working in a variety of styles, attempted programmatic planning in his Royal theatre at Berlin (1818–21), St. Nicholas church at Potsdam, Altes museum at Berlin (1822–30) and "Project for a Department Store." His Academy of Architecture at Berlin (1831–3j) was the most effective of his attempts to shed classical and medieval precedents.

In the U.S. rationalist architecture was introduced by the Frenchman J. J. Ramée, who designed buildings for Union college, Schenectady, N.Y., in 1813, and by the Englishman Benjamin Henry Latrobe (1764–1820), whose waterworks at Philadelphia (*c.* 1800) and Roman Catholic cathedral at Baltimore (c. 1820) perfectly reflected the desire for useful and theatrical spaces enveloped by classical forms. Such designers did not imitate classical precedents; Latrobe, for example, designed tobacco and corn orders for capitals in the senate rotunda at Washington. Native American architects soon caught the spirit; Charles Bulfinch (1763–1844) moved away from the academic design of his statehouse at Boston toward the rational composition of University hall at Harvard (1813–1j), a direction later followed by Robert Mills (1781–18j5) not only in his Washington monuments at Washington and Baltimore but in the Sansom Street Baptist church in Philadelphia (1808) and the jail at Charleston, S.C.

Classicism.—Latrobe attempted to dissuade amateur architects such as Thomas Jefferson from sacrificing utility for the sake of Greek and Roman details, but the classical revival swept many countries, sometimes leaving elegant legacies. Beginning about 181j, architecture and archaeology became more closely allied. H. W. Inwood and C. R. Cockerell increased the store of information about Greek architecture. Lord Elgin removed the Parthenon's pedimental sculptures and their deposit in the British museum in 1816 added to the current interest in ancient Greece. This Hellenism became more fervid when, from 1821 to 1829. the mars of Greek independence inspired Englishmen such as Lord Byron and Americans such as Nicholas Biddle to become ardent supporters of the Greek cause. The classical theme was used at George Basevi's Fitzwilliam museum at Cambridge and Harvey Elmes's St. George's hall at Liverpool. Inwood's church of St. Pancras. London (1819–22), pedantically and eclectically repeated themes from the Athenian Tower of the Winds. Choragic monument of Lysicrates and Caryatid porch. The Edinburgh high school (1819, D. Hamilton) was the Theseum (Hephaesteum) on the front of an academic building. Classical romanticism was in the architectural forefront in France also, where Napoleon's imperial aspirations left a monumental civic residue in the Arc du Carrousel, Paris (1806), by Charles Percier and Pierre Fontaine, and the church of the Madeleine, Paris (1806–42), by Pierre Vignon, which was intended to be a "temple of glory" for Napoleon's legionnaires. In Germany. meanwhile, under the influence of J. J. Winckelmann (1717–68), Goethe and Lessing, interest turned toward Greek archaeology. The architect F. K. L. von Klenze designed a "Valhalla," a Greek temple standing on an artificial hill at Regensburg in frank imitation of the Parthenon on the Acropolis. The Brandenburg gate at Berlin by K. G. Langhans (1733–1808), the Siegestor at Munich (1840) and the Aula at Göttingen established the precedent of antique settings for the Gateways to cities and universities.

The U.S. succumbed to the charm of Greek and Roman architecture during the period from 1815 to 1860. Following his apostrophe to Roman Nîmes in the state capitol at Richmond (1785–92), Thomas Jefferson put his practical mind and elegant taste to the design of a university campus. the University of Virginia, Charlottesville (1817–25), where his plan for "an academical village" ensured privacy for students and professors and protection from inclement ueather. It was dominated by the library rotunda, a copy of the Pantheon; and the pavilions, which punctuated the rhythms of low-lying dormitories in the lawns, imitated Roman and Palladian designs. Acceptance of Greek or Roman precedent in decorative details frequently required it in other matters, but in the hands of professional architects, Francis Costigan or Gideon Shryock for example. space was adeptly handled to achieve both utility and visual coherence. best exemplified by Shryock's state capitol at Frankfort, Ky., and in a building now recalled only by drawings, Bussière de Pouilly's St. Louis hotel at New Orleans (1836–40). Lesser designers graced the towns of Marietta, O., Ovid, N.Y., and Nantucket, Mass.. with Greek and Roman temples, which in many cases remain the towns' finest embellishments. They offered no sound approach to an architecture for modern times, however, and failed to express modern ideas, even in the Merchants' Exchange William Strickland erected in Philadelphia in 1834. Deluded by extraneous political symbolism, Americans housed state legislatures in modern replicas of the Parthenon, as at Nashville, Tenn. (1855, Strickland). or in other classical ideograms, as at Columbus, O. (Henry Walter), New Haven, Conn. (1827, Ithiel Town), and Indianapolis, Ind. (1832–35, Town and Alexander Jackson Davis). Stephen Girard's express wishes for serviceable and simple buildings at the college he founded at Philadelphia were ignored by his trustee, Nicholas Biddle, who persuaded the architect, Thomas Ustick Walter, to make main building (1833–47) a Greek temple with Corinthian columns; its rooms were poorly lighted, ventilated and reverberative. At its dedication Joseph Chandler spoke of its power to evoke classical grandeur and to inspire moral virtue. Greek houses, such as the one planned and owned by J. C. Stevens in New York city (184j), were sometimes ingeniously planned. Another amateur in New York. Philip Hone, noted in his diary that every departure from classical models seemed to him a departure from grace and beauty.

Romanticism. — In England, where Gothic construction still

survived in rural regions, there was a conscious revival of medieval forms. Beginning with schools, colleges and churches, *e.g.,* St. Luke's. Chelsea (1820–24), by J. Savage, the fashion was stimulated by the Oxford movement and Camden Ecclesiological society, and it received national approval when, from 1837 to 1857, the Houses of Parliament were rebuilt. The 97 designers who submitted dran-ings engaged in a battle of styles, Gothic versus classical. Gothic, which was thought to be more patriotically English, more manly and closer. to nature, emerged triumphant. An academic, regular plan. preserving the old Westminster hall, enabled the architect, Sir Charles Barry (1795–1860), to fit the new quadrangles to the old hall, while the young designer Augustus Welby Pugin (1812–52), passionate advocate of Gothic architecture, ornamented the Gothic Revival elevations. At Ramsgate, Pugin designed the Gothic chapel of St. Augustine (1846) and, at Southwark, the cathedral of St. George. Equally active as a writer, he advocated Gothic. above all others, as a Christian architecture, a point of view he stressed in *Contrasts; or a Parallel Between the Architecture of the 15th and 19th Centuries* (1836) and *True Principles of Christian Architecture* (1841), in which his basic, but highly debatable, assumption was that architecture which is good (aesthetically) nurtures a society which is good (ethically).

Pugin gained some following on the continent. Frenchmen seldom accepted moral interpretations of medieval architecture and with a few exceptions. such as Chateaubriand's house at Châtenay (remodeled 1807) and the chapel of St. Louis at Dreux (begun 1816), they frowned on Gothic Revival. English influence was stronger in Germany, where the brothers Schlegel awakened interest in Gothic buildings. Cologne completed its medieval cathedral; and there were also new Romanesque buildings, such as the Johanniskirche in Berlin (1835) by Schinkel, and picturesque Gothic castles, such as the Schloss at Neuschwanstein. Bavaria (1869–86), built for Louis II who! appropriately, invited Richard Wagner to visit him there after the "Ring" series was published.

Medievalism also flourished in the United States. Pugin gained an American following quickly, including the Episcopal bishop J. H. Hopkins, who wrote an appreciative essay about Gothic in 1838. Alonzo Potter, also a bishop, Henry Cleveland, professor of history at Harvard, and Andrew Jackson Downing, a landscape architect and architectural journalist, championed Gothic for use in churches, schools, public buildings and houses. The response was immediately favourable and James Renwick designed Gothic churches for New York's Episcopalians (Grace church, 1843–46) and Roman Catholics (St. Patrick's cathedral, 1858–79). Richard Upjohn (1802–78) matched Renwick's scholarship by erecting New York's Trinity church (1839–46) and surpassed his rival's range of expression with rustic rural churches employing board and batten construction. Gothic villas appeared in the countryside, often in picturesque compositions as in Upjohn's "Kingscote" at Newport, R.I. (1838), and in the villa for Charles Alger at Berkshire, Mass.: designed by A. J. Davis (1803–92). Gothic church forms mere used at colleges and universities, sometimes in a militaristic manner, as at the Virginia Military institute at Lexington *(c.* 1850) by Davis, or. more often, to suggest the affiliation between humanistic education and Protestant worship, as in New York university's main building (1836) and Yale's library (1842), both by Davis. and Harvard's Gore Hall library (1838), a clumsy version by Richard Bond of King's College chapel. Stretched still further, medieval forms served modern transportation, as in Thomas Tefft's design for Union depot at Providence, R.I. (1848).

The motivation behind this revival was to create a setting redolent of medieval piety and rich in moral associations. Literary associations and the fancied emotional nuances of simulated masonry vaults distracted attention from the true matrix of architectural experience: but they were beguiling.

Romantic clients and architects did not long remain content with classical or medieval reminiscence. There were also rich quarries in other historic and distant architectures. Memory sometimes slipped and an Islamic temple was built for Jews, as in J. K. Wilson's Plum street temple in Cincinnati, O. Egyptian obelisks appeared in Paris and Washington, cavetto cornices in Paris (Hôtel de Torcy, remodeled for Napoleon's stepson). Egyptian columns in New York (the Tombs, a prison. 1838, John Haviland), New Bedford, Mass. (the Pearl street railroad depot), and Cambridge, Mass. (the Mount Auburn cemetery gates). Early Christian basilicas were called to mind by the church of St. Vincent de Paul in Paris (1824–44) by J. I. Hittorfi (1792–1867) and picturesque Italian villas appeared on the hills of England and the U S. ("Prospect," Princeton, N J., 1849. John Notman). Even more exotic were the Indian, Chinese, Japanese and Persian pleasure palaces. such as the Royal pavilion at Brighton, Eng. (1818–21), by John Nash and "Iranistan." P. T. Barnum's domed extravaganza at Bridgeport. Conn. (1848). Such eclecticism was encouraged by critical writing, which was best represented by A. J. Donning's *Landscape Gardening* (1841), *Cottage Residences* (1842) and *The Architecture of Country Houses* (1850).

Organicism. — Some persons proclaimed a day in which historical stage-sets would have no place. Perhaps the most cogent mas Horatio Greenough (1805–52), a sculptor who recognized in the work of Schinkel and Latrobe the possibility of an architecture appropriate for modern institutions. It would provide useful spaces, light, air and protection from weather: its spaces would be defined by means of classical walls and columns, ornamented in ways relevant to modern society. Greenough was openly critical of Girard college's temple, saying it was "like seeing the Pitt diamond on an Indian squaw." Equally critical of the medieval towers and battlements on Renwick's Smithsonian institution in Washington, Greenough said, in a dramatic twist on the associationalist's argument. that they were expressive, admittedly, but of a politics and a religion that were foreign to those he believed America should have. He delighted in the structure of ships, bridges. hand tools and weapons. and his study of the anatomy of birds and plants led him to a far-reaching principle: form adapts to use. This organicism appeared in the writings of Ralph Waldo Emerson and the critics at Concord.

Mechanism.—A more mechanistic viewpoint emphasized the need for economical, utilitarian buildings. John Willis Griffiths, a naval architect, lectured in the eastern United States at mid century about his revolutionary "extreme clipper ships," saying that strict adaptation of form to functional purpose was the only source of beauty and utility. His viewpoint reflected that of the industrialists who erected the Stanley mill in Stroud valley, Gloucestershire (1813), and the Allendale mills at Centerdale, R I. (1822). Utilitarianism was the objective of engineers like Sir William Fairbairn. who was responsible for the mills at Saltaire, Eng (1851–53). Perhaps the strongest proponents of utilitarianism were scientists, notably Joseph Henry, the U S. physicist. Sir Francis Galton, the English physician, and Alfred Russel Wallace, the English biologist, who wanted functional laboratories hospitals and museums. without wasteful expenditures on monumental galleries. staircases or vaults.

Characteristic of the serviceable. economical and flexible workrooms they uanted were the spaces in Harvard's Museum of Comparative Zoology. designed by the Swiss biologist Louis Agassiz in 1859. The rooms were excellent for displaying a typologically arranged exhibit of biological specimens, but the pile of brick was as ugly as if it had been tossed up by a prehistoric glacier. In rejecting all considerations of design as well as style. the mechanists accomplished an architectural result that was no more satisfactory than the eclectic chimeras of romantic fancy. Physical utility could not be ignored, but a building, to be architecture, had also to be an aesthetic expression of the great themes science and industry suggested.

The Beaux-Arts. — The dilemma was frequently avoided by architects of the academic tradition in France, particularly those from the École des Beaux-Arts in Paris. The most famous architectural school of the 19th century, it sought to furnish utility nithin handsome, classical buildings. Traditional elements. such as domes and columns, and traditional principles of composition, including geometric spaces balanced around axes, character-

ized the work of J. L. Duc and J. L. Pascal. A more radical part of the École group, led by Henri Labrouste (1801–7j), attempted programmatic plans and nonarchaeological use of classical forms. Labrouste's Bihliothilque Ste. Geneviève (1843–50) and Bibliothèque Nationale (1854–68), both in Paris, were eminently successful. not only in the harmony of their spaces, but in the expression of programmatically arranged interiors and the introduction of useful devices such as iron stacks and cast-iron structure. More conservative designers, L. Visconti and H Lefuel, for example. worked upon additions to the Louvre, in which they imitated earlier portions to achieve harmony (Louvre pavilion. 1852). Victor Baltard. however, in the church of St. Xugustin (1860–68) and the Halles Centrales (1853). the central markets in Paris. used iron and glass in his programmatic arrangements of space. Baron Georges Haussmann directed Baltard and other architects in the design of the great boulevards of Paris; grand axes connected principal historic buildings and established prominent sites for monuments like the Arc de Triomphe de l'Étoile at the head of the Champs-Élysées by J. F. T. Chalgrin (1739–1811). Much of the present character of Paris remains a tribute to Haussmann; although his despotic methods were seldom available to later city planners. the example of Paris long remained a model for modern urban patterns.

1860–85

Haussmann's example, following Labrouste's innovations: ended any search for ancient buildings that might be appropriated wholly to contain modern institutions. Museums, markets, office buildings and schools demanded new and complex plans and the best designers provided them, although they did not originate a compatible style. They attempted instead modern versions of classical and medieval styles. Perhaps the most exciting of the new sequences of space can be seen in a longitudinal section of the Opéra at Paris (begun 1861) by the Beaux-Arts architect Charles Garnier (1825–98); grand entrances, foyers, staircases, vestibules and boxes lead to a huge auditorium, which is separated from the office wing by a tall stage loft. Garnier's magnificent command of the sweeping spaces was equaled by his mastery of balance, punctuation and termination; the façade, a composition of stately rhythms and playful sculpture, provided a fitting entrance for Napoleon III.

Ruskin's Influence. — Nothing comparable appeared in the United States or England during the '60s and '70s. In these countries there was a continued insistence upon the literary appropriateness of Gothic sculptural details. The high priest of medieval sentiment at this time was John Ruskin (1819- goo), who preached the aesthetic and moral excellence of the doge's palace at Venice and the campanile at Florence and convinced young architects that medieval handicraft ways might change modern civilization. His *Seven* Lamps *of Architecture* (1849) and *Stones of Venice* (1851–53) inspired the architect Thomas Deane to essay polychromy and hand-carved ornamental capitals at the Engineering building for the University of Dublin (1851). With Benjamin Woodward, Deane designed the University Museum of Natural History at Oxford university (1854–60), where the brothers O'Shea were exhorted to carve decoration after the natural foliage of the region. Other Englishmen joined the medieval brotherhood. The most influential was William Morris (1834–96), a poet, novelist and artist, a great printer and a leading socialist *(see* ARTS AND CRAFTS MOVEMENT, THE). He attempted to counteract the ugliness of much machine production by reviving the guilds and by espousing medieval principles, especially those regarding the expression of materials, structure and utility. Together with an architect, his friend Philip Webb, he created the Red house at Upton, Kent, in 1859, where brick, glass, shingles and interior spaces were expressed frankly and boldly. More ornate architecture was improvised on medieval themes by Alfred Waterhouse, William Butterfield and William Burges. Their versions of Gothic, called Victorian, are suggested by the St. Pancras station's Midland hotel (1865) and Albert memorial (1863–72), London, by Sir George Gilbert Scott (1811–78) and by George Edmund Street's New Law Courts, London (1874–82). Occasionally, R. Norman Shaw turned out a well-composed version of Tudor Gothic in which massive blocks were chastely mounted to form a picturesque composition. But restraint in the use of ornate, flaccid and tortured forms was rare and the '70s and '80s gained a reputation as a period of notoriously bad taste.

In the U.S. some architects, clients and critics considered Victorian Gothic architecture to be a way of providing a colourful foil to the ugly urban and industrial scene. Ruskinian sentiment captured the hearts of a group in New York who founded the Association for the Promotion of Truth in Art. One of its members, Peter Bonnett Wight, designed the National Academy of Design (1862–65), in which capitals were carved by hand ("to give workmen opportunity to think," according to Wight). The building was a restudy of the doge's palace at Venice, and was meant to please Ruskin. Next, Wight moved his sculptors to New Haven, Conn., where they erected the Street School of the Fine Arts at Yale, another Ruskinian building. *The Crayon* and *The New Path,* periodicals promoting Ruskin's ideas, found favour with Charles Moore and Charles Eliot Norton in Cambridge, Mass., both friends of Ruskin, who was benignly moved by Norton's efforts to improve the architecture at Harvard university. Harvard's Memorial hall (1866–78), designed by R. W. Ware and Henry Van Brunt, was a major statement of Victorian Gothic environment. Such buildings were especially popular for educational institutions, such as Princeton university (Chancellor Green library, 1873, William A. Potter) and Trinity college (later Duke university, Durham, N.C.; quadrangle, 1876, Burges), as well as for museums of fine arts and concert halls in New York, Boston, Cincinnati and Chicago. Even courthouses and post offices tended to be Victorian Gothic while Potter was supervisory architect of the treasury. Some churches, notably the New Old South Congregational at Boston (1877, Cummings & Sears), revealed dramatic spaces, interesting structures and fascinating silhouettes, but the overtones of the architecture were literary and symbolic.

Viollet-le-Duc.—During the 1880s, architects and critics who became disenchanted with Ruskin's peevish moralism turned to a Frenchman, E. E. Viollet-le-Duc (1814–79), whose archaeological work on Notre Dame de Paris, Carcassonne and other medieval sites led him to respect Gothic architecture as a coherent structural system. His *Dictionnaire raisonné* de *l'architecture française,* published between 1854 and 1868, was an encyclopaedia of exact information, and his *Entretiens sur l'architecture,* published between 1860 and 1872, developed his general theory, which he formulated for lectures he delivered at the École des Beaux-Arts. Translated into English, the *Lectures* stimulated John *W.* Root and other Chicago architects to attempt what they called "rational architecture," which was based on frank expression of structure. Although Viollet-le-Duc himself was not a talented architect, as he demonstrated in the gross Gothic Revival church he built at St. Denis, his *Lectures* offered important information about the construction of modern iron skeletons enclosed by nonbearing masonry walls. Illustrations in his book indicated the possible uses of metal, which were exploited in an important building, the Menier chocolate works at Noisiel-sur-Marne (1871–72), by Jules Saulnier. Architects generally ignored Viollet-le-Duc's suggestions, but some did attempt more robust structures, such as Philadelphia's Provident Life and Trust Company building (1879) by Frank Furness and those in the same city by Wilson Eyre, Jr., whose medievalism was more whimsical.

New Forms. — Scientists continued to have little sympathy for medieval forms. In 1876 Thomas Huxley, the English biologist, advised the trustees of the new Johns Hopkins university at Baltimore not to allow funds to "fossilize into mere bricks and mortar" and to "hire an honest bricklayer" who should erect only useful structures. The physician John Shaw Billings designed the ward pavilions at the Johns Hopkins hospital, while professors of chemistry, biology and physics designed their own laboratories. The president. Daniel Coit Gilman, wanted modern, serviceable structures such as he saw in laboratories at German and English scientific institutes, for example, the chemistry laboratory at Manchester, Eng., which was a bald working machine designed by a

professor of chemistry, H. E. Roscoe. Gilman criticized the expensive and unsatisfactory medieval piles at Trinity college and Edinburgh (George Gilbert Scott). His opinion was shared by Charles William Eliot, Harvard's president. A chemist, he had planned his own laboratory at M.I.T. and had high regard for buildings that were expandable, flexible and even expendable, since progress in science required frequent rebuilding. Critics like Clarence Cook now somersaulted from Ruskin's troupe to that of the scientists, whose aesthetic tastes were typified by Gilman's admiration for the precision, uniformity and economy of nature and of fine instruments and machines. Unfortunately, no architect could supply compatible buildings.

Had the scientists recognized it, there was an incipient new architecture that might have reconciled the differences between those who, wanting useful, economical buildings, settled for the commonplace work of bricklayers and mechanics and those who clung to medieval and classical forms to satisfy their craving for art. One could see the dichotomy even within a single building, as in London's St. Pancras station, where Scott's Gothic building stood alongside the iron and glass vaults of the train shed, without any attempt at a resolution. The shed (1868) was designed by an engineer. W. H. Barlow. Metal arches hold a canopy of glass in a powerful, grand grasp of space. Engineers designed with new materials. exposing them and shaping them in accordance with function rather than a whim of historical taste. At most, architects used cast-iron columns and ribs to simulate traditional domes, as in Nash's Royal pavilion at Brighton. Sir Robert Smirke's British museum (1823–47) and Thomas Walter's dome on the United States Capitol (1851–65).

Builders who were less bound by history achieved new forms. In the Crystal palace at the Great exhibition held at London in 1851, a botanist, Joseph Paxton, employed timber, cast iron, wrought iron and glass in a ridge-and-furrow system he had developed for greenhouses at Chatsworth in 1837. Paxton was partly inspired by the organic structure of the Amazonian lily *Victoria regia,* which he successfully cultivated. The Crystal palace contained important innovations in mass production of standardized materials and rapid assembly of parts, but its chief architectural merit lay in its cadence of colossal spaces. French designers recognized its magic, and a series of buildings for universal exhibitions held at Paris in 1855, 1867 and 1878 showed its influence. In the Palais des Machines (1889) by Ferdinand Dutert and M. Contamin a series of three-hinged trussed arches sprang, from small points. across a huge space, 385 ft. long and 150 ft. high. The English historian James Fergusson happily concluded that the Crystal palace marked the beginning of a new architecture; an English critic. Thomas Harris, coined the name "Victorian" for 19th-century architecture and looked forward to an age of iron buildings. The most important emblem of the Paris exhibition of 1889 mas the Eiffel tower (1887–89), designed by Alexandre G. Eiffel, an engineer, who had done outstanding work in the Paris exposition of 1878 and in steel structures like the trussed parabolic arches in the viaduct at Garabit, France (1880–84).

The new materials and forms were best introduced in the service of new architectural problems, such as railroad stations, which could not for long be contained within Renaissance palaces or Gothic guildhalls. As railroads became larger, they sought expressions of the fast and comfortable travel they offered; as they became chief gateways to cities, the stations acquired a distinctive, monumental character. The architectural progression can be followed: the motley. utilitarian Crown street station in Liverpool (1830) and Mount Clare station in Baltimore (1830) gave way to the Classical Revival Boston and Lowell "car house" at Lowell, Mass. (1835). New forms were sought in the arches, trusses and skylights of Sir William Tite's Nine Elms station at London (1837–38). The pagodalike towers on Henry Austin's Union station at New Haven, Conn. (1848–49), were a whimsical diversion, to be followed by Philip Hardwick's dignified Euston station, London (1839–40). All of this culminated in the Parisian Gare de l'Est (1847–52) by François Duquesnoy and Gare du Nord (1861–65) by Hittorf and F. L. Reynaud, London's King's Cross station (1851–52) by Lewis Cubitt, Berlin's Alexanderplatz Bahnhof (1880–85) by J. E. Jacobsthal, the St. Pancras at London and the station at Tours (1895–98) and Paris' Gare du Quai d'Orsay (1898–1900) by Laloux.

The emancipation of markets and stores was no less impressive. Designers erected iron and glass umbrellas such as Baltard's Halles. Members mere admitted to the Coal Exchange in London (1846–49, J. B. Bunning) through a round, towered classical porch, at the corner of two Renaissance palaces, to a magnificent rotunda hall, which was surrounded by three tiers of ornamental iron balconies and roofed by a lacelike dome of iron and glass. At Paris Eiffel, together with the architect L. A. Boileau, gave the retail shop a new and exciting setting in the Bon Marché (1876), where merchandise was displayed around the perimeters of skylighted, interior courts. The US. saw nothing comparable, but cast-iron columns and arches, appearing during the '50s, were used in commercial buildings like the Harper Brothers building at New York by John B. Corlies and James Bogardus (1849) and the Baltimore *Sun's* Iron building by R. G. Hatfield. Stores were given cast-iron faces, as in the pioneering Stewart's department store (later Wanamaker's) in New York city (1859–62) by John Kellum. Iron was frequently intended to simulate stone, and it was admired for its economy of maintenance. The material offered such neglected qualities as precision, standardization and efficient strength, however, which Van Brunt hoped would be recognized architecturally.

Unfortunately, the architects' society restricted their adventures into innovative spatial composition. The train shed was hidden behind the classical or Gothic waiting room; the skylight was thrust out of sight, as at the Bon Marché. Bold engineering was permitted in a bridge or warehouse, but time-honoured cultural institutions demanded an appropriate, traditional expression. In Germany the eclectic Renaissance architecture of Gottfried Semper (1803–79) and Alfred Messel (1853–1909) was dominant. There might be some simplification of form, as in the late work of England's Shaw or the studio (1888) of C. F. A. Voysey (1857–1941) at Bedford Park, London, and Voysey's house for Canon Grane at Shackleford, Surrey (1897). Amsterdam's Bourse (1898–1903) by H. P. Berlage (1856–1934) showed strong bold forms but there were still the traditional ones, as in the town hall at Copenhagen by Martin Nyrop (1849–1921), and little innovation was attempted in structure or materials.

H. H. Richardson. — Perhaps the architect's position during the '80s was best illustrated by the career of the American Henry Hobson Richardson (1838–86). A gentleman from a fine southern family, he graduated from Harvard, then attended the École des Beaux-Arts in Paris. Returning to New York and going later to Boston, he cast aside his weak Victorian Gothic and Napoleon III pavilions and won national acclaim for the bold and heavy masses of his Trinity church at Boston (1872–77) in which Romanesque motifs from Arles and Salamanca embellish a cruciform auditorium intended for the great preacher Phillips Brooks. The Sherman house at Newport, R.I. (1874–76), recalled Richardson's earlier mélange of styles, but it also hinted at an elimination of complications. He found his stride in his designs for small public libraries at Medford, North Easton and Quincy, Mass, and for small suburban stations along the Boston and Albany railroad tracks.

Like all great designers, Richardson recognized the need for the monumental, even subordinating utility to achieve a unified result, as in the handsomely proportioned Sever hall at Harvard (1878–80). He could be rustic, as in the gate lodge for the Ames estate at North Easton; he was adept in revealing the nature of wood shingles, brick, terra cotta and stone, as in his houses at Cambridge, St. Louis and Chicago; and he also mastered dynamic, programmatic compositions nith strong silhouettes, realized in gargantuan stone, as in his Allegheny county courthouse and jail at Pittsburgh (1884–86). His short career ended while his Marshall Field wholesale warehouse (1885–87) was being erected at Chicago. The importance of this warehouse lay in its art. Its masonry arches, which were on a scale compatible with 19th-century commercial and industrial poner. stated in light and shadow a theme that was terminated at the corners, phrased in a quieter way above and concluded by a cornice. The warehouse gave later architects in Chi-

cago their first glimpse of how stone might spring to life in the service of industry. and its lesson. usually with more emphasis on the Romanesque Revival style than on the great composition, spread to Kansas City (Van Brunt & Howe), New York city (Potter & Robertson), Boston (Shepley, Rutan & Coolidge) and Minneapolis (L. S. Buffington).

1885–1900

Still another attempt to instill modern vigour into traditional architecture was made by classicists, especially those who were centred around the École des Beaux-Arts. French students underwent a rigorous training. clearly defined in *Éléments et thkorie d'architecture* (*c.* 1900) by Julien Guadet, a professor at the École. In their best work, such as the Grand Palais and Petit Palais in Paris (1897–1900) by Charles Girault, the French Beaux-Arts architects employed iron, steel and glass in combination with masonry, they organized plans and spaces for clear circulation, monumental vistas and expression of use and they were inventive in elevations and ornamental detail while preserving classical principles of composition. Germany. Russia, England and Italy followed the French lead, as in Mengoni's Galleria Vittorio Emanuele at Milan (*c.* 1865). Americans also attended the École, beginning with Richard Morris Hunt (1827-9 j), and. although Richardson abandoned classicism for the Romanesque style. most Beaux-Arts graduates followed the style that was dominant at Paris. At its worst, the Beaux-Arts influence resulted in atrocious decoration, wasteful plans, inefficient structures and monuments that had little to say about their times. About 1875 inferior architects. such as A. D. Mullet, were in control of the design of most public buildings, and the Old Post Office in New York city, the State Department building in Washington and the city hall at Philadelphia show a reckless display of classical detail unchecked by the knowledge good Beaux-Arts designers invariably brought to their work. The commendable work of Hunt, such as the "Breakers" at Newport (1893–95) and the "Biltmore" at Asheville, N.C. (1890–9j), and the more meritorious designs of the French critic at M.I.T., Constant Désiré Despradelle, as in his Berkeley building. Boston, could not prevent the Beaux-Arts from acquiring a bad reputation. Even after it lost its vigour, however, its best exponents were enviably skilled in planning, drawing and monumental composition.

Departures from classicism were numerous during the '80s and '90s. In England and the United States, Gothicists like Sir Giles Gilbert Scott (Liverpool cathedral) and Ralph Adams Cram (1863–1942; West Point Military academy and the cathedral of St. John the Divine, New York city) essayed modern versions of Gothic architecture. which became especially popular for colleges, churches and schools that claimed English cultural heritages. Bertram Goodhue (1869–1924), a talented designer in Cram's firm, gave the Gothic Revival St. Thomas' church in New York city convincing elements. A patron of Christian-humanistic education, Andrew Fleming West hired Cram to design the graduate college at Princeton (1913) because he wanted a setting similar to the medieval quadrangles of Oxford and Cambridge.

Art Nouveau.—Such departures from classicism failed to satisfy men who wanted a totally new architecture. *Art nouveau* (*q.v.*) was the general title for a highly varied movement toward modernism that had international representation. In France bizarre forms appeared in the iron, masonry and concrete structures of Hector Guimard (Humbert des Romans and Métro stations, Paris, *c.* 1900) and Anatole de Baudot (St. Jean l'Evangéliste, Montmartre, 1894–1904). Georges Seurat's "Sunday Afternoon on the Isle of Grande Jatte" begun 1884 had an architectural counterpart in the Dufayel store's interiors at Paris. In Belgium there were Baron Victor Horta's floral, tendrilous ornament at his house at 12 Rue de Turin, Brussels (1893), and an exposition of fine spaces and undulating enclosure in his Maison du Peuple in Brussels (completed 1897). In the U.S. *art nouveau* arrived nith Louis Comfort Tiffany; in Italy furniture by A. Charpentier and C. Bugatti was exhibited an international exposition; in Scotland A. H. Mackmurdo and Charles Rennie Mackintosh expressed the new movement in buildings like Mackintosh's art school at Glasgow (1898–99). Even in Spain a representative belatedly developed in Antonio Gaudi (1852–1926), whose sculptural, fungus-like apartment house, Casa Milá, belied the structural experiments and spatial drama of his "Parc Güell" and the enigmatic church of the Holy Family, all at Barcelona. Like other *art nouveau* work, Gaudi's buildings were amazingly personal, gaining their effect through bizarre form and ornament and showing no way past the tangle of competing styles.

The Chicago School.——What was needed was a major endeavour in regard to the most important new type of building of the modern age, the large office building. The office building was made necessary by the concentration of markets, banks. railroad terminals and warehouses in small sections of growing cities, and it pushed skyward as a result of the attempt to get maximum income from expensive urban properties, the desire for the commercial prestige of tall emblems and the need of businesses for mutual proximity in the days before rapid electronic communication. The safe, fast elevator removed the major prejudice against height. Designed by traditionalist architects, the tall buildings stretched masonry construction to its limits; they frequently resembled towers comprised of smaller buildings stacked one on another, as in Hunt's Tribune building at New York (1874). The structural problem was solved at Chicago in 1884–85, when an engineer, William Le Baron Jenney. developed a metal skeleton of cast-iron columns, sheathed in masonry, and wrought-iron beams, carrying the masonry walls and windows at each floor level. Technically innovative, the building retained masonry side walls, and its elevations were disunified and inept.

Inspired by Viollet-le-Duc's rationalism, Chicago architects sought a better aesthetic expression of the metal frame. but even the talented John W. Root (1850–91), working with Daniel Burnham, failed to achieve it in the Ashland block (completed 1892), and lesser designers, such as William Holabird and Martin Roche in their Tacoma building (1887–88), also missed their chance. Even the great Louis Sullivan (1856–1924) was not successful in his early buildings such as the Ryerson (1884); covering them with gross, somewhat *art nouveau* ornament, he first accentuated the vertical columns and then the horizontal beams, in a covert admission of failure. At his best, as in his Auditorium theatre and hotel (1886–go), Sullivan treaded Richardson's path toward unified Romanesque forms. The Marshall Field warehouse showed Sullivan the way toward a theme for the skyscraper, which he first stated with assurance in the Wainwright building at St. Louis (1890). Brick piers mark each steel column and half module to create a rhythm of tall narrow bays punctuated by recessed spandrels, terminating at the roofline. It was a major, if lonely, triumph for the Beaux-Arts composition Sullivan learned at Paris. But one successful building hardly constituted a new national style. In spite of his eulogy to Whitman's nationalism, his paeans to Darwin's principles of organic growth and his protestations about a new architecture, Sullivan willingly joined other Chicagoans in helping the New York architects, Hunt and Charles Follen McKim (1847–1909), plan the World's Columbian exposition at Chicago in 1893.

A dazzling spectacle of monumental, classical architecture, the fair's midway caught the fancy of Americans who saw in its great axes, lagoons, sculpture. white buildings and large plazas an answer to the dreary urban environment of their home towns. Similar schemes were supported in their cities; some of them were designed by the fair's principal planner, Daniel Burnham, who brought the "great white city" to Cleveland, Washington, New York and San Francisco. The civic spaces of the Place de la Concorde at Paris and the squares at Nancy were emulated. There were gardens and fountains that dimly reflected those at Versailles, and their grandeur sometimes prompted a later generation to disapprove of them as symbols of callous indifference to the social and economic causes of the metropolitan cancer. Still, the best parts of many U.S. cities are as spacious as they are because of the city beautiful movement. Its most popular architect was McKim, whose Public library in Boston's Copley square (1888–95) made a dignified classical counterpart to Richardson's Trinity church. His plan for Columbia university (1895) carried the classical Beaux-Arts image into educational architecture, and for Rhode Island's government he built a classical state capitol at Providence (1895–

1902). McKim provided Pierpont Morgan with an exquisite library in New York city (1906) and adapted the baths of Caracalla for the Pennsylvania railroad station there (1906–10). All of these were reliable buildings, grand in conception and competent in detail. Similar buildings appeared in many lands, perhaps because they were so universalized, dependable and unoriginal; often they were the marks of imperialism, as in the case of those built by the French in north Africa. the English in China and India and the Americans in the Philippines.

The ferment in Chicago was neither halted nor marred by classicism's transcontinental popularity. Burnham's firm went on to produce Chicago's Reliance building (1890–95), an excellent office building nith logically ordered spaces enclosed by faceted walls of glass and a steel skeleton covered by terra-cotta panels. Sullivan found his best expression of the skyscraper in Buffalo's Prudential building (1894–1905) and developed the theory for it in an essay published in *Lippincott's Magazine* (1896). That theory received even more dramatic expression in the Schlesinger-Mayer store (later Carson Pirie Scott) in Chicago (1899–1904), in which the towered corner marked the climax of the logic of the steel frame and the entrance was made inviting with rich, naturalistic ornament. At the very end of the 19th century the important emblem of modern commerce thus received an appropriate form: its structure was made of steel, its spaces were planned efficiently, its elevations were expressive of the skeleton and its scale was marked by the fenestration and ornament. Such designs offered clients an opportunity to build well in a style that expressed its time.

20TH CENTURY
1900–30

The channels opened by 19th-century engineers like Eiffel, theorists like Morris and movements like *art nouveau* and the Chicago school enabled architects to move quickly toward a refined new architecture for the 20th century. In general, modernism revealed two main tendencies: a strong insistence upon mechanical functionalism, which resulted in a machine aesthetic for architecture; and an organic point of view, which emphasized architectural themes derived from landscape, function and materials. Unfortunately, neither point of view gained more than sporadic allegiance. Most buildings, in an age when only a small percentage were actually designed by architects, were still in 19th-century historical styles. The locus for creative architecture in the U.S. remained the middle west. Californians such as the brothers Greene and the Gills struck occasional regional and modern notes in the west; Bernard Maybeck (1862–1jj) ran an eclectic course: Roman in his Palace of the Fine Arts at San Francisco (191j), Gothic and romantic in his First Church of Christ Scientist at Berkeley (1910–12) and somewhat freer in his houses. The Chicago school uas more seminal for modern architecture and its members, such as William G. Purcell and G. G. Elmslie, fanned outward. William Drummond moved to the area south of Chicago. Louis Sullivan was called to Grinnell and Cedar Rapids, Ia., and to Owatonna, Minn., to design banks.

Frank Lloyd Wright. — The greatest of all the Chicago architects was Frank Lloyd Wright (1869–1959). His "prairie architecture" expressed its site, region, structure and materials and avoided all historical reminiscences; beginning with its plan and a distinctive spatial theme, each building burgeoned to its exterior sculptural form. Starting from Richardson's rustic, shingle houses and making free use of Beaux-Arts composition during the '80s and '90s, while he was in Sullivan's office, Wright developed his "prairie house" for the Winslows at River Forest, Ill. (1895), made it more elaborate in the Coonley house at Riverside, Ill. (1908), and, ultimately, realized in it the flowing volumes of space defined by sculptural masses and horizontal planes, of his Robie house at Chicago (1909). Meanwhile, he scored a triumph with his administration building for the Larkin company at Buffalo in 1904, which grouped offices around a central skylighted court, sealed them hermetically against their smoky environs and offered amenities in circulation, air conditioning, fire protection and plumbing. In its blocky fire towers, sequences of piers and recessed spandrels were coupled together in a composition that foretold the handsome industrial architecture of the future.

Reactionaries saw little merit in Wright's work. Critics such as Russell Sturgis thought it was at best rational but awkward and praised instead Burnham's Flatiron building and Napoleon Le Brun's Metropolitan Tower, the distorted classicism of which still pleased New York's clients. Ironically, technological progress negated the Chicago school's successes in the rational expression of the steel frame. Artificial lighting, ventilation and communication compensated for the lack of an efficient plan or large, functional windows. Freed from strict accountability to practicality and logic, the skyscraper architect could dress the skeletal frame any way he or his client chose. A distinctive dress mas an advertisement, and the Woolworth company, recognizing this, commissioned Cass Gilbert in 1913 to design a Gothic toner for them in New York city; its flamboyant summit was illuminated at night as a 24-hour advertisement.

Developments in Europe. — In England and the Netherlands, too, there mere conservatives. In London the Beaux-Arts-Georgian War Office at Whitehall was completed in 1907, and Liverpool paid its respects to medieval times with the cathedral begun in 1903. There were also presages of change in the works of the Englishman Voysey and the Netherlands' Berlage. Berlage visited Wright and returned to show younger architects, such as Dudok, the way to handle brick simply in buildings that had regional character.

Germany and Austria moved more quickly and radically. A German architect, Theodor Fischer, inspired by Schinkel's precedent, attempted innovations, nith only slight Romanesque and classical references, in his Garnisonkirche at Ulm (1908–11), and Otto Wagner, an Austrian, combined academic geometry with *art nouveau* decoration in his railroad station at Vienna (1894–97), which was followed by his simpler chapel for the cemetery of a sanatorium near Vienna (1904–07). Wagner's pupils broke free of his classicism and formed the Secessionists. The group included Joseph Olbrich (1867–1908), who joined the art colony at Darmstadt, Ger., where his houses and exhibition gallery of about 1905 were boxlike, severe buildings. Joseph Hoffmann left Wagner to found the Wiener Werkstatte, an arts and crafts movement; his best work, the Stoclet house at Brussels (1911), was a Cubist, asymmetrical composition in which white planes were defined at the edges by gilt lines. The Austrian Adolf Loos (1870–1933) opposed the use of any ornament and was determined to obtain quality in compositions of bald, functional blocks. Peter Behrens, having had contact with Olbrich at Darmstadt and with Hoffmann at Vienna, was in 1907 appointed engineer in charge of the German electrical trust (A.E.G.), for which he designed a turbine factory (1909) at Berlin, a direct expression of industry.

Behrens strongly affected three great architects who worked in his office, Walter Gropius (1883–), Le Corbusier (Charles Édouard Jeanneret, 1887–) and Ludwig Mies van der Rohe (1886–). Gropius' Werkbund exposition building at the Cologne exhibition (1914) was a model factory building in which vigorous forms were enclosed by masonry and glass; its effect was gained by its use of steel frames, its strong silhouette and the logic of its plan. There were no historical influences, nor were there any expressions of local landscape, traditions or materials. The building mas mechanistic; its beauty derived from the adaption of form to purpose.

A less rigorous modernism appeared in Scandinavia, particularly where, as in Sweden, handcrafts survived in furniture and building construction. Regional and national traditions kept history alive, and new architecture seldom revealed the doctrinaire avoidance of precedent or the blind adoration of the machine that harshened German contributions. The charm of Ragnar Ostberg's town hall at Stockholm, a programmatic composition, lay in its cloistered spaces, brick walls and ornamental decoration, as well as in its picturesque towers, minarets and colonnades: all of which were simplified versions of earlier themes in Swedish building. Somewhat similar works, though more influenced by Mackintosh! appeared in Finland, as in Eliel Saarinen's railroad station at Helsinki (1910–14), which utilized traditional masonry in strong simple forms and showed the Scandinavians' aversion to anything as

mechanistic as Gropius' factories.

France remained ambivalent. Guimard and De Baudot had essayed idiosyncratic versions of art *nouveau*, and other designers followed Henry van de Velde. a Belgian, who after 1895 stimulated a vogue for art *nouveau* in the minor arts which occasionally manifested itself in buildings, such as the house at 4 Avenue Jena, Paris. The dominant tradition, however, stemmed from the Beaux-Arts. Even the Théâtre des Champs Élysées (1911–13) by Van de Yelde and Auguste Perret (1874–1954) was an academic composition, though its ferroconcrete frame sheltered three separate auditoriums and a store.

On his own, Perret achieved a frank exposition of reinforced concrete skeletons and developed spaces within temporary partitions, as at his apartment house on the Rue Franklin. Paris, which in 1902 and 1903 marked a major advance from the Beaux-Arts tradition. Still the École's Grand Prix went to traditional designs, such as that awarded for an Institut de France in 1921, a symmetrical, classical scheme. One winner, however, Tony Garnier (1869–1948), caught the modern currents in materials, structure and composition when he evolved his masterful plan for a cite' *industrielle* (1901–04), published in 1917, in which reinforced concrete was to be used to create a city of modern buildings. With insight, Garnier developed a comprehensive scheme for residential neighbourhoods, transportation terminals, schools and industrial centres, and his plan became a major and influential scheme for a modern metropolis. Garnier received no mandate to build such a city, but his pavilion for Lyons at the International Exposition of Decorative Arts at Paris (1925) and his town hall at Boulogne-Billancourt (c. 1935) recalled the promise he had shown, though they were not so innovative and masterful as might have been expected.

For about 15 years after World War I advocates of Expressionism achieved modern, personal, highly sculptural forms (*e.g.*, Eric Mendelsohn in his factories and Einstein tower at Potsdam). Rudolf Schwarz, D. Bohm and 0. Bartning made important modern churches; but there was a return to more restraint in religious architecture as in Notre Dame de Le Raincy by Perret (1922–23).

Paris became the stronghold of the advocates of a new vision of space. Cubism, which Georges Braque and Pablo Picasso developed in 1906 from suggestions in Paul Cezanne's paintings and in primitive African sculpture. Forms were dismembered into their faceted components; angular forms, interpenetrated planes, transparencies and diverse impressions were recorded as though seen simultaneously. Soon, reflections of Cubism appeared in architecture: interior spaces were defined by thin, discontinuous planes and glass walls; supports were reduced to slender metal columns, machine finished and without ornamentation; and Cubistic voids and masses were arranged programmatically in asymmetric compositions.

Membership in the movement was international. In the Netherlands, Piet Mondrian and Theo van Doesburg began their magazine, de Stijl, in 1917. Doesburg's work for the Bauhaus art school at Weimar, Ger., brought his influence to bear upon Gropius and Mies, whose plans for houses sometimes bore a marked similarity to Doesburg's Cubistic paintings. Meanwhile, the Dutch architect J. J. P. Oud collaborated with Doesburg for a time and vigorously proclaimed the new style in houses he built at Rotterdam (after 1918), Hook of Holland (1924–27) and Stuttgart (1927). Cubism, like any other style, might have faltered and fallen into a merely decorative cliché, as at the Paris exposition of 1925, but three great architects prevented its demise.

Le **Corbusier.**—The Swiss-French architect Le Corbusier gave the new architecture a firm foundation by writing the strong theoretical statement, *Vers* une *architecture*, published in 1923. It revealed a world of new forms—not classical capitals and Gothic arches but ships, turbines, grain elevators, airplanes and machine products, which, Le Corbusier said, were indexes to 20th-century imagination. His love of machines being combined with a belief in communal authority as the best means of accomplishing social reforms, Le Corbusier directed his attention toward the problems of housing and urban patterns. An architectural attack, using standardized building components and mass production, was required. His sociological and formal ideas appeared in a Cubist project for Domino housing (1916). and his aesthetic preferences led him after World War I to develop an extreme version of Cubist painting he and Amédée Ozenfant called Purism. Returning to architecture in 1921. he designed a villa a Vaucresson (1922), whose abstract planes and strip windows revealed his desire to "arrive at the house machine . . ., standardized houses with standardized furniture." In 1922 he also brought forth his project for a skyscraper city of 3,000,000 people, in which tall office buildings and apartment buildings would stand in broad open plazas and parks with the versatile Cubist spaces between them defined by low row housing.

Much of his works thereafter—his Voisin city plan, his Pavillon de L'Esprit Nouveau at the Paris exposition of 1925, his exhibit of workers' apartments at the Werkbund exposition at Stuttgart (1927) and his influential but unexecuted submittal to the League of Nations competition—were footnotes to that dream of a new city. The villa. "Les Terrasses," at Garches (1927) was a lively play of spatial parallelepipeds ruled by horizontal planes, but his style seemed to culminate in the most famous of his houses, the Villa Savoye at Poissy (1928–30). The building's principal block was raised one story above the ground on *pilotis* (heavy, reinforced-concrete columns). floors were cantilevered to permit long strip windows and space was molded plastically and made to flow horizontally. vertically and diagonally until, on the topmost terrace, the whole composition ended in a cadenza of rounded, terminating spaces. Gaining greater facility in manipulating flowing spaces. Le Corbusier designed the dormitory for Swiss students at the Cité Universitaire (1930–32) in Paris. This was a major public building, and it suggested that an exciting new architecture might soon serve education.

Gropius.—In Germany Gropius moved in a more mechanistic direction. After completing his model factory at Cologne in 1914, he succeeded Van de Yelde as director of the ducal Arts and Crafts school at Weimar in 1919. Later called the Bauhaus (*q.v.*), it became the most important centre of modern design until the Nazis closed it in 1933. While he was at Weimar, Gropius developed a firm philosophy about architecture and education, which he announced in 1923. The aim of the visual arts, he said, is to create a complete, homogeneous physical environment in which all the arts have their place. Architects, sculptors, furniture makers and painters must learn practical crafts and obtain knowledge of tools, materials and form; they must become acquainted with the machine and attempt to use it in solving the social problems of an industrial society. At the Bauhaus. aesthetic investigations into space, colour, construction and elementary form were flavoured by Cubism and Constructivism. Moving the school to Dessau in 1925, Gropius designed the pioneering new Bauhaus (1925–26) in which steel frames and glass walls provided workshops within severely Cubistic buildings. Gropius assembled a staff of modern teachers, including Lazslo Moholy-Nagy, Wassily Kandinsky, Paul Klee, Marcel Breuer and Adolf Meyer, whose projects, such as the 116 standardized units at the experimental housing at Dessau-Theorten (1926–28), bore a highly machined, depersonalized appearance.

Mies Van der **Rohe.**—Gropius was succeeded at the Bauhaus in 1930 by Mies, whose training as a mason was supplemented by the engineering experience he gained in the office of Behrens (1908–11). Influenced by Van Doesburg's de Stijl, Mies's natural elegance and precise orderliness soon revealed themselves in projects for a brick country house and a glazed, cantilevered concrete-slab office building (1920–22). He directed the Weissenhofsiedlung at Stuttgart (1927), contributing the design for an apartment house. Such practical problems failed to show his talent, which was not fully known until he designed the German pavilion for the International exposition at Barcelona in 1929. The continuous spaces partitioned with thin marble planes and chromed steel columns drew international applause. His Tugendhat house at Brno, Czech. (1930), along with Le Corbusicr's Villa Savoye, epitomized the modern domestic setting at its best.

After 1930

After 1930 the modern movement spread through Europe. In

Switzerland Robert Maillart's experiments with reinforced concrete attained great grace in his Salginatobel bridge (1930) and Cement hall at Ziirich (1939). Finland's Alvar Aalto won a competition for the library at Viipuri in 1927 with a building of glass walls, flat roof and round skylights (completed 1934); but he retained a sympathy for wood and picturesque planning. which were evident in his house at Mairea (1938–39), the factory and housing at Sunila (1937–39), his building at the Kew York World's fair (1939) and M.I.T.'s Baker dormitory. Aalto dnd other Scandinavians gained a following among those whom severe German modernism repelled Sweden's Sven Markelius and Gunnar Asplund (crematorium. Forest cemetery. Stockholm, 1938–40) and Denmark's Kay•Fisker, C. F. Möller and Arne Jacobsen also brought regional character into their modern work In the Netherlands J. A. Brinkman and L. C. van der Vlugt, at the Van Kelle tobacco factory in Rotterdam (1929–30), aimed at more mechanistic, universal form. In England, German refugees, alone or with English designers, inaugurated a radical modernism that culminated during the '50s in school architecture and the Royal Festival hall, London (opened 1951, R. H. Matthew and J. L. Martin).

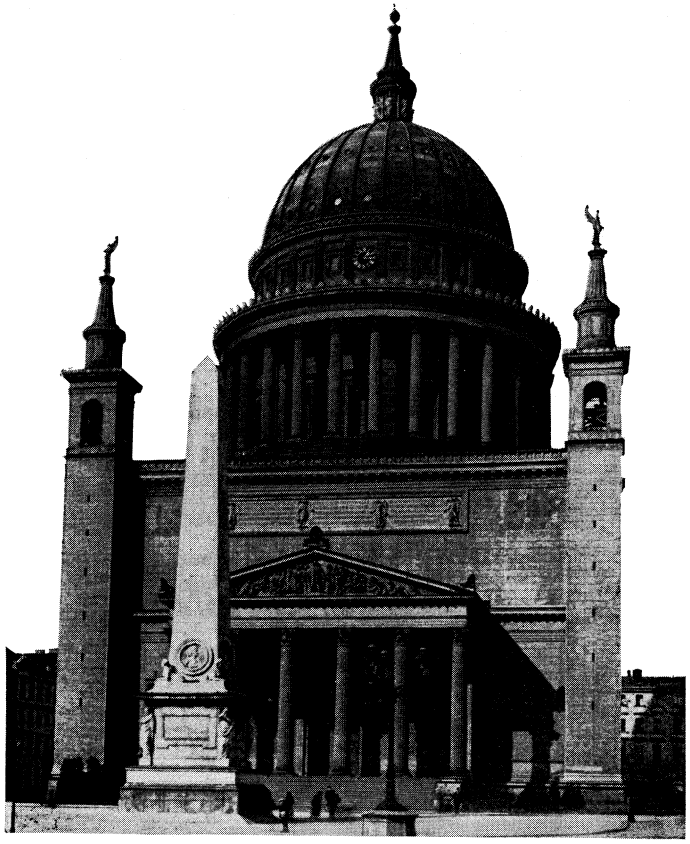
As regards industrial architecture, notable successes were achieved in the clothing factory at Congleton. Cheshire (1948), by Rudolf Frankel and the rubber factory at Brynmawr, south Wales (1951), by the Architects' Co-operative Partnership. In housing, the Churchill Gardens at Pimlico, London (1952). by Philip Powell and Hidalgo Moya and the Lawn flats at Harlow New Town. Essex (1951), by Frederick Gibberd, were notable contributions.

Russia in the period after the Revolution at first encouraged modern art and several architects, notably Bruno Taut, looked to the new government ior a sociological program. V. Tatlin's project for a monument to the third international (1920) was a machine in which the various sections (comprising legislative houses and offices) would rotate nithin an exposed steel armature. A morkers' club in Moscow (1929) had a plan resembling half a gear, and the Ministry of Central Economic Planning (1928–32), designed by Le Corbusier. was a glass-filled slab. By the time it was completed, the building was subjected to official disfavour. as Stalin's government adopted classical monuments, such as B. M. Iofan's winning design for the Palace of the Soviets (1931), which was intended to pile classical colonnades to a height of 1,365 ft. and have a colossal statue of Lenin at its summit. With its gigantic Corinthian columns, the building for the central committee of the Communist party at Kiev (1937) showed an overbearing scale and wasteful pomposity. There nere also evidences of regionalism where folk motifs appeared, as in the tentlike pavilion of Uzbekistan at the Moscow exposition of 1939. After World War II the classical, stepped skyscraper was the form used for Moscow university, which Russian architects admired for its amenities. There were evidences of simplification and mechanization of form in the Russian pavilion at the Brussels exposition of 1958, which showed a modified and more economical classicism. See also RUSSIAN ARCHITECTURE. *The* Soviet Period.

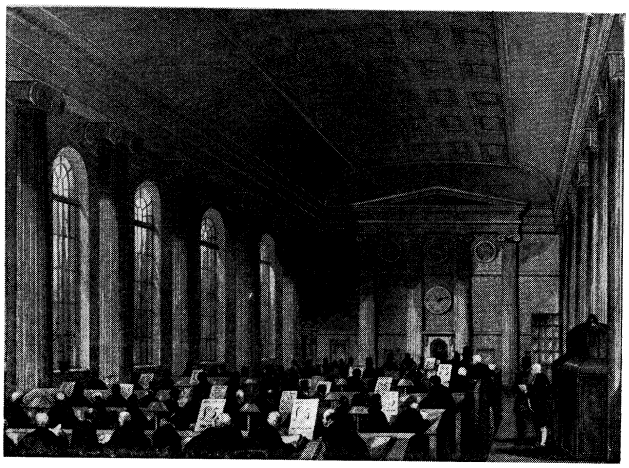
Mexico and South America broke their bonds to French, Spanish and Portuguese academic design during the '30s. Le Corbusier's influence became strong in Brazil, where Oscar Niemeyer and other architects designed the Corbusier-inspired Ministry of Education and Public Health at Rio de Janeiro (1937–42). Lúcio Costa, Félix Candela and Niemeyer were the vanguard of modernism; whole communities, as at Caracas, São Paulo, the University of Mexico and Brasilia during the '50s, were rebuilt. In Mexico there was avid support for modern design in buildings such as the Presidente Juárez housing at Mexico City (1950) by Mario Pani and Salvador Ortega. In Colombia, after World War II, enormous strides were made in thin-shelled reinforced-concrete construction. In Brazil dramatic complexes were erected from concrete (*e.g.*, the school and gymnasium at Pedregulho housing, Rio de Janeiro, 1953, Affonso Eduardo Reidy).

Until about 1935 leading architects and architectural schools in the United States tended to ignore modernism. Industry showed some inclination to respect function, materials and engineering, as was evident in Joseph Leland's glazed, skeletal buildings for the Pressed Steel company at Worcester, Mass. (1930). The National Cash Register, United States Shoe Machinery. National Biscuit, Sears, Roebuck and various automobile companies, such as Ford, sponsored functional architecture. Occasionally a traditional architect produced an innovation such as Willis Polk's Hallidie building at San Francisco. With the aid of Ernest Wilby, the engineering firm of Albert Kahn created a work of architectural merit. in Detroit's Continental Motors factory of about 1918.

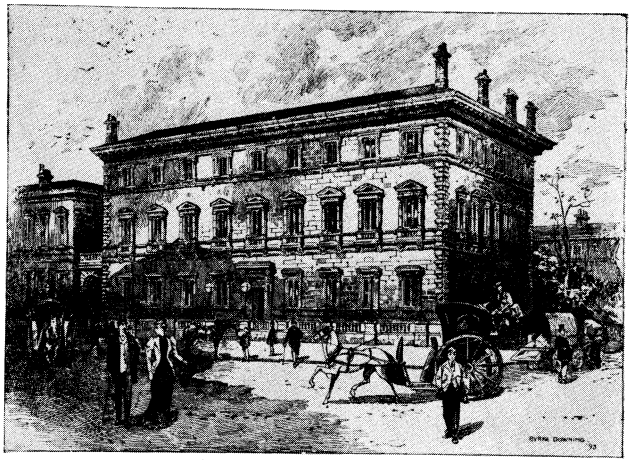
During most of this period, America's foremost architectural genius. Wright, was ignored by all except a select following. The single figure who gave international distinction to American 20th-century architecture was for the most part neglected by major universities church organizations and industries. His architecture remained the cherished property of personal clients, such as Aline Barnsdall for nhom Wright designed the "Hollyhock house" at Hollywood, Calif. (1917–20). His Autobiography recorded his frustrations in gaining acceptance for organic architecture. The first edition summarized the chief features of that architecture: a reduction of the number of rooms to a minimum and the definition of them by point supports; the close association of buildings to their sites by means of extended and emphasized planes parallel to the ground; the free flow of space, unencumbered by boxlike enclosures; harmony of all openings with each other and with human scale; the exploitation of the nature of a material, both in its surface manifestations and its structure; the incorporation of mechanical equipment and furniture as organic parts of structure; and the elimination of applied decoration. There were also four new properties: transparency, which was obtained through the use of glass; tenuity, or plasticity of mass, achieved through the use of steel in tension, as in reinforced concrete; naturalism, or the expression of materials; and integration, in which all ornamental features were natural by-products of manufacture and assembly. The Millard house at Pasadena, Calif., (1923), exemplified many of these principles; its concrete-block walls were cast with decorative patterns. Taliesin East. Wright's house at Spring Green. Wis., went through a series of major rebuildings (1911, 1914, 1915 and 1925), and each fitted the site beautifully; local stone, gabled roofs and outdoor gardens reflected the themes of the countryside. A period of withdrawal at Taliesin afforded Wright several years of intensive reflection, from which he emerged with fabulous drawings for the Doheny ranch in California (1921), a skyscraper for the National Life Insurance company at Chicago (1920–25) and St. Mark's Tower, New York city (1929). The last was to have been an 18-story apartment house comprising a concrete stem from which four arms branched out ard to form the side walls of apartments cantilevered from the stem to an exterior glass wall. Unexecuted, like most of Wright's most exciting projects. St. Mark's Tower testified to his revolutionary thinking about skyscraper architecture. His ideas gained a aide hearing in 1931 when he published the Kahn lectures he delivered at Princeton in 1930. In keeping with the needs of the United States during the depression, Wright turned his attention to the low-cost house, designing a "Usonian house" for Herbert Jacobs at Madison, Wis. (1937), and a quadruple house, "the Sun houses," at Ardmore, Pa (1939). These exemplified the residences he intended for his ideal communities, such as rural, decentralized Rroadacre City (1936), which was Wright's answer to European schemes for skyscraper cities. At about the same time, Wright sketched four masterpieces: "Fallingwater" (1936–38), the daringly cantilevered week-end house of Edgar Kaufmann; the administration building of the Johnson Wax company, in which brick cylinders and planes develop a series of echoing spaces, culminating in the forest of graceful "mushroom" columns in the main hall; the Johnson house at Racine (1937), aptly called "Wingspread"; and Taliesin West at Paradise Valley, near Phoenix, Ariz. (begun 1938), where rough, angular walls and roofs echo the desert valley and surrounding mountains. With increasing sensitivity to local terrain and native forms and materials, Wright stated more complrx spatial and structural themes than European modernists who seldom attempted either extreme programmatic plans or organic adaptation of form to a particular environment. Eventually. Wright himself developed a more universal geometry, as he revealed in the sculptural Guggenheim Museum of Non-Objective Art at New York city



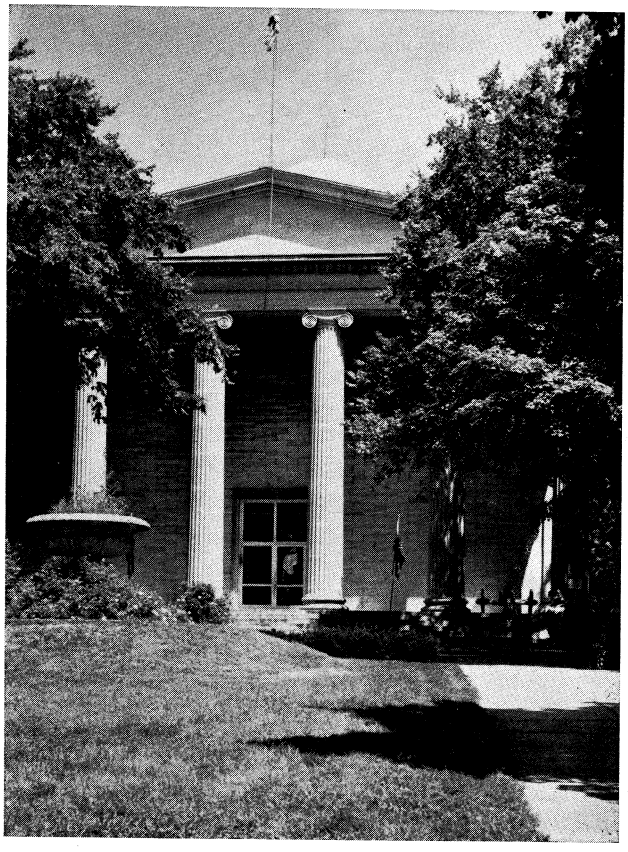
St. Nicholas church, Potsdam, Ger., 1826–49; by Karl F. Schinkel



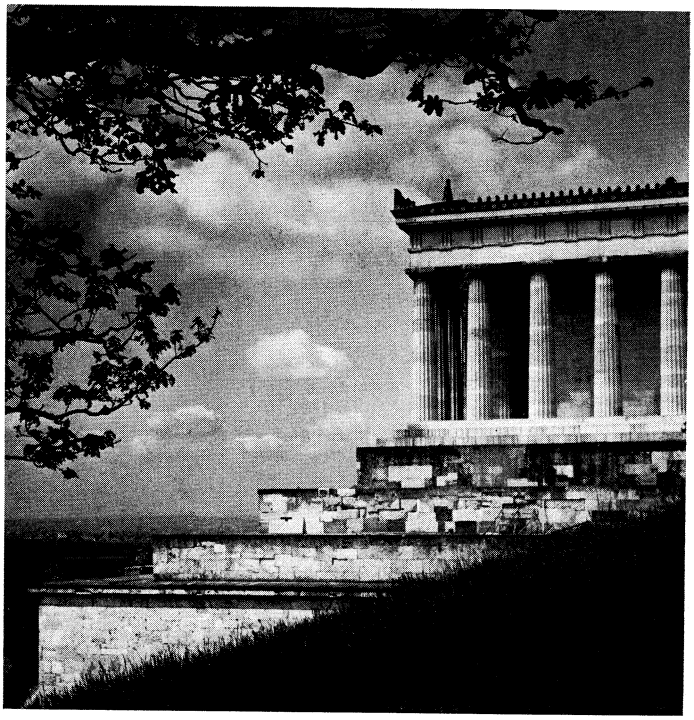
Office of the Bank of England where £5 notes were sorted and examined; remodeled by Sir John Soane, 1788–1808



Drawing of the Reform club, London, built in 1837; Sir Charles Barry, architect



Old Kentucky capitol at Frankfort, 1827–30; by Gideon Shryock



"Valhalla" at Regensburg, Ger., 1830–47; by F. K. L. von Klenze

19TH CENTURY: RATIONALISM AND CLASSICISM

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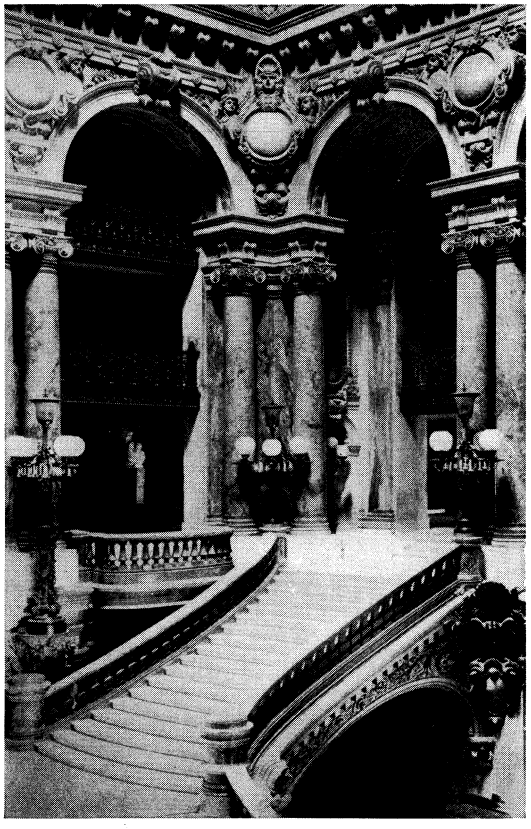
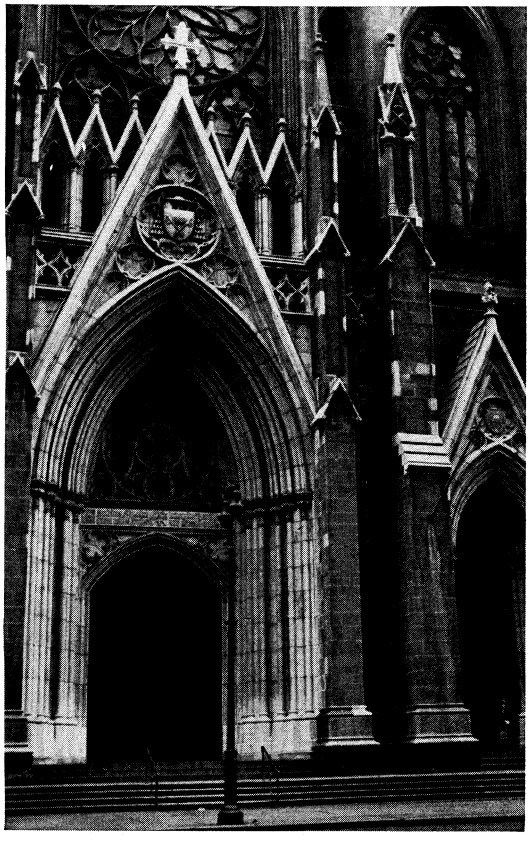
MODERN ARCHITECTURE

North end of the Houses of Parliament, London; at left is the Clock tower ("Big Ben"). Sir Charles Barry and A. W. Pugin, 1837–57



Staircase of the Paris Opéra by Charles Garnier, 1861–75

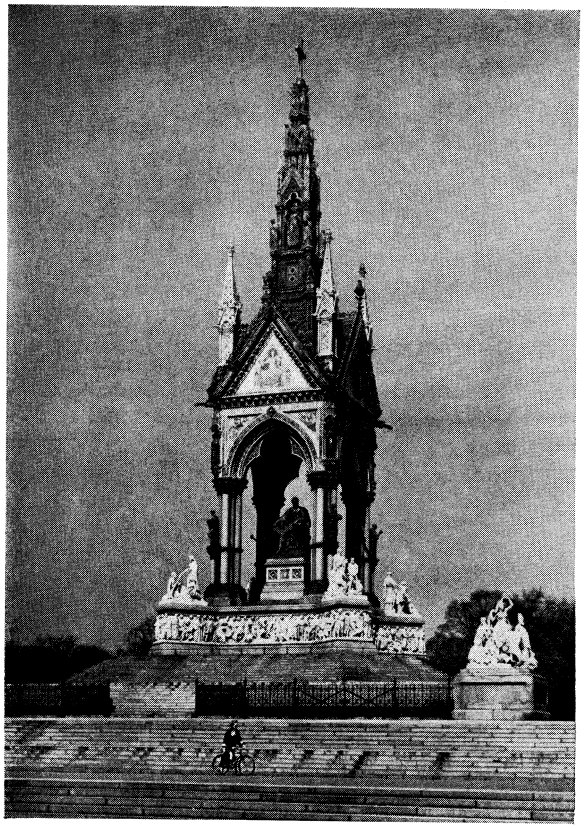
Reading room of the Bibliothèque Nationale, Paris, 1854–68; Henri Labrouste, architect



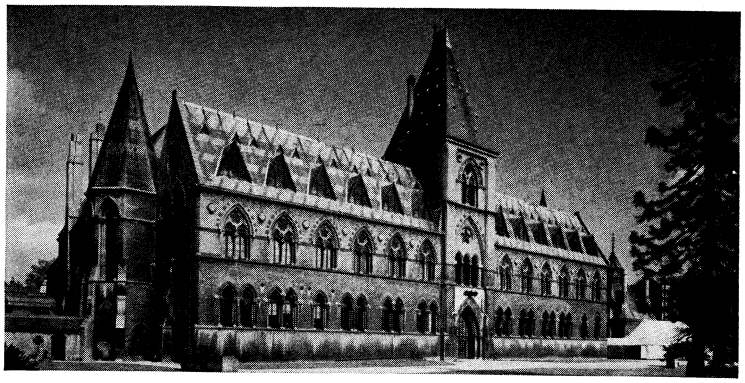
Entrance of St. Patrick's cathedral, New York city, by James Renwick, 1858–79

19TH CENTURY: ROMANTICISM AND THE BEAUX ARTS

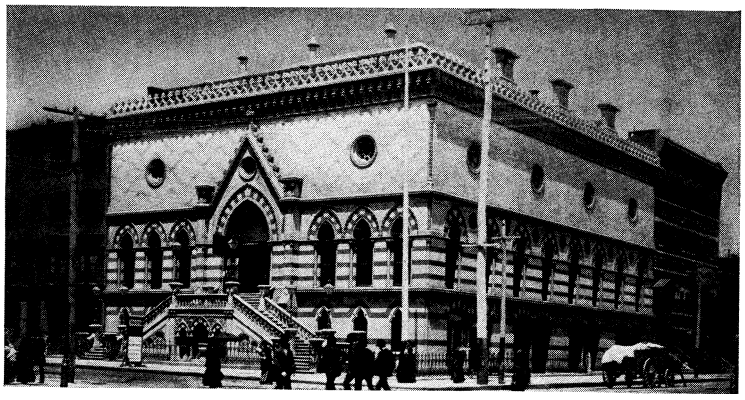
BY COURTESY OF (TOP RIGHT) COLUMBIA UNIVERSITY, (BOTTOM LEFT) BIBLIOTHÈQUE NATIONALE: PHOTOGRAPHS, (TOP LEFT) A. F. KERSTING, (BOTTOM RIGHT) MARTIN SPEEZ FROM BLACK STAR



The Albert memorial, London, **1863-72,** by Sir George Gilbert Scott



University museum, Oxford, **1854-60,** by Thomas Deane and Benjamin Woodward



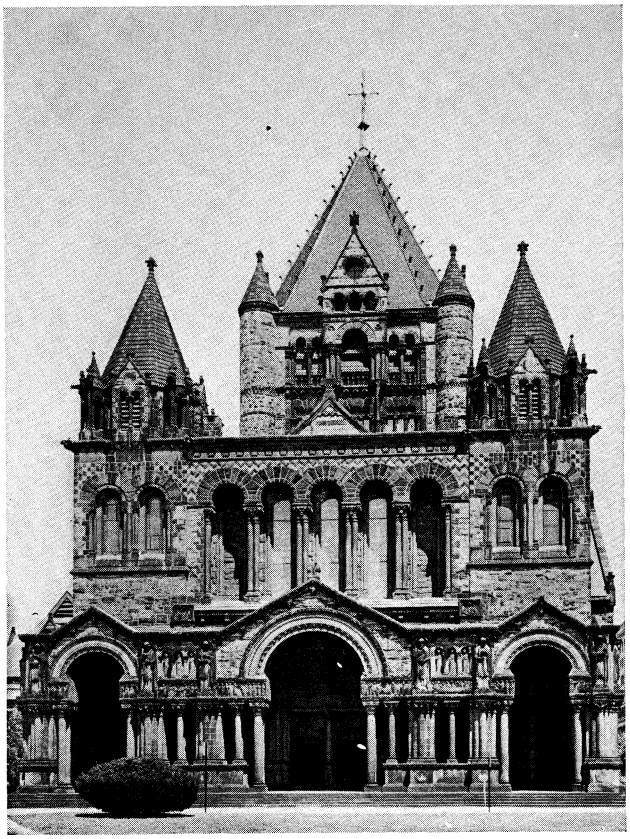
National Academy of Design, New York city, **1862-65,** by Peter Bonnett Wight

Crystal palace of the Great exhibition held in London in **1851,** a timber, iron and plate glass building designed by Joseph Paxton

19TH CENTURY: VICTORIAN GOTHIC AND A NEW FORM

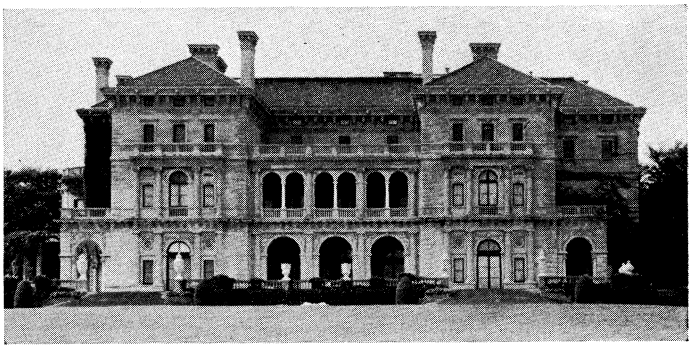
BY COURTESY OF (CENTRE RIGHT) NCTICNAL ACADEMY OF DESIGN; PHOTOGRAPHS, (TOP LE T) CENTRAL PRESS PHOTOS LTD., (TOP RIGHT) A. F. KERSTING, (BOTTOM) RADIO TIMES HULTON PICTURE LIBRARY

MODERN ARCHITECTURE

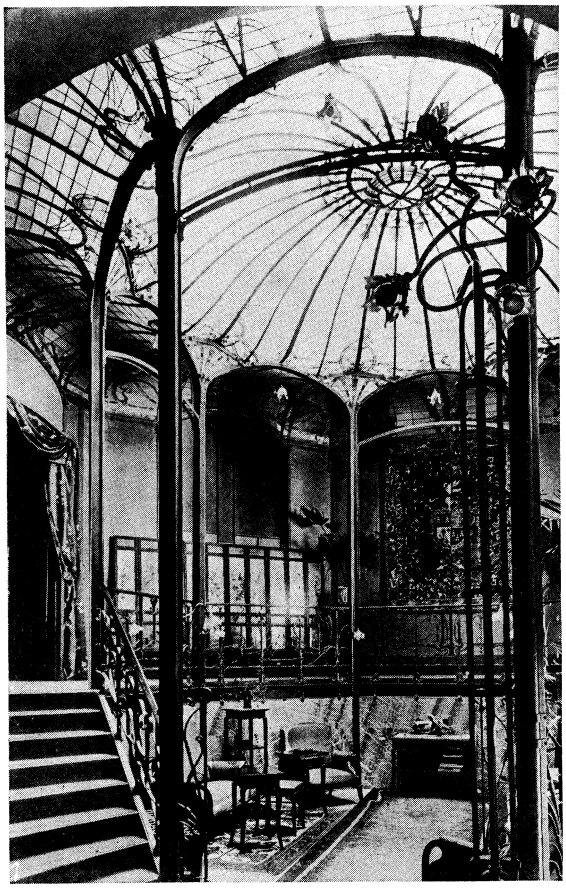


Trinity church, Boston, Maps., 1872–77, in the Rornanesaue revival style of H. H. Richardson

Richardson's design for the Marshall Field & Company wholesale warehouse, Chicago, Ill., 1885–87



"The Breakers," Newport (R.I.) home of Cornelius Vanderbilt, designed by Richard Morris Hunt, 1892–95

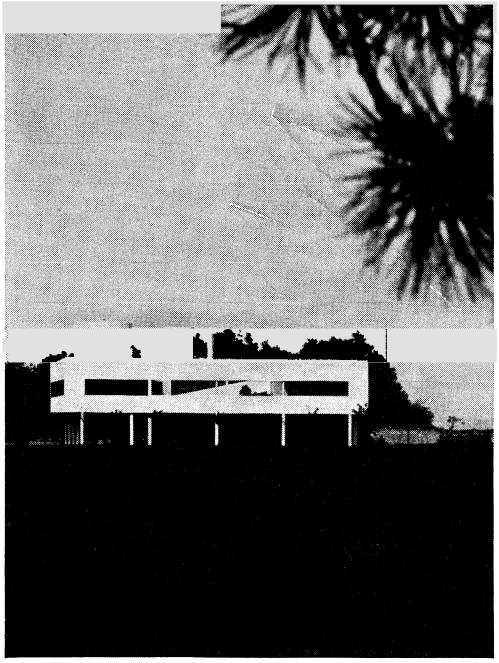


Interior of the house at 1 2 Rue de Turin, Brussels, Belg., by Victor Horta in the ***art nouveau*** manner of the 1890s

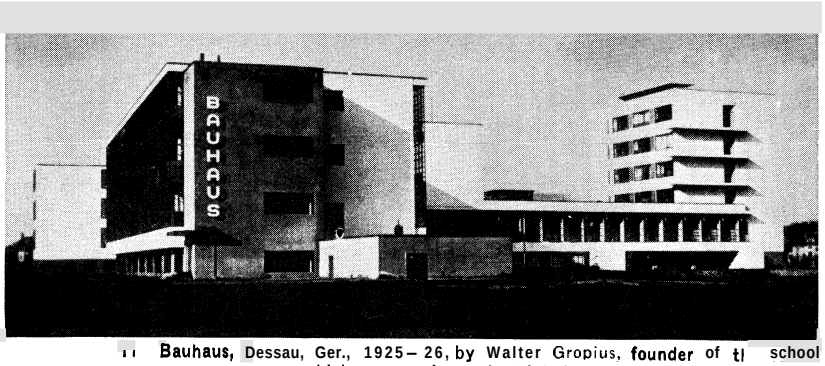
Wainwright building, St. Louis, Mo., 1890–91, one of the first skyscrapers; Louis Sullivan, architect

19TH CENTURY: THE END OF THE OLD AND BEGINNING OF THE NEW

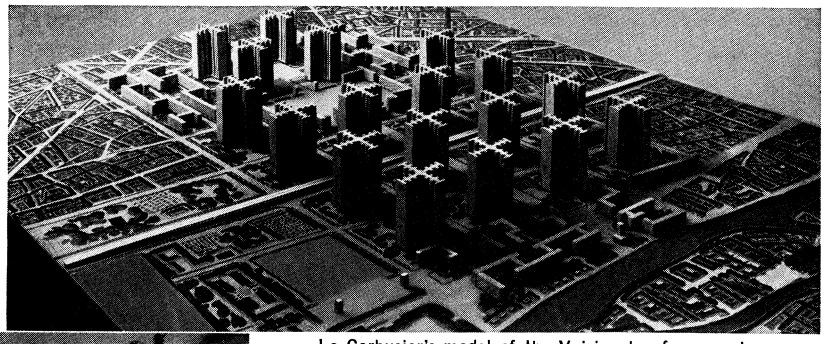
BY COURTESY OF (TOP RIGHT) MARSHALL FIELD & COMPANY, (CENTRE RIGHT) RHODE ISLAND DEVELOPMENT COUNCIL. (BOTTOM LEFT, BOTTOM RIGHT) MUSEUM OF MODERN ART, NEW YORK; PHOTOGRAPH (TOP LEFT) WAYNE ANDREWS



Villa Savoye, Poissy, France, 1928–30, by Le Corbusier (C. E. Jeanneret) and Pierre Jeanneret



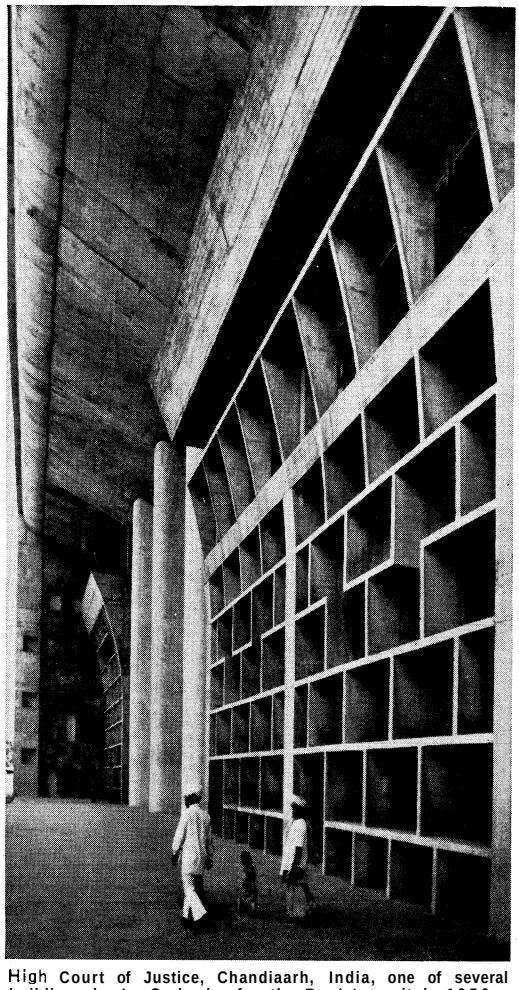
Bauhaus, Dessau, Ger., 1925–26, by Walter Gropius, founder of the school which was a major centre of design until it was closed in 1933



Le Corbusier's model of the Voisin plan for a contemporary (1922) city of 3,000,000 persons

The Tugendhat house, Brno, Czech., 1930, by Ludwig Mies van der Rohe, Gropius' successor at the Bauhaus

Mies van der Rohe's German pavilion for the International exposition at Barcelona. Spain, in 1929

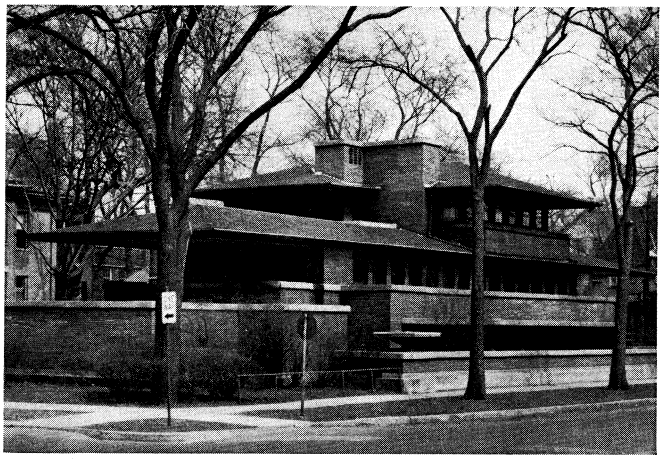


High Court of Justice, Chandiaarh, India, one of several buildings by Le Corbusier for the Punjab capital; 1956

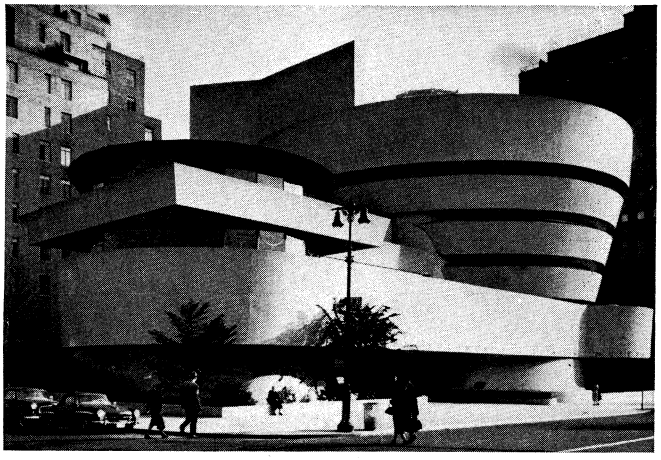
20TH CENTURY: LE CORBUSIER AND THE BAUHAUS GROUP

BY COURTESY OF (TOP RIGHT) WALTER GROPIUS, (CENTRE LEFT) MUSEUM OF MODERN ART, NEW YORK, AND MIES VAN DER ROHE (BOTTOM LEFT) MIES VAN DER ROHE; PHOTOGRAPHS, (TOP LEFT, CENTRE RIGHT, BOTTOM RIGHT) LUCIEN HERVÉ

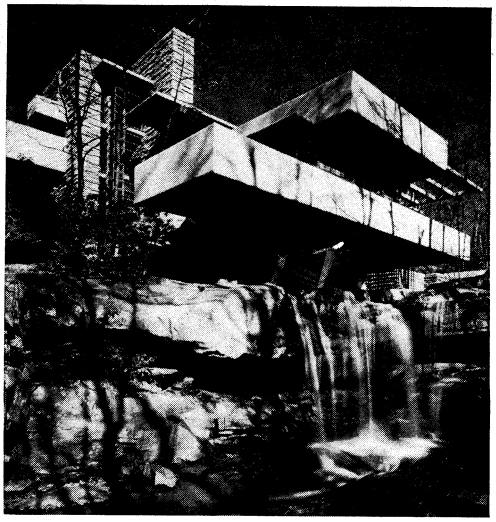
MODERN ARCHITECTURE



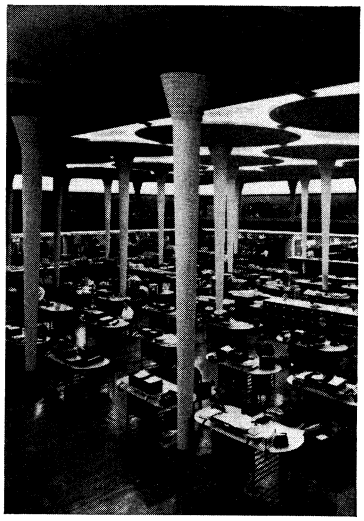
Robie house, Chicago, Ill., **1909,** considered to be the finest example of Wright's "prairie" style



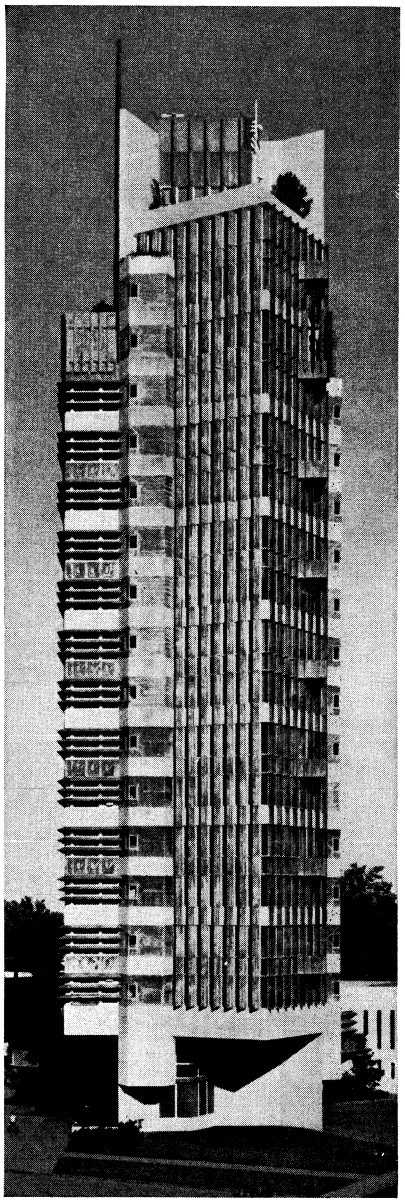
Guggenheim Museum of Non-Objective Art, New York city, Wright's last major building, completed the year he died, **1959**



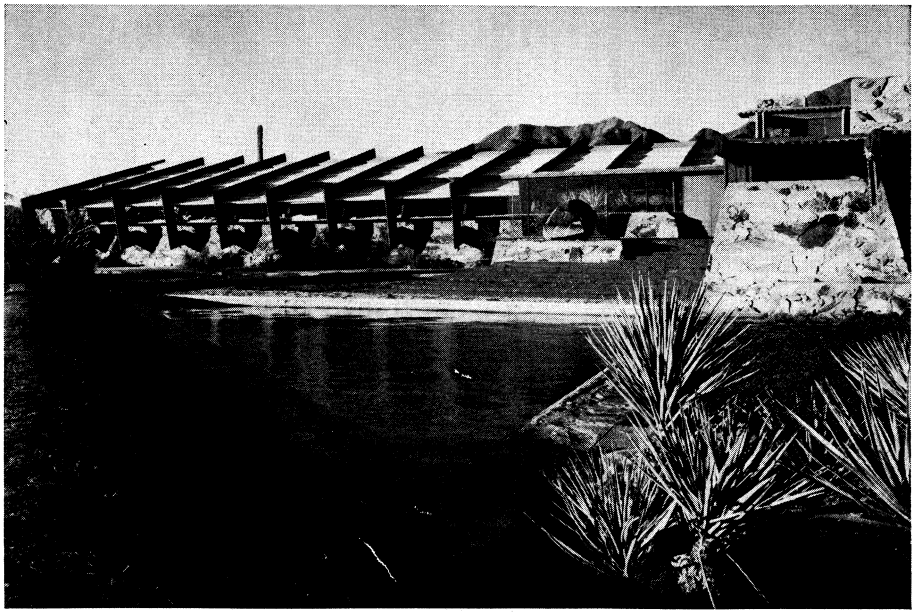
"Fallingwater," Bear Run, Pa., **1936-38,** a house for Edgar Kaufmann in which Wright employed a bold use of cantilevers



Interior of the main workroom of the administration building of the Johnson Wax company, Racine, Wis., **1936-39**



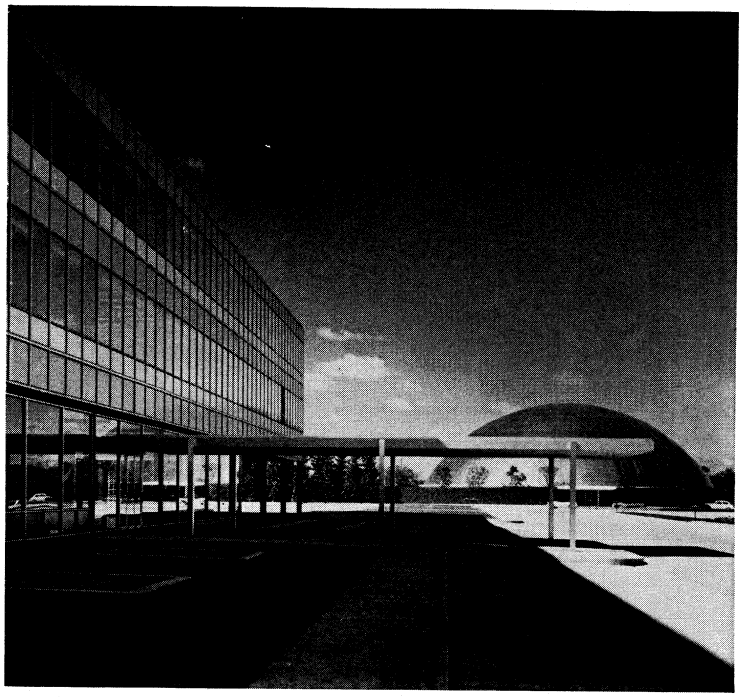
The Price Tower, Bartlesvilie, Okla., built in **1955-56,** the completion of a design Wright had prepared **25** years **earlier**



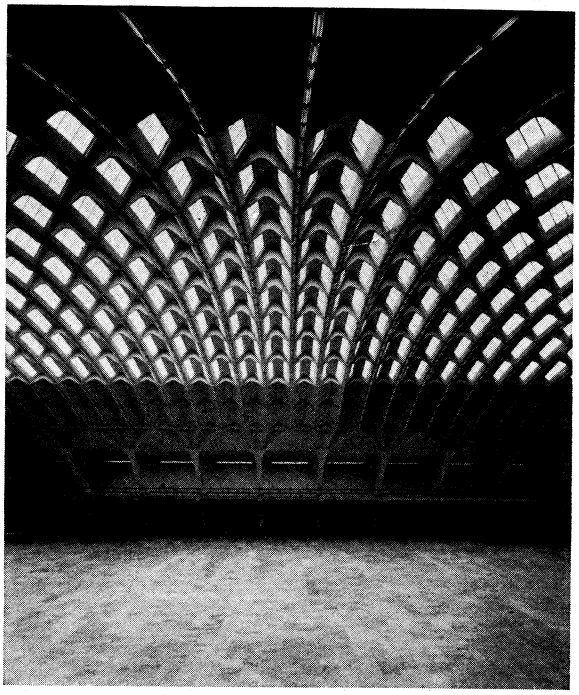
Taliesin West, Wright's home and studio near Phoenix, **Ariz.,** begun in **1938**

20TH CENTURY: FRANK LLOYD WRIGHT

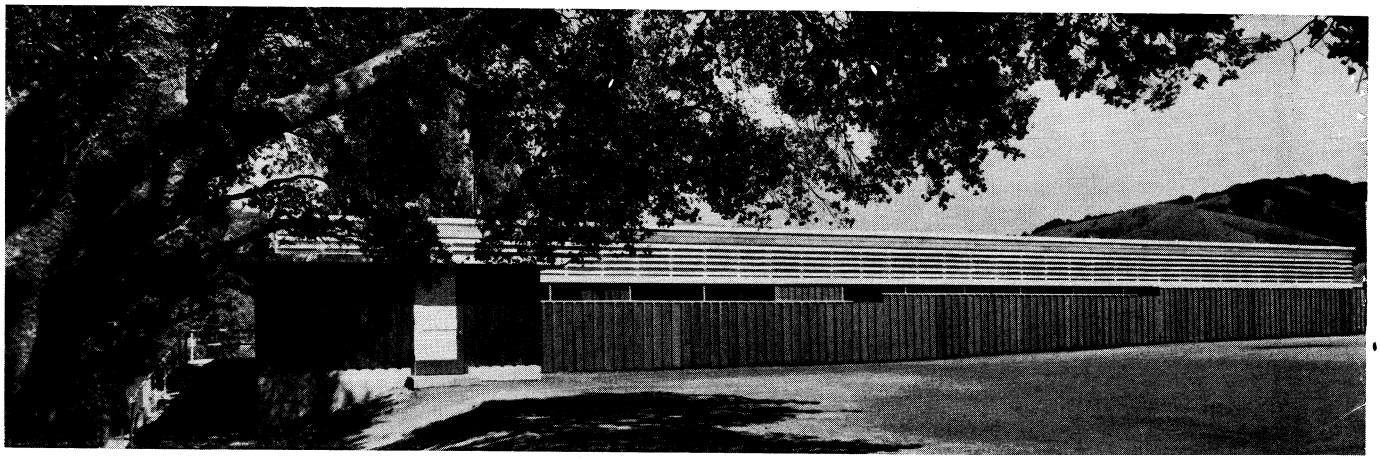
BY COURTESY OF (TOP LEFT) ARCHITECTURAL FORUM. (CENTRE) JOHNSON'S WAX, (BOTTOM RIGHT) JOE D. PRICE; PHOTOGRAPHS, (TOP LEFT) RICHARD NICKEL. (TOP RIGHT) A. DEVANEY FROM PUBLIX (CENTRE LEFT) HEDRICH-BLESSING. (BOTTOM LEFT) P. E GUERRERO



General Motors corporation Technical centre, Detroit, Mich.; by Eero Saarinen, 1955

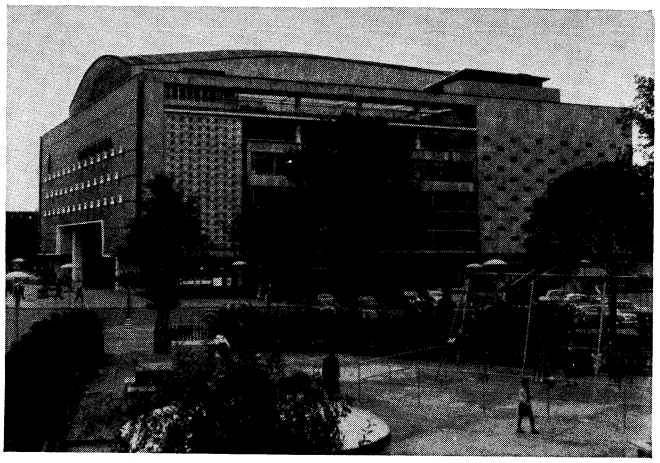


Interior of roof of exposition hall at Turin, Italy, by Pier Luigi Nervi, 1950



Elementary school at Fairfax, Calif., by John Lyon Reid

Court of the U.S. embassy at New Delhi, India, by Edward D. Stone, 1957–59

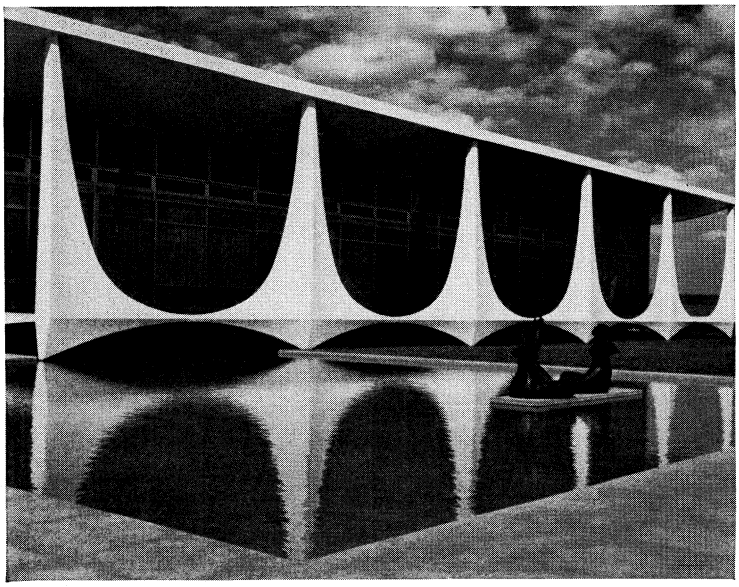


Royal Festival hall, London, by R. H. Matthew and J. L. Martin, opened in 1951

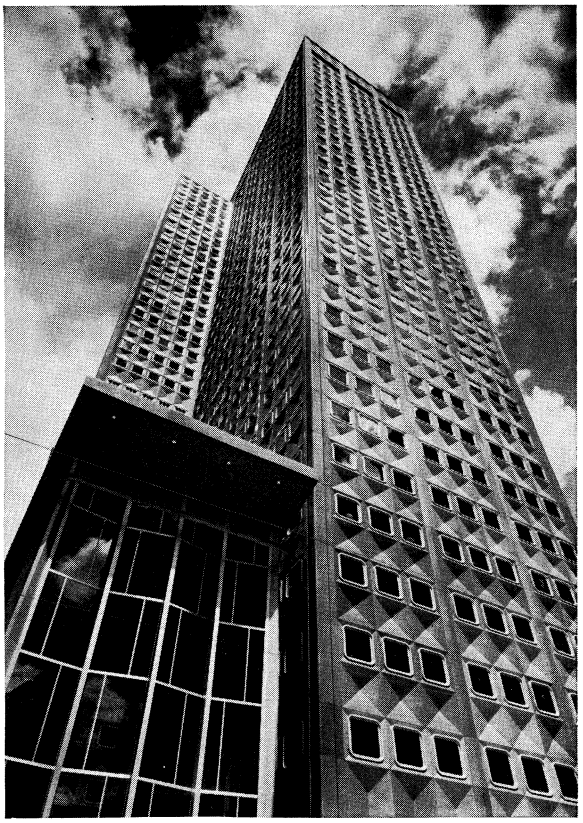
20TH CENTURY: INDUSTRIAL AND PUBLIC BUILDING DESIGNS

BY COURTESY OF (TOP LEFT) GENERAL MOTORS CORP., PHOTO BY EZRA STOLLER, (TOP RIGHT) PIER NERVI. (CENTRE) JOHN LION REID AND PARTNERS. (BOTTOM LEFT) EDWARD D. STONE. (BOTTOM RIGHT) PRESSED STEEL COMPANY LTD.

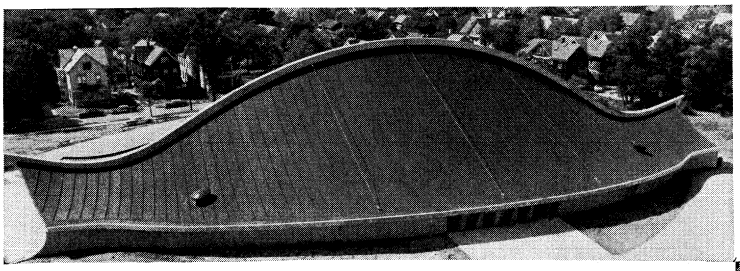
MODERN ARCHI'I'ECTURE



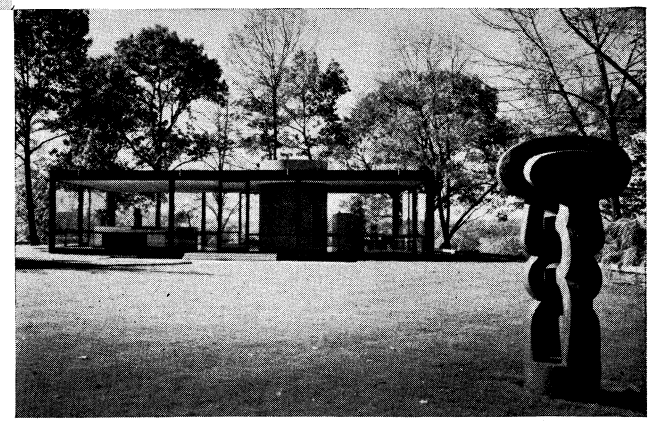
Palace of the Dawn, residence of the president, Brasília, Braz., dedicated 1960; Oscar Niemeyer, architect



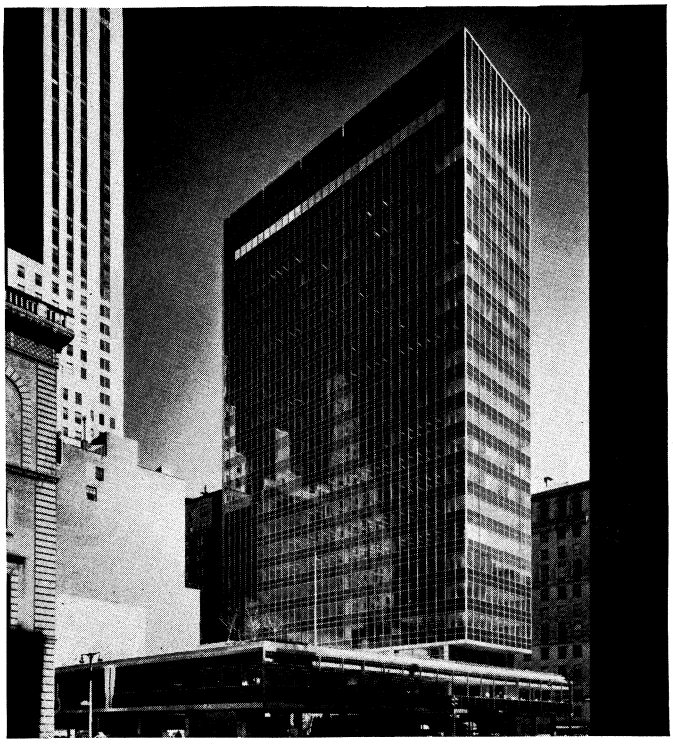
Aluminum-sheathed tower, housing offices of the Aluminum Company of America, Pittsburgh, Pa., by Harrison & Abramovitz, 1954



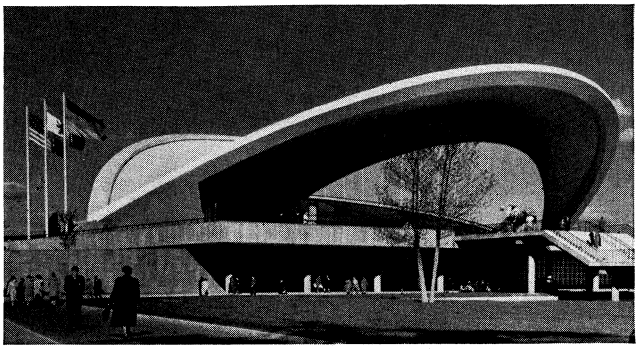
Unusual roof design of the David S. Ingalls hockey rink, Yale university, New Haven, Conn., by Eero Saarinen, 1958



Rectangular glass and steel house surrounding a brick cylinder; by Philip Johnson at New Canaan, Conn., 1949



Lever house, glass, steel and aluminum skyscraper, New York city, by Skidmore, Owings & Merrill, 1952



Congress hall, Berlin, Ger., 1957, by Hugh Stubbins

20TH CENTURY: NEW SHAPES AND THE EXPLORATION OF MATERIALS

BY COURTESY CF (TOP RIGHT) ALCOA. (CENTRE LEFT) YALE UNIVERSITY NEWS BUREAU. (CENTRE RIGHT) PHILIP JOHNSON ASSOCIATES. PHOTO BY ALEXANDRE GEORGES. (BOTTOM LEFT) SKIDMORE, OWINGS & MERRILL. (BOTTOM RIGHT) GERMAN TOURIST INFORMATION CFFICE; PHOTOGRAPH, (TOP LEFT! UNITED PRESS INTERNATIONAL

(1958–59).

In terms of volume, Wright's work was inconsequential. During prosperous days. commissions for country clubs and splendid estates were given to more eclectic architects. Henry Ford entertained the idea of asking Wright to design his house, but ultimately went elsenhere. With the aid of technology, Spanish estates nere built on the shores of Florida, French farmhouses in Philadelphia. Georgian and colonial houses in New England and pueblos in the southwest. Georgia revived its ante-bellum architecture, and Santa Barbara. Calif., which was destroyed by an earthquake in 1925, mas quickly rebuilt as a Spanish mission. The Georgian Revival style threatened to supplant regionalism as architects worked with one eye on the "White Pine Series of Architectural Monographs." Gothic was nearly universal for churches; often archaeological. as in Cram's Swedenborgian Cathedral at Bryn Athyn. Pa. (1913–28), it was only occasionally creative, as in Goodhue's St. Bartholomew's, New York city, and H. Van Buren Magonigle's First Plymouth Congregational, Lincoln, Neb. University architecture invariably failed to reflect forward-looking educational practices; Harvard's business school was housed in Georgian Revival buildings (1925), and Yale erected Gothic quadrangles for its residential colleges (begun 1929). M.I.T. moved to a new "Roman" campus in 1916, and at the universities of Colorado and California tales were invented to justify "regional" buildings. Expositions flaunted eclectic designs, usually Roman, as at the Panama-Pacific, San Francisco (1915), or regional, as was intended by the Spanish at San Diego, Calif. (1915); but modern could also be superficial, as was proved by the Century of Progress exhibition at Chicago (1933–34). An illustration of the taste of the period is the Chinese temple incongruously erected as a teahouse on the Belmont estate, Newport, in 1916.

The traditionalists also produced some memorable things in their final hour. John Russell Pope's version of the Mausoleum at Halicarnassus which he built as the Temple of the Scottish Rite at Washington in 1916 and Louis Bourgeois' Bahai temple on the shore of Lake Michigan near Chicago were not defensible by 20th-century architectural standards. Critics like Jacques Greber, Werner Hegemann and Elbert Peets, horn-ever, found much that classical taste could admire: the New York Public Library, the Cleveland Museum of Art, the University Club at New York city and the Rockefeller estate at Pocantico Hills, N.Y. Architectural schools continued to put students through a Beaux-Arts curriculum. No school considered itself complete unless it had a French patron; one of them, Pennsylvania's Paul Cret, designed superb classical buildings. such as the Pan American Union building at Washington (1908–10), the Public Library at Indianapolis (dedicated 1917) and the Institute of Arts at Detroit (1927). Many architects achieved perfection of form, as in Bacon's Lincoln memorial at Washington, and even where there was more bombast than was suitable, as in Gilbert's Supreme Court building at Washington (1935) or his Public Library at Detroit (1921), the work was seldom ugly, and its durable materials, rational plans and extravagant spaciousness suited the public need for dignity and grandeur. Only an occasional designer showed an aptitude for originality without flagrantly violating tradition, and of those who did, Magonigle in his Liberty memorial at Kansas City, Mo. (1928), and Goodhue in the capitol in Lincoln, Keb. (begun 1922), and National Academy of Sciences at Washington (1924) showed, along with Cret. a time-honoured way to create an architecture for the 20th century.

The emblem of business, the office building, continued to suffer from demands for unique. distinctive towers. Harvey Wiley Corbett. a New York architect, admitted that publicity was the ruling motivation. Sometimes a business with nation-wide suboffices developed a corporate iconography; Sears, Roebuck, Bell Telephone, Howard Johnson and the various competing gasoline companies were recognizable instantly. The Gothic skyscraper, popularized by Gilbert's Woolworth building, was used in Corbett's Bush Terminal building at New York city (1917) and Raymond Hood's ninning entry to the *Clzicago Tribune* competition (1922). Some buildings gained attention through their classical ornament (Le Brun's Metropolitan Tower); others, such as Charles Platt's Hanna building and Leader News building in Cleveland (c. 1922), were Renaissance palaces. About 1920 some architects developed simple cubical forms, and the stepped ziggurat was popularized by renderers, notably Hugh Ferriss, and artists like Georgia O'Keefe, John Marin and Charles Sheeler. This soaring and jagged form received legal support from the New York zoning law of 1916 and economic justification from the fact that, in order to obtain rentable, peripheral office space in the upper floors where the banks of elevators diminished. whole increments of office space had to be omitted. These cubical envelopes were not without ornament at their crests, as in Hood's American Radiator building in New York city (1924–25), suitably described as "one huge cinder incandescent at the top" Such decoration might be chic, as in New York city's Barclay-Vesey or Telephone building, where Ralph Walker recreated the gay interiors of the Paris exposition of 1925. In San Francisco, Miller, Pflueger & Cantin used Chinese ornament to enliven their Telephone building (1926). Paradoxically, one archaeological find led to simpler buildings when, about 1930, Mayan pyramids inspired Timothy Pflueger in his work on the 250 Sutter building in San Francisco. Clifflike blocks arose in Chicago, the Daily News and Palmolive buildings (1929) being the best examples; New York city acquired a straightforward expression of tall vertical piers and setback cubical masses in the Daily News building (1930) by the versatile Hood, mho had run the course from Gothic to modern form Philadelphia's bank and office building of the Pennsylvania Savings Fund society (1931) by George Howe and William Lescaze. a Swiss architect. gave the skyscraper its first thoroughly 20th-century form, and Hood, again, produced a counterpart in New York city. the McGraw Hill building (1932). Few of these, including the Empire State building (1929–31), did anything to solve urban density and transportation problems; indeed they intensified them. Rockefeller centre, however, begun in 1931, was. with its space for pedestrians within a complex of slablike skyscrapers, outstanding and too seldom copied.

As the example of Rockefeller centre indicates. there was a move toward simple form, which was presaged by the architecture of the TVA. European modernism gained a firm following in the United States as some of its best practitioners emigrated there. Eliel Saarinen, uho won second prize in the *Chicago Tribune* competition, gained the acclaim of Sullivan and other architects and settled at Bloomfield Hills. Mich., where he established a school of architecture at the Cranbrook academy. He designed its new buildings, gradually freeing himself from historical reminiscences. He remained sensitive to the role of art in architecture, best revealed by his use of Carl Milles' sculpture. Together with his son, Eero, Saarinen designed the Kleinhans Music hall at Buffalo (1940–41). Richard Neutra (1892–), after a visit in 1923, established a practice in California, recalled by the Lovell house at Los Angeles (1929). An exhibit of modern architecture in the Museum of Modern Art. New York city, in 1932, recorded in the book *International Exhibition: Modern Architecture* by Henry Russell Hitchcock, familiarized Americans with the international style. After 1933, as modernists fled Russia, Germany and Italy, the United States received Gropius, Breuer and Mies. Gropius mas brought to Harvard by the newly appointed dean of the architectural school, Joseph Hudnut, and established an educational focus recalling the Bauhaus. In association with Breuer, Gropius introduced modern houses to Lincoln, Mass., and formed a group, the Architects' Collaborative, whose members designed the thoroughly modern Harvard Graduate centre. Mies became director of architecture at the Illinois Institute of Technology, Chicago, in 1938 and designed its new campus.

Not all the immigrants remained in the U.S. Aalto, whose work first appeared on the American scene in the Finnish pavilion at the New York World's fair and again in Baker dormitory, returned to Finland. The European who might have contributed most was Le Corbusier. The United Nations buildings at New York city, for which he was a member of a ten-man commission headed by New York architect Wallace Harrison, is a token of the new forms he might have suggested for U.S. cities. His plan for rebuilding St. Dié (1945) was the inspiration for many city-planning proposals made after mid century.

Beginning with private houses by Hood, Lescaze, Edward Stone, Neutra, Gropius and Breuer during the '30s, American modernism came to be used for all types of buildings and gradually supplanted sentimental historicism. Programmatic school architecture accompanied progressive education; Perkins & Will, the Saarinens, John Lyon Reid. Donald Barthelme, the Architects' Collaborative and many others made attractive pavilion, "finger." campus and "cluster" plans. In church architecture. Pietro Belluschi won converts to modernism with his brick and wood churches in Oregon and Boston; Eliel Saarinen's churches at Columbus, Ind., and Minneapolis were incomparable.

After World War II, big industry turned to modern architects for distinctive emblems of quality. The Connecticut General Life Insurance company hired one of the largest and best modern firms, Skidmore, Onings & Merrill, to design their new decentralized headquarters outside Hartford, Conn. (1955–57). Lever Brothers turned to the same firm for New York's Lever house (1952), in which the parklike plaza, glazed curtain walls and thin aluminum mullions realized the dreams of Mies and others in the 1920s of freestanding crystalline shafts. The General Motors corporation's Technical centre at Detroit was compared with Versailles in its extent, grandeur and rigorous conformity to an aesthetic, the Mies-like forms of Eero Saarinen. The tower for the Aluminum Company of America at Pittsburgh advertised its own product -(Harrison & Abramovitz, 1954). Skidmore. Owings & Merrill also designed the Inland Steel building in Chicago in 1958. Perhaps the most chaste of all was the Seagram building at New York city, an elegant prism of bronzed skeleton and amber-lighted offices, designed by two of the purest architects, Mies and Philip Johnson. Wright alone avoided the rectilinear geometry. In 1953–56 he saw his Price Tower rise at Bartlesville, Okla., a richly faceted, concrete and copper fulfillment of the St. Mark's Tower he designed more than 25 years earlier.

About 1952 there was a significant shift within modernism from what had come to be called "functionalism" toward a monumental formalism. Presaged by Wright's work at the Johnson Wax company. there was increasing interest in the convolutions of highly plastic, sculptural masses and spaces. Wright's Guggenheim museum was a manifestation of it. Those who had focused their attention on the rectilinear portions oi Le Corbusier's Villa Savoye and apartment house (Unit6 d'Habitation) at Marseilles tended to ignore the plastic sculpture on the roofs of those buildings; to such people, Le Corbusier's building at Chandigarh. India (begun 1950), and the cavernous space in the lyrical Notre Dame du Haut seemed to be sports. Pier Luigi Nervi in Italy gave structural integrity to the complex curves and intricate geometry of reinforced-concrete structures, such as Bologna's tobacco factory (1949), Orbetello's hangar's (begun 1938) and Turin's exposition hall (1950). The Mexican Candela, the Spaniard Eduardo Torroja and the American Frederick Severud followed his lead. Essentially, each attempted to create an umbrella roof whose interior space could be subdivided as required. Mies constructed rectilinear versions of such a space in Crown hall at I.I.T. (1956) and in his Farnsworth house at Plano, Ill. (1952), while Johnson alloned a single functional unit, the brick cylinder utility stack, to protrude from the precise glass house he built for himself at New Canaan, Conn.

Other designers used curvilinear structural geometry, best indicated by Matthew Nowicki's Stock pavilion at Raleigh, N.C., in which two tilted parabolic arches, supported by columns, and a stretched-skin roof enclose a colossal space devoid of interior supports. In 1949 Nowicki challenged Sullivan's precept form follows function nith another, form follows form, a dictum that freed architecture from programmatic expression. The mechanistically functional Harvard Graduate centre, in spite of its superior site planning, seemed a thing of the past when, in 1955, Eero Saarinen completed a spherical triangle for M I T.'s Kresge auditorium. Stone's U S. pavilion at the Brussels fair. Hugh Stubbins' Congress hall at Berlin (1957) and the new terminals at the Idlewild International airport. Ken York (1958–59), nere outstanding examples of the monumental, single-form buildings designed by leading architects. In their search for unique silhouettes, some designers invented bizarre geometric shapes, such as those in Eero Saarinen's hockey rink at Yale (1958) and Harrison & Abramovitz' Presbyterian church at Stamford, Conn. (1958). A much more difficult task, that of unifying a modern programmatic building within an old setting, was undertaken by Paul Rudolph in the Art centre at Wellesley college. Wellesley, Mass. (1957–59), but such an approach appeared infrequently; international competitions for the opera house at Sidney, Austr. (1957), and a government centre at Toronto, Ont. (1958), were won by the exponents of monumental design. These posed problems in structural engineering and in scale, but many architects, such as Yamasaki in the McGregor building for Detroit's Wayne university (1958), attempted to make structure become decorative, while the decorative screen, as used by Stone at the U.S. embassy in New Delhi (1957–59), offered a device for wrapping programmatic interiors within a rich pattern of sculptural walls.

Having created buildings that deserved a place in the history of architecture, the modern architect and city planner awaited a mandate to give shape to the modern social unit, the metropolitan-suburban-rural community. All its components were available and tested: Mies's 860–880 Lake Shore drive, Chicago, suggested what the apartment houses might be; 100 Memorial drive at Cambridge, Mass., by Brown, Rapson, de Mars, *et al.*, and Le Corbusier's Marseilles block showed other versions. Britain's festival and the Brussels fair suggested new kinds of civic and cultural buildings, while Victor Gruen's shopping centres at Minneapolis and Detroit provided humane retail cores for pedestrians. The competitions for the opera house at Sidney and the government centre at Toronto elicited monumental public buildings. Lewis Mumford and Sigfried Giedion described how the modern city should be shaped. Le Corbusier, Eliel Saarinen, José Luis Sert, Wright, Nowicki and City Planners drew clear proposals. Louis Kahn's Mill Creek project in Philadelphia, Boston's Back Bay centre by Belluschi, Gropius and others, the British "New Towns," the reconstructed sections of Rotterdam and Brasilia showed what should have been clear by 1930: that modern architecture is a means of creating the environment needed in cities and towns.

See also under different types of architecture, such as EDUCATIONAL ARCHITECTURE; RESIDENTIAL ARCHITECTURE; etc.

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MODERNISM. The term Modernism when used of the Christian religion differs in significance in different environments: in the Roman Catholic Church Modernism is opposed to Papalism; in American Protestantism it is opposed to Fundamentalism (*q.v.*); and in the English Church it is opposed to Traditionalism.

The neoscholastic Roman Catholic modernist movement originated in Italy about 1850 and had a close connection with the liberation and unification of that country under the leadership of Giuseppe Mazzini and Count Cavour. As a religious movement, it quickly spread to France, Austria and Belgium. Leo XIII sought to direct the movement by encouraging the modern education of his clergy but this remedy, while it greatly strengthened the movement educationally under the leadership of its great scholars L. M. 0. Duchesne and A. F. Loisy (*qq.v.*) and their disciples, appeared to its opponents to be ruthlessly undermining the Catholic

faith. Hence the peasant pope, Pius X, did not hesitate to extirpate it. After Pius X in his decree *Lamentabili* and in his Encyclical letter, *Pascendi Gregis* (1907), had condemned Modernism as the sewer of all heresies and compelled suspects to take the anti-Modernist oath, Modernism expired as a movement in Roman Catholicism.

Archdeacon A. Lilley in *What We Want,* trans. from Italian (London, 1907) and *Programme of Modernism* (London, 1908), etc., provides a reliable and scholarly record and review of Roman Modernism. An interesting account of its heroism, devotion and the causes of its failure is given by Alfred Fawkes in his *Studies in Modernism* (see *Bibliography*).

Thereafter, the term Modernist was applied by its opponents to the Broad Church or Liberal Movement in the Church of England. Although differing widely in policy and methods both Roman Catholic Modernists and English religious Liberals accepted George Tyrrell's basic definition:

By a Modernist I mean a churchman of any sort who believes in the possibility of a synthesis between the essential truth of his religion and the essential truth of modernity.

The following citations from three lay English Modernists define and develop Tyrrell's definition.

Modernism is the attempt of the modern spirit, acting religiously, to refashion Christianity, not outside, but inside the warm limits of the ancient churches, to secure not a reduced, but a transiormed Christianity. (Mrs. Humphry Ward.)

Modernism is based upon evolution in science and the critical method in history: and it demands, not that the great truths of the Christian religion shall be given up, but that they shall be considered afresh in the light of growing knowledge and re-stated in a way suitable to the intellectual conditions of the age. (Percy Gardner.)

Modernism is not a religion: it is a defense of religion, and of the Christian Religion. (R. W. Macan.)

In the second half of the 19th century the great advances achieved by research in natural science and physics, in the literary and historical criticism of the Bible and in the new studies of anthropology, comparative religion and psychology, demanded, it was argued. re-interpretation and re-statement of traditional Christianity if the Christian Church were not to become discredited in the modern world. In England realization of what many regarded as a critical situation led in 1898 to the formation of the Churchmen's union (later the Modern Churchmen's union) "for the Advancement of Liberal Religious Thought." The basic task of the M.C.U. was modern Christian education, primarily of the Anglican clergy. This was also the aim of Bishop William Boyd-Carpenter's Theological college founded in the same year at Ripon but moved to Oxford in 1919 *(cf.* H. D. A. Major, *Life of Bishop Boyd-Carpenter,* London, 1925).

The educational work of the M.C.U. could not be restricted to academic studies, lectures, sermon courses, etc. Such studies involved also the re-statement of ecclesiastical dogmas, the revision of the prayer book services, the healing of Christian disunity, reform in the methods and outlook of Christian foreign missions. In their self-imposed task: members of the M.C.U. issued a great number of books and pamphlets. The union itself published two magazines: *Liberal Churchman* (London, 1904–1908), *Modern Churchman* (Oxford, 1911–1956). In 1914 the M.C.U. inaugurated widely attended annual conferences, addressed by eminent Anglican scholars.

The 1921 Conference on Christology held in Girton college, Cambridge. evoked a storm of criticism, and Masses of Reparation for the "blasphemies of the Girton Conference" were authorized in the English Roman Catholic churches. The deliverances of the Girton conference, however, were welcomed by many Anglicans and even by certain liberal theologians in other religions. So profound was the influence of the Girton conference that it led in 1922 to the English archbishops' appointing a commission to report on doctrine in the Church of England. This commission published its *Report* in 1938.

Bishop Alfred Rawlinson hailed the *Report* as "a historic landmark — undercutting all the traditional lines of partisan cleavage," which "cannot fail to promote a synthesis as between the various traditional schools." On examination the *Report* proved itself to be a modern Anglican equivalent of Peter Abélard's *Sic et Non.*

The difficulties facing the English Modernist in striving to formulate a modern Christian theology were very great. F. J. A. Hort (the disciple of F. D. Maurice) whom Bishop E. W. Barnes (*q.v.*) regarded as the founder of English Modernism, in the appendix to his *Hulsean Lectures* (1893), contributed a profound analysis of the basis of a sound Modernist theology.

Criticism is not dangerous save when it is merely the tool for reaching a result, believed on the ground of speculative postulates. . . . There can be no surer sign of decrepitude and decay in faith than a prevalent nervousness about naming and commending reason. . . . It is vain to uphold either (on the one hand) a merely Humanitarian theology: all study of Nature dissolves it hardly less: (on the other hand) a merely Pantheistic theology in combination with a humanitarian morality or anthropology. Both the Pantheistic and the Humanitarian factors are needed in theology and in morality alike, and for the union of them both. So evidence of the supermundane God can have any power if we fail to discern the radiations of transmitted and derivative Deity as the luminous and vital tissue of finite things.

Hort's postulates are basic in the expositions of the leading theologians of the M.C.U. and constitute the spirit of their numerous theological publications (see *Bibliography).*

The essential spiritual and moral convictions of the modernist were formulated in a creed consisting of seven passages selected from the Johannine scriptures and entitled *A Modern Churchman's Creed in the Words of an Ancient Churchman.* This creed (p. 98, *English Modernism* [Major's Noble lectures, Harvard, 1927]), has been widely circulated as a Creed card by the M.C.U. and is included in *Songs of Praise* (no. 433).

Meanwhile, in response to Modernist demands, the revision of the prayer book services in accordance with modern Christian devotional ideals and convictions was proceeding steadily. This was difficult as it meant housing devotionally "three religions (Catholic, Evangelical and Modernist) under one rooi." To secure this the modernists urged the departure from rigid Tudor liturgical uniformity and its replacement by prayer book services providing for supplementary and alternative insertions and additions for voluntary use where duly sanctioned by the local authorities, lay and clerical.

Archbishop Randall Thomas Davidson's patient tolerance expressed in his axiom "the longer it takes the better it will be" prompted the tripartite effort known as the *Deposited Book* of 1928. Although parliament refused to legalize it the church authorities permitted it to be used experimentally. This illegal experiment which was still proreeding in the late 1950s brought to light both the strong and the weak points in the *Deposited Book* and was expected ultimately to produce a revised prayer book more worthy of the great merits of its predecessors *(cf.* G. L. H. Harvey, *The Church and the Twentieth Century,* London, 1936).

These Modernist theological and liturgical controversies stimulated demands for Church disestablishment. This involved the profounder problems of the nature, authority and infallibility of the church. The Modernist maintains that the church has no absolute and infallible authority and rigid constitution. Nevertheless he believes, as a necessary organization for the advancement of the kingdom of God on earth the church needs the loyalty and service of Christian men. Cavour's ideal of a free church in a free state does not, so the English Modernist judges, satisfy the English spiritual psychology and political genius which needs an established church co-operating loyally with a progressive Christian state especially in the sphere of religious education, ready to welcome not church disestablishment but, if need be, church reestablishment on a more comprehensive basis, including the so-called iree churches.

Another Modernist controversial issue is concerned with disunity, especially in the foreign mission field. Anglican co-operation in the world-wide modern Christian unity movement has been restricted by its insistence that episcopacy is of the *esse* of the Christian Church. The English Modernist holds with Richard Hooker that it is of the *bene esse* of the English Church and on that account desires its retention but not so as to exclude full Christian communion with non-episcopai churches, and not least in the foreign mission field; *e.g.,* South India.

English Modernism holds that it is only by enlightened loyalty to its foundation motto, derived from Augustine: "In essentials unity, in nonessentials liberty, in all things charity" united to practising faith in the Divine promise: "I have yet many things to say unto you but ye cannot bear them no . Howbeit when He, the Spirit of truth, is come, He shall guide you into all the truth . . ." (John xvi, 12) that a universal Christian civilization can ultimately be secured.

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(H. D. A. M.)

MODERSOHN-BECKER (or BECKER-MODERSOHN), **PAULA** (1876–1907), German artist and a leader in the modern movement, was born on Feb. 8. 1876, in Dresden. As a pupil of Fritz Mackensen she became a member of the circle formed by the A'orpsweder school, an artists' colony near Bremen. Between 1900 and 1906 she spent four periods of study in Paris, finding artistic inspiration in the Gauguin circle and the "Nabis" group. She soon transmuted this influence into a form of her own, however. She increasingly freed herself from the lyrically tinged naturalisrn of her early Worpsweder years and became, after Cézanne, Van Gogh, Gauguin and E. Munch, one of the founders of 20th-century painting. In her posed and figure compositions. her still lifes, portraits and self-portraits, she helped to a great extent to develop the expressive form language of modern painting several years before the Facve and Briicke groups. In spite of her early death on Nov. 20, 1907, she left an extensive volume of work of about 400 paintings and more than 1,000 drawings.

See G. Pauli, *Paula Modersohn-Becker* (1919). (GR. B.)

MODES, ECCLESIASTICAL. The scales of early ecclesiastical music are not those used in the classical music of modern times. They form a series of eight, differing from one another not merely in pitch but in character. See PLAINSONG.

MODICA, a town of Sicily, in the province of Ragusa, 57 mi. W.S.W. of Syracuse by rail and 33 mi. direct. Pop. (1957 est.) 34.154 (commune). It lies on a hill between two valleys, the site of the Sicel town of Motyca; the modern part of the town extends along the river Mauro, an inundation of which did much damage in September 1902. Six miles southeast is the valley of the Cava d'Ispica, with hundreds of grottoes cut in its rocky sides, some Sicel tombs. but mostly catacombs or tombs of the early Christian and Byzantine periods, or cave dwellings of the latter age.

MODIGLIANI, AMEDEO (1884–1920), Italian painter and sculptor and a leading figure among the Parisian artists of his day, was born of a Jewish family at Leghorn, It.. on July 12. 1884. Modigliani studied at the academies of Venice and Florence; his early admiration for Italian Renaissance painting—especially Sienese—was to last him all his life. In 1906 he left Italy and settled in Paris, first in Bfontmartre and subsequently in Montparnasse, where he remained until his premature death on Jan. 25, 1920. After 1918 his health had slowly deteriorated, in spite of the devoted care of his wife Jeanne Hebuterne and his friend and dealer Leopold Zborowski. Addiction to drugs and alcohol certainly hastened his end. His wife leaped from a window a few days after his death, killing herself and an unborn child.

The first paintings done by Modigliani in Paris (*e.g.*, "L'Amazone" of 1908) show the influence of Henri de Toulouse-Lautrec and of Picasso's early work. Very soon, however, he turned to Cézanne. as can be clearly seen from "Le Violoncelliste" and "Le hlendiant de Livourne" (both 1909). Between 1910 and 1914 Modigliani seems almost to have abandoned painting for sculpture. His drawings had attracted the attention of Constantin Brancusi, who encouraged him to carve heads and figures in stone. Several heads were shown at the Salon d'Automne in 1912; their elongations and simplifications reflect the influence of African art.

Late in 1914 financial difficulties forced Modigliani to begin painting again. The impact of Cubism may be seen in portraits such as that of Beatrice Hastings (Barnes foundation, Merion, Pa.), the English poetess with whom he lived from 1914 to 1916. However, it was not Cubism but the characteristics of Modigliani's sculptured heads—long necks and noses, simplified features and long oval faces—that soon pervaded his painting. These mannerisms are first noticeable in the oil portraits that he made between 1915 and 1917 of many leading figures of Montparnasse artistic life. During the last three years of his life Modigliani painted mainly nudes and portraits of women.

Modigliani was a superb natural draftsman, as his many drawings bear nitness. As a painter his style was a tight, linear one; unlike his Cubist and Fauve contemporaries in Paris, he was little concerned with analysis of form or with the expressive qualities of colour. He might indeed have remained a sculptor had not his development been interrupted in 1914. Like most sculptors he was almost exclusively interested in the human figure; he painted no still life and only three landscapes. Modigliani's men and women and children are presented very directly, usually seen half-length or head alone against a simple background. Their most remarkable aspect is the entirely personal atmosphere with which they are invested. a kind of mute sympathy between artist and sitter that implicates the spectator and helps to account for Modigliani's enormous popularity.

See Arthur Pfannstiel, *Modigliani et son Oeuvre* (1956). (A. Bs.)

MODJESKA, HELENA (HELENA MODRZEJEWSKA, NÉE OPID) (1840–1909), Polish-U.S. actress, whose repertory included several Shakespearian roles and a variety of emotional parts in modern drama. The daughter of a musician, Michael Opido, she was born at Cracow, Pol., on Oct. 12, 1840. After her marriage, to a Pole, Gustav Modrzejewski. she joined a company of strolling players. In 1868 she married Count Bozenta Chlapowski, a Polish politician and critic, and began to act at Warsaw, where she remained for a number of years. Her chief tragic roles were Ophelia. Juliet, Desdemona. Queen Anne in *Richard 111,* Louisa Miller, Maria Stuart. Schiller's Princess Eboli, Marion Delorme, Victor Hugo's Tisbé and Juliusz Slowacki's Mazeppa. In comedy her favourite roles were Beatrice in *Much* Ado About *Nothing,* and Donna Diana in the Polish translation of an old Spanish play of that name. Mme. Modjeska also played in modern pieces by Gabriel Legouvé, Dumas (father and son), Guillaume Augier, Alfred de Musset. Octave Feuillet and Victorien Sardou. In 1876 she went with her husband to California, where they settled on a ranch. This enterprise was a failure, and Mme. Modjeska returned to the stage. She appeared in San Francisco in 1877, in an English version of Adrienne *Lecouvreur.* She continued to act principally in the United States, but was also seen from time to time in London and elsewhere in the United Kingdom. Mme. Modjeska died on April 9, 1909, near Los Angeles, Calif.

See M. Collins. *The Story of Helena Modjeska* (1883) and (autobiographical) *Memories and Impressions* (1910).

MODJESKI, RALPH (1861–1940), U.S. engineer, was born at Cracow, Poland, Jan. 27, 1861, his mother being the actress, Helena Modjeska. He graduated at the École des Ponts et Chaussées. Paris, with high honours, and settled in the United States. From 1892, he practised as consulting bridge engineer at Chicago, Ill.; as a designer and builder of bridges he did distinguished work. Among his best-known bridges are the government bridge over the Mississippi at Rock Island; the McKinley bridge at St. Louis; bridges over the Mississippi at Thebes (Ill.) and at Memphis (Tenn.); the Northern Pacific bridge over the Missouri at Bismarck (N.D.); also bridges over the Columbia and Willamette rivers in Oregon. He was a member of the Quebec Bridge commission, and consulting engineer for the Ohio river bridge at Metropolis (Ill.), for the Chicago, Burlington and Quincy railroad, and the Thames river bridge at New Haven (Conn.), for the New York, New Haven and Hartford railroad. He was chosen chief engineer and chairman of the board of engineers of the Philadelphia-Camden bridge over the Delaware river, which, on its completion in 1926, was the longest suspension bridge in the world. Modjeski was appointed chief engineer of the Huey P. Long bridge over the Mississippi at New Orleans, and was chairman of the board of consulting engineers for the Trans-Bay bridge at San Francisco, completed in 1936.

MODOC, a North American Indian tribe which formerly ranged over the area between Klamath lake, Oregon, and Clear lake. California. In speech and custom there was little distinction between them and the Klamath, their near neighbours to the north. In 1863 the two tribes agreed to relinquish most of their territory

and take up residence on a reservation around Upper Klamath lake However. an insurgent band of Modocs under the leadership of a subchief knonn to the whites as Captain Jack bolted the reservation in 1870, and efforts to induce their return precipitated the Modoc nar of 1872–73. About 80 narriors and their families retreated to the bad lands in the vicinity of the Lava Bed National monument. where they were able to resist dislodgment. Following the treacherous murder of Gen E R. S. Canby, who headed a peace commission in April 1873, the war was prosecuted more vigorously. Captain Jack surrendered and was hanged in October. His folloners were removed to Oklahoma. (H G. BT.)

MODULATION, in music, signifies the passing from one key to another. The term "transition" is also used, though principally to designate very brief and transient modulations to keys not dwelt in.

Modulation is of various kinds, as "natural" when the change is to one or other of the "relatives" of the original key; "extraneous" nhen it is to keys other than relative, *i.e.*, more remote; or "enharmonic" when it is effected by a change of notation. Modulation constitutes one of the greatest resources of music as we know it and is employed by modern composers to an ever-increasing extent.

See ENHARMONIC; KEY; HARMONY.

MODULATION (ELECTRONIC), the process by which some characteristic or characteristics of one wave (the carrier) are caused to vary in accordance with the instantaneous amplitude or frequency of another wave (the signal).

Speech provides a familiar example in which the mouth varies or modulates a sound stream to produce recognizable words. The mere production of a steady tone conveys no intelligence unless the tone is interrupted, such as by turning it off and on in accordance with some prearranged code. This type of modulation is synonymous with that used in the familiar dot-dash telegraphic code.

In radio or the audio portion of television, the transmission of a steady signal by the transmitter tells nothing except that the station is or is not operating. Speech. music and other wave forms can be transmitted by a refinement of the modulation scheme described for telegraphic code, such as causing the amplitude or frequency of the transmitted wave to vary in direct proportion to the frequency of a sound or picture signal. If the amplitude is varied. the process is called amplitude modulation (AM); if the frequency is varied, frequency modulation (FM).

Because of unsatisfactory antenna radiation at low frequencies and the desirability of operating on many frequency levels to allow simultaneous transmission of many programs nithout interference, as well as the presence of filtering problems, it is necessary to use a high-frequency carrier and to modulate it with a low-frequency signal. The high frequency carrying the modulation is commonly termed the R.F. (radio frequency) carrier.

In addition to the AM and FM schemes already mentioned. phase modulation and pulse modulation are also used. the last finding application in radar and other tracking devices. *See* also RADIO; RADIO RECEIVER. (A. L. SY.)

MODULE, in architecture, is an arbitrary unit adopted to regulate the dimensions. proportions or construction of the parts of a building. A number of modules. based on the diameter of a column, were used in determining the proportions of the order (*q.v*) in classical architecture. In Japanese architecture, room sizes were determined by combinations of 3-ft. by 6-it. rice mats called *tatami.*

In modern architecture, design modules may be used to spread the proportioning and dimensioning of plans. The metre has proved useful for this purpose; Frank Lloyd Wright used a 4-ft. rectilinear or diagonal grid; and Le Corbusier developed and widely published an additive proportioning system named by him the *Modulor.* Other modules reflect repetitive building elements such as the standard office size or the hospital bed unit.

In addition to these applications in space planning. modules may also serve as the basis for co-ordinating the dimensions of the various materials and pieces of equipment to be assembled in the course of constructing a building. The purpose is to assuie that all of the elements will go together without wasteful cutting and fitting at the building site, and to lower costs by perinitting the quantity production and distribution of modular products with the assurance that they may be incorporated into any building plan.

An increasing amount of attention has been devoted to this subject since the development in the 1930s of the Bemis 4-in. cubical module (10 cm in Europe), and progress has been made in stimulating the manufacture of modular building products. In the 1950s an effort was made to combine into a single "number pattern" several of these modular systems to offer the designer a larger range of approved dimensions in the critically important first few feet and to reduce the cost to the manufacturer of converting to modular products. Most architects and producers of building materials continued, however, to use modules based on their own special needs and interests, without co-ordination.

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MOE, JORGEN ENGRETSEN: see ASBJORNSEN, PETER CHRISTEN.

MOERIS, LAKE OF. The history of the lake which once occupied a considerable area of the Fayum depression, and which is represented by the shallow Birkat Qaroun, has been much elucidated by the geological and archaeological work which has been carried out in the desert margin of the depression. From the results obtained it would appear that in later Paleolithic times the lake level reached a point about 130 ft. above sea level. or about 280 ft. above the present lake. During Neolithic times the level fell slowly for about 140 ft., though there were occasional interruptions when it remained at one level long enough to allow formation of beaches which can still be traced. Throughout this period primitive settlements occupied its shoreline, and down to early dynastic times the level does not seem to have varied greatly. Later, however: through the dynastic period the level of the lake fell slowly as a result probably of climatic conditions of greater aridity, though the fall was retarded at times as the volume of surplus water brought in from the Nile in order to irrigate the cultivated lands was more or less.

The cultivated lands above the level of the lake which were irrigated from the Nile were some of the most fertile in Egypt so long as the supply canals from the river were maintained in good order, though this doubtless varied with the political conditions of Egypt. The Egyptian name of the lake was Shei, "the lake," later Piom, "the sea" (whence Fayum); Teshei, "the land of the lake," was the early name of the region. At its capital Crocodilopolis and elsewhere the crocodile god Sobk (Suchus) was worshiped. Senusret II of the 12th dynasty built his pyramid at Illahun. Amenemhet III built his near Hawara, and the vast labyrinth attached to it was probably his funerary temple. This king was afterward worshiped in more than one locality about the lake under the name Marres (his praenomen Nemare) or Peremarres; *i.e.*, Pharaoh Marres. In the reign of Ptolemy Philadelphus veterans from the Syrian War were settled in the "Lake" (*Limne*), and the latter quickly became a populous and very fertile province. Strabo's account of the Lake of Moeris must be copied from earlier writers, for in his day the outflow had been stopped probably for two centuries, and the old bed of the lake was dotted nith flourishing villages to a great depth below the level of the Nile. Large numbers of papyri of the Ptolemaic and Roman periods have been found in and about the Fayum, which continued to flourish through the first two centuries of the Roman rule. The level of the lake varies from year to year with the amount of irrigation water reaching it from the Nile. Its average level is now about 147 it. below sea level. (F. LL. G.)

MOESIA, a district inhabited by a Thracian people, bounded on ,the south by the mountain ranges of Haemus and Scardus, on the west by the Drinus, on the north by the Danube and on the east by the Euxine. Some, however, place the boundary much farther west. Each was governed by an imperial consular legate and a procurator. It corresponded in the main to modern Serbia and Bulgaria. In 7j B.C., C. Scribonius Curio, proconsul of Macedonia, penetrated as far as the Danube, and gained a victory over the inhabitants, who were finally subdued by M. Licinius Crassus,

grandson of the triumvir and also proconsul of Macedonia, during the reign of Augustus about 29 B.C.; the country, however, was not organized as a province until the last years of the reign. Originally one province, under an imperial legate (who probably also had control of Achaea and Macedonia), it was divided by Domitian into Upper and Lower Moesia, the western and eastern portions respectively, divided from each other by the Cebrus river. As a frontier province, Moesia was strengthened by stations and fortresses erected along the southern bank of the Danube. and a wall was built from Axiopolis to Tomi as a protection against Scythian and Sarmatian inroads. After the abandonment of Dacia (*q.v.*) to the barbarians by Aurelian (270–275) and the transference of its inhabitants to the south of the Danube, the central portion of Moesia took the name of Dacia Aureliani. The Goths, uho had already invaded Moesia in 250, hard pressed by the Huns, again crossed the Danube during the reign of Valens (376), and with his permission settled in Moesia. But quarrels soon took place. and the Goths under Fritigern defeated Valens in a great battle near Adrianople (378). These Goths are known as Moeso-Goths, for whom Ulfilas made the Gothic translation of the Bible. In the 7th century Slavs and Bulgarians entered the country and founded the kingdoms of Serbia and Bulgaria.

MOFFAT, a small burgh in Upper Annandale, Dumfries, Scot., 21 mi. N.N.E. of Dumfries by road. Pop. (1951) 2,114. Moffat was famous for its sulfur and saline waters in the middle of the 18th century, and is now a holiday and angling town. The spa lies 1½ mi. N.E. of the town, and there are also springs at Hartfell (33 mi. N.) and Garpol (2 mi. S.W.). At Moffat house, which is now a hotel, James Macpherson (*q.v.*) published "Ossianic Fragments."

Dumcrieff house, outside the town, a former seat of Lord Rollo, was the home of J. L. McAdam (*q.v.*), the road builder.

MOFFAT TUNNEL, begun in 1923 and completed in 1928, is 6.2 mi. long and pierces the continental divide 50 mi. W. of Denver, Colo.. at an elevation of about 9,200 ft. above sea level. The 16 by 24 ft. tunnel, which provides for a single-track standard-gauge railroad, was driven parallel with and 7j ft. to the north of an 8 by 8 ft. water tunnel with which it is connected at about 1,500-ft. intervals by cross cuts. It rises on a grade of 0.3% from the eastern entrance toward the centre and descends on 0.8% and 0.9% grades to the western entrance. The railway tunnel eliminated about 30 mi. of 4% grades over Rollins' pass, reduced the maximum grade of the Denver and Rio Grande Western railroad from 4% to 2% and the maximum curvature from 16% to 12%. About 173 mi. of the distance between Denver and Salt Lake City was to be saved. The water tunnel transports water for municipal and agricultural purposes in and around Denver from the western slope of the divide. The tunnel cost $15,470,000.

MOGADOR (ES-SUEIRA), a seaport on the Atlantic coast of Morocco, in 31° 50′ N., 9° 20′ W., chief town of the *contrôle* civil of Chiadma. The town stands from 10 to 20 ft. above high water on a projecting ridge of calcareous sandstone. In certain states of wind and sea it is turned almost into an island, and a sea wall protects the road to Safi. On the land side stretch miles of sand dunes studded with broom, and beyond, the argan forests, distinctive of southern Morocco. Approached from this side the city bursts on the view like a mirage between sky and sea. It is a well-planned, clean town.

The harbour is well sheltered from all winds except the south-west, but escape is difficult with the wind from that quarter, as the channel between the town and Mogador Island is narrow and hazardous.

Pop. (1952) 22,291, of whom 15,579 were Moslems and 1,277 Europeans.

A place called Mogador is marked in the 1351 Portolan of the Laurentian library, and the map in Hondius' *Atlas* minor shows the island of Mogador, I *Domegador;* but the origin of the present town is much more recent. Mogador was founded by Mohammed ben Abd Allah in 1760, and completed in 1770. The Portuguese called it after the shrine of Sidi Megdul, which lies toward the south halfway to the village of Diabat, and forms a striking landmark for seamen. In 1844 the citadel was bombarded by the French. Mogador was temporarily occupied by U.S. troops in Nov. 1942.

MOGILA, PETER (c. 1596–1647), metropolitan of Kiev from 1632, belonged to a noble Wallachian family. He studied for some time at the University of Paris, and became a monk in 1625. Mogila is known as the promoter of the Orthodox Confession, drawn up at his instance by the abbot Kosslowski of Kiev, approved at a provincial synod in 1640 and accepted by the patriarchs of Constantinople, Jerusalem, Alexandria and Antioch in 1642–43 and by the synod of Jerusalem in 1672.

MOGILEV, a former province of western Russia, now in the Ukrainian S S.R. (*q.v.*).

MOGILEV ON THE DNIEPER, a town of the Belorussian Soviet Socialist Republic, U.S S.R., in 53" 55′ N., 30° 18′ E., on a hilly site on both banks of the river and on the railway. Pop. (1959) 121,000. It has clothing and tanning industries, an artificial-fibre mill and machinery works. It trades in corn, salt, sugar and fish from the south. It has an ancient Tatar tower. a 17th-century church, a cathedral built for the Roman Catholics and one built for the Greek Orthodox Church by Catherine II of Russia and Joseph II of Austria in 1780. Mogilev is mentioned in the 14th century as a dependency of the Vitebsk, or of the Mstislavl principality. At the beginning of the 15th century it became the property of the Polish kings. But it was continually plundered—either by Russians, or by Cossacks. In 1654 it surrendered to Russia, but in 1661 the Russian garrison was massacred by the inhabitants. In the 18th century the town was taken several times by Russians and by Swedes. and in 1708 Peter the Great ordered its destruction by fire. It mas annexed to Russia in 1772.

Near there the French under Louis Davout defeated the Russians under Peter Bagration on July 23, 1812. In Mogilev were located the headquarters of supreme command of the Russian armies during World War I frorn 1915 to 1917. It was the scene of much strife in the 1917–20 period, and it was held by the Germans from 1941 to 1944.

MOGILEV ON THE DNIESTER (MOGILEV-PODOLSK), a town of the Ukrainian Soviet Socialist Republic, U.S.S.R., on the left bank of the river in 48° 27′ N., 27° 45′ E. Pop. (1956) 19,000. It has several flour mills, a distillery, a sugar refinery and a chalk factory. Mogilev, named in honour of the Moldavian hospodar Mohila, was founded by Count Potocki about the end of the 16th century. Because of its situation on the highway from Moldavia to the Ukraine, at the passage across the Dniester, it developed rapidly. For more than 150 years its possession was disputed between the Cossacks, the Poles and the Turks. It remained in the hands of the Poles. and was annexed to Russia in 1795.

The town suffered much during World Wars I and II and the Revolution.

MOGOLLON. The Mogollon culture was one of three ancient major Indian cultures of the southwestern United States region and is significant because it reveals the little-known, formative stages through which all civilizations pass. The area once occupied by the Mogollon Indians lies in east central and southeastern Arizona and west central and southwestern New Mexico. Much of this country is mountainous. in contrast with the high plateau country occupied by the Anasazi Indians and the low desert area occupied by the ancient Hohokam Indians.

The Mogollon culture developed from a relatively simple one, the Cochise, a culture which is characterized as a food-gathering rather than a hunting complex, for nuts. roots and edible plants were collected and formed the principal part of the Cochise food pattern. although a few animals were hunted for food. Primitive stone tools such as milling stones, mortars, pestles, choppers and scrapers were made and used. The Cochise did not develop pottery, houses or agriculture.

At some time between 4000 and 2000 B C. corn or maize was introduced into the southwest, probably from Mexico. Soon after this, beans and squash made their appearance. After the introduction of these plants, more food was available, permitting a larger population and more leisure. Men had time to develop new arts, skills and inventions. For example, in the course of a few centuries, pottery and houses appeared. The houses were built below

ground level and are called pit houses. Thus to the basic Cochise culture traits such as easily recognizable types of stone tools were added bronn or red pottery. pit houses. corn, beans and squash and many other traits.

The term "Mogollon" signifies the addition of these later traits to the older, basic Cochise culture.

First Period, 300 **B.C.–A.D.** 500.—The first true Mogollon period, in which are found pottery. houses, corn, beans, squash and new types of stone tools, dates from about 300 B.C. to about AD. 500. During that period, the people began to accumulate possessions and therefore had interests to protect — homes, crops, food warehouses and other personal possessions. A feeling of gregariousness seems to have overcome suspicion, and the people increasingly banded together in groups or villages. Villages were not necessarily well laid out; each householder built more or less where he pleased, but within the vaguely defined village limits. Each pit house, however, conformed to a uniform pattern. This pattern demanded that the houses be round and partly below ground and that the food be stored in pits below the floors; also that the houses be supplied with a tunnel side-entrance facing east. Often the villages were situated on high, narrow, defensible mesas. Each house was probably occupied by several families related by blood or marriage.

The Mogollon Indians of the early period probably had religious convictions and dogmas and carried on sacred rites in specially built, large pit houses, called kivas.

The Sfogollon civilization, therefore, at its inception (about 300 B.C.), may be described as undeveloped but developing, rural and somewhat isolated, although limited contacts with other groups may be conjectured. The Mogollon people of that time, crude and primitive in many ways, had already overcome many obstacles on their uphill journey toward civilization.

Second Period, c. A.D. 500–900.—The next major period constitutes a span of about 400 years (*c.* A.D. joo–goo): when slow but progressive changes occurred. Apparently fear of enemies had disappeared, for larger villages were built near streams or springs rather than on mesas. Round pit houses were replaced by smaller, rectangular buildings. These homes probably housed only the mother, father and offspring. Cooking was done in fire pits within the house, and food was stored on the floor in basketry and pottery containers. New and more efficient stone tools were adopted, and the spear thrower was replaced by the more accurate and potent bow and arrow. During that period religious services were probably held both in the home and in the kivas. Great advancement took place in the arts as reflected in pottery, basketry, sandals and textiles.

Shortly after the year 500 the Mogollon potters began to decorate their pottery. The first designs were executed with red paint on a brown background. The designs became so complex and were so competently executed that they have been praised by modern ceramists. Basketry and sandals were better woven, and cotton cloth bearing woven designs in colour came into being.

Thus advances were made in the arts: architecture, handicrafts and domestic economy, and the population increased.

Third Period, c. A.D. 900–1250.—The third and last period began about A.D. 900 or 950 and ended about A.D. 1250. Profound changes occurred: pit houses were replaced by surface apartment houses from one to three stories in height, with masonry walls; the red-on-brown ware was supplanted by a pottery decorated with black paint on a white background. These traits plus some others were probably introduced to the area by Pueblo Indian migrants whose homeland was in northern New Alexico (see PUEBLO). There is ample evidence that these newcomers lived peacefully with the older inhabitants of the area in the same villages. Although there was a peaceful penetration by other peoples and some new ideas were introduced, many of the older Mogollon traits continued to flourish. This was, therefore, an early example of cultural intermixture (acculturation).

Finally, about A.D. 1250, the Mogollon culture that had flourished for about 4,000 years (include the early Cochise manifestation as well as the later hybrid) came to an end in the original homeland. The houses and villages were abandoned and the people gradually straggled off — perhaps northward or westward—to make new homes. Various reasons for this exodus have been advanced—war, pestilence, soil exhaustion, change of climate; by the early 1960s, however, none of these hypotheses had gained wide acceptance.

See also INDIAN, NORTH AMERICAN; NORTH AMERICA: *Archaeology.*

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MOGUL, or MUGHAL, the Arabic and Persian form of the word Mongol. It is inaccurately used to describe the dynasty of emperors of India founded by Baber (Babur) in 1526 A.D. On the male side Baber reckoned his descent from Timur (*q.v.*), who was a Barlas Turk; through his mother he was descended from Jagatai. the second son of the Mongol ruler Jenghiz Khan. It is therefore more correct to refer to the Mogul empire in India as a Timurid or Turki empire.

See INDIA: *History.* (C. C. D.)

MOHAIR, the hair of a variety of goat originally inhabiting the regions of Asiatic Turkey of which Angora is the centre, whence the animal is known as the Angora goat.

The typical mohair fibre is 7 to 8 in. long, very lustrous owing to its physical structure (which although akin to wool is different in that the wool scales are only indicated instead of being fully developed, while the fibre is always solid), $\frac{1}{600}$ to $\frac{1}{800}$ of an inch in diameter, of a soft elastic handle, and usually of a clear white transparent colour. The staples of which the fleece is formed should be uniform in length and clearly defined; naturally lending themselves to a good "spin"—a difficult attainment in the case of mohair (see WOOLLEN MANUFACTURE). There are many varieties of mohair, and in Constantinople, the centre of the Turkish mohair trade, a large variety of fleece is recognized.

Owing to the demand for raw material exceeding the supply, from 1820 onwards there has been a great deal of crossing of the well bred Angora with the common kind of goat: in fact, it has been said that by 1863 the original Angora had practically disappeared. The growing demand for mohair further resulted in attempts on a commercial scale to introduce the goat into South Africa—where it was crossed with the native goat — the United States, Australia, and later still New Zealand. Perhaps the introduction of the Angora into Australia and New Zealand may in part be due to its value as a scrub and blackberry browser.

The manufacture of fabrics from mohair — as in the case of alpaca and cashmere—was in the first instance due to the genius of the rearers of the goat. It would, indeed, be interesting to know if the present day mohair goods — often styled "alpacas" — really had their origin in the earlier products of Asia Minor. That fabrics of mohair n-ere in use in England early in the 18th century is obvious from Pope's allusion: —

> "And, when she sees her friend in deep despair,
> Observes how much a chintz exceeds mohair."

Raw mohair was first exported from Turkey to England about 1820. and from that date onwards marked strides were made in its manufacture into useful yarns and fabrics. England has always had, and still maintains. supremacy in this manufacture. The larger part of both the Turkish and Cape clips is at least converted into yarn in Yorkshire mills. Quantities of these yarns are also woven into dress goods, dust cloakings. pile fabrics. imitation furs, etc.. in Workshire. but even greater quantities of mohair yarn are exported to Russia. Germany. Austria, etc., to be converted into astrakhans. ordinary braids, brush braids, etc. In the first decade of the 20th century the mohair braid trade received a blow from the introduction of artificial silk.

The history of the introduction of the Angora goat from Asia

Minor into the other countries mentioned is as follows. In 1838 pure-bred Angoras were introduced into Cape Colony. These pure-bred goats crossed with the common goat laid the basis of the Cape flocks. In 1856–57 other importations of pure-bred goats were made. From 1868 to 1897 further importations were made, but these were not of the pure-bred goat. The introduction of Angoras into the United States took place in 1849. Other importations of goats from Asia Minor were made between 1857 and 1880, and interchanges of blood also took place between the United States and Cape Colony. Between 1856 and 1875 some 300 goats were introduced into Australia.

MOHAMMED (more correctly, MUHAMMAD) (c. 570–632), founder of Islam (*q.v.*), the Muslim religion, was born in Mecca. According to Arab terminology referring to the genealogy or clan, the full form of his name is ABULQASIM MOHAMMED IBN 'ABDULLAH IBN 'ABD AL-MUTTALIB IBN HASHIM.

Significance of His Personality. — Few men have exercised so deep and lasting an influence as Mohammed: a religious influence, first and foremost, since the teaching handed down by Mohammed remains a living faith and a doctrine observed by nearly one-seventh of the world's population. A historical influence too, since, in less than *20* years. the movement he started had shaken two great powers, the Byzantine empire and the Sassanid empire in Persia, founding a new civilization. A political and social influence as well, since Islam as preached by Mohammed is both a religion and a system for the organization of the community. Moreover. after the death of Mohammed a whole system of traditional teaching was developed, presenting his behaviour in the various circumstances of life as a model for the faithful, so that the influence of Mohammed's personality was reflected in the everyday conduct and outlook of succeeding generations of Muslims (see HADITH).

But though it is impossible to overestimate Mohammed's historical importance, it is necessary, in a quite different sense, to emphasize the fact that his position in the actual doctrine of Islam — at least in its orthodox form — is a comparatively modest one. For one of the basic tenets of Islam is that the Koran (*q.v.*) is a divine revelation of which Mohammed was simply the vehicle. Therefore. according to the strict doctrine, Mohammed has no supernatural quality. "I am not an innovator among the apostles. I am only following what has been revealed to me and I give sincere warnings" (Koran, xlvi, 8). But Mohammed is not the author of the Koran; any orthodox Muslim would regard such a suggestion as blasphemous. That is why the Muslims reject the term "Mohammedanism" by which the west often designates their religion. They themselves prefer to call it Islam, meaning "confident submission" (to God).

It was not long, however, before hagiography took over and began to idealize Mohammed's life. In a different way, since the 19th century, the liberal and modernizing reformers of Islam, wishing to humanize their religion and guard against what they considered to be the excessive predominance of its metaphysical or legalistic aspects, have strongly individualized the figure of Mohammed, conferring upon him, even to the risk of sentimentality. a theological position not recognized by orthodoxy. Western critics, however, have sometimes gone too far in the opposite direction. The information derived from historical sources, which deal chiefly with the last *20* years of his life, and the researches of modern scholars suggest a figure rather many-sided but utterly genuine. One of the most remarkable aspects of his biography is. in fact, this often moving contrast between the extent of his achievement and the real humanity of his character.

Sources for His Life. — Shortly after Mohammed's death Muslims started to write his life (sira), often in an idealized form. The earliest of these biographies have not survived; the chief traditional one, *Kitab Sirat Rasul Allah,* by Ibn Hisham, is based on the earlier sira by Ibn Ishaq. Most later Islamic historians rely on this work. but the *Kztab al Maghazi* by al-Waqidi and the *Kztab al-Tabaqat al-Kabir* of Ibn Said are also important. All date from the 8th–9th centuries.

The most important historical source, however, for Mohammed's life is the Koran itself, giving the very words that he uttered as a revelation and that were collected in his lifetime. The final text was established as early as *c.* 650 and has not been altered since. The hadith, reporting the sayings of Mohammed in various circumstances as told by "chains of authorities" and collected by traditionists, are less reliable, as a number of them have been interpolated in the course of history; those that have earned the greatest regard are by al-Bukhari and Muslim ibn al-Hajjaj, both of the 9th century.

Reference to Arabia in contemporary non-Arabian chronicles is disappointingly rare. Inscriptions and written sources relating to the period have been little studied, but there are allusions, sometimes revealing. in contemporary poetry.

His Youth. — The posthumous son of 'Abdullah. a member of the prominent Meccan family of Hashem, a subdivision of the Quraish (Koreish) clan, Mohammed lost his mother when he was six years old The orphan mas taken care of first by his grandfather. 'Abd al-Muttalib, and later by his paternal uncle, Abu Talib. But the Hashemites had suffered serious reverses of fortune, so that their influence had declined. Entrusted to a Bedouin nurse. Halima, the child Mohammed must then have spent his early years in poverty as a shepherd boy, living the existence of the nomads in the mountainous regions near Mecca. Later he accompanied some of the caravans, first probably those of his uncle Abu Talib, which the Meccan tradesmen organized regularly, northward into Syria or south toward Yemen. In his trading expeditions he showed himself both successful and honest, qualities that caused a widow. Khadija, to entrust him with the management of her business affairs. At the age of 25 Mohammed married Khadija, and the marriage. which lasted until her death *20* years later. was a particularly happy one. Many years older than her husband. she was his truest confidant, the first to believe in him and the first convert to Islam.

Thus, until the age of about 40. when he started preaching, Mohammed lived a peaceful life and attained relative prosperity. Indeed, in a town racked by commercial speculations, in a world where every Arab had taken part in some armed fighting, the life of Mohammed might have appeared unusually quiet and uneventful. In a climate where men grow old early, he was already past the age of adventure and ambition. Suddenly, his whole existence changed: a new phase of his life began

Mohammed Begins to Preach. — About the year 610. Mohammed had formed the habit of withdrawing periodically into the mountains near Mecca to meditate and pray. One night on Mt. Hira. according to the tradition, he had an overwhelming spiritual experience: the word of God was revealed to him by the archangel Gabriel. Mohammed himself related that he heard an imperious voice and that a luminous being grasped him by the throat and commanded him to repeat the sacred words. At first, he tried to flee; Khadija later described his doubts, his self-questioning as to the genuineness of his message. his dread of resembling the visionary poets to be seen in the markets at Mecca with their pretense of being possessed. Then came a period of inner emptiness when "the revelation was silent." and his distress was even greater. Finally he was again seized by the conviction that he had a message to convey. His hesitation ceased. and around 613 he began his preaching. This took the form of a rhythmical recitative packed with exhortations and vivid comparisons. In content it was a fervent and reiterated proclamation of the all-powerfulness of the one God, Creator of the universe, who would summon all his creatures into his presence for judgment on the day of resurrection. But this God of justice was a God of mercy too. He had filled the earth with the signs of his glory and grace. Every man was morally responsible to him for the conduct of his own life. Every man must respond to the divine love and blessings by faith, prayer and charity. Mohainmed did not preach this as a new doctrine. He declared that his teachings formed part of the prophetic tradition. He constantly reminded his listeners of the apostles of monotheism, such as Abraham, Moses and Jesus, who had been sent in earlier times with the same message. Their "reminders" and "warnings," as the Koran calls them, were now being repeated, in Arabic, owing to the revelation made to Mohammed.

Reaction at Mecca. — There was no immediate opposition.

During the first few years. indeed, Mohammed spoke only to a small, intimate group of his family and friends. The hostile reaction of Mecca arose gradually as he began preaching to a wider circle and was probably due in great part to economic considerations. For it is a mistake to suppose. as was done for a long time, that Islam originated among nomads of the desert. Islam took shape in a town, a town characterized by an avid interest in trade and finance. Mecca stood in a rocky valley with no agricultural resources, and all its profits came from trading. The temple had become a place of profitable pilgrimages. accompanied by fairs and markets. A mercantile republic had thus grown up—an oligarchy governed by a council which included the richest traders.

Mohammed's preaching was a frontal attack on this system. Opposition to him at first took the form of mockery and interminable polemics. Then came persecution, which developed to such an extent that in 615 he advised the most vulnerable of his followers to take refuge in the Christian land of Ethiopia. Membership of the Hashemite clan, which had so far afforded some protection to Mohammed in his immediate entourage, was no longer effective. Matrimonial or commercial relations with the clan were forbidden. With these political trials came personal sorrows. In 619, "the year of mourning," both Khadija and Abu Talib died. Mohammed then began to seek refuge outside Mecca. Help came from Yathrib. which after its hospitality to Mohammed was renamed "Madinat an-Nabi," the city of the Prophet. Medina.

The Medina Period. — Unlike Mecca. Yathrib was not a trading centre but an oasis, where an agricultural community lived by cultivating date palms. Two hostile tribes, the Aws and the Khazraj, were vying for precedence. The population also included three Jenish tribes. Tension between the two parties had reached a pitch where it seemed that only arbitration by someone unconnected with the conflicting clans could dispel it. Mohammed. as the head of a community whose principle was to transcend tribal divisions. was fitted to be the arbiter. Moreover, the presence of considerable Jeuish settlements at Yathrib might have encouraged the Prophet to hope that his monotheistic doctrines would find a better reception there.

The first negotiations, conducted in secret, culminated in 622 in an agreement known as the pact of Aqaba, by which the new disciples took an oath of fidelity. In small groups the Muslims began to settle at Yathrib. The Meccans, alarmed, decided to strike at the leader. They plotted to assassinate Mohammed, who was still in Mecca almost alone. But he managed to escape during the night and, after hiding for a time on Mt. Thaur, reached Yathrib on Sept. 24. Thus began the hegira or emigration (see HEJIRA). The hluslims reckon their era from this year, starting July 16, 622. In that year Islam found its form, asserting itself not only as a religion but also as an organized community.

The date also marks a turning point in the life of Mohammed. The preacher now became a politician and a ruler and before long a military leader as well. The text of a charter that forms the first constitution of Islam has been preserved. It shows remarkable political insight. Thus, one of the first measures was to integrate the refugees from Mecca with the original population of Medina. For this purpose, Mohammed instituted legal bonds of brotherhood between each immigrant and one of the Ansar ("assistants," "helpers"). as the hosts at Medina were now called. So religious unity did not prevent recourse to the already existing Arab custom of brotherhood. The two principles reinforced each other.

Mohammed also set himself to win over the Jews, assuring them of freedom to practise their religion and even including certain of their rites in Islam (such as the custom of turning toward Jerusalem when praying) as a witness to the fundamental unity and permanence of monotheism. In return, the Jews were to accept the ne civil authority and contribute to military expenses. These political and economic restrictions appeared irksome to the Jews, who had enjoyed a favourable situation in Yathrib. They also refused to acknowledge Mohammed as a prophet and opposed to him their own biblical writings. Relations became strained. Less than two years after the hegira Mecca took the place of Jerusalem as the direction in which to pray. Simultaneously the doctrine of original monotheism gained strength — of a monotheism older than Judaism or Christianity, symbolized by Abraham and the temple at Mecca with Islam as its authentic representative.

Military Campaigns. — If Mecca was to be the centre of Islam, the exile at Medina could be regarded only as a temporary necessity. Moreover, the Meccans, who controlled the trade of Arabia. were bringing economic pressure to bear on the refugees and their hosts. The *émigrés,* who had lost all their property, were beginning to feel the pinch of poverty. The war began gradually, in the Bedouin manner, with a succession of raids and skirmishes. Reprisals and counterreprisals intensified. The losses on both sides were comparatively slight. But success or failure had far-reaching psychological repercussions on the tribes, which were highly sensitive to gain or loss in prestige. The first considerable victory was won by the Muslims, at Badr, in the spring of 624. Despite their inferior numbers, the Muslims' dash carried the day. But the Meccans were bent on avenging their dead and reasserting their impaired authority. A year after Badr, an army of 3.000 men advanced upon Medina. The Muslims made an ill-judged sortie and were defeated at Ohod. largely through lack of discipline. Mohammed himself was wounded.

However, the Meccans were incapable of following up their victory. Not until March 627, when they had persuaded a number of Bedouin tribes to join their cause, did they bring a strong force against Medina again. Mohammed then resorted to tactics which were unfamiliar to the Arabs, accustomed to brief, isolated raids. Avoiding the mistake made at Ohod, he did not sally out to meet the enemy in the usual way but had a ditch dug around Medina. The Meccan horsemen were disconcerted and bored. The coalition started breaking up. Bad weather added to the discouragement of the besieging force, and it finally dispersed.

Pact of **Hudaibiya** and Return to Mecca. — The "battle of the ditch" had restored the initiative to Mohammed. He used it. however, chiefly as a means to negotiation. The opposing forces were now more equally matched and the Meccans were tired of a war that was damaging their trade. They were further appeased by Mohammed's declared intention of not merely respecting the traditional pilgrimage but making it one of the basic rites of the new religion. After various overtures, including the resumption of trade between the two cities, Mohammed secured a truce to enable himself and his companions to undertake their pilgrimage. They set out on their peaceful march, but as they drew near the city their way was barred by an armed group. The Muslims stopped and camped at Hudaibiya, where a Meccan delegation came to parley. As a result of these negotiations Mohammed agreed to three conditions: the Muslims would return to Medina without visiting the temple at Mecca and would return the following year for a visit not to exceed three days; Meccans who emigrated to Medina would be extradited on request: and there would be a ten-years' truce during which each party should be free to cross the other's territory and remain neutral in the event of either's becoming involved in war with a third party.

This agreement, knoan as the pact of Hudaibiya, made concessions that many of Mohammed's companions found exaggerated and that gave rise to violent criticism. But it proved successful. It obliged the Meccans to give official recognition to a group of fugitives they had despised and to accept them as entitled to conduct negotiations with the chief city of Arabia. It also gave Mohammed time to establish his position at Medina once and for all.

The agreed pilgrimage. which took place in 629, found Mecca almost deserted, for the inhabitants had withdrawn to the neighbouring hills. Once their pious purpose had been fulfilled, the Muslims departed, as required by the treaty. This display of strength combined with moderation impressed the Meccans. The time was ripe for a solution. An opportunity arose when a quarrel Bared up between two tribes and Mecca unwisely gave its support to one of them, thus breaking the pact of neutrality. At once, in Jan. 630. the Muslims aere ordered to advance on Mecca. The city capitulated almost without a blow and nearly all the inhabitants accepted Islam. Thus the patience, the risks accepted. the restraint imposed on followers throughout the preceding years of negotiations at last bore fruit.

The same moderation prevailed in the hour of victory. Moham-

med made a ceremonial entry into the temple and ordered al! the idols to be overthrown and the building to be converted from a pagan shrine into a Muslim sanctuary. But apart from this symbolic act he was careful not to offend the population. By a general amnesty and other evidence of liberality, Mohammed succeeded, indeed, in gaining the lasting support of his former enemies.

Relations With Judaism and Christianity.— Established in its spiritual capital, Islam gradually took shape as a religion distinct from Judaism and Christianity. True, the Prophet's preaching had always stressed the essential unity of the monotheistic creeds, which is proclaimed in many verses of the Koran: "God has ordained for you the religion he commended unto Noah and which we have revealed to thee and we commended unto Abraham and Moses and Jesus" (xlii, 13). And to the "people of the Scriptures" the Muslims are told to say "We have faith in that which has been revealed to us and in that which has been revealed unto you. Our God and your God are one, and unto him we are resigned" (xxix, 46). But from the early days at Medina, despite all appeals to the Torah and to the name of Moses. the Jews had shown themselves reserved. Reluctant to change their manner of life, they were more inclined to favour the Meccans. However. they proved unable to unite against Mohammed, so that in the intervals of his campaigning outside Medina he was able to crush their sporadic moves within the city. Several of their groups were banished. After the pact of Hudaibiya had given him security from the Meccans, he struck his most severe blow, capturing (628) the important oasis settlement of Khaibar. populated entirely by Jews.

Relations with the Christians remained more satisfactory. The Koran declares that "Those who are most disposed to friendship with the faithful [*i.e.,* the Muslims] are they who call themselves Christians; this is because they have priests and monks, and because they are free from pride" (v, 82). While the community was struggling to survive and organize itself, it did not have to take account of the Christians. who were few at Mecca and Medina. But. as Islam spread and contacts with Christian communities developed, differences of doctrine were shown to be so fundamental and profound as to make a division inevitable in the long run. This became manifest, for instance, in 631 during the episode known as the Najran meeting. Theological discussions with a deputation from Najran, a fertile valley in Yemen, inhabited by one of the largest Christian communities in Arabia. broke down over the dogma of the incarnation of Christ. Despite this failure. however, Mohammed had part of the mosque set aside for the Christians to perform their rites.

Government From Mecca; the Last Years.— The period 630–631 was not only that of various embassies sent to Mohammed. It was also marked by military expeditions, with which the Muslim state initiated its expansion. Around 630–631, Mohammed's authority was firmly established and the unification of the Arabian peninsula proceeded steadily. Mohammed thereupon reorganized his administration. Almsgiving was transformed into a government tax at fixed rates. Religious connections had now been permanently substituted for the system of clans and tribes. Paganism was outlawed. The Muslim community was based on the principle of equality and governed entirely by the Koranic law. The verses of the Koran daring from this period are no longer cast in the breathless rhythm of the Meccan phase. Their style is calmer and they deal chiefly with the structure of society. The former social system had been particularly unfavourable to women; the new laws entitled them, for example, to own property and to inherit it The husband's obligations were defined for the first time. and the legal maximum number of wives was reduced to four.

In considering the status of women in Islam, it is only fair to remember the position they had previously occupied in Arabia. Western critics have often reproached Mohammed for his own polygamy. Here again we should bear in mind the life led by the Arab tribal chiefs. As long as Khadija was alive, Mohammed remained unswervingly faithful to her. Among his later wives there were two of whom he seems to have been especially fond— 'A'isha (*q.v.*), his favourite, whom he married as a very young girl, after the battle of Badr. and Zainab. Their personalities were not without influence on the life of the community. Only Mohammed's female offspring. all by his first marriage. survived One of his daughters, Fatima (*q.v.*), married 'Ali (*q.v.*), Mohammed's first cousin and one of his earliest converts. There were two children of this marriage, Hasan and Hussain (*q.v.*). If matters had been settled by right of birth, these should have succeeded to the Prophet's position. But the elective system was adopted, and the dispute over the succession caused the first and only major schism in Islam's history.

As early as the pilgrimage of 631, Mohammed had designated one of his earliest companions. Abu Bakr (*q.v.*), to preside over the ceremonies. In the following year Mohammed himself led the pilgrimage. He had by then begun to feel the effects of the malady to which he later succumbed. and this ceremony, known as the "farewell pilgrimage," served as a final recapitulation, a collective scrutiny of his lifework by both himself and the community. Tradition has preserved the moving terms of this farewell. In his last sermon he urged his followers not to split up after his death, affirmed yet again the unity of God and the brotherhood of the faithful, enjoined the community to watch over the rights of women and proclaimed the abolition of blood feuds and of usury. Then he returned to Medina and died there on June 8. 632. Tradition says that Abu Bakr, the newly elected *khalifa* (caliph, successor), said to the sorrowing faithful: "If you are worshipers of Mohammed, know that he is dead. If you are worshipers of God, know that God is living and does not die." Thus Mohammed's life ended as his preaching had begun, in the absolute devotion. amounting to self-effacement, of the man to the mission.

Mohammed's biographers have tended to make a sharp division between his two periods of activity—as the prophet and preacher of Mecca and as the politician and lawgiver of Medina. Critics of the 20th century, however, tend to modify this distinction, which seems to have no psychological or historical justification. The balance, the composure and the grasp of possibilities so often displayed by Mohammed at Medina would be unaccountable if the apostle of Mecca were no more than a passionate being in the throes of inspiration. Inspired he was, but he had foresight too. Yet the inner tension that set him to preaching never really subsided. There is ample evidence that Mohammed's main influence was not through any doctrinaire theological teaching but through stimulating leadership and a moral ascendancy over those who came within his range. His own stimulus throughout his career came from religion. His life derived its unity from faith.

See ISLAM; see also references under "Mohammed" in the Index volume.

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MOHAMMED I (1389?–1421), surnamed Chelebi. Ottoman sultan, the youngest of the sons of Bayezid I, restored the unity of the Ottoman dominions, which Timur had deliberately dismembered after his victory over Bayezid at Ankara (July 1402). The eldest son, Suleiman, had fled after the battle and with Byzantine support established his rule in Rumelia; Mustafa, the second son, was carried off by Timur to Samarkand. Mohammed, with the conqueror's approval, ruled Amasia. After 1403 he added Bursa and Iznik to his possessions by defeating his brother Isa. He then came to an understanding with another brother Musa, whereby the latter would defeat Suleiman and then recognize Mohammed's suzerainty. But on Suleiman's defeat and death Musa established himself in Rumelia (1410). Alarmed by his aggressive acts, the

emperor Manuel II assisted Mohammed to overthrow him (July 1413). Mohammed was thus left as the undisputed sultan, a title assumed by none of his brothers. Mohammed reigned with wisdom and humanity and won back many, though not all, of the Anatolian principalities. In 1416 there appeared a pretender who claimed, probably with truth, to be the missing brother Mustafa. His revolt was soon suppressed and he took refuge in Constantinople. It nas probably the fact of this man's existence that impelled Mohammed, on his deathbed at Adrianople, to urge his ministers to aithhold news of his death until his son Murad could be summoned to Bursa to be proclaimed sultan (spring 1421).

(G. L. L.)

MOHAMMED II (1431?–1481), surnamed Fatih, Ottoman sultan, succeeded his father, Murad II, in 1451, having previously reigned briefly in 1444. He had grown up with the conviction that the house of Osman was destined to rule an empire (see MURAD II) and did not long delay the beginning of his career of conquest. He owed his name Fatih ("conqueror") to his capture of Constantinople (1453); but his armies fought many other victorious campaigns, in most of which he took part.

Mohammed's fame is based not only on his military achievements. Himself a poet and a remarkable linguist. he was a patron of the arts and of scholarship (see E. J. W. Gibb, History of Ottoman Poetry, 1900–09). Among the visitors to his court was Gentile Bellini, nho painted his portrait. In the precincts of his mosque at Constantinople he built the great school known as the Court of the Eight Colleges, at which boys were trained for the civil and military services.

In his code of lams (Qanunname), which laid the foundations of the imperial administration, one section has brought on its author the disapproval of European historians: it consists in a recommendation to his successors that they kill their brothers on coming to the throne. This advice was generally followed till the 17th century. The fact that Mohammed did not frame this policy for himself alone but also enjoined it on his descendants indicates that he was moved not so much by considerations of personal security as by the desire to safeguard the state in perpetuity from the dynastic disputes that had threatened it down to his father's day. He died on June 2, 1481, having just set out on an expedition to the east. (G. L. L.)

MOHAMMED III (1567–1603), Ottoman sultan, succeeded his father, Murad III, in 1595. During this reign. the real power was in the hands of the queen mother, Safiye, as it had been during her husband's lifetime. The one noteworthy action that Mohammed performed in defiance of his mother's wishes was to take part in the campaign of 1596, which led to the capture of Erlau in Hungary. The abuses which had crept into the administration, particularly the financial administration, since the time of Suleiman continued unchecked. In 1603 the spahis of the capital mutinied, demanding the abolition of the harem regime. The grand vizier Yemishji Hasan. by using janissaries to quell the revolt, began a feud between the two corps which mas to have evil consequences for the empire. Mohammed III died in Dec. 1603 and was succeeded by his son Ahmed. (G. L. L.)

MOHAMMED IV (1642–1692), surnamed Avji ("huntsman"). Ottoman sultan. son of the deposed Ibrahim I, succeeded his father in 1648 at the age of seven, being the only Ottoman prince left alive. Until 16 j6 power was in the hands of harem factions; from that year onward it rested with a series of grand viziers, beginning with the tu-o great Kopriiliis. The sultan was not devoid of spirit; he took part in several campaigns, notably those of 1663 and 1672, against Austria and Poland, respectively. He preferred, however, to devote his energies to hunting. No minister ever succeeded in curbing his enormous expenditure on this occupation. The disastrous defeat of the Turks at Mohács in Hungary (Jan 22, 1687) cost Mohammed his throne. Deposed in November of the same year by a revolt of the army in the field, he spent the last three years of his life in retirement at' Adrianople, where he died on Dec. 17, 1692. (G. L. L.)

MOHAMMED V (1844–1918), called Reshad, Ottoman sultan, was born at Topqapu on Nov. 3, 1844, a younger son of the sultan Abdul-Mejid (1823–61). He led a quiet and retiring life and suffered at times considerably from the jealousy and suspicion of his elder brother, the sultan Abdul-Hamid II. On the deposition of Abdul-Hamid he became sultan on April 27, 1909. He was, for the most part, merely a tool in the hands of the Committee of Union and Progress and, though he was supposed to dislike the pro-German policy of Enver Pasha, was unable to take any effective steps to oppose him. He died at Yildiz on July 3, 1918.

MOHAMMED VI (1861–1926), called Vahid ed-Din, the last Ottoman sultan of Turkey, succeeded his brother Mohammed V in 1918. After the armistice at the end of World War I he co-operated with the Allied powers against the Turkish nationalists (see TURKEY: History) and, after the abolition of the sultanate, left Constantinople on a British battleship on Nov. 17, 1922, being deposed from the caliphate on Nov. 23. He died at San Remo, May 16. 1926.

MOHAMMED AHMED IBN SEYYID 'ABDULLAH (1843–1885), called the mahdi. Sudanese religious leader, was born in Dongola, the son of a boatbuilder. He received a religious education and was early recognized for his devotion. In 1871 he went into religious retirement on Abba Island, about 150 mi. above Khartoum on the White Nile. He attracted many pupils and followers and quarreled with certain religious leaders whom he regarded as overworldly. He began to travel far afield among the peoples of the Sudan and grew to resent their sufferings under the Egyptian regime, which had degenerated since the death of Mohammed Ali. He practised severe austerities, and the conflict between his strongly mystical habit of mind and the circumstances which he saw around him led him to the belief, which must have come to him with the force of a revelation, that he was the mahdi, the awaited deliverer. In March 1881 he began to speak of his mission and to proclaim the necessity for a holy war against the corrupt rulers of the Sudan. In Aug. 1881 he defeated the small expedition sent against him when he first openly announced his intentions. and he was successful against a much larger Egyptian force in the following year. The revolt became general. He occupied El Obeid, the capital of Kordofan, in Jan. 1883 and destroyed an army of 10,000 men under the English general Hicks Pasha in November. Meanwhile, with the British occupation of Egypt, Sudanese affairs had become the concern of the British government. There followed General Gordon's ill-defined mission, his defense of Khartoum and his death at the hands of the mahdi's troops—said to have occurred in spite of the mahdi's wishes. (See EGYPT: History; GORDON, CHARLES GEORGE; and SUDAN: History.) The mahdi died on June 22, 1885, at Omdurman.

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MOHAMMED ALI (c. 1769–1849), also known as Mehemet Ali from the Turkish form of his name, was the founder of the royal house of modern Egypt. The circumstances of his birth and parentage are obscure. Even the traditional date of his birth, 1769, is suspect in view of the lack of evidence and of the fact that this year was known to be that of Napoleon's, with whom he wished to be compared. His ancestry is believed to have been Albanian, and he grew up at Kavala in Macedonia, where, in the last years of the 18th century, he already had a wife and a substantial position as a tobacco trader. The invasion of Egypt by the French under Bonaparte in 1798 led to the mobilization of Ottoman forces in the Balkans, and Mohammed Ali went to Egypt as an officer of these forces. He first became prominent in 1803 as the commander of the considerable Albanian contingent in Egypt. The central government in Constantinople was particularly weak at this time and after the evacuation of the French army Egypt endured a period of internal strife. In this struggle, the prize of which. because of the weakness of the Turkish government, was likely to be the uninterrupted enjoyment of the fruits of the government of Egypt, the Mamelukes had some support from the English. But Mohammed Ali concentrated his attention upon the city of Cairo, where he received sufficient support to ensure his being acclaimed pasha after he had occupied the city in 1805. The sultan made an attempt to displace him,

but accepted the situation in 1806, confirming him in the office by the issue of an imperial firman in return for an annual payment. Mohammed Ali made a determined effort to establish his authority and to restore order and was helped in this by the defeat in 1807 of the British forces which had reoccupied Alexandria. But his complete authority was not established until he had successfully trapped and killed the greater part of his opponents in the episode known as the massacre of the Mamelukes, in Cairo (March 1811), which supplied the pattern for Mahmud II's suppression of the janissaries in Constantinople 15 years later. The remaining Mamelukes fled south, where the last of them were destroyed by the pasha's eldest son. Ibrahim Pasha (*q.v.*), in 1816.

Meanwhile, the holy cities of Mecca and Medina had been occupied, in defiance of the Turkish government, by the fanatical Wahhabis. whom the sultan had urged Mohammed Ali to expel. After the massacre of the Mamelukes Mohammed Ali sent troops to Arabia. thereby taking the first step toward the creation of what was to be a considerable empire. The campaign was long but successful. The holy cities were quickly captured. The Egyptians were heavily counterattacked, but they held on for a time (1813–15) under the direct command of Mohammed Ali. The slow reduction of the Wahhabi power was brought to completion by Ibrahim Pasha. The Wahhabi capital fell. and its prince was taken to Cairo and put to death in 1818. Soon afterward, from June 1820, hlohammed Ali's forces were directed southward. Under the command of his third son. Ismail, the Egyptians subdued the oasis of Siwa and began the process by which a great part of the Sudan was brought under Egyptian control. This was largely accomplished by force of arms (although the ports of Suakin and Massana were secured from the sultan in return for an annual payment). Khartoum, founded in 1823, was to become the capital of the new provinces in 1830.

Mohammed Ali had early set out upon the path of internal "reform," by which he meant. change more in accordance with the western model. This involved the creation of armed forces disciplined and equipped by western standards. He soon had a powerful fleet and an army of veterans nith many European officers. It was probably in part at least in order to pay for his army and navy that he introduced a large number of changes into the internal structure of Egyptian society and into the country's economy (see EGYPT: *History*). For good or ill these changes entitle Mohammed Ali to be called the founder of modern Egypt.

To Sultan Mahmud II. whose uhole policy was directed to strengthening the central power. Mohammed Ali must have seemed an overmighty subject; and it uas no doubt against his will that in 1822 the ill-success of his arms against the insurgent Greeks forced him to summon the pasha to his aid. The immediate price was the pashalik of Crete; and in the event of victory the pashaliks of Syria and Damascus were to fall to Mohammed Ali. that of the Morea to his son Ibrahim. The part played by the Egyptians in the Greek War is described elsenhere (see GREEK INDEPENDENCE, WAR OF). The intervention of the powers, culminating in the shattering of the Egyptian fleet at Navarino (*q.v.*), robbed Mohammed Ali of his reward so far as Greece was concerned; Mahmud had an excuse for withholding the rest of the stipulated price of Egyptian assistance. This disappointment would not perhaps in itself have sufficed to stir Mohammed Ali to revolt. But in the spring of 1831 tno pashas. Husain of Bosnia and Mustafa of Scutari, had succumbed to the sultan's arms; and it was likely that, so soon as he should feel himself strong enough, he would deal in like manner nith Mohammed Ali. It was perhaps to anticipate that peril that hlohammed Ali determined to open the struggle. On Nov. 1. 1831. his troops crossed into Syria. Wild rumours went abroad as to his intentions. He was master of the holy cities. and the official *Moniteur Ottoman* denounced his supposed plan of aiming at the caliphate in collusion with the sherif of Mecca. As for the pasha himself. he loudly disclaimed any such disloyal pretensions: his aim nas to chastise Xbdullah, pasha of Acre. who had harboured refugees from Egyptian conscription; to overthrow Khosrev, who had encouraged him in his refusal to surrender them; to secure the fulfillment of the sultan's promise with regard to Syria and Damascus. Mahmud. on the other hand, was torn between hatred of the pasha and hatred of the Christian powers which had forced him to make concessions to the Greeks. In the end, however, his pride prevailed; in April 1832 the Turkish commander in chief Husain Pasha left Constantinople for the front; and in May the ban of outlawry was launched against Mohammed Ali.

The events which followed belong to the history of the eastern question (*q.v.*). So far as Mohammed Ali's own fortunes were concerned, the convention of Kutaiah (April 8, 1833), which closed his first successful war with the Porte, gave him the objects of his immediate ambition; and, though still nominally only the sultan's representative, he ruled an empire stretching from Khartoum to the borders of Anatolia. But the peoples who had welcomed him as a deliverer soon found his yoke more intolerable than that of the Turks. In particular, they disliked his application to them of compulsory military service. The Syrians broke into revolt in 1834, and four years later it was an insurrection of the Arabs of the Hauran which served Mahmud as the pretext to go to war. Again the Egyptian arms were victorious; but the intervention of the powers robbed Mohammed Ali not only of the spoils of his most recent victories but also of those secured in 1833, and in the end he had to be content with the hereditary pashalik of Egypt and the government of Nubia, Darfu, Kordofan and Sennar, conferred upon him by firmans of the sultan in 1841. With this Mohammed Ali passes from the stage of history. He was an old man; his mind was soon to give may; and for some time before his death on Aug. 2, 1849, the reins of power were held by his son and successor. Ibrahim. See also references under "Mohammed Ali" in the Index volume.

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MOHAMMEDANISM: see ISLAM; for Mohammedan art, law, etc., see ISLAMIC ART, ISLAMIC LAW, etc.

MOHAMMERAH (modern KHORRAMSHAHR or KHURRAMSHAHR), a town and port of southwest Iran in Khuzistan (Ostan 6). situated in lat. 30° 25. long. 48° 10′ on the right bank of the Karun river (*q.v.*) at the point where it enters the Shatt-al-Arab (*q.v.*). Until the beginning of the 19th century the old village of the same name lay on the left bank of the Karun on the island of Abadan (*q.v.*) opposite the present town. Pop. (1956) 43,840. The place first came into prominence in 1837, when it was attacked and demolished by the Turks on the ground that it was becoming a thriving commercial port to the detriment of Basra. Persia claimed an indemnity of £1,000,000; the Turks claimed that both Mohammerah and Abadan were Turkish territory.

The British and Russian governments intervened to prevent war and by the treaty of Erzerum (1847), Mohammerah and its anchorage, and Abadan Island were allocated to Persia. One of the principal difficulties in effecting this settlement was the fact that in 1765 the Karun, which had hitherto entered the Persian gulf by a separate channel via Marid, Qubban and the Khor Musa, left that channel and followed a small canal which had been dug to connect Marid with Mohammerah by the Bahmishir, then a branch of the Shatt-al-Arab, thus depriving Persia of the advantages of independent access to the Persian gulf.

On the inclusion of Mohammerah and district in Persian territory they were constituted, administratively, a deputy-governorship under the provincial governor of Xrabistan (Khuzistan) with headquarters at Shushter; but in practice they were farmed out or delegated to the ruling shaikh of the Muhaisin section of the Chaab. the Shia tribe of Arabs inhabiting the region. This system ended in 1924 when Riza Khan succeeded in bringing the south of Persia under control of the central government. (See PERSIA.)

At that time, Shaikh Khazaal Khan, G.C.I.E., K.C.S.I., lost the semi-independent rule of Mohammerah which he had held since 1897. A British vice-consulate has been established at Mohammerah since 1891.

Mohammerah is connected by river with Ahwaz (105 mi.); good motor roads connect the town with Ahwaz (80 mi.), Basra

(25 mi.), Abadan (9 mi.).

The only local product of importance is dates. which are exported in considerable quantities from the date groves which line the Shatt-al-Arab and Bahmishir rivers It is. however, a port of importance. The average rainfall at Mohammerah is 8 in per annum, as compared with about double that amount at Masjid-i-Sulaiman. 120 mi. north. The climate is hot but not unhealthful.

MOHAVE (MOJAVE), a Yuman (*q.v.*) tribe on the lower Colorado river near Needles. Calif. National unity prevailed among the small clusters of dwellings scattered along the periodically inundated bottom lands where crops were grown. Half the vegetal food was derived from mesquite beans and other wild plants. Fishing was considerable, hunting minor. Houses were low, gable-roofed. rectangular structures covered with brush and sand. Men commonly wore only a breechclout, women a full petticoat—both garments being made of woven willow bark. Clay vessels of fair quality were prevalent; basketry was minimal. The Mohave mere exceptional in this region as travelers.

Warfare mas frequent, undertaken with enthusiasm and often sanguinary. Combat was formalized, the massed company being led by champions. A cylindrical club wielded with an upward smashing blow was the favoured weapon Their patrilineal exogamous clans were not localized and served largely to provide a bond of fellowship. A unique feature was the use of the meaningless clan name for women alone, who might also be particularized by nicknames. These clan names had totemic reference to animals and plants.

Great significance was attached to stylized dreams, which were considered the source of all special powers. In dreams a man projected himself back to the world's beginning, experienced all happenings of the myths, and was endowed with ability to cure, hunt, fight. etc. Public ceremonial took the form of singing a cycle of dreamed songs nhich recited a myth, ordinarily the narrative of a journey. Some cycles consisted of hundreds of songs.

By the 1960s the 18th-century population of about 3,000 had decreased two-thirds.

See A. L. Kroeber, *Handbook of the Indians of California,* Bureau of American Ethnology, *Bulletin* 78 (1925). (L. SP.)

MOHAVE DESERT: *see* MOJAVE DESERT.

MOHAWK, the easternmost tribe of the Iroquois confederacy, occupied three villages west of Schenectady, N.Y., beyond Schoharie creek on the south side of the valley of their name. The location and removal of these settlements in historic times links them with Laurentian peoples whom Jacques Cartier encountered between Quebec and Montreal in the 16th century. Their place names—Ticonderoga, Saratoga, Canajoharie, Oneonta—dot the waterways of their tribal territory from Canada to Pennsylvania. On the west were the related Oneida (*q.v.*).

The deep-seated fear and hatred of the Iroquois among descendants of neighbouring Algonkin tribes stems from wars of displacement going back to protohistoric times. The general trend of Mohawk "castles," so-called from fortified hilltops situated back from the river, to open townsites on the river plain reflects an enhanced military position at the expense of the Mahican. The trade at Albany in axes, guns and kettles implemented a superior native organization. Traditionally, their leader Hiawatha mas the first to accept the principles preached by the prophet of peace Dekanawida, who founded the Iroquois league. The Mohawk had nine representatives in the league, three from each of their village bands of the Turtle, Wolf and Bear, inhabiting 180 houses and comprising over 500 families, or approximately 2,500 people.

After contact with Europeans, their population decreased rapidly. Substantial losses resulted from defections to the Christian settlements on the St. Lawrence river, principally at Caughnawaga; these converts (the "praying Indians of Quebec") espoused the French cause, raided Deerfield for captives and guided expeditions against their erstwhile brothers of the league. The resident Mohawks, "fastening a chain" and "planting a tree of peace" at Albany, tortured the Jesuits, accepted Dutch Reformed ministers and sent three of their young men to London with Peter Schuyler to the court of Queen Anne, requesting military assistance and Anglican missionaries. Their affairs during the mid-18th century were guided by Sir William Johnson (*q.v.*); during the American Revolution they remained loyal to their pro-British leader Joseph Brant (*q.v*) and followed him to Canada, where they have descendants at the Bay of Quinte and Six Nations reserve at Brantford. Ont. Their total number in the 1960s was about 5.000. A few are successful farmers, but the Laurentian Mohawk are workers in structural steel, having a passion for dangerous occupations. *See* also IROQUOIS. (*W.* N. F.)

MOHEGAN and **MOHICAN.** These cognate tribes of Algonkin affinities occupied eastern Connecticut (Mohegan) and much of the Hudson valley in New York (Mohican). They were similar to the other Algonkin of the middle Atlantic and New England coast. J. Fenimore Cooper's *Last of the Mohicans* notwithstanding, mixed blood remnants of both tribes survive near Norwich. Conn., and Stockbridge, Mass., respectively, whereas other elements have lost their identity among the Delaware, Iroquois or other tribes.

MOHINDERGARH, a town and district in Punjab, India. The town, headquarters of the district, lies 65 mi. S.W. of Delhi on the Delhi-Bikaner railway. Pop. (1951) 7,961. It was founded by Mahdud Khan during the reign of the Mogul emperor Babur. A fort built by the Marathas in the 17th century was renamed in 1861 by Maharaja Karinder Singh after his son, Mohinder Singh. The town is known for embroidered footwear.

MOHINDERGARH DISTRICT (area, 1,343 sq.mi.; 1961 pop. 547,-164), a semiarid tract with stony and sandy ridges on the south, was constituted from exclaves of the former princely states of Jind, Patiala and Nabha. A government college at Narnaul (18,180) is affiliated to Punjab university. There is a cement factory at Dadri (pop. 8.795). The Sirsa branch of the Western Jumna (Yamuna) canal provides irrigation. Wheat. gram and millets are the main crops. (S. S. BH.)

MOHL, HUGO VON (1805–1872), German botanist, famous for his recognition of the true nature of cells. was born at Stuttgart on April 8, 1805, and took his degree in medicine at Tübingen in 1828. He then studied for several years at Munich. In 1835 he became professor of botany at Tubingen, retaining that post until his death there on April 1, 1872. Mohl was concerned chiefly with the structure of the higher forms, including both gross anatomy and minute histology. He gave currency to the word "protoplasm," first used by J. E. Purkinje; he recognized under the name of "primordial utricle" the protoplasmic lining of the vacuolated cell and first described the behaviour of the protoplasm in cell division; he observed cell division in the alga *Conferva glomerata.*

Mohl also held the view, later generally adopted, of growth of cell wall by apposition. He was the first to explain the true nature of pits, and he shoned the cellular origin of vessels and of fibrous cells. His early investigations on the structure of palms, cycads and tree ferns laid the foundation for all later knowledge of this subject; so also did his work on *Isoetes* (1840). Mohl's later anatomical work was chiefly on the stems of dicotyledons and gymnosperms. He was extremely skillful with the microscope, and polished and set his own lenses.

The most notable of Mohl's numerous papers were republished in *Vermischte Schriften* (1845). His important *Die Vegetabilische Zelle* appeared in 1851 (Eng. trans., 1852).

MOHL, JULIUS VON (1800–1876), German orientalist, brother of Hugo von Mohl (*q.v.*), was born at Stuttgart on Oct. 25, 1800. Having studied theology at Tübingen (1818–23), he abandoned the idea of entering the Lutheran ministry and in 1823 went to Paris, at that time, under Silvestre de Sacy, the great European centre of oriental studies. From 1826 to 1833 he was nominally professor at Tübingen but continued his studies in London and in Oxford. In 1826 he was charged by the French government with the preparation of an edition of the *Shah Nama (Livre des rois),* which became his lifework. The first volume appeared in 1838; the seventh and last was left unfinished at his death, being completed by Barbier de Meynard. He resigned his chair at Tübingen in 1834 and settled in Paris. In 1844 he was nominated to the Academy of Inscriptions and in 1847 he became professor of Persian at the Collège de France. He served for

many years as secretary and then as president of the Société Asiatique.

Mohl's annual reports on oriental science from 1840 to 1867, collected after his death under the title *Vingt-sept ans d'histoire des études orientales* (Paris, 1879), are an admirable history of the progress of eastern learning during these years. He died in Paris on Jan. 3, 1876.

His wife. Mary (1793–1883), daughter of Charles Clarke, had passed a great part of her early life in Paris, where she was intimate with Madame Récamier. For nearly 40 years her house was one of the most popular intellectual centres in Paris. She died in Paris on May 14, 1883. Madame Mohl wrote *Madame Récamier, with a Sketch of the History of Society in France* (London, 1862).

See Kathleen O'Meara, *Madame Mohl, her Salon and Friends* (1885); and M. C. M. Simpson, *Letters and Recollections of Julius and Mary Mohl* (1887).

MÖHLER, JOHANN ADAM (1796–1838), German Roman Catholic theologian, was born at Igersheim, Württemberg, on May 6, 1796. He studied at Tübingen, where. after taking orders, he began to lecture in 1822, becoming full professor in 1828. His most famous work, *Symbolik* (1832), defending Catholic doctrine against Protestant theologians, was perhaps the most effective of the polemical writings of its time, and provoked replies from F. C. Baur. P. K. Marheineke and Karl Nitzsch. The feeling aroused in Tübingen by the controversy induced Möhler to move (1835) to the Catholic atmosphere of Munich. He was dean of Würzburg when he died (April 12, 1838).

Mijhler wrote *Die Einheit in der Kirche oder das Prinzip des Katholicismus* (182j); *Athanasius der Grosse u. d. Kirche seiner Zeit*, 2 vol. (1827). besides the *Symbolik*, Eng. trans. by J. B. Robertson, 1843; 8th ed. (1871–72) and *Neue Untersuchungen der Lehrgegensätze zwischen den Katholiken u. Protestanten* (1834). His *Gesammelte Schriften u. Aufsatze* were edited by Dollinger and his *Patrologie* by Reithmayr in 1839.

See J. Friedrich, *J. A. Möhler* (1894); Vigener, *Drei Gestalten* aus *dent modernen Katholicisnzus* (1926).

MOHOLY-NAGY, LASZLO (LADISLAUS) (1895–1946), Hungarian painter. photographer and art teacher, was born at Bacsbarsod. Hung., July 20, 1895. He studied law in Budapest, joined the poetry circle of Endre Ady and published wood cuts of Cubist influence in the avant-garde journal *Ma*. He went to Berlin in 1921 to realize his vision of a nonrepresentational art consisting of pure visual fundamentals: colour, texture. light and equilibrium of forms. In 1923 he headed the metal workshop of the Bauhaus school and edited the *Bauhausbook* series. During his Bauhaus years (1923–29) he evolved the two contributions for which he is known.

As painter and photographer he worked predominantly with light. His "photograms" were composed directly on the film and his "light modulators" (oil paintings on transparent or polished surfaces) included mobile light effects. As an educator, Moholy-Nagy evolved a widely accepted curriculum developing natural visual gifts instead of specialized skills in the student. His dictum was: "Everybody is talented." Fine arts training was abolished in favour of "designing the whole man." In 1937 he organized in Chicago, Ill., the New Bauhaus (later the Institute of Design), the first American school based on the Bauhaus program. He died Nov. 24, 1946. in Chicago.

See also PAINTING: *The Bauhaus Group*.

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MOHR, KARL FRIEDRICH (1806–1879), German chemist, designer of laboratory apparatus and one of the originators of the doctrine of the conservation of energy, was born at Coblenz on Nov. 4, 1806, the son of a chemist. He studied under L. Gmelin and, after five years at Heidelberg. Berlin and Bonn, returned to Coblenz to assist his father. He gave up business in 1857, and devoted himself to research work until 1863 when he returned to the university at Bonn, where he became a professor in 1867. He died there on Sept. 28, 1879.

Mohr was the leading scientific pharmacist of his time in Germany; he was the author of many improvements in analytical processes. He invented the pinchcock, the cork borer, Mohr's balance for the determination of specific gravities and other pieces of apparatus. His methods of volumetric analysis were expounded in his *Lehrbuch der chemischanalytischen Titrirmethode* (1855). His *Geschichte der Erde* (1866) also obtained a wide circulation. In a paper "Über die Natur der Wärme," in the *Zeitschrift fur Physik* (1837), he gave one of the earliest general statements of the doctrine of the conservation of energy.

MOHS, FRIEDRICH (1773–1839), German mineralogist, born at Gernrode in the Harz mountains, was professor at Graz and at Freiburg and. lastly, professor of mineralogy and superintendent of the imperial cabinet at Vienna from 1826 onward. His great work was the *Grundriss der Mineralogie* (Eng. trans., *Treatise on Mineralogy*, by Welhelm Haidinger, 1825). He died at Agardo, near Belluno, Italy. on Sept. 29, 1839.

MOHS' SCALE. One of several ways of determining the hardness (designated H) of a mineral is by testing its resistance to scratching or abrasion. This test is performed by observing if the smooth surface of a mineral of unknown hardness is scratched by a sharp edge or point of a series of minerals or other substance whose hardnesses are known. Rapid mineral identification is greatly facilitated whenever the approximate hardness is easily determinable.

A series of ten minerals (all common except the last. diamond) has been devised, as an arbitrary scale of reference, against whose hardnesses the relative hardness of any other species may be checked. This scale of species, arranged in order of increasing relative hardness, is:

1. Talc	6. Feldspar
2. Gypsum	7. Quartz
3. Calcite	8. Topaz
4. Fluorite	9. Corundum
5. Apatite	10. Diamond

Thus if a mineral is scratched by feldspar but not by apatite, its H = 5.5. It is known as the Mohs' scale of hardness after its originator Friedrich Mohs (1773–1839), German mineralogist, who first revealed it in 1812.

In the determination procedure it is necessary to observe whether the known species is harder and is actually producing a groove, or whether it is softer and is itself being abraded by the unknown to leave a removable mark. If the unknown species is fine grained, friable or pulverulent, the scratch test may only loosen grains from the aggregate without testing the individual mineral surfaces; thus certain textures or aggregate forms may hinder or prevent a true hardness determination.

As supplements to the mineral scale there usually are added: fingernail, 2+; copper penny, about 3; pocketknife blade, 5+; ordinary window glass, 5.5; and steel file, 6.5. (E. W. HH.)

MOHUN, CHARLES MOHUN, 4TH BARON (1677–1712), duelist, son of the 3rd baron Mohun (who died in 1677 as the result of a wound received in a duel), mas born in London on April 11, 1677. The boy had no regular guardian and before he was 15 had become notorious for rowdyism, had fought a duel and had been tried on a charge of murdering William Mountfort, the rival of his friend Richard Hill, who was in love with the actress Mrs. Bracegirdle. By an overwhelming majority he was found not guilty by his peers. This verdict has been severely criticized, notably by Thomas Macaulay. In 1699 Mohun was tried for another alleged murder but was acquitted unanimously. His boon companion, Edward Rich, earl of Warwick (1673–1701), who was tried on a separate indictment for the same crime; was found guilty of manslaughter. In 1712 Mohun forced the 4th duke of Hamilton, with whom he had been at law for some years, into a desperate duel in Hyde Park in which both combatants were killed (Nov. 1j). Thackeray has made use of this incident in *Henry Esmond*.

On Lord Mohun's death the barony, created in 1628 in favour of his great-grandfather, John Mohun (*c*. 1592–1641), became extinct.

MOHUN, MICHAEL (*c*. 1625–1684), English actor, played at the Cockpit in Drury Lane before the Great Rebellion. He

served in the king's army and emigrated. At the Restoration he returned with Charles II and played a great variety of parts, usually as second to Charles Hart.

MOI, a name used collectively for the hill tribes of Tongking in Indochina who are probably of mixed race with Mongolian, Indonesian and Caucasian blood. Generally speaking their polity is one of pure democracy, the chief, if any, being elected. In marriage patrilineal endogamy is reported to be the rule, though exogamy is permitted in some groups. There are traces of polyandry and of a matrilineal system of genealogy and inheritance. A man works for his bride in her father's house, and the heir of a dead man marries his widow.

The Moi seem to be Buddhist by religion but venerate stones. The dead are in some places buried, in others exposed on platforms. Trial by ordeal takes the form of a diving test to see which can stay under water the longest. Like the Karens they have a quasi-biblical legend of the creation, and they have a legend about Amazons who smelt copper. They shave the heads of their children habitually, and their own when in mourning, a trace, perhaps, of Hindu influence. Their medicine men practise legerdemain and cure sickness by "extracting" the cause in the form of "dirt."

The tribes have separate buildings for the unmarried, and the approaches to their villages are made under tunnels of thorn which can be cut down to block the way. They use a flexible sawing thong to make fire, piston bellows, the gourd organ and as weapons the crossbow and the gun arrow—both may be used with poison.

MOIRE. A textile fabric possessed of a distinctive watered or shaded ribbed effect produced by various methods of finishing. A moire or watered finish is generally applied to fine ribbed silk fabrics of the poplin type, though similar effects are also sometimes produced in cotton fabrics. Although a ribbed weave is more conducive to the development of a moire or watered effect, similar effects can also be obtained with other weaves in fabrics of comparatively close and firm texture, and more especially in those produced from silk, artificial silk and mercerized cotton. The moire effect results entirely from the varying angles at which the rays of light are reflected from the surface of the fabric.

Moire effects are produced from two distinctly different methods of finishing. One of these produces the true moire effect, known as "moire antique" and "moire Anglaise," which is a purely physical phenomenon. This moire antique effect is obtained by first damping the material and folding it with the face side inward, and with the two selvages running together side by side. The cloth is then passed between heated cylinders under considerable pressure. This is the more permanent of the two styles. The second is an imitation produced mechanically by means of engraved copper rollers. (H. N.)

MOISSAN, HENRI (1852–1907), French chemist, winner of the 1906 Nobel prize in chemistry for his isolation of the element fluorine and development of the Moissan electric furnace, was born at Paris on Sept. 28, 1852. He was educated in Edmond Fremy's laboratory at the Musée d'Histoire Naturelle and attended lectures by E. H. Sainte-Claire Deville and Henri Debray. He received his doctoral degree in 1885 with a thesis on the cyanogen series. In 1879 he was appointed to a junior post in the Agronomic institute, Paris, and was subsequently professor of toxicology (1886) and of inorganic chemistry (1889) at the school of pharmacy and at the Sorbonne, of inorganic chemistry (1900). He was awarded the Lacase prize in 1887. He died in Paris on Feb. 20, 1907. Moissan often said "Fluorine has shortened my life ten years."

Moissan's first research was on a biological problem and dealt with the inrerchange of oxygen and carbon dioxide in leaves, but he soon went over to inorganic chemistry. His early work in this field was on the oxides of the iron group metals, and of chromium; he also made a careful study of the chromous salts. In 1884 he turned to the study of fluorine and prepared several new compounds, including phosphorus and organic derivatives. In 1885 he found that potassium fluoride could be dissolved in certain proportions in liquid hydrofluoric acid to give a solution which conducted electrolytically and which remained liquid at low temperatures. A year later by electrolyzing this solution in a platinum tube using platinum-iridium electrodes he obtained for the first time the highly active fluorine gas. He made a full study of the properties of the gas and of its combinations with other elements.

In 1892 Moissan developed the electric arc furnace as a means of obtaining high temperatures for experimental work. By its aid he prepared many new compounds, especially carbides, silicides and borides, and melted and volatilized substances which had previously been regarded as infusible. His claim to have prepared tiny artificial diamonds (see GEM: Synthetic Gems) by cooling rapidly a solution of carbon in molten iron was not confirmed. He discovered the abrasive carborundum (silicon carbide) but this method was not suitable for commercial production. He studied the chemistry of the carbides and the action of water on them, and was led by the results to suggest that petroleum formation may be caused by a similar process occurring in the earth. Moissan also prepared the hydrides of calcium. sodium and potassium, finding them to be nonconductors of electricity.

He was one of the best scientific lecturers in Paris. He was a skilled experimenter and insisted that his laboratory be immaculate. Even a few drops of water on the floor brought a rebuke.

Moissan's published works include Le Four *électrique* (1897) and Le *Fluor* et ses compose's (1900), besides numerous papers. A *Traité* de chimie *minérale* (5 vol.) was published under his direction in 1904–06.

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MOISSI, ALEXANDER (1879–1935), Austrian actor, was born on April 2, 1879, at Trieste on the Adriatic sea. His father was Albanian, his mother Italian. While taking voice lessons in Vienna, Moissi had the opportunity (frequently as a supernumerary) to study the acting technique of Josef Kainz, the star of the Imperial Burgtheatre, whom he was to emulate first in Prague then at Max Reinhardt's Deutsches Theatre and Kammerspiele in Berlin. During World War I, Moissi was interned in Switzerland. After his release in 1917 he became associated once again with Reinhardt's enterprises in Berlin and Vienna.

In 1920, when the Salzburg festival was initiated, he was the first Jedermann in Hugo von Hofmannsthal's version of the old morality play. But his greatest parts remained Fedja in Leo Tolstoi's The Living Corpse, Oswald in Henrik Ibsen's Ghosts, Hamlet, Oedipus and Montezuma in Gerhart Hauptmann's Der *weisse* Heiland—roles in which the neuroses of a melancholiac could be expressed in terms of vocal lyricism.

Moissi died in Vienna on March 22, 1935. **(A.** M. N.)

MOJAVE DESERT, an arid region of eastern California, United States, lying north of the San Gabriel-San Bernardino mountains and extending from the southern Sierra Nevadas to the Colorado river valley, south of latitude 36°. Southeastward it merges into the Yuma desert. The area has typical mountain-and-basin topography: steep rugged mountains rise abruptly above broad basins floored smoothly with sand and gravel and draining to central salt flats.

Summer days are hot (maxima over 100° F.); winters have warm days (50°–60° F.) and cold nights (15°–30° F.). Frosts are common in winter and snow occasionally falls. Annual rainfall averages less than five inches.

In the basins, vegetation consists of widely-spaced low shrubs, especially creosote bush (Larrea tridentata) and burroweed (*Franseria dumosa*). Cacti occur sparingly on south-facing rocky slopes. Higher areas have thicker brush and some stands of weird Joshua trees (Yucca brevifolia). The highest mountain ranges have open woodlands of pinyon and juniper.

The northern portion is grazed by cattle. Various chemicals are extracted from the salt flats and there is some mining. The southwestern part, adjacent to Los Angeles, is undergoing rapid urban and recreational development. (R. F. LN.)

MOJI, a Japanese port and industrial city, Fukuoka prefecture, an important part of the northern Kyūshū heavy industrial belt, is in northeastern Kyūshū on Shimonoseki strait, 33° 56' N., 130°

58' E. Throughout most of its history, Moji was an insignificant fishing village, although it is credited by Japanese mythology as being the place where Korean kings paid tribute in prehistoric times and it was the site of an 11th-century fort when the Taira clan fought their last battle with the Minamoto clan. After it became the ferry terminus of the Kyūshū railway in 1887, it grew rapidly.

In 1942, Moji and Shimonoseki (on Honshu) were connected by the Kammon railroad tunnel 11,854 ft. long, of which one-third was under Shimonoseki strait; this was followed in 1958 by a double-deck motor tunnel. Pop. (1955) 145,027; area 25 sq.mi.

(C. A. MR.)

MOKANNA (*al-Moqanna'*, the Veiled), the name given to Hakim, or 'Ata, a man of unknown parentage, originally a fuller in Merv, who posed as an incarnation of deity, and headed a revolt in Khurasan against the caliph Mahdi. For about three years he sustained himself in the field against the troops of the caliph and for two years longer in his fortress of Sanam. Then, reduced to straits in 779, he and his followers took poison and set fire to the fortress. He is a hero of Moore's Lalla Rookh.

MOKHA (MOCHA, Arabic *al-Makha*), a town of Yemen, on the Red sea coast, 13° 19′ N. and 43° 12' E. Formerly the chief port for the Yemen coffee export, it diminished in importance. The coffee grown in the mountain districts of Haraz, 'Udain and Ta'izz is now shipped at Hudaida or Aden, though the article retains the trade name of "Mocha."

The town lies in a small bay 40 mi. N. of Perim at the southern entrance to the Red sea. The neighbouring country is an arid plain, the town being supplied with water by an aqueduct from the village of Mawza', situated 16 mi. E. This is probably the Muza of the Periplus, a great seat of the Red sea trade in antiquity, which like other old Tihama towns, formerly seaports, has long since been left by the receding sea.

MOKP'O, a port and city at the southwestern tip of Korea, became a thriving commercial seaport after its opening in 1897. The deep harbour is well sheltered by peninsulas and islands. Rail lines connect hlokp'o to the inland areas and make the port a major commercial centre of southwest Korea.

The industries of the city are rice milling, cotton ginning, brewing, fish processing and vegetable oil milling. Pop. (1960) 129,667. (S. McC.)

MOKSHANY, an agricultural town of the Russian S.F.S.R., U.S.S.R., in the Penza oblast, in 53° 25′ N., 44° 35' E. Population 9,786. Mokshany was built in 1535 as a fort to protect the country from the raids of the Tatars and the Kalmucks and is supposed to occupy the site of the hleshcheryak town of Murunza, mentioned as early as the 9th century.

MOLASSES, the sirup obtained from the drainings of raw sugar or from sugar during the process of refining. In U.S. usage the word usually applies to both forms of the sirup, but in English usage the second form is more usually known as "treacle" (see SUGAR).

The word, which in early forms appears as *melasses, molassos,* etc., is from the Port. *melaço,* or Fr. *mélasse, cf.* the late Lat. mellaceum, syrup made from honey (mel). The geological term "molasse" (Lat. *mollis*) is applied to the soft greenish sandstone of the district between the Jura and the Alps.

MOLAY, JACQUES DE (c. 1243–1314), last grand master of the Knights Templars, was born at Molay (Haute-Saône). He entered the order in 1265 and served in Syria. About 1295 he was elected grand master of the order. After the Templars had been driven out of Palestine by the Saracens, Molay took refuge with the remnant of his followers in Cyprus. There he received a summons (in 1306) from Pope Clement V to go to Paris. He was there when, on Oct. 13, 1307, every Templar in France was arrested on the orders of King Philip IV, and a prolonged examination of the members of the order was held.

When examined by officers of the French king, who probably used torture, Molay confessed his personal guilt and that of his order; when examined by papal agents, however, he retracted his confessions and asserted his and his order's innocence. Thus he confessed on Oct. 24 and 25, 1307, retracted in Feb. 1308 and confessed again in the following June. When he was again examined in Nov. 1309, broken in spirit, he would neither repeat his confessions of guilt nor defend his order. But when, after years of captivity, he was sentenced to life imprisonment he vigorously proclaimed the innocence of the Templars. At the king's command he was thereupon burned at the stake, as a lapsed heretic, on March 19, 1314.

See works cited under TEMPLARS; also E: Besson, *Étude sur Jacques de* Molay (1877); G. Lizerand, "Les Dépositions du grand maître Jacques de Molay au proces des Templiers," *Moyen Age* (1913).

MOLD (formerly Mould, Welsh Yr *Wyddgrug*), a market town and urban district in the West Flintshire parliamentary division of Flintshire, in the fertile Alyn valley of North Wales, 11 mi. W. of Chester by road. Pop. (1961) 6,857. Area 1.8 sq.mi. Bailey hill, at the northern end of the town, was an early fortification, and in old records the fort was known as Moaldes, Monhault or Monthault (de monte alto). Maes Garmon ("the battlefield of Germanus"), associated with early Christian legend, is about a mile west of Mold. Mold castle, probably built by Robert Monthault in the time of William Rufus, often changed hands in Welsh border warfare.

Mold is the centre of a coal mining district. Daniel Owen, leading Welsh novelist of the 19th century, was born there.

MOLDAVIA (Rumanian MOLDOVA, Hungarian MOLDVA, Polish MULTANY, Turkish BOGDAN), one of the two historic Rumanian principalities which until 1812 included Bessarabia (*q.v.*). After its union with Walachia on Nov, 9, 1859, it became a part of the kingdom of Rumania (*q.v.*).

MOLDAVIA, one of the Soviet Socialist republics of the U.S.S.R., carved out in 1940 from the Rumanian province of Bessarabia and the former Moldavian X.S.S.R. It is bounded on the west by Rumania and on the north, east and south by the Ukraine.

Physical Geography.— Central Moldavia is a plateau rising to 1,400 ft. and extending westward beyond the Prut river along which runs the Soviet-Rumanian frontier. Its northern part is the treeless Balti steppe, and to the south lies the dry Bugeac (Budzhak) steppe, both covered with rich, black earth. The republic has a warm climate with a mean annual temperature of 50° F. Annual rainfall is from 16 to 20 in.

History.— The Moldavian A.S.S.R. was created on Oct. 12, 1924, as part of the Ukrainian S.S.R., a Soviet protest against the recovery of Bessarabia by Rumania (*q.v.*). In 1933 it had a population of 615,000, including 48.5% Ukrainians, 30% "Moldavians" and 12% Jews. Its area was 3,243 sq.mi. Its capital was Balta (pop. 21,712); in 1928 the capital was moved to Birzula (Kotovsk) (pop. 10,748) and later to Tiraspol (pop. 25,748).

When in 1940 Rumania yielded to a Soviet ultimatum and ceded Bessarabia to the U.S.S.R., the Soviet government formed a Moldavian S.S.R. which comprised the major part of Bessarabia. Three Bessarabian districts and also the greater eastern part of the Moldavian A.S.S.R. were attributed to the Ukraine. In June 1941 the Rumanians, fighting as Germany's allies, reincorporated into Rumania the whole of Bessarabia, but the Soviet armies reconquered it in the autumn of 1944 and the Moldavian S.S.R. was restored.

The Paris peace treaty with Rumania (Feb. 10, 1947) recognized the 1940 Soviet-Rumanian frontier. Political control in Moldavia remained in Russian hands. By Sept. 1, 1952, the Moldavian Communist party had 37,466 members, of whom 25% were "Moldavian"-speaking.

Area and Population.— The area of the Moldavian S.S.R. is 13,012 sq.mi., with about 1,600 sq.mi. on the left bank of the Dniester, the pre-1940 Soviet-Rumanian frontier. In 1941 the total population, most of whom were Orthodox, was estimated at 2,700,000, including 1,755,000 Rumanians (65%), 270,000 Ukrainians, 17,500 Russians and 290,000 Jews.

After World War II the Rumanian population was resettled in the Astrakhan and Rostov provinces of the R.S.F.S.R. and Kazakhstan. By mid-1955 it was estimated that 500,000 Rumanians had been deported. In 1959 the population of the republic was 2,583,477.

The capital of Moldavia is Chisinau (Kishinev) on the Byk

river: in 1959 it had a population of 217,096. Other towns are: Balti (Byeltsy), Tighina (Bendery), Orheiu (Orgheyev), Soroca (Soroki), Cahul (Kagul) and Tiraspol.

By 1951 the republic had 1,920 primary, vocational and secondary schools with 422,000 pupils, and a state university. The "Moldavian" language was written in the Cyrillic alphabet.

Economy. — The climatic conditions of the republic are especially suitable for the cultivation of vines, tobacco, sugar beet, cotton and maize, as well as for fruit growing. About 4,980,000 ac. of arable land were in cultivation in 1950, including 3,700,000 ac. under grain, 667,000 ac. under cotton and other industrial crops. and 280,000 ac. under vineyards. Wine and sugar production, food canning, fruit drying and cotton and wool spinning were the chief industries. (K. SM.)

MOLDAVITE: *see* TEKTITE.

MOLDENKE, RICHARD GEORGE GOTTLOB (1864–1930), **U.S.** metallurgist who was an authority on cast iron and malleable castings, was born at Watertown, Wis., on Nov. 1, 1864. Graduated from Columbia university, New York city, with a Ph.D. degree in 1887, Moldenke became a consultant to many foundries in the United States and other countries. His research, including studies on cupolas and coke, led to important advances in the industry.

In 1917 he published *The Principles of Iron Founding*, 2nd ed. (1930). Moldenke died at Plainfield, N.J., on Nov. 17, 1930.

MOLDING, in architecture and the decorative arts, is a transitional or terminal element usually appearing horizontally in a cornice, architrave, or capital or curved in an arch. A molding is a modeled surface, most frequently a band and approximately continuous, with a constant profile or one with rhythmically repeated elements.

Moldings doubtlessly originated in prehistoric building, where they served specific structural functions. As monumental architecture developed, moldings were gradually translated from wood or other ephemeral materials into more permanent ones, most often stone. In this gradual transition moldings were retained as a matter of conservatism or taste; in stone they were elaborated and refined, contributing order and richness to a decorative system. Although their original structural function was satisfied by other means, moldings were used in a manner that implied a structural logic. From this usage, best characterized in the orders of architecture of ancient Greece, it was possible later to develop theories for the correct form and employment of moldings, according to which several basic shapes were standardized in the vocabulary of architectural design.

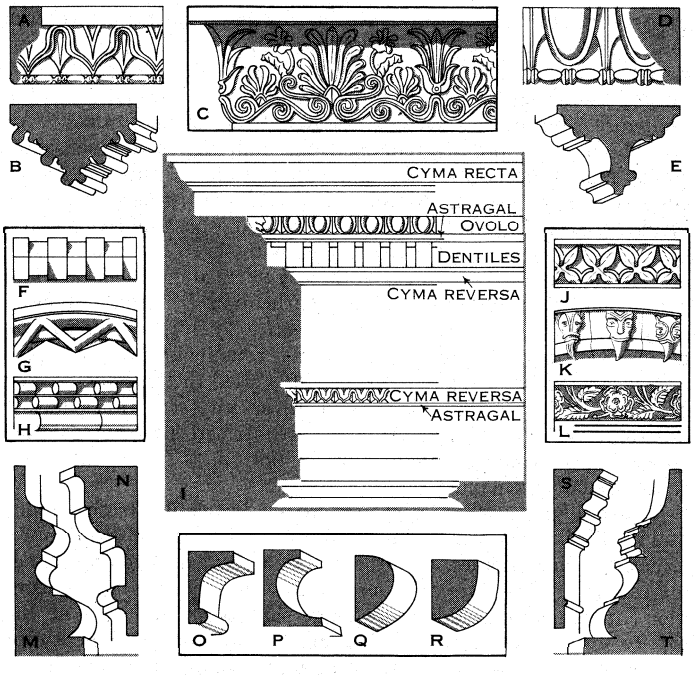
See ORDER.

TYPES OF MOLDING

Flat or Angular. — (1) The facia, face or band is a continuous member with a flat surface, parallel to the surface it ornaments and either projecting from or slightly receding into it. (2) Fillet, listel or regula are terms for a relatively narrow band, usually projecting, commonly used to separate curved moldings or to finish them at top or bottom. (3) Bevel or chamfer molding is an inclined band. facia or fillet. (4) A splay is a large bevel.

Single Curved. — (1) The cavetto is a concave molding with a profile approximating a quarter-circle, quarter-ellipse or similar curve. (2) Scotia molding is similar to the cavetto, but has a deeper concavity partially receding beyond the face of the general surface which it ornaments. (3) A flute is a small groove of semicircular, segmental or similar section. (4) Ovolo, a convex molding, has a profile approximating a quarter-circle or quarter-ellipse. (j) Torus, a convex molding, approximates a semicircle or semiellipse. (6) Roll or bowtell molding is convex, approximating three-quarters of a circle. (7) An astragal is a small torus, often with fillet attached below. (8) Apophyge molding is a small exaggerated cavetto.

Compound. — (1) The cyma recta, a projecting molding, consists essentially of a cavetto above an ovolo, forming in profile one continuous double curve, often used as a crowning member, in which case it is sometimes known as a cymatium. When used as a base the convex portion is uppermost. (2) The cyma reversa or ogee. a projecting molding essentially a reversed cyma recta with ovolo above cavetto, is used for a crown or a base. (3) Bird's beak or thumb molding is essentially similar to the cyma reversa, except that the upper convexity is separated from the lower concavity by a sharp edge. (4) Keel molding is a projection consisting of a roll molding with a small fillet attached at its outermost surface.



SOME TYPES OF MOLDING

(A) Greek cyma reversa with the water leaf; (C) Greek cyma recta with anthemions; (D) Greek ovolo with egg and dart; (I) classic entablature; (M, N) Roman base and capital; (S, T) Greek base and capital; (F) Byzantine dentil: (G, H, J, K) Romanesaue; (B, L) English Gothic; (E) Elizabethan; (O) cavetto and torus; (P) scotia; (Q) torus; (R) ovolo

HISTORY

The basic forms of molding developed largely in the classical architecture of ancient Greece, although there were some similarities in pre-Greek architecture. They persisted with modifications in the main stream of architectural development in the western world.

Pre-Greek Architecture. — The most conspicuous early use of moldings in architecture occurred in Egypt, probably by 3000 B.C. There; building having progressed from reeds and mud to stone, walls were usually crowned with a cornice consisting of a cavetto underlined with a small torus. The torus was usually painted to represent reeds tied together, and the cavetto with a series of vertical forms suggesting the tops of reeds used as walling. In Mesopotamia the typical brick wall construction produced an architecture in which moldings were practically absent.

Archaeological evidence has indicated that moldings appeared on Hittite columns and the arched portals of the Assyrians. In ancient Persia the shafts of columns were ornamented with flutes and the capitals with moldings of floral inspiration. In Aegean architecture the ovolo was used in the capitals of columns at Cnossus (c. 1500 B.C.) and Mycenae (c. 1200 B.C.) in much the same way as the echinus of the later Greek Doric column.

Greek Architecture. — The Doric was the first and simplest order of architecture developed by the Greeks; its essential elements having taken permanent form by the end of the 7th century B.C. In the Doric order, moldings still retained much of their original structural appearance, being restricted largely to a variety of facias and a cymatium in the cornice. Most attention was given to refining the bulging elliptical profile of the echinus (an ovolo) of the capital of the column, which by the 5th century B.C. had become almost a straight line.

The Ionic order was also fully developed, through the Ionians

of Asia Minor, by the 5th century. There the angularity of the Doric yielded to the plastic surface; curved moldings predominated, adding sculptural richness to the total effect. And the curved moldings themselves were enhanced, especially in the Hellenistic period, by carving inspired from natural forms. Although the basic profiles remained, the moldings were given additional names descriptive of their decoration. Thus the simple tubular astragal became the bead and reel, consisting of elliptical beads separated by disklike reels. The ovolo became the egg and dart, consisting of ovoid solids framed with sharp ridges of similar curvature. separated from each other by vertical dart shapes. The cyma recta was adorned with the anthemion (a stylized honeysuckle or palmette) or the acanthus leaf. The cyma reversa was enriched by a repetition of leaf forms, tonguelike in appearance and separated by slender stems, usually called the leaf and tongue or tongue and dart molding. The torus was sometimes fluted. horizontally, or carved in guilloche, an intricate pattern of interlacing bands winding around circular buttons. The cavetto and scotia usually remained undecorated.

The moldings of the Corinthian order were similar to the Ionic; and in all three orders moldings were often painted. Furthermore, Greek molding profiles were characterized by a constantly changing radius of curvature and were usually quirked. having the convex (or concave) moldings brought sharply in (or out) at the top to emphasize shadow. Subtlety of profile and delicacy of carved detail were characteristic of Greek molding.

Roman Architecture. — Moldings in Roman architecture, based on modifications of the three Greek orders plus the Tuscan, were more vigorous and robust in appearance. Although the basic profiles and decorative systems were retained, the moldings suggested the work of the engineer more than the sculptor. The curves were often determined mechanically, and the standardized details revealed some quality of mass production. Nevertheless, the tendency was toward greater richness, and among new surface decorations were stylized fish scale or imbrications, spiral rope moldings, rows of flat vertical leaves and others.

Early Christian and Byzantine Architecture. — Classical forms in architecture persisted for several hundred years after the decay of Rome in the 4th century. In early Christian churches secondhand Roman moldings and other details were often used in combinations violating the strict canons of classical composition. Similar naïveté or decadence was especially apparent in the Syrian churches of the 5th and 6th centuries, where moldings were usually in the form of a large torus draped like a heavy ribbon, alternately horizontal and vertical, in one sinuous line, without regard for the original logical arrangement.

Likewise in Byzantine architecture. from the 6th century on, moldings were reduced to their simplest elements and used sparingly. The articulation of moldings on wall or entablature was less favoured than broad, smooth surfaces of rich inlaid materials. Moldings were often reduced to two-dimensional patterns; the molded entablature block over the column was simplified to an inverted truncated pyramid (the dosseret), with carving in low relief.

Basic Byzantine forms were perpetuated in the medieval architecture of Greek and Slavic lands. They persisted through the 16th century in Russia, where the principal molding was a large, bold torus ornamented with stylized animal and vegetable figures; the simple curvature of an arch was often interrupted by sharp angles with similar designs. In these derivative styles moldings assumed a purely decorative character.

Islamic Architecture. — Roman and Byzantine forms were adopted as the architecture of Islam, which lacked a national building tradition. Thus the variety in Moslem architecture depended on the pre-existing architecture of conquered provinces, and moldings were used according to local traditions. The most conspicuous instance was the revival and perpetuation of Byzantine architecture by the Ottoman Turks, from the 16th century on. In the eastern expansion of Islam, however, Persian influence predominated over Byzantine, and moldings were further reduced in favour of smooth decorated surfaces.

This development culminated in the 17th century in India, in such structures as the Taj Mahal at Agra, where small moldings appeared with considerable delicacy and originality. The Moslem architecture of India was little influenced by the earlier Indian style.

India and the Far East. — Although early architectural decoration in India was related in some degree to Greek prototypes, the Buddhist and Hindu artistic traditions were largely an independent development. The decorative system requires a vocabulary of its own, although it can be described approximately in classical terms. The molding forms most frequently used were similar to the facia, bevel, ovolo (inverted) and torus. Usually large in scale and frequently carved with natural leaf forms, they were characteristically composed in layers with sharp shadow lines, producing a stacked-up, sculptured effect. Similar compositions occurred in southeastern Asia.

In China and Japan the prevalent use of wood reduced the role of moldings to the decoration of masonry bases for walls and columns, where a simple torus was often undercut to produce a powerful line of shadow.

Pre-Columbian Architecture. — The architecture of America before Spanish conquest in the 16th century also requires descriptive terms of its own. However, the stone moldings most commonly appearing in Mayan, Toltec and Aztec art approximate the basic classical profiles. Base courses and cornices were often large sweeping bevels. Broad facias were used to frame panels of abstract geometrical sculpture or stylized animal forms. Similar decorative bands — sometimes horizontal, sometimes crenelated — provided the major articulation of large wall surfaces. Survivals of this decorative tradition gave a strong indigenous stamp to later Spanish buildings.

Romanesque Architecture. — In western Europe basic Roman forms persisted into the 11th and 12th centuries, the Romanesque period. Through crudity of technique, moldings tended to be robust and simple, consisting chiefly of roll moldings on the edges of arches, and of cavettos and cyma reversas in cornices and in the capitals of columns. However, innovations and variations appeared in the regional schools of Romanesque architecture. In Tuscany and Provence the nearest approximation of antique classical forms obtained. In Lombardy moldings (often brick) were enriched with spirals and other geometrical forms reminiscent of barbarian jewelry.

In the Norman Romanesque of France and England the classical shapes were broken with zigzags and chevrons, or studded with little pyramids and birds' heads. There were such varieties as the billet molding, being a torus broken into small separated sections, and the rope or cable molding, a spirally carved molding that resembles a rope. Many of these details were originally accentuated in brilliant colours.

Gothic Architecture. — The old forms were further modified in the Gothic period, extending from the 13th through the 15th centuries. The new structural system based on the ribbed groin vault and pointed arch provided new opportunities for an integral decorative system. Keel moldings on arches and ribs became standard. The cyma, cavetto and torus were used in cornices and capitals, but with increasing exaggeration and originality in form, and often decorated with crockets. In the late, or flamboyant, Gothic of the continent there was the greatest variety of moldings, composed with alternations of sharply projecting members and deep shadows, often interpenetrating in complex tracery patterns.

In the early Gothic of England, especially the Decorated period, forms were more complicated, the moldings consisting of a combination of basic forms worked into one deeply undulating profile; while later, in the Perpendicular period, a general simplicity and flatness was common. Richness was provided by carvings of vine patterns, or repetitions of rosettes (or the Tudor rose), square blocks or heraldic insignia. In the late Gothic period, on the continent as in England, many forms of stone moldings were adapted to timber framing and wood paneling.

Renaissance and Baroque Architecture. — Roman classical forms were revived in Italy in the 15th century and soon transmitted to all western Europe. In the early Renaissance there were

some compromises with vestiges of medieval forms; in the 16th century the strict rules of classical usage were well understood. However. by the late 16th century, especially in the work of Michelangelo, moldings were treated with a strong sense of sculptural plasticity and freedom in composition, which led to the inventiveness of the baroque. The qualities of the baroque depended on compositions in curving lines and receding surfaces, integrated with sculpture and colour. They attained their greatest richness in the Spanish churrigueresque style, especially in Mexico, and greatest delicacy in the decorative arts of the Louis XV style in France.

Reaction to the exuberance of the baroque came in the 18th century, from the prestige of official art academies, when the return to strict classical forms inevitably led to the imitative neoclassical style.

The 19th and 20th Centuries. — The romantically inspired neoclassical style of the 19th century initiated a general eclecticism, in which moldings appeared in classical. medieval, oriental or Renaissance style, or in combinations of them, not only in stone and brick, but in plaster, wood and cast iron.

Out of this stylistic confusion of the Victorian period came the search for new and appropriate forms, notably in the work of Louis Sullivan (U.S.). Moldings were once again inspired directly from nature, especially the nature of the building materials concerned, and used according to structural or functional logic. This provided a new aesthetic for modern architecture, in which classical or other historical moldings have disappeared. Modern moldings, whether in uood, masonry or metal, have generally acquired the simpler forms of functional structural elements and a correspondingly limited use.

In traditional carpentry, however, the basic classic profiles have survived as standard manufactured moldings with a descriptive vernacular nomenclature, including apron, base, beak, bed. bolection, chain, crown, dentil, drop, edge, flush, lip, neck, panel. paternoster, pellet, reeding, roll, scroll, shoe, thumb, tooth, wave and zigzag moldings.

See also ORNAMENT, ARCHITECTURAL; CAPITAL; DOGTOOTH; JOINERY. (E. A. C.)

MOLÉ, LOUIS MATHIEU, COMTE (1781–1855), French statesman. was born in Paris on Jan. 24, 1781. His father, a president of the *parlement* of Paris, was guillotined during the Terror, and Molé's early days were spent in Switzerland and in England with his mother, a relative of Lamoignon-Malesherbes. After his return to France Napoleon attached him to the staff of the council of state, and subsequently gave him many high offices. Except for a short term of office as minister of marine he was in opposition under the Restoration. He was foreign minister, without real power, for a few months in 1830, and in 1836 he became prime minister and foreign minister.

Personal and political differences rapidly arose between Molé and his chief colleague Guizot, and led to an open rupture in March 1837. Mole, supported by Louis Philippe, held his ground against the general hostility until the beginning of 1839, when the chamber was dissolved, but Molé resigned on March 31, 1839. After the revolution he sat in the constituent assembly, and in 1849 in the legislative assembly, where he was one of the leaders of the right until the *coup d'état* on Dec. 2, 1851, drove him from public life. He died at Champlâtreux (Seine-et-Oise) on Nov. 23, 1855.

See P. Thureau-Dangin, *Histoire de la monarchie* **de** *juillet* (1884–92); and Robert Cougny, *Dict. des parlementaires français* (1891).

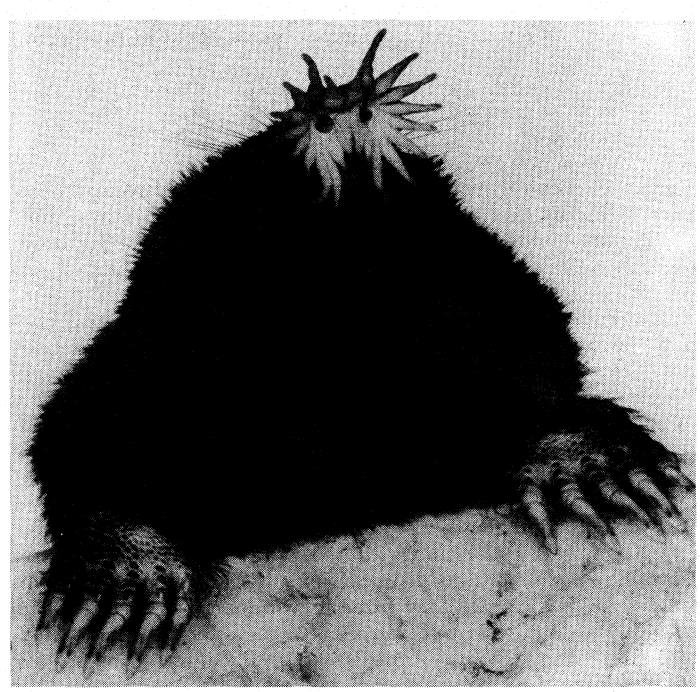
MOLÉ, MATHIEU (1584–1656), French statesman, son of Edouard Molé (d. 1614), who was for a time *procureur-général,* was educated at the University of Orleans. Admitted *conseiller* in 1606, he was *président aux requites* in 1610, *procureur-général* in succession to Nicolas de Bellièvre in 1614, and he took part in the assembly of the notables summoned at Rouen in 1617. He fought in vain against the setting up of special tribunals or commissions, to try prisoners charged with political offenses, and for his persistence in the case of the brothers Louis and Michel de Marillac he was suspended in 1631. In 1641 he was appointed the first president of the *parlement.*

In the long conflict between Anne of Austria and the *parlement,* Molé played a conciliatory part. In the popular tumult known as the day of the barricades (Aug. 26, 1648) he sought out Mazarin and the queen to demand the release of Pierre Broussel and his colleagues, whose seizure had been the original cause of the outbreak. Next day the *parlement* marched in procession to repeat Molé's demand. On their way back they were stopped by the crowd. "Turn, traitor," said one of the rebels to Molé, seizing him by the beard, "and unless you wish to be massacred, either bring back Broussel or bring Mazarin as a hostage." Many magistrates fled; the remnant, headed by the intrepid Molé, returned to the royal palace, where Anne of Austria was induced to release the prisoners.

Molé failed to prevent the outbreak of the first Fronde, but he negotiated the peace of Rueil in 1649. He refused honours and rewards for himself or his family, but became keeper of the seals, and therefore retired from the presidency of the *parlement.* He died on Jan. 3, 1656.

The *Mémoires* of Molé were edited by Aimé Champollion-Figeac, for the Societé de l'histoire de France, 4 vol. (1855) and his life was written by Baron A. G. P. de Barante in *Le Parlement* et *la Fronde* (1859). *See* also the memoirs of Omer Talon and of De Retz.

MOLE, in zoology the name applicable to the common mole *(Talpa europaea),* a small, soft-furred, burrowing mammal, with minute eyes, and broad, strong forelimbs, adapted for digging, belonging to the order Insectivora and the family Talpidae. In a wider sense may be included under the same term the other old world moles, the North American star-nosed and other moles, the African golden moles of the family Chrysochloridae; and, in a still looser sense, to the Asian zokors, the African strand moles, belonging to the order Rodentia, and the Australian marsupial mole. The common mole is about 6 in. long, with a tail of 1 in. The body is long and cylindrical, and because of the forward position of the front limbs, the head appears to rest between the shoulders; the muzzle is long and obtusely pointed, terminated by the nostrils; the minute eyes are almost hidden by the fur; the ears are without conches, opening on a level with the surrounding skin; the forelimbs are short and muscular, terminating in broad, naked, shovel-shaped feet, the palms directed outward; the hind feet are long and narrow, and the toes have slender claws. The body is densely covered with soft, erect, velvety fur, generally black, with a grayish tinge. Albino and other colour varieties are known.



PHOTOGRAPH, LYNWOOD CHACE

STAR-NOSED MOLE (CONDYLURA CRISTATA) FOUND IN EASTERN CANADA AND NORTHEASTERN UNITED STATES

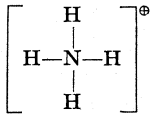
The food of the mole consists of earthworms, in pursuit of which it forms underground excavations. The mole is most voracious and, if deprived of food, succumbs in from 10 to 12 hours. Moles take readily to the water. The sexes come together about the second week in March, and the young—generally from four to six in number—are brought forth in about six weeks.

Much misconception has prevailed with regard to the structure of the mole's "fortress"; *i.e.*, the large breeding hillock, which is generally placed in bushes, or amid the roots of a tree; a good account, however, is given by Xdams (*Mem. Manchester Lit.* and *Phil. Soc.* 1903, vol. 47). Moles are disliked on account of the way in which they spoil lawns and pastures, and they destroy large numbers of the useful earthworm; but they are useful in aerating and turning the soil. The mole is the most important wild fur-bearing animal of the British Isles (see FUR).

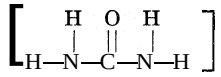
The word mole also refers to a mark or stain, and particularly a dark-coloured raised spot on the human skin. This word, O.E. *mál,* is probably cognate with Lat. *maculus,* "spot." Its meaning of stain is seen in the corrupted form "iron mold," properly "iron mole," a stain produced on linen or cloth by rust or ink.

Mole also denotes a large structure of rubble, stone or other material, used as a breakwater or pier (see BREAKWATER). This word comes from the Lat. moles, "a mass," "large structure.". The "Mole of Hadrian" is the mausoleum of that emperor, now the castle of St. Angelo at Rome, Italy

MOLECULAR REARRANGEMENTS are chemical processes which result in changes in the basic arrangements of bonds between atoms in molecules. A historically important example is the conversion of ammonium cyanate ($NH_4^{\oplus}OCN^{\ominus}$) to urea ($NH_2CONH_2$) which was discovered by F. Wöhler in 1828. Ammonium cyanate is an ionic substance, analogous to sodium chloride, comprised of positive ammonium ions having four hydrogens attached by covalent bonds to nitrogen

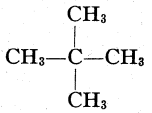


and negative cyanate ion with oxygen and nitrogen attached to carbon in a linear fashion $[O{=}C{=}N]^{\ominus}$. When ammonium cyanate is heated, the ammonium ion adds to the carbon-nitrogen double bond of cyanate ion and affords urea, a nonionic substance with a very different arrangement of bonds between the several atoms



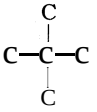
The ammonium cyanate–urea rearrangement is historically important as the first example of the conversion of a typical inorganic compound to a typical organic compound but is hardly representative of the types of molecular rearrangements of current interest.

Molecular rearrangements can be divided for practical purposes into two simple classes. In the first class are those rearrangements, such as the ammonium cyanate–urea conversion, which involve no change in molecular formula but only changes in arrangements of the chemical bonds between atoms. Since different chemical species with the same molecular formula are called isomers, this kind of rearrangement may be called isomerization—the conversion of one isomer to another. In the other class of rearrangements, the basic arrangement of the bonds between atoms in a molecule is altered as an adjunct to a substitution, elimination or addition reaction. Rearrangements of this latter type may be said to violate the customary working hypothesis of practicing organic chemists called the principle of minimum structural change. These concepts are well illustrated by specific examples from the clasiical researches of F C Whitmore on the reactions of neopentane and neopentyl derivatives. Neopentane has a central carbon atom bonded to four CH_3— or methyl groups, as they are commonly called.



neopentane

Substitution reactions are available for replacement of the hydrogens of the methyl groups of neopentane by a variety of different atoms or groups. The principle of minimum structural change suggests that such processes should not be accompanied by any change in the arrangement of carbon–carbon bonds in the neopentane skeleton.

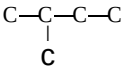


neopentane carbon skeleton

This is found to be true for many but not all substitution reactions. Thus, the following sequence of substitutions at one carbon of the neopentane molecule occurs without detectable rearrangement of the carbon skeleton.

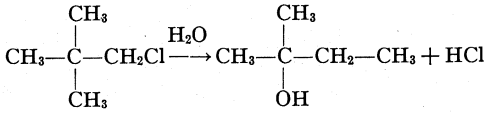
$$RCH_3 \rightarrow RCH_2Cl \rightarrow RCH_2MgCl \rightarrow RCH_2CO_2H \rightarrow RCH_2NH_2$$

(Here is abbreviated the $(CH_3)_3C$— part of neopentane to R, and RCH_3 is then neopentane.) However, other reactions and, particularly, all attempts to convert RCH_2Cl or RCH_2NH_2 to RCH_2OH give rearrangements of the neopentane skeleton and formation of substitution products of isopentane.



isopentane carbon skeleton

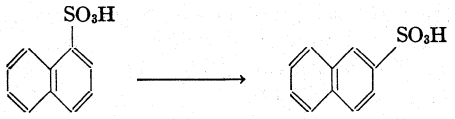
Thus,



Fortunately for the synthetic organic chemist, relatively few reactions result in carbon skeleton rearrangements so that it is usually possible to carry out a long sequence of transformations with reasonable assurance that the backbone of the molecule will remain unaltered. The neopentane system, however, is particularly prone to rearrange. This predilection for rearrangement can be used as a test for the general propensity of a given type of reaction to give rearrangement products according to whether or not rearrangement is observed with neopentyl derivatives. Cyclopropylcarbinyl derivatives, $(CH_2)_2CHCH_2X$, with X as the replaceable group, provide a still more sensitive test for possible rearranging substitutions since the carbon skeleton of such compounds is extraordinarily easily converted to that of the isomeric cyclobutyl derivatives $(CH_2)_3CHX$.

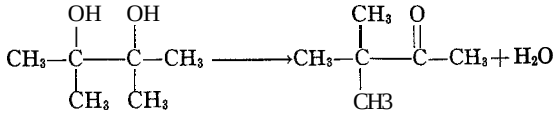
The classification of molecular rearrangements into isomerizations and rearranging substitution, elimination or addition reactions is one of practical convenience and can hardly be rigorous. Indeed, isomerization at some intermediate stage characterizes all substitution, elimination or addition reactions which result in a change in carbon skeleton. In practice, an over-all isomerization is usually easily recognized since the starting material and product have the same molecular formula but different physical and chemical properties. It is often much more difficult to establish that rearrangement has occurred in a substitution, elimination or addition reaction because there will be an over-all change in chetnical composition, as well as a change in physical and chemical properties.

An early example of a molecular rearrangement was the discovery by W. Brande (1819) and M. Faraday (1826) that naphthalene-α-sulfonic acid is isomerized to the β-isomer by heating.

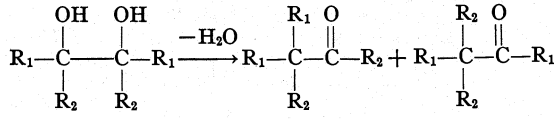


naphthalene-a-sulfonic acid naphthalene-β-sulfonic acid

An important general type of rearrangement was observed by R. Fittig (1860) when he found pinacol to be converted to pinacolone by elimination of water.

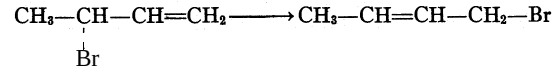


Much research has been done with symmetrically substituted pinacols to determine the relative "migration aptitudes" of various types of groups. Thus, for the reaction,



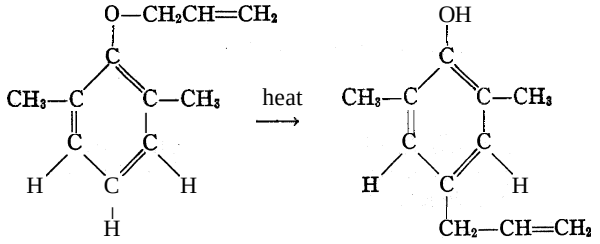
the ratio of the two possible products may be said to represent the ratio of the relative migration aptitudes of R_1 and R_2. Unfortunately ratios of migration aptitudes obtained in this way do not always carry over well to other types of rearrangement reactions.

The rearrangements discussed so far are all examples of "1,2-shifts" which can be written in the general form, R—A—B—X ⟶ X—A—B—R, where R and X are groups which exchange positions on the adjacent atoms, A—B. Many types of rearrangements are known involving shifts of groups between nonadjacent atoms. The facile isomerization of a-methylallyl bromide to y-methylallyl bromide is an example of a 1,3-shift.



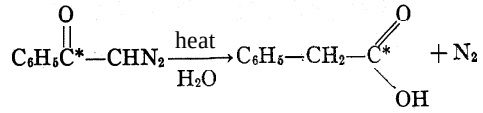
α-methylallyl bromide γ-methylallyl bromide

The para-Claisen rearrangement of 2,6-dimethylphenyl allyl ether is a 1,s-shift.



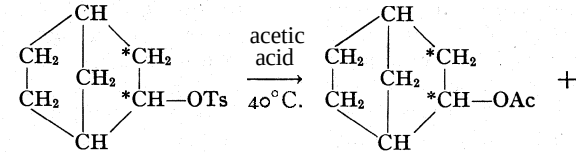
2,6-dimethylphenyl allyl ether 2,6-dimethyl-4-allylphenol

The study of molecular rearrangements has been greatly facilitated by the use of isotopic atoms as tracers to find out which atom of a starting material becomes a particular atom of the product. For example, isotopically labeled carbon has been used to show that the Wolff rearrangement of a-diazoketones to carboxylic acids actually proceeds with a change in carbon skeleton. In this case, carbon atoms of mass 13 (C^{13}) were used to label the carbonyl (C=O) carbon atoms of phenyl diazomethyl ketone to distinguish them from the other ordinary C^{12} carbon atoms in the molecule.

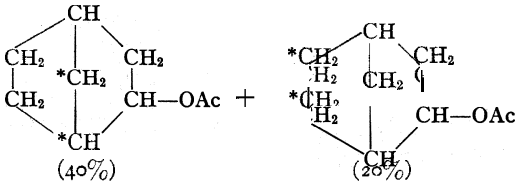


C^{13}-labeled phenyl diazomethyl ketone
(C* indicates position of labeled atom)

The reaction product was found to have all of the C^{13}-label in the carboxyl ($-CO_2H$) carbon as would be expected for a carbon-skeleton rearrangement. In some cases, the use of isotopic tracers has revealed very extensive carbon-skeleton rearrangements in reactions of which might otherwise appear to be simple substitutions. The substitution of an acetoxy group ($-OAc$) for the p-toluenesulfonate group ($-OTs$) of carbon-labeled norbornyl p-toluenesulfonate affords a striking example of substantial carbon-skeleton rearrangernent under exceptionally mild conditions.

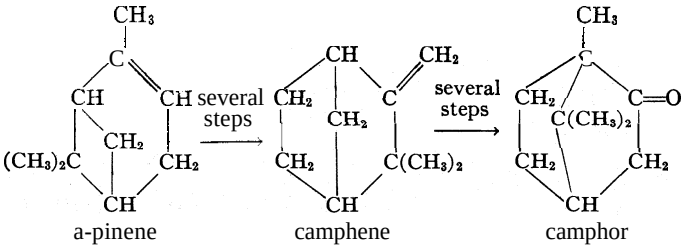


norbornyl p-toluenesulfonate (40%) normal product



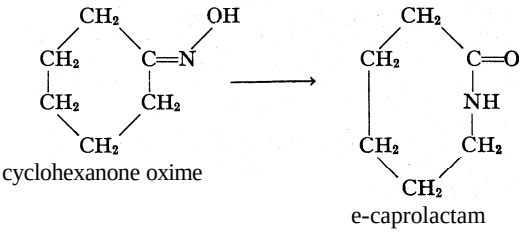
rearranged products

A number of molecular rearrangements are key steps in large-scale industrial syntheses. The conversion of a-pinene (derived from turpentine) to synthetic camphor by way of camphene involves a plethora of 1,2-shifts from carbon to carbon.



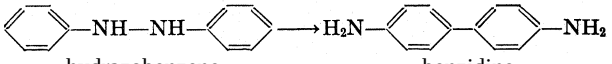
a-pinene camphene camphor

Rearrangement of cyclohexanone oxime to r-caprolactam is a simple 1,2-shift from carbon to nitrogen. The product is easily convertible into a high polymer



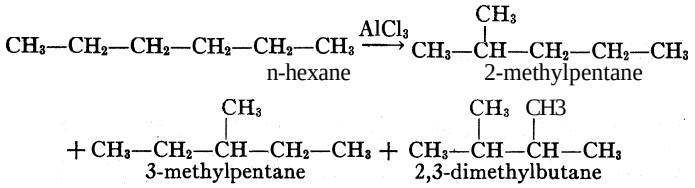
cyclohexanone oxime e-caprolactam

with nylonlike properties. Hydrazobenzene is isomerized by acid in a 1,10-rearrangement to benzidine which is a valuable dye intermediate.



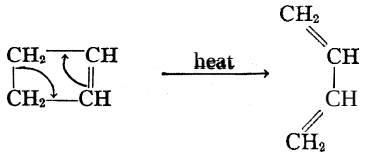
hydrazobenzene benzidine

Rearrangement of straight-chain petroleum hydrocarbons to their branched-chain isomers is carried out on a large scale as a means of upgrading gasoline for use in high-compression engines. Branched-chain hydrocarbons have superior antiknock properties as compared with the corresponding straight-chain compounds. Thus, the isomerization of n-hexane with the aid of aluminum chloride to a mixture of 2- and 3-methylpentanes and 2,3-dimethylbutane gives a large increase in octane rating since n-hexane has an octane rating of only 26, whereas the methylpentanes are near 70 and 2,3-dimethylbutane is 93.

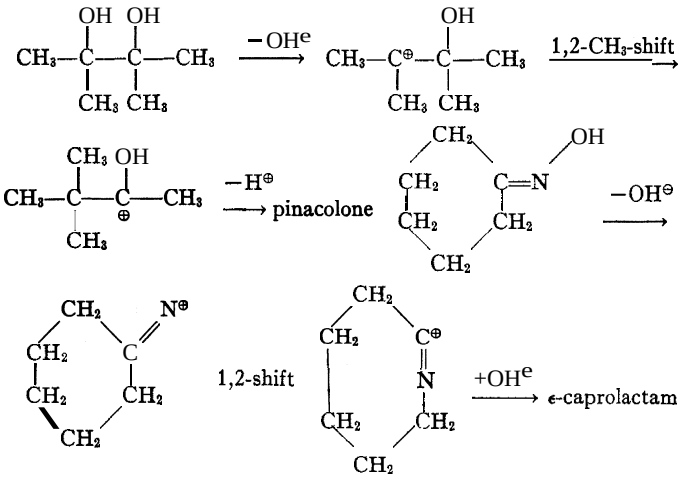


Much progress has been made in the study of the mechanisms by which molecular rearrangements take place. No one mechanism or type of mechanism will suffice for the correlation of all rearrangements. This conclusion is in accord with the finding that rearrangements may be induced by agents as diverse as strong acids, strong bases, free-radical catalysts, heat and electromagnetic radiation. Key steps for several types, given below, illustrate the difficulty of producing any satisfactory single theory of rearrangements as often attempted in the past.

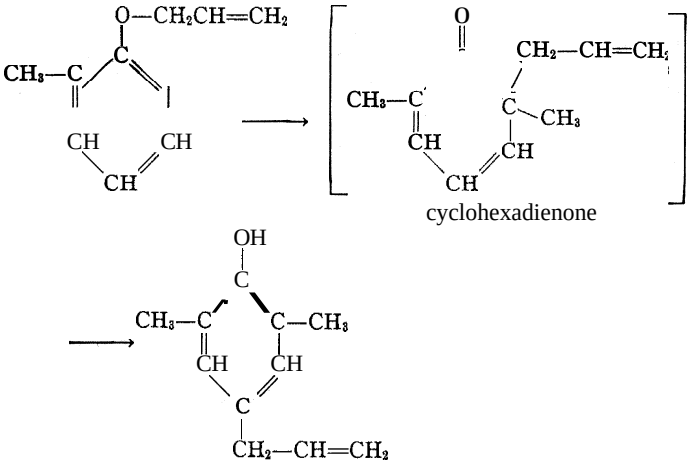
The conversion of naphthalene-α-sulfonic acid to the β-isomer is a dissociation–resubstitution process with naphthalene and sulfuric acid as the intermediates. The thermal isomerization of cyclobutene to butadiene is a simple monomolecular process involving merely a rearrangement of the bonds in the molecule.



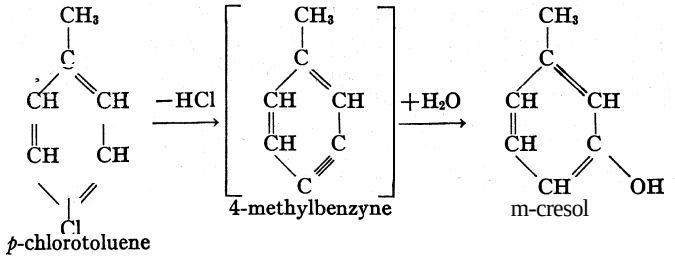
The pinacol–pinacolone and cyclohexanone oxime–caprolactam rearrangements involve loss of OH^{e} (with the aid of strong acid) and 1,2-shifts of the resulting cationic species.



The *para*-Claisen rearrangement has been shown to proceed by way of an unstable cyclohexadienone intermediate so that the over-all 1,s-shift is the result of two successive 1,3-shifts.



The formation of m-cresol from the high-temperature alkaline hydrolysis of p-chlorotoluene is believed to be the result of an elimination-addition process with a "benzyne"-type substance as a transitory intermediate.



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MOLECULAR SPECTRA. If the light from the flames of reacting gases, as for example the blue cone of a flame of coal gas burning in air, is examined in a spectroscope, it is often found to consist not of continuous radiation, but of a series of bright lines or bands.

The simplest spectroscope consists of an entrance slit, a collimating lens to give parallel rays which fall on a prism, and a second lens to view the spectrum.

Line spectra, which consist of series of lines, often well separated, but seldom with much apparent regularity. arise from atoms, and band spectra arise from molecules consisting of two or more atoms.

The study of molecular spectra has been of great importance in the development of physics and chemistry and in the elucidation of the structure of molecules, and the subject has significant application in other fields, notably in astrophysics, thermodynamics and in qualitative analysis.

The methods used for the observation of molecular spectra depend upon the wave-length region which is being examined. Molecular spectra may be observed from wave lengths as long as 1 cm., down to wave lengths of the order of 10^{-5} cm. or 1,000 Angstrom (A).

At the long wave-length end of this range, special techniques of radar are used: in these, sharply monochromatic radiation is passed through the gas under observation contained in a tube or "wave guide," and the power at the end of the tube is measured. The frequency is changed until the power drops; at this point the gas in the tube is absorbing some of the radiation, and the frequency corresponds to a line of the absorption spectrum of the gas. At shorter wave lengths, in the infrared region, in the range 10^{-2} to 10^{-4} cm., it is again the absorption spectrum which is of greatest interest. Continuous radiation; *i.e.*, radiation containing all the required wave lengths, is passed through a cell containing the gas or substance under examination. The radiation is then dispersed into its components by a prism, which may commonly be of rock salt (NaCl) or of sylvine (KCl), or by a grating, and the radiation is then allowed to fall on a detector; the wave length falling on the detector may be varied by rotation of the prism or grating and the absorption spectrum is observed as a variation of the intensity of radiation measured by the detector as a function of the wave length.

For the wave-length range below about 10^{-4} cm. (or 10,000 A) photographic plates may be used for detection, although photoelectric recorders are also of importance, especially where quantitative measurements of intensities are required. Since photographic plates integrate the energy falling upon them, very weak sources of energy may be studied in this region, even, for example, the light of the night sky, but instruments may roughly be divided into two classes, those used for feeble sources, which are luminous and of comparatively low-resolving power, and predominantly high-

resolving power instruments; it is perfectly practicable in this region to resolve lines differing in wave length by not more than two or three parts in 1,000,000. The visible range of wave lengths is from about 7,000 Å in the red to about 4,000 Å in the violet; the study of spectra in the near ultraviolet region from about 4.000 Å down to 2,000 A presents no special problems, except that ordinary glasses become poor transmitters at about 3 500 A; below this, quartz is used for prisms and lenses, but this too transmits poorly below about 1,900 A. Moreover the gelatin of the photographic emulsion begins to absorb at 2,300 Å, and atmospheric oxygen absorbs at 1.800 A. For spectroscopy in the Schumann region, below 1,900 A, it is necessary then to work with special plates and with spectrographs from which all air has been evacuated.

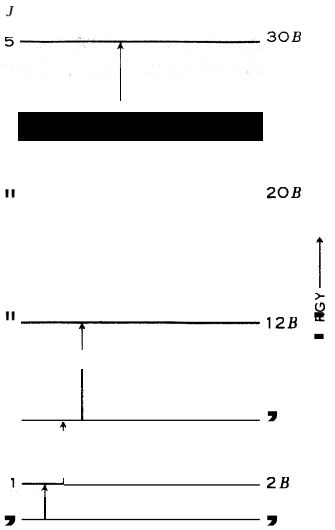

FIG 1(A) —ROTATIONAL ENERGY LEVELS FOR A DIATOMIC MOLECULE. THE VERTICAL ARROWS REPRESENT TRANSITIONS WHICH GIVE RISE TO THE ROTATIONAL SPECTRUM ILLUSTRATED IN FIG 1(B)

In the microwave and infrared regions, it is the study of absorption spectra which has so far been of the greatest importance. At wave lehgths below about 12,000 A, however, the study of spectra in emission is of comparable interest. Sources examined in this way include arcs, flames, electric discharges through gases and vapours, and. of course, celestial objects. *(See* SPECTROSCOPY; SPECTROSCOPY, ASTRONOMICAL.)

Molecules are found to be capable of existing in certain states of energy. Spectral lines arise when a molecule jumps from one energy state to another. The fundamental relation is $E_1-E_2=h\nu$ which expresses the fact that if a molecule is capable of jumping from one state with energy E_1 to another of energy E_2, then the frequency of the radiation emitted or absorbed is given by $(E_1-E_2)/h$ where h is a universal constant, Planck's constant. A molecule may possess energy in virtue of (1) translational motion (equal to $\frac{1}{2}mv^2$ where m is the mass and v the velocity); (2) rotation; (3) vibration (we may think of the molecule as consisting of a system of point masses, the atoms connected by weightless springs); (4) the arrangements of the electrons in the molecule. Translational energy levels lie close together and are of little importance in what follows; allowed energy states arising from (2) to (4) are in general more and more widely separated in energy in the direction (2) to (4).

The rotational energy states of a simple diatomic molecule, such as hydrogen chloride (HCl) are given approximately by

$$E_{rot}=B.\ J(J+1)=0,\ 2B,\ 6B,\ 12B,\ 20B\ \ldots$$

where J is a quantum number, taking the values $J=0, 1, 2, 3\ \ldots$ and B is a constant depending on the moment of inertia of the molecule. In fact $B=h^2/8\pi^2(\frac{m_H\cdot m_{Cl}}{m_H+m_{Cl}})r^2$, where m_H, m_{Cl} are the masses of the hydrogen and chlorine atoms respectively, and r is the distance between them. Transitions between the energy levels, with absorption or emission of radiation, are limited to those in which J changes by ± 1, so that the rotation spectrum of such a molecule may be represented as in fig. 1: it consists of a series of lines each separated by about $2B$ in energy from its neighbour. Spectra of this kind were first observed in 1927. The values of the moments of inertia for ordinary molecules are such that B, in frequency units, is commonly of the order of 10^{10}/sec.$=10^4$ mc. or about 0.3 cm.$^{-1}$. Since the wave length, λ, is related to the frequency v by $c=\nu\lambda$, where c is the velocity of light, the wave length corresponding to $\nu=10^{10}$ is about 3 cm. The experimental difficulties of working in this region were such that,

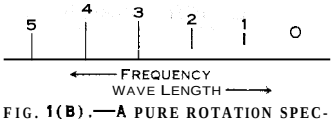

FIG. 1(B).—A PURE ROTATION SPECTRUM. THE NUMBERS ABOVE THE LINES REPRESENT THE VALUE OF J FOR THE INITIAL STATE OF THE TRANSITION

apart from pioneer work at rather shorter wave lengths, no studies of the pure rotation spectra of inolecules were possible until the development of radar techniaues. These techniques provide convenient sources of radiation at wave lengths corresponding to the energy jumps of molecules from one rotational state to another, and this branch of spectroscopy, "microwave" spectroscopy, became of the greatest importance from 1945 onward.

It will be seen that if the energy separation between two rotational levels is measured, then, if the values of the quantum nurnber J can be assigned, the value of the moment of inertia of the absorbing molecule can be determined. Since frequencies may be measured with great precision in the microwave region, moments of inertia and hence interatomic distances in molecules, which are of the order of 1×10^{-8} cm., may be measured with high accuracy. Further, since the resolving power, that is, the capacity to separate lines lying close together in the frequency scale, in microwave techniques may be high, it is possible to study fine details of rotational spectra arising for example from isotope effects, the interactions of electronic and nuclear motion and the asymmetry of electrical charge in the absorbing molecules.

At shorter wave lengths, that is, higher energies, lie spectra which arise from simultaneous changes in rotational and vibrational energy ($\tilde{\nu}=100$ to 10,000 cm.$^{-1}$ or $\lambda=10^{-2}$ to 10^{-4} cm.). Vibrations in molecules are often like those of the simple harmonic oscillator, for which the energy levels are

$$E_{vib}=hc\omega(v+\tfrac{1}{2})$$

where ω is a characteristic frequency, here in cm.$^{-1}$ units, and v is a quantum number, taking the values $v=0, 1, 2\ \ldots$. For a polyatomic molecule containing N atoms, there will in general be $(3N-6)$ such frequencies; for a diatomic molecule, there is only one frequency corresponding to vibration of the two atoms along their line of centres. In this case, the molecule has a single set of equidistant vibrational energy levels, neighbours being separated by ωcm.$^{-1}$. A transition between the rotational levels of two vibrational levels is called a vibration-rotation band. The structure of such a band is illustrated in fig. 2. The number of observable transitions is limited: commonly the rule is either $\Delta J=\pm1$, or $\Delta J=0, \pm1$.

Consider an absorption band in which molecules initially in rotational states J^{rr} in the vibrational level $v=0$, absorb quanta of radiation and undergo transitions to rotational states J^{r} in the vibrational level v=1. A molecule in the level $J^{rr}=1$ may go either to $J'=0$ or J'= 2, assuming that we have the case $\Delta J=\pm1$. The former transition gives rise to the line $P(1)$, the latter to $R(1)$, numbering according to the J-value of the lower level. Similarly the transition $(J'=10)\leftarrow(J''=9)$ gives rise to the $R(9)$ line. and so on. The band in this case consists of two branches of lines, an R-branch and a P-branch, the former at higher, the latter at lower energies. It will readily be seen that the spacing between successive lines is approximately equal to $2B$, except that there is a line missing at the origin, for the separation between the lines $R(0)$ and $P(1)$ is about $4B$.

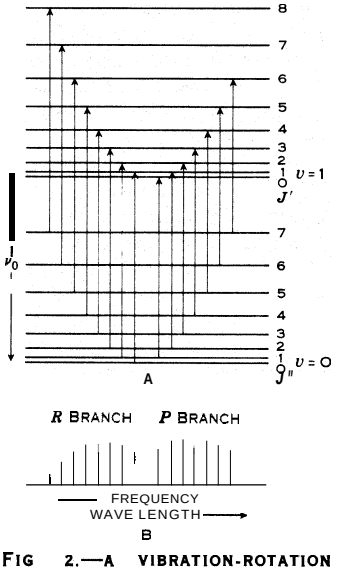

FIG 2.—A VIBRATION-ROTATION BAND OF A DIATOMIC MOLECULE. THE ENERGY LEVELS AND TRANSITIONS (IN ABSORPTION) ARE ILLUSTRATED IN (A), AND THE APPEARANCE OF THE BAND IN (B). ν_0 REPRESENTS THE DIFFERENCE IN ENERGY BETWEEN THE VIBRATIONAL LEVELS v=0 AND v=1

A vibration-rotation band of a real diatomic molecule is a little more complex than described above, for (1) the rotational energy levels are not those of a rigid rotator, but are given by $E_{rot/hc} = B\,J(J+1) - D\,J(J+1) + \ldots$, where D, much smaller than B, expresses the centrifugal expansion of the molecule as it rotates; (2) the vibrational energy levels converge with increasing v, thus $E_{vib/hc} = \omega_e(v+\frac{1}{2}) - x_e\omega_e(v+\frac{1}{2})^2 + \ldots$ where

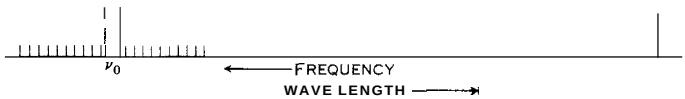

FIG 3.— THE RAMAN EFFECT FOR A DIATOMIC MOLECULE. THE WEAK LINES ON EITHER SIDE OF THE EXCITING FREQUENCY ν_0 ARE THE LINES OF THE PURE ROTATIONAL EFFECT: THE STRONGER "LINE" AT MUCH GREATER SEPARATION ARISES FROM THE VIBRATIONAL EFFECT

$x_e\omega_e$ is much smaller than ω_e; (3) the rotational constant depends on the vibrational quantum number according to

$$B_v = B_e - \alpha(v+\tfrac{1}{2}) + \ldots$$

where a is much smaller than B_e.

In a real vibration-rotation band, these effects lead to decreasing separations between successive R lines with increasing J, and to increasing separations between successive P lines with increasing J. In such a band (as in fig. z), the heights of the lines are roughly proportional to their intensities. The intensity of a spectral transition is in general given by the product of a constant, a power of the frequency (ν^1 in absorption, ν^4 in emission), a weight factor for the transition, and the number of molecules in the initial state of the transition. In thermal equilibrium, this number decreases exponentially with increasing energy by a Boltzmann term $e^{-E/kT}$, where E is the energy (per molecule), k is Boltzmann's constant, and T is the absolute temperature in °K. Since the weight factor for the transitions increases with increasing J for the lines in a vibration-rotation band. while the Boltzmann factor decreases, there are observed maxima of intensity, dependent on the temperature, in the R- and P-branches, as illustrated in fig. 2.

The weight factors cannot be discussed here, but it may be pointed out that, in the case of a diatomic molecule, they are zero both for pure rotation and vibration-rotation spectra, unless the molecule possesses electrical or magnetic asymmetry. Thus homonuclear molecules such as nitrogen (N_2) and chlorine (Cl_2) do not give these spectra, while heteronuclear molecules such as hydrogen chloride (HCl) and carbon monoxide (CO) do. We may also observe that the intensities of the vibration bands in absorption, $v' \leftarrow v''$, fall very rapidly in the sequence $1 \leftarrow 0$, $2 \leftarrow 0$, $3 \leftarrow 0 \ldots$.

Most of the information which has so far been derived from the study of vibration spectra in the infrared region has been obtained from measurements of the position of the lines: these give the structural constants, particularly B, D, ω_e and $x_e\omega_e$, which in turn provide detailed information about molecular architecture and molecular mechanics. The absolute intensities of spectral transitions are at once more difficult to measure and less susceptible to theoretical interpretation. The measurement, however, of relative intensities has proved of great utility in its practical application to quantitative analysis, for the infrared spectrum of a molecule is a highly characteristic property—a molecular fingerprint in fact—and in consequence from what were formerly the special, and indeed temperamental, equipments of a few research laboratories were developed familiar tools of routine analysis in industrial laboratories.

Information about the rotational and vibrational energy states of molecules may also be obtained otherwise than by the study of the absorption or emission of radiation. When light falls on atoms or molecules, the distribution of electrons around the nuclei may be somewhat changed and in consequence some light is scattered. It is indeed the scattering of sunlight by the atmosphere which, as was shown by Lord Rayleigh, is responsible for the blueness of the sky. This scattering, a "classical" effect which is explicable without appeal to quantum theory and which is now called Rayleigh scattering, occurs without change of wave length. In addition, molecules may also show a much weaker, nonclassical, scattering with change of wave length. The intensity of this effect, the Raman effect, depends upon the detailed ways in which the polarizability varies during molecular rotation and vibration: since the intensities of the infrared spectra depend on different molecular properties, namely on the behaviour of the electric dipole moment, during rotation or vibration, it will be seen that the infrared and Raman effects are, in general, complementary.

Suppose that the frequency of the monochromatic "exciting" radiation is ν_0. Then the Raman effect is characterized by the appearance in the scattered radiation of other frequencies, $\nu = \nu_0 \mp \Delta\nu$. Lines for which $\nu = \nu_0 - \Delta\nu$ are called Stokes lines; lines at higher frequencies than ν_0 are anti-Stokes lines. The values of $\Delta\nu$ prove to be characteristic of the scattering molecules. Let us consider a rigid rotating diatomic molecule of rotational constant B. The rotational Raman spectrum is found to contain lines corresponding to the changes $\Delta J = 0$ or $+2$. For $\Delta J = 0$, $\nu = \nu_0$, but for $\Delta J = 2$, we obtain an S-branch on either side of the exciting line. $S(0)$ lies at $\nu_0 \pm 6B$, $S(1)$ at $\nu_0 \pm 10B$, $S(2)$ at $\nu_0 \pm 14B$ and so on. The formation and appearance of such a spectrum is illustrated in fig. 3.

At bigger separations, $\Delta\nu$, the Raman spectrum of a diatomic molecule contains at least two further "lines." These are the piled up Q-branches ($\Delta J = 0$) of the vibrational effect: with long exposures, lines of the S-branches may also be seen. Neglecting this rotational structure, $\Delta\nu \sim \omega$, or, more exactly, $\Delta\nu = \omega_e - 2x_e\omega_e$.

Experimental difficulties in observing these Raman effects—particularly the rotational effects—are considerable, for the spectra are of low intensity. The techniques were, however, greatly improved from 1955 onward, and the closely spaced rotational Raman spectra of molecules, even as heavy as benzene, were satisfactorily resolved by the late 1950s.

One further important class of spectra remains for consideration—namely electronic spectra. Let us first examine the way in which the energy of a system of two atoms may change as the distance between the atoms is varied. If two atoms are far apart, their interaction is negligible: if they are brought sufficiently close together, the electron-electron and nucleus-nucleus interactions will lead to repulsion; *i.e.*, atoms are to some extent incompressible. At intermediate distances two cases may be distinguished: either (1) the atoms interact to form a stable chemical bond, with a reduction in the potential energy, or (2) the atoms repel each other at all distances. These two cases are illustrated in fig. 4, in which potential energy is plotted as a function of the interatomic separation. Now, just as electrons are capable of being arranged around the nuclei of atoms in different ways to give states of different electronic energy, so also with molecules, and electronic spectra arise by transitions between the rotational and vibrational states of two different electronic states of a molecule. Since such states are often quite widely separated in energy, the transitions occur at wave lengths between about 10^{-4} to 10^{-5} cm. or 10,000 to 1,000 A (1Å = 10^{-8} cm.): this range includes visible light from violet at about 4,000 Å to red at 7,000 A. Such a transition is called an electronic band system. It is, for example, such a transition between two electronic states which gives chlorine gas its green-yellow colour, iodine vapour its purple colour, and it is a transition in ozone which renders the earth habitable by absorbing the sun's ultraviolet radiation at wave lengths below about 3,000 Å.

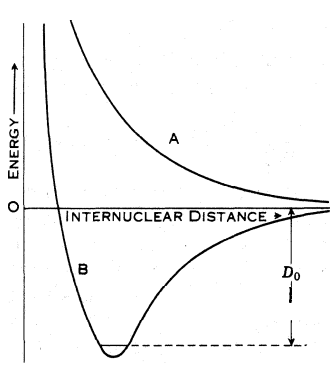

FIG 4.— POTENTIAL ENERGY AND DISTANCE FUNCTIONS FOR DIATOMIC MOLECULES (A) SHOWS THE FORMATION OF A STABLE MOLECULE. WITH DISSOCIATION ENERGY. D_0. (B) SHOWS REPULSION: NO STABLE MOLECULE IS FORMED

The appearance of an electronic spectrum of a diatomic

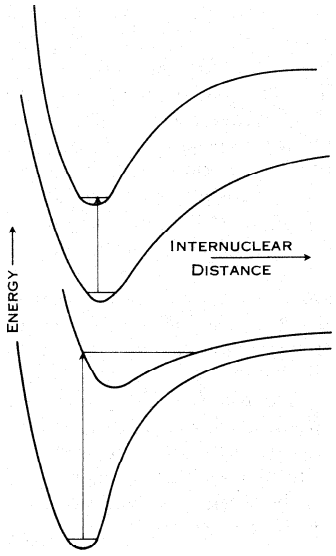

FIG 5 — TRANSITIONS BETWEEN ELECTRONIC STATES OF DIATOMIC IN (A) $R_e' \sim R_e''$ IN (B) $R_e' > R_e''$ THE VERTICAL ARROWS REPRESENT THE STRONGEST TRANSITIONS IN THE ABSORPTION SPECTRUM

molecule depends upon the values of the constants ω'', ω', B'', B', the vibrational and rotational constants for lower ($''$) and upper ($'$) states. Selection rules (of the kind $\Delta J = \pm 1$ or 0) limit the number of rotational transitions, but the vibrational transitions depend upon the relative orientations of the potential energy curves for the upper and lower electronic states. Two possibilities are illustrated in fig. 5(A) and 5(B). Roughly, it can be said that electronic rearrangements are swift compared with nuclear motion, so that transitions which can be represented by vertical lines in potential energy diagrams are the most probable.

If the minima of the potential energies for upper and lower states happen to occur at about the same internuclear distance (fig. 5[A]) then it is found that most of the intensity of the system is concentrated into the rotational transitions associated with the changes in vibrational levels from $0 \leftrightarrow 0$, $1 \leftrightarrow 1$, $2 \leftrightarrow 2$ and so on. If, honever, there is a big difference between the values of the internuclear distances at the minima. then the most probable vibrational transitions are from high v' to low v'' and from low v' to high v'', and the $0 \leftrightarrow 0$ band may be too weak to be observed. How closely the vertical lines are spaced depends on the magnitude of the rotational constants B' and B'', which are in turn determined by the magnitudes of the moments of inertia. Light molecules give bands of open structure; heavy ones, bands of structure sometimes irresolvably close. Moreover, the interaction of electronic and nuclear motion may in certain cases lead to more complicated expressions for the energy levels than those for the rigid rotator, and more branches may be found in a band than the two or three branches mentioned above. In some cases the positions of the vibrational energy levels of a particular electronic state may be followed to high values of the vibrational quantum number.

It is found that the intervals between successive vibrational levels decrease with increasing value of v, and it may be possible to extrapolate to the point at which the interval becomes zero (see fig. 6). On the potential energy diagram, this corresponds to the limit for two noninteracting atoms at relatively large internuclear separation. The energy difference between the lowest vibrational level ($v = 0$) and the dissociation limit is called the dissociation energy, and represents the energy necessary to separate the two atoms in the normal state of a diatomic molecule to infinity. It has been found in this way, for example, that the energy required to break up the oxygen molecule (O_2) into two oxygen atoms, is about 120 Kcal/mole (1 mole $= 6 \times 10^{23}$ molecules).

Atoms of identical nuclear charge and identical number of extranuclear electrons but differing nuclear mass are called isotopes. Thus naturally occurring oxygen (O_2) contains mostly atoms of relative mass 16.000 atomic weight units. O^{16}, but also a small proportion of heavier atoms O^{18}, and a still smaller proportion of O^{17} atoms. The spectra of two isotopic molecules such as 16_{O_2} and 18_{O_2} or HCl^{35} and HCl^{37}, are not identical, for the heavier molecule has a bigger moment of inertia. and thus a smaller value of the rotational constant B than the lighter one; furthermore, the characteristic vibration frequency for the heavier molecule will be less than that of the lighter one. The interpretation of these effects in terms of the mass changes is comparatively straightforward. and certain isotopes were in fact first discovered by observations of their spectra, notably O^{18}. The study of isotope effects remains of great importance in the elucidation of the spectra of polyatomic molecules.

At shorter wave lengths than can commonly be photographed in air (on account of the strong absorption by oxygen) there lie spectra which although similar to the electronic spectra already discussed. are in a sense more analogous to atomic spectra. In this region. a series of band systems have been found for some molecules, the series converging to a high energy limit. These are interpreted as arising from the progressive excitation of an electron from the molecule: the convergence limit marks the point at which ionization, *i.e.*, complete loss of the electron. becomes possible. This is the process which may be written $MX \rightarrow MX^+ + e^-$. Such series are called Rydberg series.

We may now turn to a brief consideration of some of the applications of molecular spectroscopy. The most direct is clearly the determination of molecular structure. In the case of diatomic molecules, we can expect to get reliable information about the size of the molecule. *i.e.*, the equilibrium internuclear distance, about its characteristic vibration frequency, ω, and its energy of dissociation. In the case of polyatomic molecules where, so far, the infrared Raman and microwave spectra have proved most helpful (the electronic spectra of polyatomic molecules are generally very complex), we can again expect to get—at least in the case of not too complicated molecules—information about the equilibrium configuration of the molecule and about the ways in which the molecule can vibrate.

In most of what has been said above: the emitting or absorbing molecules have been considered to be in the dilute. gaseous state. As we proceed from this state to that of a compressed gas and thence to the more concentrated liquid or solid states it is generally found that the spectra change, the fine structure arising from rotational changes is lost, and evidence is obtained about the nature and extent of interactions between molecules.

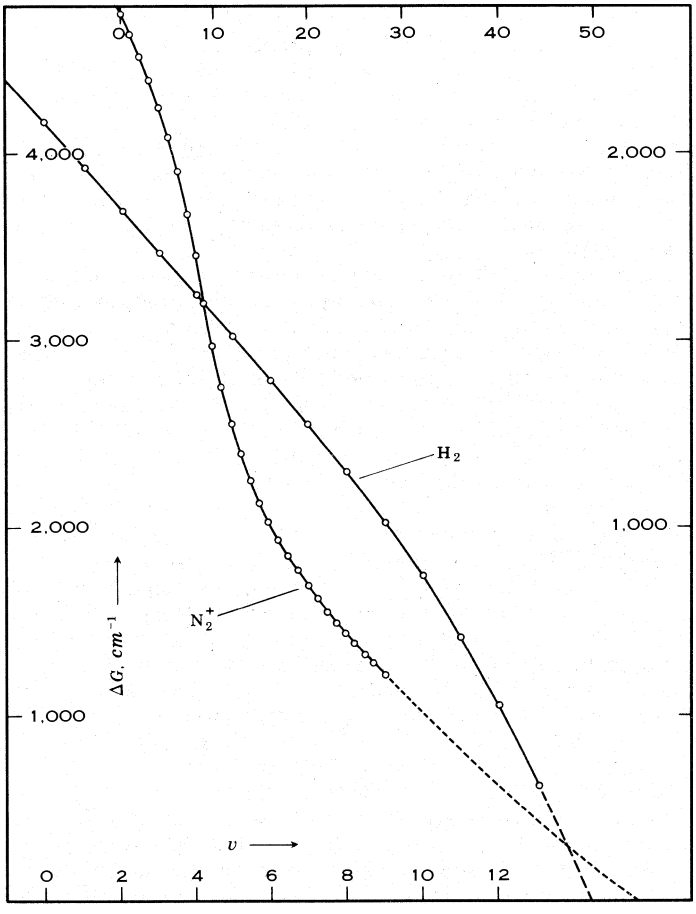

FIG 6 —THE SEPARATIONS BETWEEN SUCCESSIVE VIBRATIONAL LEVELS PLOTTED AGAINST VIBRATIONAL QUANTUM NUMBER (1) FOR THE LOWEST ELECTRONIC STATE OF H_2 (LOWER AND LEFT SCALES). (2) FOR AN EXCITED STATE OF N_2^+ (UPPER AND RIGHT SCALES)

Since the populations of molecules in different energy states are determined, in equilibrium. by their temperature, and since the intensities of spectral lines are proportional to their populations in the initial states of the quantum jumps, the measurement of relative intensities of lines may lead to a determination of the temperature of the emitting molecules. This has been applied to sources as inaccessible as the flames from rocket motors, to the measurement of the temperature of the upper atmosphere by spectroscopic examination of the aurora, and to the measurement of stellar temperatures.

The spectrum of a molecule is, as has been remarked, a highly characteristic property, and may be used to prove the presence of a particular molecule in a remote source and even, from the intensity, to estimate its concentration. Most of what is known about the atmosphere of the planets and of the composition of the stars has been discovered through the study of their spectra.

Spectroscopy is less a separate branch of scientific knowledge than a system of special and powerful techniques. In the 19th century the emphasis, follouing R. W. von Bunsen and G. R. Kirchhoff, in the application of these techniques, lay in the direction of qualitative analysis through atomic spectra: its triumphs were the discoveries of new elements, caesium and thallium for example, and the identification of helium in the sun. Little progress in molecular spectroscopy was made until a theory of the energy levels in molecules was formulated, particularly in the decade 1920–30. Then follo ed a period of intensive testing and strengthening of the theoretical background, now adequate for treating many of the problems associated with molecules containing only tuo atoms.

After 1945, more and more attention was paid to the complex problems of the spectra of polyatomic molecules, and technical advances, notably in infrared detectors, in absorption techniques, in high resolution Raman spectroscopy and the development of microwave spectroscopy, led to rapid progress in the elucidation of the architecture of the simpler polyatomic molecules. The study of transitions between closely spaced energy levels developed in presence of electric or magnetic fields, sometimes in molecular beam experiments, became of great interest, especially for the determination of detailed properties of stable molecules. For example, positions of hydrogen atoms in certain crystals, difficult to detect by X-ray diffraction, were located by means of nuclear magnetic resonance, in which are observed transitions between energy levels arising when nuclei possessing a magnetic moment are placed in a magnetic field.

Likewise, knowledge of unstable molecules was greatly advanced by the development of flash photolysis, in which products formed by rapid absorption of large numbers of quanta are examined spectroscopically at short-time intervals after the flash. Such studies are relevant to special problems of chemical reactivity in flames and combustion processes. Thus, the first definite information about the structure of the methyl radical was obtained from the flash photolysis of mercury dimethyl.

Indeed, experiment had outstripped theory by the late 1950s, and the quantitative interpretation of the structure of polyatomic molecules was yet to be found. (R. F. Bw.)

MOLECULE, CHEMICAL. The chemical molecule may be defined as the smallest part of a chemical substance that can exist free in the gaseous state, with retention of the composition and chemical properties that are possessed by the gaseous material in bulk. As so defined, the molecule is identical with the unit, likewise designated by the name "molecule," which is postulated in the kinetic theory of gases (see KINETIC THEORY OF MATTER). From the chemical point of view, however, the foregoing definition is somewhat too restrictive. since many substances cannot be obtained in the gaseous state without partial or complete decomposition. If the concept of the molecule is to be retained for such substances, therefore, it must be generalized so that it has meaning with respect to states of matter other than the gaseous. One such generalization, which is widely adopted, is made possible by the fact that many, although not all, of the nonvolatile substances mentioned can be dissolved in inert solvents (*i.e.*, in solvents with which they do not react chemically). Thus. many proteins (*q.v.*) are soluble in water.

The molecule of a substance can accordingly be defined as the smallest part of it which exists free either in the gaseous state or in dilute solution in an inert solvent. Ordinarily, in those cases in which a direct comparison can be made, the molecule of a given substance is found to be of the same weight in the gas and in solution; several significant types of exception exist, however, as will be mentioned again later. With substances which can be neither vaporized nor dissolved in inert solvents, the concept of the molecule loses most of its utility, as well as its meaning, and is not commonly employed.

The molecule may be defined also, in a superficially different but usually equivalent way, as either a single independent atom or an aggregate of atoms which is held together by relatively strong (valence) forces, and which, therefore, acts as a unit. (See ATOM; VALENCE.) (Although, according to this definition, a molecule may consist of a single atom. as, for example, a molecule of helium or other rare gas, an unfortunate tendency has arisen in certain circles to limit the term molecule to aggregates of two or more atoms.) The relation between this definition and the preceding one can be clearly seen if it is realized that a pure substance in bulk consists of a very large number of molecules, or aggregates of the type described. which (aside from possible variations in isotopic composition) are exactly alike, and which exert only relatively weak forces upon one another. Consequently, a division of a sample of the substance into progressively smaller parts produces no change in either composition or chemical properties until parts consisting of single molecules are reached.

Further subdivision then leads to still smaller particles which usually differ from the original substance in composition, and which almost always differ from it in chemical properties because, in the last stages of the fragmentation. one or more strong valence bonds are necessarily ruptured (or, if the molecules in question consist of single atoms, these atoms themselves must be broken up).

The Molecule in the Solid State. — Since it has been found that atoms joined by strong valence bonds are always relatively close to one another in space, a method by which the concept of the molecule can be extended to the solid state is at once suggested. In solid naphthalene, for example, examination of the crystal structure has shown that the substance consists of identical aggregates, each composed of ten carbon and eight hydrogen atoms. In each aggregate, each atom is close to, and so must be relatively strongly bonded to, at least one other atom of the same aggregate; but no two atoms in different aggregates are comparably close to one another. Consequently, the aggregates can be regarded as identical with the individual molecules.

The molecular weight of naphthalene in the gaseous state and in solution has been measured by the procedures mentioned below; under these conditions likewise, the molecules consist of ten carbon and eight hydrogen atoms each.

Although many solid substances resemble naphthalene in that they consist of distinct molecules, the nature of many others is entirely different. Sodium chloride (common table salt), consists of sodium ions and chloride ions so arranged that each sodium ion is surrounded by six equidistant chloride ions, and each chloride ion is surrounded by six equidistant sodium ions. Hence. no distinct aggregate identifiable with a molecule of sodium chloride exists, unless each entire crystal be considered as a single molecule. Consequently, in sodium chloride, and in all other solids of similar type, the concept of the chemical molecule loses its significance.

Molecular Sizes and Weights. — The absolute sizes and weights of individual molecules cannot be determined by purely chemical methods; various other methods, however, have been successfully applied to the determination of both their' linear dimensions and their weights. Thus, it has been shown that the lengths. or diameters, of most molecules lie between 10^{-8} and 10^{-7} cm.. and that most molecules weigh between about 10^{-23} and 10^{-20} g. Some substances, such as the proteins, consist of much larger molecules, and a few consist of molecules large enough to

be "seen" with the electron microscope. These are extreme cases, however; ordinarily molecules are much smaller.

More important chemically than the absolute weights of the individual molecules are their relative weights with respect to one another. For this purpose, the weight of the hydrogen atom was originally adopted by convention as the unit in terms of which the weights of all other atoms and molecules were to he expressed. Thus. the atomic weight of hydrogen was by definition exactly 1.0000, that of oxygen was about 15.87, and so on. (See ATOM: Atomic *Weights*.)

Subsequently, however, it was found more convenient to use, as the standard unit, one-sixteenth the weight of an oxygen atom, so that the atomic ueights of hydrogen and oxygen became about 1.008 and exactly 16.0000, respectively. This second convention has been universally adopted.

The weight of a molecule in terms of the foregoing conventional unit is called the molecular weight of the corresponding substance. It is numerically equal to the sum of the atomic weights of all the atoms which make up the molecule. Thus, since the molecule of oxygen contains two atoms of oxygen, the molecular weight of oxygen is 32.0000; since the molecule of water contains two atoms of hydrogen and one of oxygen, the molecular weight of water is about 18.016; and so on. If the molecular weight of a substance is M, then M grams of that substance is called a gram molecule or, more briefly, a mole. Thus, a mole of oxygen weighs 32.0000 g.; one of water weighs about 18.016 g.; and so on.

It is a corollary of Amadeo Avogadro's law (see AVOGADRO'S CONSTANT) that the number of molecules in a mole is the same for all substances. This number (Avogadro's number or Avogadro's constant) is approximately $6\,023 \times 10^{23}$. The absolute weight of a single molecule of any substance is the weight of a mole of that substance divided by Avogadro's number.

The Effect of Variations in Isotopic Composition. — The discovery of isotopes (*q.v.*) established the fact that different atoms of even the same element may differ in weight. This fact has two consequences important for the purposes of the present discussion. In the first place, the unit of atomic and molecular weights (one-sixteenth the weight of an oxygen atom) is not unique since at least three isotopes of oxygen, with an extreme variation in weight of more than 10%, are known to exist. In the second place. different molecules of a given substance may have different absolute weights, and hence correspond to different molecular weights, if they are not of identical isotopic composition.

From the practical chemical point of view, however, these ambiguities are unimportant, since the average atomic weight of each element is almost always found to be constant within the experimental error of measurement, regardless of the source of the element or of its state of combination. In all ordinary chemical experiments. the numbers of molecules involved are so enormous that only the average atomic and molecular weights are important.

Consequently, the unit of atomic weights may be taken as one-sixteenth the average weight of an oxygen atom; and the corresponding so-called chemical atomic and molecular weights in general may be defined as the average weights (expressed in this unit) of the atoms and molecules in question. This convention, which has been adopted universally by chemists, has been employed implicitly in the preceding discussion, and it will be employed throughout the remainder of the present article (except in the following paragraph).

Physical Atomic and Molecular Weights. — An alternative system of atomic and molecular weights can be based upon the definition of the fundamental unit as one-sixteenth the weight of the most common of the isotopes of oxygen. The so-called physical atomic and molecular weights calculated on this basis are particularly useful if one is interested in the weights of individual atoms or molecules rather than in the average weights of large numbers of atoms or molecules. In general, the physical atomic and molecular aeights are approximately 1.000275 times as great as the corresponding chemical quantities.

The Determination of Molecular Weights. — Several experimental methods have been devised for the determination of molecular weights. Of these, the most fundamental is based upon Avogadro's law. which states that equal volumes of any two gases at the same temperature and pressure contain the same number of molecules. This law, which is rigorously true only for perfect gases, is obeyed approximately by all actual gases, and it becomes increasingly nearly true as the pressure is decreased. Consequently, the ratio of the molecular weights of any two substances is approximately equal to the ratio of the measured weights of equal volumes of the gaseous substances at the same temperature and pressure; and the equality becomes more nearly exact as the pressure is lowered. Since the molecular weight of oxygen is by definition 32.0000, that of any further substance can be determined by comparison with oxygen. Thus, it has been found that one mole (32.0000 g.) of oxygen occupies 22.4 litres at 0° C. and 760 mm. pressure; consequently, the gram molecular weight of any other substance is seen to be equal to the weight of it in grams which mould occupy 22.4 litres in the gaseous state at 0° and 760 mm. If the substance is not gaseous under these conditions, the required weight can often be calculated with tne aid of the perfect gas laws from the measured density of the gas under any suitable experimental condition.

The molecular weights of substances which cannot be vaporized can often be determined in solution in an inert solvent since the lowering of the freezing point of any given solvent, the raising of its boiling point, the decrease of its vapour tension at any temperature and the osmotic pressure of the solution are all directly proportional to the number of solute molecules present in a given weight of solvent (see SOLUTIONS). Consequently. the molecular weight of the solute must be inversely proportional to the magnitudes of the effects, of the types listed, produced by a given weight of it in a given weight of solvent. Since the value of the proportionality constant depends both upon the property studied and also (ordinarily) upon the solvent used. but not upon the solute, it must be determined by comparison with some substance, the molecular weight of which has previously been determined in the gaseous state. Thus. it has been found that one mole of any solute dissolved in 1000 g. of water lowers the freezing point by 1.85j° C. and raises the boiling point by 0.51° C.

As with the methods based directly upon Avogadro's law, these methods also give only approximately correct values of the molecular weights, but they become more nearly exact as the solutions are made more dilute.

Empirical and Molecular Formulas. — The empirical formula of a substance is the simplest formula which describes its chemical composition. Thus, benzene (*q.v.*) contains 7.74% hydrogen and 92.26% carbon. Since the atomic weights of hydrogen and carbon are 1.008 and 12.010. respectively, and since these are in the ratio of 7.74 to 92.26, it follows that the numbers of hydrogen and carbon atoms in a molecule of benzene must be equal. The empirical formula of the substance is therefore CH.

The molecular formula of a substance describes not only the chemical composition but also the molecular weight of the substance. Thus, the molecular weight of benzene can be found by any of the above methods to be in the neighbourhood of 78, whereas the calculated weight corresponding to the unit CH is 13.018. Evidently, therefore, the molecule of benzene must contain exactly six such units, so that the molecular formula is C_6H_6. An alternative. but equivalent, definition of the molecular formula is that it is the formula which specifies the numbers of atoms of each element present in a single molecule of the substance in question.

Association **and** Dissociation in Solution. — As has already been mentioned, molecular weights measured in the gaseous state and in solution, although they are usually identical, may be different. Two distinct types of discrepancy are encountered; the molecular weight of a substance may be either greater or less in solution than in the gas. In the former case, the substance is said to be associated in solution; in the latter, it is said to be dissociated. Association occurs commonly in nonpolar solvents

like benzene when the molecules of the solute contain hydroxy groups (OH) or amino groups (SH,). *(See* ASSOCIATION, CHEMICAL.) On the other hand, the most important type of dissociation is the electrolytic dissociation undergone by acids. bases and salts when dissolved in ionizing solvents like water. It has been shown that. in aqueous solution, most salts and some acids and bases are almost completely dissociated into ions, but that a few salts and many acids and bases are only partially dissociated. Sodium chloride. for example. exists in aqueous solution almost entirely as a mixture of sodium ions (Na^+) and chloride ions (Cl^-); on the other hand, acetic acid (*q.v.*) exists mostly as undissociated molecules (CH_3-CO_2H), and to only a small extent as hydrogen ions ($H-$) and acetate ions (CH_3-CO_2^-). If the attemvt is made to measure the molecular weight of a substance in a solvent in which it is dissociated into ions, the numerical result of the experiment should correspond. ideally, to the average weight of the various ions and molecules present. Actually, however. the situation is complicated by the strong electrostatic interactions between the charged ions.

The result of these interactions is that, unless the concentration of the ions is extremely low. the effects of the solute upon the freezing point. etc.. are appreciably smaller than those which would have been produced by an equal concentration of uncharged molecules *(see* SOLUTIONS: *Solutions of Electrolytes).* Consequently. the extent of dissociation appears to be less than it really is.

The Determination of Very Large Molecular Weights. —The determination of the molecular weight of a substance that has a very large molecular weight is relatively difficult. Such a substance (for example. a protein) is almost certainly nonvolatile. so the method based directly upon Avogadro's law is inapplicable. Moreover. the various methods which could be used for the determination of the molecular weight in solution are unsatisfactory. since the effects produced by the presence of the solute, being inversely proportional to its molecular weight, are very small and may he too small to be measured precisely, or even to be observed. For such substances. "minimum molecular weights." which can be obtained from analytical data. are frequently useful. Hemoglobin. the protein responsible for the red colour of blood. for example, contains about 0.335% iron. If each molecule of hemoglobin contains n atoms of iron. the molecular weight of hemoglobin is easily shown to be about $16{,}700n$. Since n cannot be less than one. the minimum molecular weight of the protein is therefore 16,700. Moreover, since n must be an integer. the true molecular weight must be an integral multiple of 16.700. Such information is often of value in the determination of the true molecular weights.

The most generally useful methods for the determination of actual, as distinguished from minimum. molecular weights of large molecules involve the use of the ultracentrifuge. The principle underlying these methods is that. when a solution of the substance is subjected to extremely great centrifugal forces, the solute is forced measurably away from the centre if it is more dense than the solvent. or toward the centre if it is less dense than the solvent. The molecular n-eight of the solute can be calculated either from the rate of sedimentation or from the final distribution of solute after equilibrium has been reached. In this way, molecular weights of any magnitude. provided that they be sufficiently large. can be determined. A more recent method. which, like the ultracentrifugal one. is restricted to the study of extremely large molecular weights. is based upon the scattering of light by solutions of the substances of interest. The principles of this method, however. are too technical to he discussed further here. If, by either of these methods. a rough value of the true molecular weight of any substance is obtained, a comparison with the minimum molecular weight often permits the derivation of a more precise value. Thus, since the molecular weight of hemoglobin. for example. must be of the form $16{,}700n$ (where n is an integer). knowledge that the molecular weight lies between, say. 60.000 and 70.000 is sufficient to show that n must be exactly equal to four, and that the molecular weight is approximately 66.800.

Molecular Weights of Solids.—If a substance is solid under ordinary conditions. and if analysis of its crystal structure shows that it consists of individual molecules, the molecular weight is, of course, simply the sum of the atomic weights of all the atoms contained in a single molecule. On the other hand, if the analysis of the crystal structure shows that a given solid does not consist of individual molecules, then its molecular weight is an essentially meaningless concept. For such substances as these latter, one speaks instead of the formula weight; this is the weight corresponding to the empirical formula.

With sodium chloride. for example. the empirical formula is NaCl. even though no molecules consisting of one atom of sodium and one of chlorine are present in the solid. Consequently. since the atomic weights of sodium and chlorine are 22.997 and 35.457, respectively. the formula weight of sodium chloride is $22.997 + 35.457 = 58.454$.

Speaking somewhat loosely, one frequently refers to 58.454 g. of sodium chloride as constituting a mole of the substance.

(G. W. WD.)

MOLE-RAT, the name of a group of blind burrowing rodents typified by the large grey *Spalax typhlus* of eastern Europe, western Asia and Egypt, which represents the old world family Spalacidae. The mole-rats are characterized by the want of distinct necks, small or rudimentary ears and eyes, short limbs provided with powerful digging claws, and a rudimentary tail; they make burrows in sandy soil, and feed on bulbs and roots. Bamboorats (*Rhizomys*) from India and Burma, and *Tachyoryctes* from East Africa, differ by the absence of skin over the eyes, the presence of short ears, and a short, sparsely-haired tail. They burrow among tall grass, or at the roots of trees. Another group is the African family Bathyergidae, which contains several genera—living south of the Sahara, one of which is almost naked. *(See* RODENTIA.)

MOLESKIN, a term employed not only for the skin of a mole but also, from a real or fancied resemblance, for a stout, heavy cotton fabric of leathery consistence, woven as a satin twill on a strong warp. It is much worn by workingmen, and is used for gun-cases, carriage-covers, and other purposes in which a fabric capable of resisting rough usage is desirable.

MOLESWORTH, MARY LOUISA (1839–1921), Scottish writer, daughter of Major-General Stewart, of Strath, N.B., was born in Rotterdam on May 29, 1839, and was educated in Great Britain and abroad. In 1861 she married Major R. Molesworth. Her first novels, *Lover and Husband* (1869) to *Cicely* (1874), appeared under the pseudonym of "Ennis Graham." Mrs. Molesworth is best known as a writer of books for the young, such as *Tell Me* a *Story* (1875), *Carrots* (1876), and *The Cuckoo Clock* (1877).

She died in London on July 20, 1921.

MOLESWORTH, SIR WILLIAM, BART. (1810–1855), English politician, son of the 7th baronet, was born on May 23, 1810, in London. After succeeding to baronetcy in 1823, he studied at Edinburgh, Cambridge, Offenbach, Rome and Naples. On the passing of the Reform act of 1832 he was returned to parliament for the eastern division of Cornwall. He made the acquaintance of Grote and James Mill, and in April 1835 founded, in conjunction with Roebuck, the *London Review,* as an organ of the "Philosophic Radicals." After the publication of two volumes he purchased the *Westminster Review,* and for some time the united magazines were edited by him and J. S. Mill. From 1837 to 1841 he sat for Leeds, and acquired considerable influence in the house of commons by his speeches and by his tact in presiding over the select committee on transportation. But his radicalism made little impression either on the house or on his constituency. From 1841 to 1845 he had no seat in parliament, occupying his leisure time in editing the works in Latin and English of Thomas Hobbes of Malmesbury, a recreation which cost him no less than £6,000. In 1845 he was returned for Southwark, and retained that seat until his death. On his return to parliament he devoted special attention to the condition of the colonies, and was the ardent champion of their self-government. In Jan. 1853 Lord Aberdeen included him in the cabinet as first commissioner

of works, the chief work by which his name was brought into prominence at this time being the construction of the new Westminster bridge; he also was the first to open Kew Gardens on Sundays.

In July 1855 he was made colonial secretary but he died on Oct. 22.

The titles of his speeches and works are given in the *Bibl. Cornubiensis*, vol. i. and iii.

See also Mrs. Grote's *The Philosophical Radicals (1866)* and Mrs. Fawcett's Life (1903).

MOLFETTA, a seaport and episcopal see of Puglia, Italy, in the province of Bari, 16 mi. N.N.W. of Bari by rail. Pop. (1951), 35,150. The old cathedral of S. Conrad is Romanesque. The old town is surrounded by walls; the new town is more spacious, and is an active seaport. The town was given by Charles V to the duke of Termoli in 1522, and was sacked by the French under Lautrec in 1529. In 1640 the fief passed to the Doria, then to the Spinola family.

Two miles southwest is the Pulo di Molfetta, a large circular depression in the plain, on the edge of which was an important neolithic settlement.

MOLIÈRE (1622–1673), often called the greatest of French writers, was born and died in the heart of Paris. The registers of Saint-Eustache show him to have been baptized as JEAN BAPTISTE POQUELIN on Jan. 15, 1622. His mother died when he was ten; his father, one of the appointed furnishers of the royal household, gave him a good education at the Collège de Clermont (the school which, as the Lycée Louis le Grand, was to train so many brilliant Frenchmen, including Voltaire) and clearly intended him to take over his royal appointment, but this the young man renounced in Jan. 1643, determined to break with tradition and seek a living on the stage. Within six months we have his signature to an act of association (June 30, 1643) with nine like-minded persons to produce and play comedy with a view to maintaining their company under the name of the Illustre Théâtre. His stage name. Molière. is first found in a document dated June 26, 1644. He was to give himself entirely to the theatre for 30 years and to die exhausted at the age of 51.

According to Tallemant des Réaux it was a successful actress, Madeleine Béjart, who persuaded Molière to take to the theatre. but her acting could not save the young company. Documents of 1645 show Molière twice in prison for debts on the building and properties. Existence in Paris, with two well-established theatres already, seemed financially impossible, so from the end of 1645, for the next 13 years, Molière and his friends sought to gain a living in the provinces. The Illustre Théâtre seems to have been soon dissolved. its survivors associating themselves with a certain Charles Dufresne, under the patronage of the 2nd duc d'Épernon (Bernard de La Valette) and for a time, until his conversion to austere piety, of the prince de Conti (Armand de Bourbon). No history of these years is possible; municipal registers and church records show the company emerging here and there. A letter from the intendant of Languedoc to the consuls of Albi in 1647 asks that they be paid dues and expenses. They were in Lyon intermittently from the end of 1652 to the summer of 1653 (when the poet Charles d'Assoucy comments on their good living and generosity) and again in 1657; they were at Montpellier in 1654 and 1653 and at Béziers in 1656. Clearly they had their ups as well as downs. The unchronicled years are of crucial importance to Molière's career, forming a rigorous apprenticeship to his later work as actor-manager, teaching him how to deal with colleagues, authors. audiences and authorities. His rapid success afterward in Paris, in the face of distinctly adverse conditions, is inexplicable without these years of training. To these years belong Molière's first two known plays: *L'Étourdi, ou le Contretemps,* performed at Lyon in 1655, and *Le Dépit amoureux,* performed at Béziers in 1656.

The turning point in his career was probably the afternoon of Oct. 24, 1658, when, in the guardroom of the Louvre on an improvised stage. the company acted Corneille's *Nicomède* before the king, Louis XIV, and followed it with what Molière described as one of those little entertainments which had won him some reputation and which he used to offer to provincial audiences. This was *Le Docteur amoureux,* which apparently brought the house down and secured the company's adoption by Monsieur (the king's brother Philippe, later duc d'Orléans). From this date onward the known facts about Molière almost exclusively concern his activity as actor-manager and author. Whereas earlier writers used to speculate at length on the details of Molière's personal life, all that need be given here is a brief summary of the principal events as an introduction to his work.

For two years after his success of Oct. 1658, Molière's company had the use of a hall in the Petit-Bourbon, a great house adjacent to the Louvre. There took place the first performances of *Les Précieuses ridicules* (Nov. 18, 1659) and of *Sganarelle, ou le cocu imaginaire* (May 28, 1660). *Les Précieuses ridicules (see* below) was repeated many times in 1660 In the same year he took out a privilege to print the texts of his plays and resumed again his right to his father's appointment as furnisher to the king. In Jan. 1661. on the demolition of the Petit-Bourbon. the company moved to a hall in the Palais-Royal, where all Molière's future plays were to be staged except those which he was commanded to produce for royal galas or private patrons. His one tragedy, *Donz Garcie de Navarre, ou le prince jaloux* (Feb. 4, 1661), was a failure, but *L'École des maris* (June 24) was another success. *Les Fâcheux* (Aug. 17) was composed for an entertainment at Vaux.

On Feb. 20. 1662. Molière married Armande Béjart. It is not certain whether she was Madeleine's daughter, as contemporaries thought. or her sister, as the documents state. She bore Molière three children. but only one of them, his daughter, survived to maturity. Their married life was not happy, and the flirtations of Armande were made the subject of hostile pamphlets.

L'École des femmes (see below), first staged on Dec. 26, 1662, ran till Aug. 12. 1663, but caused considerable outcry, to which Molière replied in two more comedies, *La Critique de l'École de femmes* (June 1) and *L'Impromptu de Versailles* (at Versailles in October). In 1664 he produced *Le Mariage forcé* in the Louvre (Jan. 29) and. for a gala at Versailles, not only *La Princesse d'Élide* (May 8) but also the first version of *Tartuffe* (May 12; *see* below) This great comedy provoked more opposition than any of his other works, and his next play, *Dom Juan, ou le festin de Pierre* (Feb. 15, 1665; *see* below), caused another scandal. In the following August, however, despite the attacks on Molière the king himself took over from Monsieur the patronage of the company, which was henceforth known as *la troupe du Roi.* On Sept. 13, 1665, at Versailles appeared *L'Amour médecin,* in which Molière began that satirizing of the medical profession which he was to make more pointed as ill-health from 1666 onward brought him more experience of doctors.

The year 1666 saw *Le Misanthrope* (June 4; *see* below), Le *Médecin malgré lui* (Aug. 6) and *Mélicerte* (Dec 2). The last-named was composed for a series of winter entertainments at Saint-Germain, to which Molière subsequently added *La Pastorale comique* (Jan. 5, 1667) and *Le Sicilien, ou l'amour peintre* (Feb. 10). In the following months Molière was seriously ill, but he returned to the theatre in June. On Aug. 5, 1667, *Tartuffe,* with the subtitle *L'Imposteur,* was shown publicly for the first time in Paris, but on the next day it was banned by order of the *président* Guillaume de Lamoignon. The archbishop of Paris. Hardouin de Péréfixe. reinforced this ban with ecclesiastical censure. This was the occasion of the defense of the play in a famous pamphlet *Lettre sur l'Imposteur.* In 1668, after producing *Amphitryon* at the Palais-Royal (Jan. 13) and *George Dandin* at Versailles (July 18), Molière on Sept. 9 at the Palais-Royal gave the first performance of *L'Avare (see* below). Early next year authorization was at last given for public performances of *Tartuffe,* which began on Feb. 5, 1669. *Monsieur de Pourceaugnac* (Oct. 6, 1669) was written for the king's stay at Chambord, and *Les Amants magnifiques* (Feb. 4. 1670) for Saint-Germain. *Le Bourgeois gentilhomme (see* below) was first performed at Chambord on Oct. 14, 1670, and *Psyché,* a most spectacular production, in the Tuileries on Jan. 17, 1671 (it was subsequently transferred to the Palais-Royal). This was followed by *Les Fourberies de Scapin* at the

Palais-Royal (May 24) and *La Comtesse d'Escarbagnas* (at Saint-Germain, Dec. 2. 1671). *Les Femmes savantes (see* below) was presented at the Palais-Royal on March 11, 1672.

In Aug. 1672 Molikre fell ill again. On Feb. 10, 1673, he appeared in the first performance of his last play, *Le Malade imaginaire (see* below). at the Palais-Royal. During the fourth performance of it on Feb. 17. 1673 he was taken gravely ill on the stage. Carried back to his house in the rue de Richelieu, he died there in the same night. As he had not been given the sacraments or the opportunity of formally renouncing the actor's profession, he was buried without ceremony and after sunset on Feb. 21.

THE MAN OF THE THEATRE

This great writer was not in the usual sense an author. He wrote little that could be then called literature or that was meant for publication: some poems, one in praise of his friend Pierre Mignard's decoration of the Val de Grâce, and a translation of Lucretius, unfinished and unpublished. His comedies were written for performance and were only published after the text of two of them had been pirated by Jean Ribou. Molière took out a "privilege" to publish in 1660 but made no use of it till 1662. He left seven of his plays unpublished. never issued any collected edition. never as far as is known read proofs or bothered with his text. It was as an actor that he wrote, for acting purposes. Comedies, in his view, were made only to be acted. This fact was forgotten in the 19th century, and it is to 20th-century actors such as Louis Jouvet, Charles Dullin and Jean Louis Barrault that we owe a new sense of his dramatic genius.

Competition, the fight for existence, was the keynote of Molière's whole career. His company had to share the hall of the Palais-Royal with the Italians. To keep his actors and his audiences, in face of the established theatres at the Hbtel de Bourgogne and the Marais, was an unremitting struggle. His fame was in the first place due to his winning the contest, as it were, singlehanded. He held his company together by his personality; he made up for lack of authors by writing more plays himself. The asperity of the struggle has been uncovered only by patient research. He could never sit back and enjoy leisure; his works could not be slowly elaborated or rewritten. He could be sure neither of his actors nor of his authors—Racine, whose first play, La *Thébaïde*, he had put on in 1664, transferred *Alexandre* in 1665 to the Hbtel de Bourgogne while Molière's company was actually performing it. He was constantly in trouble with the authorities: even *Les Précieuses ridicules* had to be taken off for a fortnight three weeks after the first production; *Dom Juan* ran for 15 performances only; *Tartuffe* was held back for years. His life had the luck of the theatre: everything was uncertain, experimental. . Certain plays brought him enormous successes, *L'École des femmes* in 1662, *Tartuffe* at long last in 1669. Recruits to the company made up for desertions. He enjoyed royal favour less than has been said. and it was capricious. The pension promised to the company by Monsieur in 1658 was never paid, the court supported his lighter plays more than his greater works. It seems that he had practically lost the royal favour to Lully in his last years. The receipts of his company show great fluctuation. As they fell, we find him writing more. René Bray (see *Bibliography*) calculates that he wrote 31 of the 95 plays put on the stage by his players in the 14 years 1660–73. To meet the situation caused by his own illness, the seven weeks of mourning for Anne of Austria and the proscription of *Tartuffe* and *Dom Juan*, he wrote five plays within the season of 1664–65, of which only one, *Le Médecin malgré lui*, was financially successful.

His own acting was at once his disappointment and his glory. He aspired to be a tragic actor and was not considered such by his contemporaries, partly because audiences then favoured the pompous style of strutting and chanting and roaring. He had rather the build! the elasticity, the india-rubber face of the born comedian. Though neither a great talker nor what is known as a merry man. he imitated gesture and speech irresistibly. He had the tireless energy of the actor, always ready to make a scene out of any incident, putting himself on the stage: he gave Harpagon his own cough, Alceste his own moods, and made a play out of his own green room The characters of his greatest play are very like the members of his company. It was quite in character that he died playing the part of the sick man that he actually was.

It cannot be that his acting genius has had no influence on his writing. since he wrote what he could most naturally act. He gave himself choleric parts, servants' parts, a henpecked husband. a foolish bourgeois, a superstitious old man who cursed "that fellow Molière": the comparison with Charlie Chaplin in our own day recurs constantly. His success, on stage and in writing scenes and composing parts. was due in part to this energy but also to another quality that one can only describe as intensity of dramatic vision. He seems to have been incapable of visualizing a situation without vivifying it. dramatizing it, forcing it to the limit of probability and often recklessly beyond. Here again actors have helped to recover an aspect of his genius that scholars had neglected, his theatrical violence. To think of his plays as arguments for a reasonable view of things is to miss their true vitality. He imagines characters so excited that their language becomes incoherent. their actions absurd. He seems always to have sacrificed plot to vivacity. This is natural if one remembers his medium and gifts. He who could get anything across was satisfied to get a scene across, no matter what rules of writing it defied. To think of him as the cool apostle of reason, like the *raisonneurs* of his plays, is a heresy that dies hard. but careful study of the milieu in which as a craftsman of the theatre Molikre worked should make such a heresy impossible. The comedies are not sermons; any doctrine they may contain is incidental and not an attempt to improve or instruct. The ideas discussed do not belong so much to the author as to the public whom they were intended to please. Had we been able to ask their author what he thought of hypocrisy or atheism, he would have marveled at the question and agreed with Lamoignon that the theatre was not the place to discuss such matters. Despite continued argument to the contrary. there is no documentary evidence that Molière ever tried to get his own views across in his plays, whether on marriage, or on the church, or on hell or on class distinctions. Strictly speaking, we do not know his views on these subjects. All we know is that he worked for the theatre and that he used to the full his gift, unique and amazing, of forcing the maximum of dramatic suggestion out of any scene or conversation that he imagined If he has left us a vivid picture and a sympathetic picture of an atheist. that is because of his imagination, not because of his ideas His picture of the earthy servingman is no less vivid and sympathetic. Scholars who have tried to make his plays prove things and convey lessons have made little sense of his work and have been blind to its inherent fantasy and imaginative poaer.

NINE GREAT PLAYS

If (as would seem to be the case) the power of Molière's writing lies in its creative vigour of language and suggestion. the usual divisions of his work into comedy of manners, comedy of character and farce are not helpful. There is again no evidence that he set out in any given instance to write a certain sort of play. The evidence is rather that an occasion presented itself for him to animate figures around a skeleton theme. The work that emerged mas always actable (it was meant to be), in fact it frequently left an indelible impression, one that audiences wished to see over and over again. This impression is given by the vigour and life of the words, not by the story or plot of the play. To recount Molière's plots is therefore to leave out the essentials of his plays. For purposes of information, however, it may be well to give some account of the content of his main plays.

Les Précieuses ridicules (1659).—This play, the first that Molikre wrote for a Parisian audience, is in many ways typical of all that were to follow. Its origin has been shown to be polemic, nithin the coterie of the finance minister Nicolas Fouquet, of the most violent kind. Its satire was so personal that it had to be taken off for a fortnight: what we now read or see is a revised and generalized version. It is built on the theme of two provincial girls anxious at all costs to be in the fashion of Paris as established by the *Précieuses,* and their exposure by valets masquerading as their

masters. The play does not obey the canons and rules laid down by contemporary theorists of drama. It has no discernible exposition or denouement; the unities do not arise. The entertainment is provided in a succession of scenes that enforce the comic contrast between desire for elegance without common sense on the one hand and plain downright presence of mind without any real culture on the other. The girls can risk fatuities like "voiturez-nous ici les commodités de la conversation" ("carriage us here the conveniences of conversation") while the valets grossly offer to show their wounds and are actually undressed on stage by their masters. The fun seems too obvious for comment, yet by the end we know in detail what an intelligent observer might have seen in the *Précieuses:* the affectation, in the name of culture and distinction, of thinking material things vulgar, of regarding marriage as something altogether shocking ("une chose tout à fait choquante") coupled nith an entire lack of discernment that failed to distinguish between taste and valets' fooling.

L'Ecole des femmes (1662).—Some good judges have considered *L'École des femmes* to be Molière's masterpiece, in the sense that he never came nearer to pure comedy. Based on *La Précaution inutile* (1661). Paul Scarron's adaptation of a Spanish story, the comedy shows how a man may be so exasperated by feminine coquetterie that he decides to marry a fool. Arnolphe is a pedant, aho has thought out a complete scheme and "cooked up" a girl in a convent from the age of four, so that she shall be entirely untrained in the ways of the modern world. The gradual portrayal in Agnès of an awakening temperament, all the stronger for its naïveté and limitations, is one of the marvels of modern comedy. The crowning fantasy is to imagine the pedant falling in love himself, he who had dismissed "all that" as beneath him, and nith the person nhom he had done his best to make unlovable He has to eat his words, and his elephantine gropings toward the language of love are his punishment and the spectators' delight As we shall see, this play aroused much hostility. partly perhaps because men felt that here was an ebullience of comic power for which nothing could expect to be sacrosanct.

Tartuffe (1664–69).—When in Molière's own street a hypocrite seduced his landlady, Molière's friends must have felt uneasy about his notion of making a play on that theme, for fear of what the church and the authorities would say. Yet he did make just such a play, and it brought him more trouble and more notoriety than any other. *Tartuffe* was played (in a three-act version now lost) before the king at a Versailles gala in 1664. It seems reasonable to think that it portrayed a pious crook, Tartuffe, so firmly established in a bourgeois household that he can make the master, Orgon, promise him his daughter's hand and disinherit his son in Tartuffe's favour. This went near the bone, for lay directors of conscience were in fact placed in families to reprove and reform manners. The play showed the "holy" man's sensuality tempting him too far, into making love to his employer's wife. Caught in the act, he recovers by masterly self-reproach. Orgon. taken in completely by appearances, not only pardons him but urges him to see his nife as much as possible "pour faire enrager le monde" ("to infuriate people"). Molière must have seen a lot in this theme, for in the final version, as publicly performed in 1669, the play is lengthened to five acts and contains two seduction scenes, and the interest is transferred from the gullible bourgeois to the paradox in Tartuffe himself, outwardly an inhuman ascetic but actually a very human sensualist and glutton. It is difficult to think of a theme more likely to give offense in 17th-century Paris. yet the tenacity with which Molière stuck to his design is matched by the brilliance of dramatic execution The play seems to exploit another case of the dichotomy discovered in *L'École des femmes*. Arnolphe came to grief because he trusted in nit and forgot instinct. Tartuffe seems to have been imagined on similar lines. It is a recurrent theme, for which Molière seemed to delight to invent new cases.

Dom Juan, ou le festin de Pierre (1665).—This play, meant to be a quick money raiser, was a costly failure that had only 15 performances before it was mysteriously removed and never either repeated or published by Molière. It is a priceless example of his art. Dom Juan thinks himself free from all obligation and believes neither in God nor hell nor doctors, nor in the sacredness of promises, yet as an aristocrat assumes that others will keep their obligations to him who acknowledges no obligation. His servant Sganarelle is his opposite in every point, earthy where he is lofty, timorous where he is scornful, superstitious where he is skeptical. They form the perfect French counterpart to Don Quixote and Sancho, yet the play had no success until modern actors showed its power.

Le Misanthrope (1666).—By contrast *Le Misanthrope* almost from the beginning was treated as a masterpiece by discerning critics. if not by the general public. It is a drawing room comedy, constructed from the elements of Molikre's own company, with himself in the role of Alceste, the hasty, well-meaning but blind critic of everybody else, the more irritating because he claims the highest motives, and Molikre's wife as the flirt Célimène, who is equal to every occasion. The technique of structure is as simple as it is profound and poetic. After railing against humanity. Alceste has to face a fop and give an "honest" opinion on his poem: he is too good-natured to do so at first, then really speaks his mind, with disastrous results. He thinks he has a cast-iron case against Célimène but crumples up at once when it does not go his way. The marvel is that this brilliant pathological sketch of a doctrinaire is so appealing and his increasing moodiness so entertaining. He is always ready to see the mote in another's eye, regardless of the beam in his own, as ignorant of his real nature as Arnolphe, Tartuffe or Dom Juan.

L'Avare (1668).—Sooner or later it was inevitable that Molière would attempt a modern rendering of the ancient comic figure of the miser. *L'Avare* is in prose that reads as if the author had nished to turn it into verse; the stock situations are all renewed, and gradually a picture emerges of a man rendered inhuman by love of money. Harpagon's mania is imagined to the point of cruelty, pathology and insanity, all in breath-taking scenes of great dramatic force. For those who think comedy must cause laughter the play is too stark. Goethe started a bad fashion by calling it tragic. Yet it would seem to be imagined in much the same way as *L'École des femmes* and the other plays often regarded as greater, involving as it does (in differing forms, of course) a basic separation between the forces of mind and intention. devoted to cruel and inhuman ends. and the underlying instincts and human nature. which is not so homogeneous nor so much a servant of the mind as the subject would have it be. In his distress Harpagon becomes human once more, but a pitiful specimen. quite different from what he thought himself to be. There is laughter in this comedy, but it is incidental; the basic comic suggestion is rather absurdity. incongruity. paradox.

Le Bourgeois gentilhomme (1670).—That the master's gaiety or imaginative powers were not yet exhausted is proved by *Le Bourgeois gentilhomme,* an apparent exposure of the contemporary desire of the *bourgeoisie* to compete in magnificence with the great nobility, yet perhaps the least dated of all the comedies. The imaginative power is shown in the fact that the comic figure who might have turned out an unpleasant sycophant and climber is in fact delightful. good-natured, fatuous yet naive and genuine. His nature (which again he despises) gives us more pleasure than his follies which he thinks to be sensible. Molière seems to return here to the vein of comedy that he had exploited in *Les Précieuses ridicules* and in the farces, of imagining fatuity, not only in the bourgeois but in the masters, and pitting it against common sense in the nife and servant.

Les Femmes savantes (1672).—As if he recognized the value of such presentation, Molikre renewed it 18 months later with *Les Femmes savantes,* which in lesser hands would have been. as some have thought it, a satire on bluestockings, but which becomes the most refreshing comedy with every appearance of the main character, a bourgeois more sensible than his wife but less forceful. The contrast is so delightful that we forget the less pleasant parts of the play and the fact that Trissotin is a cruel caricature of a respected living contemporary, the abbé Charles Cotin.

Le Malade imaginaire (1673).—Molière's last play is about a hypochondriac nho fears death and doctors. As the fourth performance of it caused his hemorrhage and death, the irony of events has masked or made readers reluctant to probe the irony of the

choice of subject. The power of suggestion is still present, in the author's delineation of servitude to jargon and professionalism, in his imagination of fatuity in young Diafoirus (a would-be doctor with some learning but no sense) and in the old but ever fresh opposition of youth and sense (Angélique and Béralde) to superstition and greed and charlatanry (Argan, Béline, Purgon).

THE ESSENCE OF THE COMEDY

Few great authors can in their lifetime have given so much pleasure to so many people (that is, before the days of cheap editions) as did Molikre. This consideration enables us to see in true perspective the hostility that. his plays aroused, not only from professional rivals but from public authorities. The writer now acknowledged to be the greatest classical author of France was in his own day decried as impious and unhealthy. The printed attacks on him are almost all without merit; the plays put on the stage against him enjoyed favour only because of the play they were attacking. *Les Précieuses ridicules* provoked *Les Véritables Précieuses* of Antoine Baudeau de Somaize, *Sganarelle* provoked *La Cocue inzaginaire* of François Doneau, and *L'École des femmes* raised such a chorus of discussion that Molikre joined in with a dramatic reply in *La Critique de l'École des Femmes* and some months later with *L'Impromptu de Versailles*. Both these playlets of his make excellent points, discussing how much should be read into plays, praising the taste of the court and of the pit and breaking a lance for the new realism that demanded recognizable human types in plays rather than the heroic gallant figures of a previous generation. Dorante, in scene 6 of *La Critique,* states that "vous n'avez rien fait, si vous n'y faites reconnaitre les gens de votre siècle . . . c'est une étrange entreprise que celle de faire rire les honnêtes gens" ("you haven't achieved anything in comedy unless you give recognizable portraits of contemporary types . . . making decent people laugh is a strange business"); and later in the same scene he makes his famous statement about the rules which some were anxious to impose on all writers for the stage: "Je voudrais bien savoir si la grande règle de toutes les rkgles n'est pas de plaire et si une pièce de théâtre qui a attrapé son but n'a pas suivi un bon chemin" ("I wonder if the golden rule is not to give pleasure and if a play that achieves its purpose has not been following the right track"). Now that most documents of the controversy over *L'École des femnzes* are long since dead, *La Critique* stands as Molière's nearest approach to an exposition of his guiding principles. *L'Impromptu,* no less original an invention, gives not only a charming picture of the manager with his company but the only direct answer that Molière ever made to personal attacks: "Je leur abandonne de bon coeur mes ouvrages, ma figure, mes gestes, mes paroles, mon ton de voix et ma façon de réciter . . . Mais . . . ils me doivent faire la grâce de me laisser le reste . . . voila toute la réponse qu'ils auront de moi" ("I gladly let them do what they like with my works, my appearance, my gestures, my words, my tone of voice and my way of reciting . . . But . . . they should be kind enough to leave me what remains. That is the only answer that they will get from me").

This restraint and lightness of touch now seem more remarkable than the violence of the attack on *L'École des femmes,* but that attack was a slight thing compared to the storm raised by *Tartuffe* and *Dom Juan*. The official condemnations of *Tartuffe* in 1665 and the even more savage pamphlets of Pierre Roulle, curé oi Saint-Barthélemy, and B. A. sieur de Rochemont (probably a pseudonym) drew from the poet valuable statements concerning his art. On *Dom Juan* he made no public reply since it was never officially condemned. The documents, in defense of *Tartuffe* are two *placets* to the king, the preface to the first edition of the play in 1669 (all published under Molière's own name) and the famous *Lettre sur l'Imposteur* of 1667. The *placets* and the preface are aesthetically disappointing, since Molière was forced to fight on the ground chosen by his opponents and to admit that comedy must be didactic. There is no other evidence that Molière thought this, so it is not unfair to assume that he used the argument only when forced. The *Lcttre* is much more important. It provides in a few pregnant lines the aesthetic basis, not only of *Tartuffe* but of Molière's revolutionary conception of comedy:

"Le ridicule est la forme extérieure et sensible que la providence de la nature a attachke à tout ce qui est déraisonnable, pour nous en apercevoir et pour nous obliger a la fuir. Pour connaitre ce ridicule il faut connaitre la raison dont il signifie le défaut et voir en quoi elle consiste . . . la disconvenance est l'essence du ridicule . . . il s'ensuit que tout mensonge, déguisement, fourberie, dissimulation, toute apparence differente du iond, enfin toute contrariété entre actions qui procèdent d'un même principe, est essentiellement ridicule" ("The ridiculous is the outward and visible iorm that nature's providence has fixed to all that is contrary to reason, in order to draw our attention to it and to make us avoid it. To appreciate it, we must appreciate that reasonable quality of which it suggests the lack and perceive what constitutes that quality . . . the essence oi the ridiculous is incongruity . . . thence it follows that all lying, disguising, cheating, dissimulation, any outward show different from the underlying reality, in short any contradiction between actions arising from the same principle, is essentially ridiculous").

Here surely is the insight which enabled Molikre to create something entirely new in comedy. Didactic comedy, satiric comedy, farce, all these were known before his time and none of them are his invention. But the comedy that is only incidentally funny and essentially rests on a constant double vision, of the right and the wrong together, of the normal and the abnormal, of the true and the specious, of the intelligent and the pedantic, this form of the comic is his invention and his glory.

Comedy depends. in Mme. de Stael's view: on constant intrusion of the physical into the realm of intellect. Bergson preferred to describe it as the intrusion of the mechanical into the domain of the spontaneous. The mixing of registers, so to speak, which is suggested by both these definitions, is a constant feature of Molière's work that does not emerge in such thumbnail accounts of the chief plays as given above. The wit, the insight, the fun emerge as frequently in the light plays as in the more serious (Diderot reminds us that a one-act farce is as complex a product of the imagination as *Le Misanthrope*). Characters are made to play a part, then forget it. speak out of turn, overplay their role, so that in all cases the spectator has the delicious suggestion of two registers mixed. Beaten into acting as a doctor, Sganarelle in *Le Médecin malgré lui* not only invents the right sort of jargon, he enjoys it and. to say something. utters inanities about Hippocrates. Overjoyed to find a patient ignorant of Latin so that he can utter further nonsense. he finally comes up to his famous howler of putting the heart on the right instead of the left. Interrupted by a mild protest, he has to keep up his role of scholar with the immortal "Nous avons changi: tout cela." Harpagon in *L'Avare,* describing his miserable condition without his money is pathetic: "Mon esprit est trouble et j'ignore où je suis qui je suis et ce que je fais . . . c'en est fait. je n'en puis plus, je me meurs. je suis mort, je suis enterré" ("My mind is disturbed and I don't know where I am, who I am, n-hat I'm doing . . . it's all over. I can stand no more: I'm dying, I'm dead. I'm buried"). His very violence has carried him beyond the rational into the absurd. This is not an accident but the sign of a powerful imagination on the part of the writer who seems untiring in creating cases of this kind. In the same part of the same play, an even more powerfully poetic suggestion comes through Harpagon's incoherence: "Je veux aller quérir la justice et faire donner la question à toute ma maison . . . si I'on ne me fait retrouver mon argent, je demanderai justice de la justice" ("I want to call the law in and have my whole household put to torture . . . if they don't restore my money, I will have the law on the law"). Does Alceste do any more than this in complaining "J'ai pour moi la justice et je perds mon procès" ("I have justice on my side and I lose my case")? What is here imagined? Surely the tendency to confuse social institutions with moral qualities, to think that if me have courrs of justice it is scandalous that complete justice is not in our case given.

This insight into human behaviour so French and so inaccessible to others is near the centre of Molière's appeal to his own nation. When Voltaire described him as "le peintre de la France" he was not referring to realism but to French attitudes for which Molikre has imagined an immense variety of incarnations. This may be what gives the French an almost "proprietary" interest in Molière: they appear to regard him as "their" author in a curiously possessive way and to feel at home with aspects of his work

that others may tend to overlook. Three of these may best close this survey.

First of all is its formality. Molikre's public were delighted by the realism and naturalness of his work precisely because they did not expect these things in literature as we do. Drama for them was formal and as far removed from ordinary speech as possible. Much of his work is in fact in verse. Apart from his acting and the provoking of laughter, his public wished to be "charmed" by spectacle, by a fusion of light and colour and movement in which music and dance were as important as speech. Modern productions that omit the *intermèdes* and ballets are far from the original effect. A similar sense of form is in all the comedies, in the opposition of characters, the arrangement of scenes and speeches, the comic repartee carried to its conclusion in defiance of realism.

Psychology is now no longer regarded as a governing feature of Molikre's work. To speak of him as having created comedy of character, wherein forms of social mania are studied, is an overemphasis of academic criticism. Is the psychology, even in the greater plays, so deep and sound? The French prefer to see them as creations of fantasy, an imaginative and poetic quality that vivifies ideas and attitudes only to drop them and pass on when a point has been taken. *Le Misanthrope* is not usually in France held to be a study of misanthropy or even a French equivalent of *Hamlet* but a subtly arranged chorus, so to speak, of voices and attitudes that illumine the attitude of the individual in society. The play charms by its successive evocation of this single and central theme. To speak your mind is easy when you are annoyed or detached or disapproving or when society has hurt you, and to be frank may be honourable and idealistic; it may equally well be egoistic and self-seeking and rude and spiteful. All centres round a concept: our inability to see ourselves or. as the charming Célimène puts it. "ce grand aveuglement où chacun est de soi." It is in this fantasy playing on the mystery of the self-centred character that Molière is. in the eyes of his own people, unsurpassed.

A third quality admired in France is a kind of intellectual penetration that distinguishes parts of a man from the whole man. Montaigne, to whose thought Molière owed much, has separated "acquired qualities." learning or politeness or professional competence, and .'natural qualities," such as self-interest, humanity, animality, what we would often just call "human nature." Conversations in Molière seem designed as crucibles in which the shock of characters and interests makes social veneer peel off. How many dialogues in his plays start with politeness and end with open insults?

The final achievement of Molikre's imagination may well be the double vision to which his comic genius led him—the simultaneous presentation of a quality and its opposite. the norm and the aberration, the scandal and the reaction, ingenuity and nature; scheme and reality, principle and practice. Dandin, in *George Dandin* (1668), may well be one of his greatest creations. If taken seriously, then he is a pathetic figure out of place in comedy. But there is never time to take him seriously and indeed for the French *he,* as something in flesh and blood, does not exist, as they see only his emphases, his judgments, his terribly human and typical blunders. For many people a man is not comic who is so outwitted by a faithless wife as to make him want to drown himself. The French see not a man but a comic attitude. that of expecting that the world will help the honest, and of finding that it inexplicably hits him (or rather us) again and again. This is so, yet it is a scandal to our sense of order: "J'enrage d'avoir tort lorsque j'ai raison" ("It infuriates me to be wrong whem I'm right"). The subject is trivial, the intellectual suggestiveness is limitless. A way has been found for comedy to embrace everything, things in the mind and outside it. thanks to the double vision that keeps the contrasting terms both present to the charmed spectator. Things that are not are evoked to illumine things that are. As the beaten Sosie in *Amphitryon* puts it "Cela choque le sens commun Rlais cela ne laisse pas d'être" ("That conflicts with common sense. But it is so. for all that"). *See* also Index references under "Molière" in the Index volume.

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MOLINE, a city of Rock Island county, northwestern Illinois, U.S., just above the upper rapids of the Mississippi river 167 mi. W. by S. of Chicago. The name was derived apparently from the Spanish word *molino,* meaning "mill." Swedish immigrants played an important part in the settlement of the town, laid out in 1843. John Deere, inventor of an improved steel plow. settled in Moline in 1847 and established a small shop there. With the advantages of a broad agricultural hinterland and exceptional transportation facilities, Moline, sometimes called "The Plow City." was by 1890 a centre of plow production. Farm implement manufacturing, a major industry, is a part of a large industrial complex whose products include heating and ventilating equipment, tools, clothing and furniture. For comparative population figures *see* table in ILLINOIS: *Population.* It is a part of the Davenport-Rock Island-Moline standard metropolitan statistical area *(see* DAVENPORT). (D. L. A.)

MOLINET, JEAN *(c.* 1433–1507), French poet, chronicler and head of the *rhétoriqueurs,* a Burgundian school of poetry. was born at Desvres (Pas de Calais). In 1475 he succeeded Georges Chastellain as historiographer of the house of Burgundy. His continuation of Chastellain's chronicle, covering the years 1474–1504, remained unpublished until 1828 when it was edited by J. A. Buchon. A selection from his poetical works was published in 1531. *Les Faictz et dictz de feu . . . Jehan Molinet. . . .* He also translated the *Roman de la rose* into prose (1503). He became, in 1501, canon of the church of Notre-Dame at Valenciennes, where he died on Aug. 23, 1507.

MOLINOS, MIGUEL DE (1628–1696), Spanish priest, proponent of an extreme Quietism; was born at Muniesa, Aragon, on June 29, 1628. He studied theology at the Jesuit Colegio de San Pablo, Valencia. where he was ordained priest in 1652. Sent to Rome in 1663. he soon became one of the city's most esteemed spiritual directors. There in 16; j he published his *Spiritual Guide,* a small handbook of the contemplative life that was an immediate sensation. Some attacked its doctrine and had their efforts put on the *Index Librorum Prohibitorum,* while those who defended it received ecclesiastical advancement. In 1685, when his influence with the people was at its zenith, his favour in ecclesiastical circles most marked and his friend Innocent XI was pope, Molinos was arrested by the papal police, tried and eventually sentenced to life imprisonment for heresy.

The occasion of this sudden reversal of opinion would appear to have been the discovery of his personal immorality, which in turn revealed what had previously remained hidden (perhaps even from himself): the antinomian implications of his doctrine *(see* ANTINOMIANISM). In the "Summation" of his trial he is found defending his own and his followers' sexual aberrations as sinless purifying acts, which, effected by the devil and passively permitted

by the truly interior Christian, providentially deepen such a one's quiet repose in God. But as the doctrinal propositions, chiefly from his correspondence, were successively brought forward, his moral sense seems to have been jarred into life once more. He admitted that he had been wrong and offered no further defense. He died in prison at Rome on Dec. 28, 1696.

Ambiguities and misapprehensions long attended the historical evaluation of Molinos, chiefly because in the Guide, his only work generally known, doctrines which brought about his condemnation are not to be found; it evidences at most a speculative climate not unfavourable to their origin and development. See also **QUIETISM**.

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MØLLER, POUL MARTIN (1794–1838), Danish author whose novel of student life heralded a new realistic approach and so marked an important stage in the history of Danish literature, was born near Nakskov on March 21, 1794. After taking a degree in divinity at Copenhagen, he began his literary career by translating Homer. To recover from a broken engagement, he went to China as a chaplain on a Danish ship (1819–21); the literary results were some journals, a number of *Strøtanker* ("Aphorisms"), nostalgic poems about Denmark and Copenhagen (*e.g.,* "Scener i Rosenborg Slotshave") and a witty parody of statistical-topographical descriptions, Laegdsgaarden *i Ølsebymagle.* He had already shown gifts as a poet in both humorous and melancholy moods (*e.g.,* "Torbisten og Fluen" and "Aprilvise"), and as a prose-writer in *Eyvind Skaldaspiller,* a saga pastiche. After his return he earned his living by teaching classics, while studying philosophy.

Møller first read his most famous work, *En dansk Students Eventyr,* a novelle originally planned as a historical novel in the manner of Sir Walter Scott but in its final (though fragmentary) form describing contemporary student life, to the students' union at Copenhagen in 1824. His own character is reflected in the three main characters: Curly Frits, the irresponsible idler; the pedantic Magister; and the antiromantic Bertel. Blade af *Dødens* Dagbog ("Leaves From Death's Diary"), a poetic fragment inspired by Byron, and other sketches such as his witty essay "Quindelighed," demonstrate both his mastery of style and his lack of energy to complete anything. Møller was lecturer in philosophy at Christiana (Oslo) university from 1826 to 1828, when he became professor, and from 1831 he held the chair of philosophy at Copenhagen, where he died on March 13, 1838. Among his students was Søren Kierkegaard (*q.v.*), who much admired him.

The most important of Møller's later works, apart from several philosophical essays, is the poem Kunstneren *mellem Oprørerne,* advocating the artist's freedom from political commitments. Møller's realistic approach to literature in a romantic age may be summed up in his aphorism: "All poetry that does not come from life is a lie."

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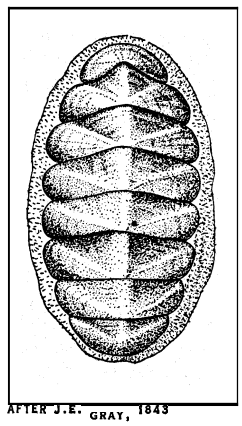
MOLLIEN, NICOLAS FRANÇOIS, COUNT (1758–1850), French financier, was born in Paris on Feb. 28, 1758. He entered the ministry of finance as a young man, and put his great financial ability at the service of successive governments. Under Colbert he improved the returns from the farmers-general of the taxes; he helped the conclusion of the Anglo-French treaty of 1786; after the coup *d'état* of Brumaire (Nov. 1799) he held successive financial appointments, and was constantly consulted by Napoleon, who, however, refused to accept the advice of his finance minister against his "continental system." He was again finance minister during the Hundred Days, and, though he declined office after the Restoration, was consulted in connection with the annual budgets.

MOLLUSCA. An important group of invertebrate animals constituting a main subdivision or phylum of the animal kingdom and comprising such forms as land and aquatic snails and slugs, oysters, mussels, cuttlefish and squids. The group is very large, containing more than 60,000 living species, and, judged by its distribution, it has been highly successful, as its members have populated the sea, fresh water and the land. They manifest great diversity of habit and structure, and range in size from the giant squids of the Atlantic, which span more than 50 ft. in length, to snails less than a millimetre in length in the adult state.



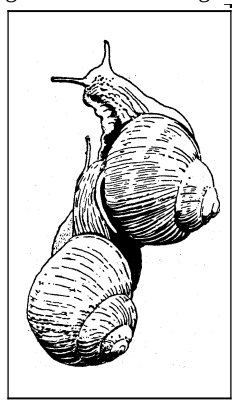
AFTER J.E. GRAY, 1843

FIG. 1.—EUDOXOCHITON NOBILIS

The phylum is divisible into five classes: the Amphineura (chitons or coat of mail shells), the Gastropoda (limpets, whelks, snails and slugs), the Scaphopoda (or tusk shells), the Lamellibranchia (oysters, mussels and scallops), and the Cephalopoda (squids, cuttlefish and octopods). Certain problematical fossil forms, the Conularida, are sometimes treated as a class of the Mollusca. Their exact zoological position is, however, debatable, and they cannot be adequately discussed here (see GASTROPODA).

The Gastropoda are the largest class of molluscs, and easily outnumber the rest. The Scaphopoda are a small group of but five families. In the past such animals as Tunicates, Brachiopods and Cirrhipedes were included in this phylum, and a well defined concept of the latter was only formulated towards the end of the 19th century. Thiele and Odhner at the present time hold the view that the Solenogastres or Aplacophora, a subdivision of the Amphineura, are more closely related in certain respects to certain groups of worms than to the Mollusca. This view is not accepted here and the Solenogastres are treated as molluscs (*see* AMPHINEURA).

Definition and Classification.—The Mollusca are invertebrate animals, typically elongate in form and having an originally symmetrical organization. The viscera are sheathed in an outer integument, of which the lower part is modified as a muscular organ of locomotion, the foot, and the upper part (the mantle) is extended on each side and hangs down as a free fold around the body, enclosing a space, the mantle-cavity. The mantle secretes a calcareous shell and its under surface within the mantle cavity gives rise to the organs of respiration (gills or "false" gills), or is modified in terrestrial, air-breathing molluscs to form a lung. In all Mollusca except the Lamellibranchia the anterior tegumentary region is modified as a more or less mobile head usually provided with sensory appendages and sense organs. This threefold division of the body constitutes the essential plan of molluscan organization. In addition, it should be noted as especially characteristic of the phylum that (1) there are very scanty traces of segmentation; (2) the coelom is represented by the pericardium and gonad but is much reduced by the extensive vascular system; (3) the alimentary system (except in the Lamellibranchia) is characterized by the peculiar tongue beset with chitinous teeth (radula); (4) the nervous system consists essentially of a circumoesophageal ring composed of an upper or cerebral half and a lower or labial portion, from the point of junction of which arise longitudinal pallial and pedal cords on each side, and (5) the cleavage of the egg is spiral and segmentation usually gives rise to trochophore and veliger larval stages.



BY COURTESY OF E. STEP

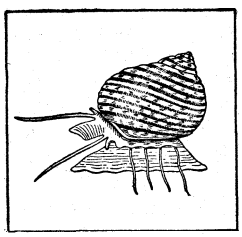
FIG. 2.—ROMAN SNAIL (ABOUT ½ NATURAL SIZE)

The Amphineura are exclusively marine, of elongate shape and symmetrical organization, having the mantle beset with spicules. In the most familiar forms (*Chiton*) the shell is divided into eight

separate plates. The Gastropoda are asymmetrical and characterized by the atrophy or disappearance of the organs of the original left-hand side, and by the spiral winding of the shell and visceral mass. The Scaphopoda are marine; the mantle is fused in the mid-ventral line, so as to enclose the visceral mass in a sheath which secretes a tubular shell. The Larnellibranchia are aquatic: the mantle is divided into right and left lobes which secrete a bivalve shell: the head is undeveloped and the gills become highly complex, subserving nutrition as well as respiration. The Cephalopoda are marine molluscs in which the head and foot are fused. The edges of this mass are produced into appendages; the ventral surface is much abbreviated and locomotion is mainly accomplished by the ejection of jets of water through an organ (the funnel) developed from the foot.

MORPHOLOGY

The structure and modification of the various organ systems are described in detail under each class but there are certain anatomical and physiological features which may be considered here.



AFTER QUOY AND GAIMARD, 1835

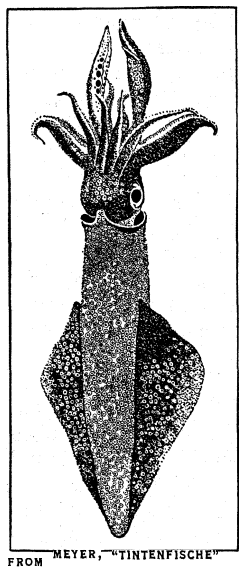
FIG. 3. — MONODONTA CANALIFERA, SHOWING MANTLE LOBES; ABOUT NATURAL SIZE

External Features. — The main divisions of the body (head, visceral mass, mantle and foot) are usually quite manifest. In the Scaphopoda and Amphineura, however, the head is moderately developed, and in the Lamellibranchia it is absent. In the Gastropoda it is usually very mobile and well-equipped with sense organs. In the Cephalopoda it is fused with the foot; the appendages formed from the edge of the latter are arranged in a circlet round the mouth, and the transference of prey to the latter and a firm grasp on it, while it is being masticated by the jaws, are thus facilitated. The central nervous system (see below) tends to become concentrated in the head in Gastropoda and Cephalopoda. The occurrence in certain Gastropoda of a sheath of hard connective tissue around the ganglia and of cephalic cartilages enclosing the latter in the Cephalopoda produces an amount of "cephalization" uncommon in invertebrate animals. In the Lamellibranchia the mantle attains considerable importance. From it are developed the siphons by which the animal maintains connection with the water when burrowing in sand or mud. Its derivatives, the gills, are important not only in respiration but also in nutrition and in the incubation of the young. In the Cephalopoda it is of great functional importance in locomotion and (as a mechanical factor) in respiration and excretion.

The shell is secreted by the mantle in all molluscs. It consists in most cases of an organic matrix of conchyolin (an albuminoidal substance), impregnated with mineral salts. The latter consist mainly of calcium carbonate, but small quantities of calcium phosphate and magnesium carbonate are also found. The shell is formed in various layers, two in the pearl producing ones, an external one of prisms of calcite and an inner of arragonite, which latter forms the nacre or mother-of-pearl. The shell grows in area by the addition of organic and inorganic matter secreted by the edge of the mantle and in thickness by addition of new matter to the inner layer secreted by the whole surface of the mantle. In addition to these two layers there is usually an external horny shell-epidermis or periostracum and a fourth more localized layer, the hypostracum, on the areas in which are inserted the muscles by which the shell is attached to the animal.

Internal Anatomy. — The alimentary system is divisible into three main regions — an anterior section comprising the mouth, pharyngeal mass and oesophagus, the mid-gut composed of the stomach and liver, and the intestine. In the Lamellibranchia the first of these is imperfectly developed. These animals feed on small particles and minute planktonic organisms and the mandibles, radula, pharyngeal musculature found in molluscs, which live on coarser food, are absent. In all molluscs the liver is the most important digestive organ and it may have absorptive and excretory functions. In the Gastropoda, Lamellibranchia and Scaphopoda there is an additional organ of digestion, the crystalline style. This is a rod of gelatinous substance containing digestive enzymes. It either lies free in the initial part of the intestine or is lodged in a special coecurn developed therefrom. The Gastropoda and Lamellibranchia exhibit remarkable parallel modifications of this coecurn. In the Cephalopoda there is a spiral coecurn opening into the stomach which may be homologous with the style-sac; but, as in certain Gastropoda this and a spiral coecurn coexist, the coecurn of the Cephalopoda possibly represents the gastropod spiral coecum.

Circulation and Respiration. — The blood of most molluscs is colourless but haemoglobin and haemocyanin occur in certain forms. The blood is largely contained in a vascular system, but the latter rarely ends in capillaries and usually opens into capacious spaces (lacunae). These ramify among the various internal organs and their extensive development rather restricts the area of the primary body cavity (coelom). The heart usually consists of a ventricle and two auricles. The blood is oxygenated in the surface tissues of the mantle either in the respiratory organs (gills) or in the inner surface of the mantle cavity ("lung" of air-breathing Gastropoda) or in the exposed surface of the mantle (certain Gastropoda, Scaphopoda). The gills are either true ctenidia (feather-like structures consisting of a hollow vascular axis supporting lateral filaments) or accessory branchial structures of various kinds. The surface of the ctenidia is covered with cilia in all molluscs but the Cephalopoda. By these cilia the water in the mantle cavity is kept in circulation. In the Lamellibranchia the food particles are sorted out by currents produced by the cilia and conveyed to the mouth. In the Cephalopoda the water in the mouth cavity is kept in circulation by the contraction and expansion of the mantle.



FROM MEYER, "TINTENFISCHE"

FIG. 4.—LOLIGO (CUTTLEFISH) (REDUCED)

Coelom, Renal and Reproductive Organs. — The coelom is represented in most Mollusca by the pericardiurn and (when persistent) the cavity of the gonad. In the Cephalopoda there is a capacious gonadial portion of the coelom from the wall of which the ovary and testis are developed. In this class and certain Amphineura (the Aplacophora) the pericardium and gonadial coelom communicate with each other, but in all other molluscs the two portions of the coelom are separate. It is however to be inferred that the primitive connection between pericardium and gonad occurred in the ancestors of such molluscs, as in the more primitive members of the Gastropoda and Lamellibranchia the gonad opens into the duct connecting the kidney and the pericardium. It is not certain if the renal and generative ducts in all the groups of Mollusca are always true coelomoducts (*i.e.*, evaginations of the coelomic cavity). The kidneys open internally into the pericardium in all the classes except in *Nautilus* and the Scaphopoda. Whether this connection actually indicates that the kidneys are in all cases coelomic outgrowths is not certain. True nephridia only occur in larval Gastropoda and Lamellibranchia. In certain members of these two classes which have been carefully studied the adult kidneys are certainly mesodermal in origin and may be regarded as coelomoducts. In the Aplacophora, the archaic Gastropoda and the Scaphopoda there are no separate genital ducts, the ova and spermatozoa being discharged through the kidneys. This is likewise found in certain Lamellibranchia, but the genital conduit is gradually shifted toward the external end of the kidney and eventually acquires a separate opening. In the Neritacea among the Aspidobranchiate Gastropoda and the rest of that class in such forms as have been specially studied there is a separate genital duct formed from the originally left-hand kidney. In the Cephalopoda and Polyplacophora the gonaducts and kidneys are entirely separate.

The Nervous System. — The nervous system consists of

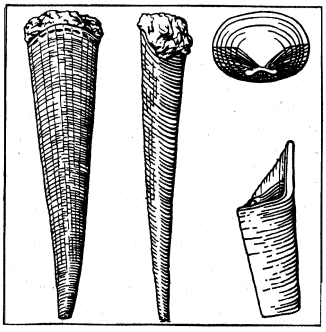
ganglionic centres, nerve cords and sense organs. The term "central nervous system" is not usually employed in connection with the nervous organization of the Mollusca; but there is in fact a central group of ganglia connected by commissures and a peripheral system of nerves, localized ganglia and end organs. The general plan of the system has been already indicated. The chief areas of the body and organs are innervated as follows. The head and its sense organs are supplied with nerves from cerebral ganglia situated on the dorsal side of the circumoesophageal ring. The mantle and foot are innervated from pallial and pedal ganglia respectively from which the main pallial and pedal cords originate. The viscera receive their nerve supply from the labial commissure (the ventral part of the circumoesophageal ring) through a stomato-gastric system and also from a visceral commissure beset with ganglia which arises from the pallial ganglia. In primitive Mollusca the various ganglia are diffuse and the commissures joining them are long. In Gastropoda and Cephalopoda there is a marked tendency for the ganglia to be concentrated around the oesophagus and fused in a solid ring. The term "central nervous system" then becomes highly suitable. Whether this concentration has any functional significance is uncertain. It may be responsible for the highly co-ordinated movements performed by the Cephalopoda, but as far as nervous efficiency is concerned there does not seem much difference between those Gastropoda in which the ganglia are concentrated and those in which they are diffuse.

Reproduction. — The sexes are separate in most Mollusca and hermaphroditism is usually found in specialized forms. Sexual dimorphism is seldom marked. Copulation only occurs in the Cephalopoda and in certain Gastropoda in which a penis is found, but in some Lamellibranchia in which there is no copulatory organ fertilization is nevertheless internal. The eggs are laid separately in the Amphineura, Lamellibranchia, Scaphopoda and more archaic Gastropoda; in most aquatic Gastropoda and in the Cephalopoda they are deposited in masses which through the development of special capsules and supporting structures may become very complex.

In a few Gastropoda, Lamellibranchia and Amphineura the eggs are incubated in the maternal body; but truly viviparous forms are rare. Parthenogenesis has been recorded in a single species of Gastropoda, Paludestrina *jenkinsi.*

Bionomics.—The most primitive living molluscs are aquatic and the earliest fossil representatives (Lower Cambrian Gastropoda and Lamellibranchia) seem to have lived in the sea. The greater part of the modern Mollusca have retained this character. During the Devonian period they began to populate fresh water and in the Carboniferous they invaded the land. From that time onward the population of fresh water and land has continued, that of land with increasing rapidity and evolutionary diversification, that of fresh water more slowly and with less variety of form and habit.

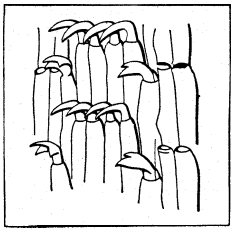
The relative numbers of marine, fresh-water and terrestrial forms may be gauged by the following list which gives the number of species in the British molluscan fauna as far as they can be thus classified. Marine 714, Fresh water 69, Land 91.



FROM ZITTELL, "PALAEONTOLOGY" (MACMILLAN)

FIG. 5.—HYLOTHES MAXIMUS

The Amphineura, Scaphopoda and Cephalopoda are exclusively marine in distribution and do not tolerate any reduction of the normal salinity of sea water. The fresh-water fauna is made up principally of two groups—certain Taenioglossa (*Viviparus,* Hydrobia, *Melania, Ampullarius*) and Basommatophora (Lymnaea and Planorbis) among the Gastropoda and the Unionidae, Cyrenidae, etc., among the Lamellibranchia. The large terrestrial fauna is mainly drawn from a single suborder (the Stylommatophora) and a few families (*e.g.,* Helicinidae, Cyclophoridae, Auriculidae, etc.) of other Gastropoda. In other words, the population of fresh water is the achievement of a restricted group of Gastropoda and Lamellibranchia and the highly successful invasion of land has been carried out by the Gastropoda alone. As far as the Lamellibranchia are concerned the failure to populate land is readily explained, as their mode of nutrition has become highly specialized and entirely depends on water-borne particles and organisms. The absence of Cephalopoda from land and fresh water is not so easily explained. The Dibranchia are specialized for rapid swimming, so that the reason for their restriction to water is obvious. The littoral Octopoda, which live mainly on or just off the sea-bottom, can move over the latter with considerable agility so that locomotor specialization cannot be invoked to account for their absence from the land. In all likelihood the marked participation of the mantle in the locomotor function and its development as a muscular pumping organ in relation to respiration has deprived it of that capacity for being converted into an organ for breathing air characteristic of terrestrial Gastropoda. As for their failure to colonize fresh water there is no satisfactory explanation beyond the obvious suggestion that they may be physiologically intolerant of fresh and brackish water.



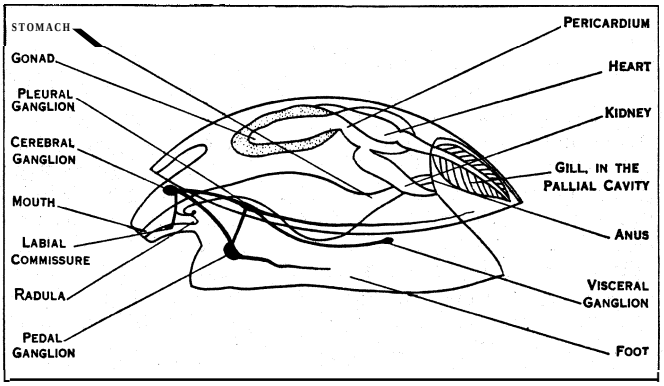
TORY" (MACMILLAN)

FIG. 6.—RADULA OF LIMPET

The marine Mollusca have a world-wide distribution as sedentary, swimming and floating animals and they are found at considerable depths in the sea, a few being found at a depth of more than 2,900 fathoms. Certain groups are specialized for living permanently at great depths, *e.g.,* the Cirroteuthidae among the Dibranchiate Cephalopoda and the Septibranchia among the Lamellibranchia. The Pteropods, Heteropods and a few other Gastropoda, and the smaller cranchiiform Cephalopoda are adapted in adult life as plankton organisms. By far the greater part of marine molluscs are sedentary and live on the bottom in relatively shallow water.

Land and fresh-water Mollusca are likewise of almost universal distribution. The terrestrial forms are usually limited in their range by the requirement of a measure of humidity, shelter from excessive heat and light and of a certain amount of lime in the soil.

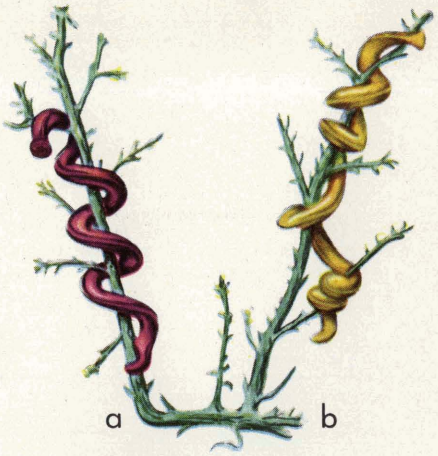
Some of the living Cephalopoda are of large size and have predatory habits; nearly all of them are highly mobile and vigorous animals and in these respects they are unique among invertebrate animals and afford the closest parallel to the vertebrates in organization and activity. The rest of the phylum are principally sluggish animals usually of small size and retiring habits. The greater number are vegetarian in diet. Certain Gastropoda are, however, carnivorous and, though their prey consists of either sessile animals such as Hydroids and sponges or slow-moving animals such as other molluscs, they are more vigorous and aggressive. The majority are, however, encumbered by their shell, and rely on passive defense rather than attack or flight in dealing with their enemies.



FROM LANKESTER, "TREATISE ON ZOOLOGY" (A. & C. BLACK)

FIG. 7.— SCHEME OF A PRIMITIVE MOLLUSC

The Scaphopoda and Lamellibranchia live a specialized life



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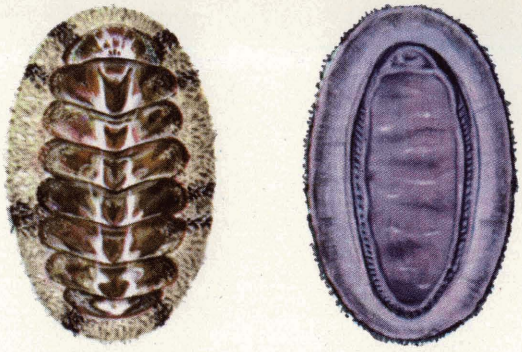

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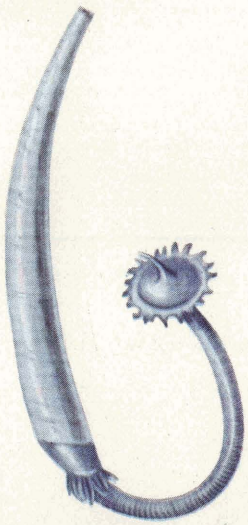

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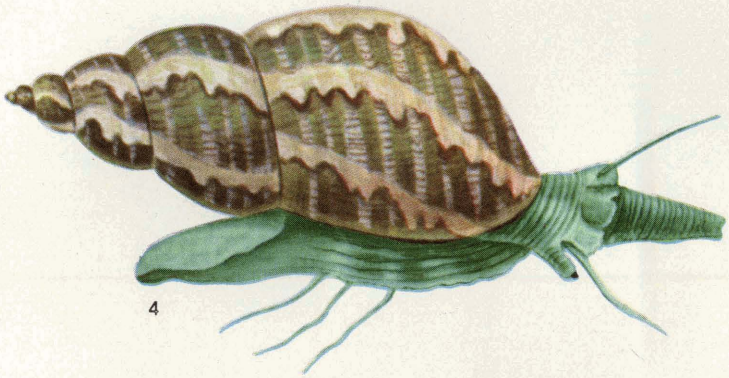

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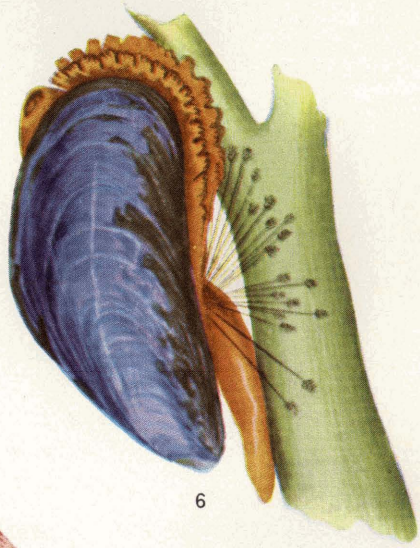

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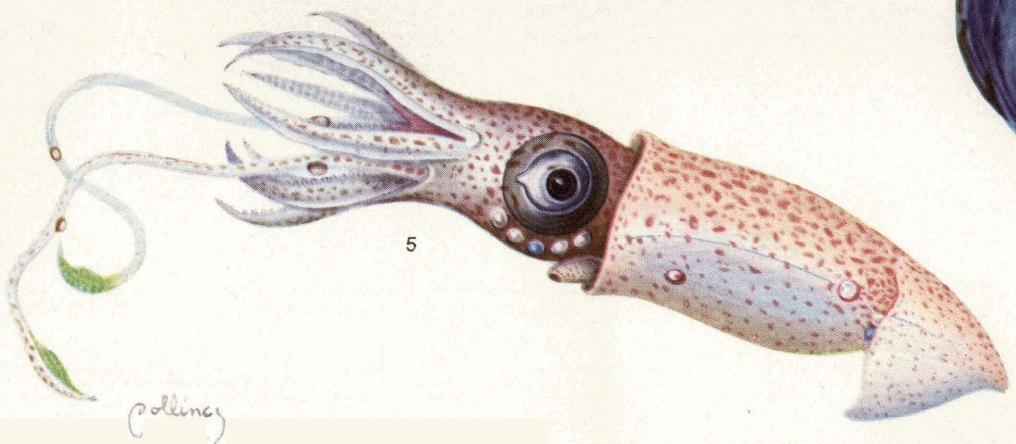

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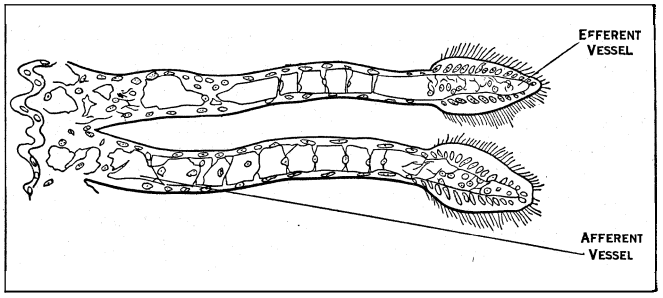
PAINTED FOR **ENCYCLOPÆDIA BRITANNICA** AFTER (1) PRUVOT; (3) M. SARS; (4) KIENER AND QUOY & GAIMARD; (5) CHUN; (6) MEYER AND MOEBIUS

REPRESENTATIVES OF THE CLASSES OF MOLLUSCA

1. Two **solenogastrid** Amphineurans—a, *Myzomenia* ***banyulensis;*** b, ***Nematomenia*** *flavens*. Both about twice natural size
2. Loricab Amphineuran, ***Acanthopleura*** *granulata—a,* from above; b, from below. Natural size
3. **Scaphopod,** ***Siphonodentalium*** *lofotense*. About *12* times natural size
4. Gastropod, ***Phasianella*** *australis*. Natural size
5. Abyssal **Cephalopod** with luminescent organs, *Thaumatolampas* ***diadema***. Twice natural size
6. Lamellibranch, ***Mytilus edulis***. Natural size

buried in sand or mud. To this sort of life the lamellibranchs are particularly well adapted. They can live for a long time buried below the surface; but, as is pointed out in the article on this group, this mode of life is not necessarily a sluggish and inactive one. Not only is a considerable amount of energy required to burrow in a semisolid medium, but also those Lamellibranchia



FROM ROBSON, "ANNALS AND MAGAZINE OF NATURAL HISTORY" (TAYLOR & FRANCIS)

FIG. 8.— GILL FILAMENTS OF HYPSOBIA NOSOPHORA

which live on open beaches must be always under the necessity of regulating their position during rough weather when the surface layers of sand are in continual motion. The Amphineura are mostly sluggish, semiadherent forms. The Gastropoda are more varied in their habits and include active carnivorous families, adherent and floating forms. Others are climbers, burrowers and swimmers. Both the Gastropoda and Lamellibranchia include commensal and parasitic forms as well as genera which bore into solid substances (rock, coral, etc.).

The Mollusca are on the whole short-lived. Most pulmonate Gastropoda are biannual, though some large Helicidae live as long as seven years. The marine Streptoneura live for several years but the Nudibranchs and Tectibranchs seem to be "annuals." The Cephalopoda, as far as is known at present, seem to have an average life of four to five years. Certain Lamellibranchia are knonn to live as long as 20 years.

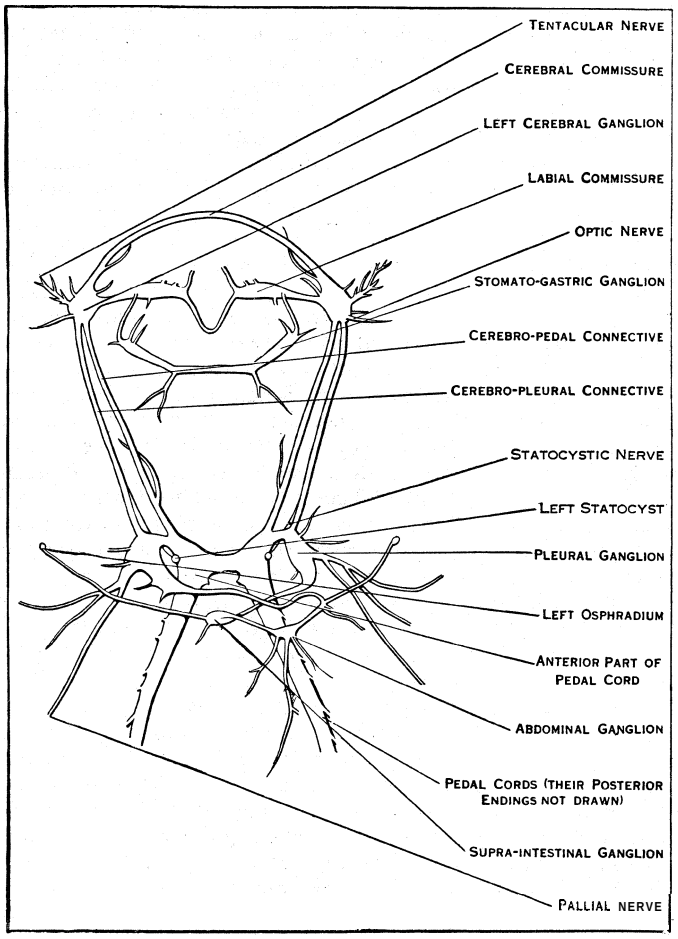
Interrelationships of the Various Classes.—Although it has been urged that the Solenogastres are not molluscs and should be placed in a different phylum and although von Ihering has tried to prove that the Rlollusca as at present constituted are not a homogeneous group, there seem to be no adequate grounds for doubting Pelseneer's dictum (1906) that the internal organization of the members of the phylum is remarkably uniform. In spite of very marked plasticity in external parts, the fundamental structural plan as sketched above remains singularly constant and unaltered. It is also significant that the larger classes all tend to show similar types of modification. To cite a single instance, the shell in all Mollusca save the Scaphopoda exhibits a constantly recurring tendency to become covered by the mantle and atrophied.

Nevertheless the relationship between the various classes is by no means clear. They each represent distinct evolutionary tendencies and it is by no means certain how far we can state that certain classes are more closely related than others. Grobben, for example, united the Gastropoda, Scaphopoda and Lamellibranchia into a grade, the Prorhipidoglossomorpha, distinct from the Amphineura and Cephalopoda. This association is up to a certain point justifiable. But it fails to express (a) the peculiar position of the Lamellibranchia which must have diverged along their distinctive evolutionary path at an early date in the history of the phylum and (b) the considerable resemblances between the Gastropoda and Cephalopoda. It is a useful working hypothesis to assume that there are three distinct elements in the phylum: (1) the Amphineura representing the most primitive age of development, (2) the Cephalopoda and (3) the Gastropoda, Lamellibranchia and Scaphopoda. It is true that the Amphineura (particularly the Chitons) have a simpler organization than the other Mollusca and may be considered to be the most primitive members of the phylum, though it is peculiar that they are not found as fossils until the Silurian (Ordovician?), whereas the other chief classes are recognizable in the Cambrian. Nevertheless it is not easy to employ the total complex of characters which each class represents. as an index of relationship or to decide with confidence which of those characters are actually primitive or how far resemblances have been brought abour by convergence. For that reason it seems desirable to stress the individual and peculiar destiny of each class rather than insist on any grouping of the classes.

Relationships with Other Phyla.—A great deal of discussion has been devoted to the origin of the Mollusca. There are, however, two main and radically opposed views on this subject. The one emphasizes the resemblance betneen the trochophore larva of the hlollusca and the similar larva of the Annelida, and holds that the Mollusca are descended from the same ancestral form as the Annelida. The other theory (propounded by Lang and Thiele) stresses certain structural features of the adult as well as embryological data, and its authors would derive the Mollusca from the free-living Platyhelmia (Turbellaria). It is sufficient to say here that at present this question is unsettled, though the majority of zoologists would probably incline to the view that the hlollusca are more closely related to the Annelida than to any other phylum.

Historical.--The first systematic study of the Mollusca is due to Aristotle, who described various kinds of Cephalopoda, Gastropoda, etc.. in his *Historia Animalium* and *de Partibus Animalium* and noted their habits with considerable accuracy. He made, however, a radical distinction between the naked forms and shelled forms which is no longer recognized.

The foundation of the modern study of the group may be attributed to Martin Lister, who in his *Historia conchyliorum*



FROM LANKESTER, "TREATISE ON ZOOLOGY" (A. & C. BLACK)

FIG. 9.— NERVOUS SYSTEM OF PATELLA VULGATA

(1685) gave anatomical and conchological descriptions of many Gastropoda and Lamellibranchia; but the group was for a long time imperfectly understood and the "testaceous" Mollusca were still kept separate by Linnaeus from the "naked" form and associated with different groups of invertebrates. Linnaeus's "Mollusca" (1758) were a heterogeneous assemblage and did not include the shell-bearing forms. It was Cuvier (1799) who finally assigned to the Mollusca the position as one of the chief primary

groups of the animal kingdom. Among the naturalists of that period Poli and delle Chiaje made important investigations into the anatomy of various molluscs. It should be pointed out that the study of the Mollusca has always been characterized by an inevitable duality of method. On the one hand, conchological studies upon the form and the sculpture of the shell have contributed to our knowledge of the specific and generic variety of the group as well as of the geographical distribution of its members. Of such studies may be mentioned the earlier treatises of Martini and Chemnitz, Reeve and Sowerby and the later studies of Adams, Gwynn Jeffreys, Alder and Hancock, Von Martens, E. A. Smith and H. Fischer. On the other hand, the recognition of the limits and character of the group and the elimination from it of members of other phyla are due to anatomical and embryological research by such scientists as Vaughan Thompson. Kowalevski, Milne Edwards, Lacaze Duthiers, Kölliker, Spengel, Owen, Huxley, Lankester and Pelseneer. (G. C. R.; X.)

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MOLLUSCOIDA: see BRACHIOPODA.

MOLLWITZ. In 1741 Frederick the Great was besieging the Silesian towns of Brieg and Neisse when an Austrian army under Neipperg advanced to their relief. (See AUSTRIAN SUCCESSION, WAR OF THE.) In snowy weather each army was for some time in ignorance of the other's whereabouts, but Frederick eventually located the Austrians in the village of Mollwitz. He got to within two miles of them before they mere alarmed; then solemnly formed his army in the usual two lines, with cavalry on the flanks, and advanced in parade order with bands playing. Neipperg sent his cavalry under Romer to delay the Prussians while he drew up his own army, his right on the boggy Langwitz stream, his left on Gruningen. He had 20,000 men, including 8,600 excellent cavalry, but only 18 guns. Frederick's army was similarly formed and of equal strength. but he had only 4.000 indifferent cavalry; he had, however, 60 guns. His cavalry on the right, under Schdlenburg, had crowded into the infantry, which had to throw back three battalions en potence, a formation which later proved valuable. At 2 P.M. on April so. 1741 the Prussian guns opened fire on the Austrian army, ahich was still forming up. The fire was severe and Romer decided that the best way to avoid it was to attack. He launched 30 squadrons against Schülenburg's 10 and swept them headlong from the field. Frederick was involved in their rout and was persuaded by his lieutenant Schwerin to save himself in flight. The Austrian cavalry now turned upon the Prussian foot. Twenty years of drill had given Frederick's infantry a steadiness and fire control that no cavalry could shake. Five times Romer hurled his squadrons against their ranks, on one occasion attacking the second line from the rear; five times they were driven off with heavy loss, Romer himself being killed. Neipperg sent forward Goldlein's infantry, but they could not face the rapid fire of the Prussians, with their new iron ramrods. Seeing his enemy waver, and knowing his own ammunition to be failing, Schuerin, now in command, ordered the advance. In perfect formation, with colours flying and bands playing, the Prussian infantry bore down upon the demoralized Austrians, and Neipperg wisely anticipated a rout by ordering a retreat. Weak in cavalry, Schwerin made no effective pursuit. The Austrians lost 4,400 men and nine guns, the Prussians 4,613 and one gun. Frederick's share in his first battle scarcely presaged his future glory.

MOLLY MAGUIRES, a term applied to certain men in the anthracite coal-producing counties of Schuylkill, Luzerne, Carbon and adjacent counties in Pennsylvania, who violated property rights of coal-mine operators and even committed murder during the years 1862 to 1876. In those areas there had been a large immigration of Irish workers. Foreign-born Welsh and Germans were numerous. There were draft riots during the Civil War, and the area was divided by racial, religious and language barriers, anti-Catholicism and labour struggles. Radicalism, born of Chartist, Marxist and former nationalist loyalties, vied with trade union organizational attempts and with the vigorous *laissez faire* conduct of mine and railroad operators during times of coal price fluctuations to make the vicinity ripe for violence.

The Irish, a surplus labour force inexperienced in mining, were often embittered by arbitrary wage cuts, company stores, employment discrimination and blacklisting of independent spirits. Many joined the Workingmen's Benevolent association (an early union) in its pioneering efforts to win concessions from the Anthracite Board of Trade, the Mahanoy Valley and Locust Mountain Coal association and individual operators. Many Irish Catholics were members of the Ancient Order of Hibernians, a fraternal order with secret but entirely benevolent printed ritual.

As early as 1862 a newspaper account of coal-mine violence assigned blame to the "Molly Maguires," which in Ireland 20 years before had been an antilandlord agitational group. By the mid-1870s the mine operators and much of the public came to believe that sabotage and certain murders were the work of "Mollies" and that these were local Hibernian leaders, perhaps associated in an inner order, who were dedicated to violence. It appears that some Hibernian lodges in anthracite counties were then in the control of lawless men who found the "Mollie" label a help in local politics and in engineering deeds of violence.

Franklin B. Gowen (1836–89), president of the Philadelphia and Reading Railroad and its Coal and Iron company placed James McParlan, a member of the National Detective agency, among the Irish Catholics of the area in 1873. Personable, he gained admission to the Hibernians and won full confidence of local leaders, reporting daily to his employers. In 1876–77, in a series of sensational trials, McParlan testified on inner workings of the local "Mollies." By 1880. 19 men were hanged and others imprisoned, and consequently the violent acts ceased and the society was disbanded. Some injustices may have been performed, however, as guilt by association conquered the local mind, impressed overwhelmingly non-Irish juries and intimidated potential witnesses for the defense.

There is justification for considering the Molly Maguire episode an aspect of the capital against labour struggles in the coal mines. Yet those convicted of violence were not orthodox trade-union leaders, and murders committed under "Mollie" auspices often avenged personal grievances. Court convictions, publicity and more prosperous times apparently combined to bring the era of violence to a close.

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MOLOCH or MOLECH (in Hebrew, with the doubtful exception of 1 Kings xi. 7, always "the Molech"), the name or title of the divinity which the men of Judah in the last ages of the kingdom were wont to propitiate by the sacrifice of their own children. The Hebrew consonants might simply be read "the king" (*mélek*), an appellation for the supreme deity of a Semitic state or tribe: the traditional pronunciation (Μολόχ), which goes back as far as the Septuagint version of Kings, probably means that the old form was perverted by giving it the vowels of *bōsheth,* "shame," the contemptuous name for Baal (*q.v.*).

The phrase employed in speaking of these sacrifices is that of dedication—"to make one's son or daughter pass through (or by means of) fire to (the) Molech" (2 Kings xxiii. 10; but elsewhere without the words "through fire" Lev. xviii. 21). It appears from Jer. vii. 31, xix. 5; Ezek. xvi. 20 seq., that this phrase denotes a human holocaust, and not a mere consecration to Molech by passing through or between fires. We learn from 2 Kings iii. 27 that the piacular sacrifice of his son and heir was the last offering which the king of Moab made to deliver his country. Even the Hebrew historian ascribes to this act the effect of rousing divine indignation against the invading host of Israel. Ahaz's sacrifice of his son (2 Kings xvi. 3) may have been an isolated act of despair; but in the 7th century, however, when religion was transformed into servile fear (Mic. vi. 1 sqq.), the example of

Manasseh (2 Kings xxi. 6) did not stand alone, and Jeremiah and Ezekiel frequently refer to the "high places" for the sacrifice of children by their parents which rose beneath the very walls of the temple from the gloomy ravine of Hinnom or Tophet (Jer. xxxii. 3j; Ezek. xvi. 18 *sqq.*, xxiii. 37). The children apparently were not burned alive; they were slain and burned like any other holocaust (Ezek. *loc. cit.;* Isa. lvii. 5), their blood was shed at the sanctuary (Jer. xix. 4; Ps. cvi. 38).

The horrid ritual was so closely associated with Yahweh worship (Ezek. xxiii. 39) that Jeremiah protests that it is not of Yahweh's institution (vii. 31, xix. 5). So too the idea of sacrificing the firstborn to Yahweh is rejected in Micah vi. After all, such a sacrifice could only be paid to the supreme deity; and Manasseh and his people never ceased to acknowledge Yahweh as the God of Israel. Thus the way in which Jeremiah (Jer. xix. 5), Leviticus (xviii. 21, xx. 2–5) and the author of Kings, seem to mark out the Molech or Baal as a false god, distinct from Yahweh, is precisely parallel to the way in which Hosea speaks of the golden calves or Baalim. In each case the people were worshipping Yahweh under the title of Molech or Baal; and the prophet refuses to admit that this is so, because the worship itself is an apostasy to heathenism. Note, also, the explanation attempted in Ezekiel xx. 25 *seq.*, 31. The seat of the cult appears to have been at Jerusalem, and the period during which it flourished does not favour any strong Phoenician influence. Nor does it seem to be of Babylonian origin. On the whole, the biblical tradition that the Molech-cult was Canaanite and indigenous (Deut. xii. 29 *sqq.*, xviii. 9 *seq.*) holds the ground. *See* HEBREW RELIGION. (W. R. S.; S. A. C.)

MOLSHEIM, a town of France, capital of an arrondissement in the department of Bas-Rhin, at the foot of the Vosges, on the Bruche. Pop. (1936) 3,504. It is the seat of a sub-prefect. Its industries embrace the manufacture of iron and steel goods and organ-building. There is also some trade in wine and grain. Molsheim was known in the 9th century as Molleshem, and formerly was the seat of a famous Jesuit college, later removed to Strasbourg and united with its university.

MOLTKE, ADAM GOTTLOB, COUNT (1710–1792), Danish courtier, was born on Nov. 10, 1710, at Riesenhof in Mecklenburg. Frederick V. made him hofmarskal (court marshal), and overwhelmed him with marks of favour, making him a privy councillor and a count and bestowing upon him Bregentved and other estates. As the inseparable companion of the king, Moltke's influence soon became so boundless that the foreign diplomatists declared he could make and unmake ministers at will. Moltke looked askance at liberal projects for the emancipation of the serfs, but, as one of the largest landowners of Denmark, he did much service to agriculture by lightening the burdens of the countrymen and introducing technical and scientific improvements. On the decease of Frederick V., who died in his arms (Jan. 14, 1766), Moltke's dominion was at an end. The new king, Christian VII., could not endure him, and exclaimed, with reference to his lanky figure: "He's stork below and fox above." In July 1766 he was dismissed from all his offices and retired to his estate at Bregentved. He lived in retirement till his death on Sept. 25, 1792.

His memoirs, written in German and published in 1870, have considerable historical importance. *See* H. H. Langhorn, *Historische Nachricht über die dänischen Moltkes* (Kiel, 1871).

MOLTKE, ADAM WILHELM, COUNT (1785–1864), Danish statesman, son of the minister Jodchim Godske Moltke (1746–1818), and grandson of Adam Gottlob Moltke, was born at Einsiedeisborg in Funen, on Aug. 2j, 1785. In 1831 he succeeded Johan Sigismund Mösting (1789–1843), as minister of finance. On the death of Christian VIII. he was one of the most prominent members of the Council of State, and when the constitutional crisis came in 1848 he seemed marked out as the man who could bridge over the gap between the old era and the new. The services which Count Moltke rendered to Denmark cannot be too highly appreciated. The mere fact that a distinguished statesman who had served the last two absolute kings of Denmark now voluntarily placed himself at the head of a ministry which included the most advanced of the popular agitators, gave the new government prestige. It was this, his first administration, which introduced the constitution of June 5, 1849, and he also presided over the third constitutional ministry which was formed in July 1851; but he resigned on Jan. 27, 1852, because he could not approve of the decree which aimed at transforming Denmark into a composite, indivisible monarchy. Moltke continued to sit in the Landsting, or Upper House, but henceforth kept in the background. He was a member of the consultative Rigsraad from 1855 to 1863. He died on Feb. 15, 1864.

See Swalin, *Det danske Staatsraad* (Stockholm, 1881); Madvig, *Livserindringer* (Copenhagen, 1887).

MOLTKE, HELMUTH CARL BERNHARD, COUNT VON (1800–1891), Prussian field marshal, for thirty years chief of the staff of the Prussian army, the greatest strategist of the latter half of the 19th century, and the creator of the modern method of directing armies in the field, was born on Oct. 26, 1800, at Parchim, Mecklenburg, of a German family of ancient nobility. His father in 1805 settled in Holstein and became a Danish subject, but about the same time was impoverished by the burning of his country house and the plunder by the French of his town house in Lübeck, where his wife and children were. Young Moltke therefore grew up in straitened circumstances. At the age of eleven he was sent to the cadet school at Copenhagen, and entered the Danish army in 1818. But at twenty-one he resolved to enter the Prussian service, in spite of the loss of seniority, and he became second lieutenant in the 8th Infantry Regiment stationed at Frankfort-on-Oder. At twenty-three he entered the war academy, doing brilliantly in the final examination in 1826. He then for a year had charge of a cadet school at Frankfort-on-Oder, after which he was for three years employed on the military survey in Silesia and Posen. In 1833 he was transferred to the general staff in Berlin. His tastes inclined him to literature, to historical study and to travel. He published a short romance, *The Two Friends* (1827); an essay, *Holland and Belgium in their Mutual Relations . . .* (1831); and *An Account of the Internal Circumstances and Social Conditions of Poland* (1832). In 1832 he contracted to translate Gibbon's *Decline and Fall* into German for which he was to receive £75, his object being to earn the money to buy a horse. In eighteen months he had finished nine volumes out of twelve, but the publisher failed to produce the book and Moltke never received more than £25.

Turkish Experience.—He had already travelled in south Germany and northern Italy, and in 1835 on his promotion as captain he obtained six months' leave to travel in south-eastern Europe. After a short stay in Constantinople he entered the Turkish service, being duly authorized to do so from Berlin. He spent two years at Constantinople, learned Turkish, and surveyed for the sultan the city of Constantinople, the Bosporus and the Dardanelles. He travelled in the sultan's retinue through Bulgaria and Rumelia, and made many other journeys on both sides of the Strait. In 1838 he was sent as adviser to the Turkish general commanding in Armenia, who was to carry on a campaign against Mehemet Ali of Egypt. He rode several thousand miles in the course of his journeys, navigating the dangerous rapids of the Euphrates, and visiting and mapping many districts where no European traveller had been since Xenophon. In 1839 the army moved south to meet the Egyptians, but upon the approach of the enemy the general became more attentive to the prophecies of the mullahs than to the advice of the Prussian captain. Moltke resigned his post of staff officer, and took charge of the artillery, which, in the ensuing battle of Nisib, was the last portion of the Turkish army to run away.

Moltke with infinite hardship made his way back to the Black Sea, and thence to Constantinople. His patron Sultan Mahmud was dead; so he returned to Berlin where he arrived, broken in health, in December 1839. When he left Berlin in 1834 he had already "the courtier's, soldier's, scholar's eye, tongue, sword." When he returned it was with a mind expanded by a rare experience, and with a character doubly tempered and annealed. While away, he had been a constant letter-writer to his mother and sisters, and he now revised and published his letters as

Letters on Conditions and Events in Turkey in the Years 1835 to 1839. No other book gives so deep an insight into the character of the Turkish Empire, and no other book of travels better deserves to be regarded as a German classic.

One of his sisters had married an English widower named Burt, who had settled in Holstein. Her stepdaughter, Mary Burt, had read the traveller's letters, and when he came home as a wooer was quickly won. The marriage took place in 1841, though there were no children, and Moltke's love-letters and letters to his wife are among the most valuable materials for his biography. On his return in 1840 Moltke had been appointed to the staff of the 4th army corps, stationed at Berlin; he was promoted major on his wedding day. He published his maps of Constantinople, of the Bosporus and of the Dardanelles, and, jointly with other German travellers, a new map of Asia Minor and a memoir on the geography of that country, as well as a number of periodical essays on various factors in the Eastern Question. His *Russo-Turkish Campaign in Europe, 1828–29, described in 1845 by Baron von Moltke, Major in the Prussian Staff* (1845), was recognized by competent judges as a masterpiece. Moltke at this period became one of the first directors of the Hamburg-Berlin railway, and in 1843 published a review article entitled *What Considerations should determine the Choice of the Course* of *Railways?* which reveals a mastery of the technical questions involved in railway construction.

In 1845 Moltke was appointed personal adjutant to Prince Henry of Prussia, a Roman Catholic who lived at Rome. He spent much of his leisure there in a survey, of which the result was a splendid map of Rome (Berlin, 1852). In 1846 Prince Henry died, and Moltke was then appointed to the staff of the 8th army corps at Coblenz. In 1848, after a brief return to the great general staff at Berlin, he became chief of the staff of the 4th army corps, of which the headquarters were then at Magdeburg, where he remained seven years, during which he rose to lieutenant-colonel (1850), and colonel (1851). In 1855 he was appointed first adjutant to Prince Frederick William (afterwards crown prince and emperor), whom he accompanied to England on his betrothal and marriage, as well as to Paris and to St. Petersburg to the coronation of Alexander II. of Russia. Prince Frederick William was in command of a regiment stationed at Breslau, and there as his adjutant Moltke remained for a year, becoming major-general in 1856. On Oct. 23, 1857, owing to the serious illness of King Frederick William IV., Prince William Became prince regent. Six days later he selected Moltke to be chief of the general staff of the army.

Moltke devoted himself to the adaptation of strategical and tactical methods to changes in armament and in means of communication, to the training of staff officers in accordance with the methods thus worked out, to the perfection of the arrangements for the mobilization of the army, and to the study of European politics. In 1859 came the war in Italy, which occasioned the mobilization of the Prussian army, and a consequent reorganization, by which its numerical strength was nearly doubled. The reorganization was the work not of Moltke but of the king, and of Roon, minister of war; but Moltke watched the Italian campaign closely, and wrote the history of it ascribed on the title-page (1862) to the historical division of the Prussian staff.

The Danish Campaign. — In December 1862 Moltke was asked for an opinion upon the military aspect of the quarrel with Denmark then becoming acute. He sketched a plan for turning the flank of the Danish army before the attack upon its position in front of Schleswig, and hoped that by this means its retreat to the islands might be intercepted. When the war began in February 1864, Moltke was kept at Berlin. The execution of the plan was mismanaged, and the Danish army escaped to the fortresses of Duppel and Fredericia, each of which commanded a retreat across a strait on to an island. The allies were now checked; but Duppel and Fredericia were besieged by them, Düppel taken by storm, and Fredericia abandoned by the Danes without assault; but the war showed no signs of ending, as the Danish army was safe in the islands of Alsen and Fiinen. On April 30 Moltke was sent to be chief of the staff to the commander-in-chief of the allied forces, and, so soon as the armistice of May and June was over, persuaded Prince Frederick Charles to attempt to force the passage of the Sundewitt and attack the Danes in the island of Alsen. The landing was effected on June 29, and the Danes then evacuated Alsen. Moltke next proposed a landing in Fiinen, but the Danes no longer felt safe in their islands, and agreed to the German terms. Moltke's appearance had quickly transformed the aspect of the war, and his influence with the king thus acquired a firm basis.

Campaign of *1866.* — *(See* SEVEN WEEKS' *WAR.)* Accordingly, in the Austrian campaign of 1866, Moltke's plans were adopted, and he was almost invariably supported in their execution. The campaign in Denmark had revealed the amazing superiority of the breech-loader, with which only the Prussian troops were armed, over the muzzle-loader still used by all other armies. Moltke had mastered, as none of his contemporaries had done, the methods of Napoleon. In 1866 each of his decisions was Napoleonic. The first was to employ almost his whole force (280,000) against the preponderant enemy, Austria, with her Saxon satellite (270,000) and to paralyse the other German states with a mere fraction (48,000). With this small force he first captured the whole Hanoverian army (17,000) and then dispersed the south German armies (about 100,000). The second decision was to deploy 280,000 men upon the very long frontier separating Prussia from Austria and Saxony, there to form three armies, the Elbe army at Torgau, the first army (Prince Frederick Charles) in Lusatia, and the second army (the Crown Prince) at Landshut and Waldenburg in Silesia. His plan, resembling that of, Napoleon in 1805, was to bring these three armies together by a concentric advance into the enemy's territory, Bohemia, where he believed the Austrian army to be assembling. The three armies had no sooner reached these positions than the king was persuaded to order the second army to march eastwards towards Neisse to meet an expected Austrian invasion from Moravia. Moltke's plan seemed to be upset, but on June 15 the political crisis came to a head and Prussia declared war. On the same day Moltke learned that the Austrian army had assembled not in Bohemia, but in Moravia. He immediately instructed the Crown Prince to turn back and march westwards to his original positions, and the Elbe army to advance through Dresden to join Prince Frederick Charles, who was to advance southwards through Lobau. The Saxon army retreated from Dresden and joined the first Austrian army corp on the Isar. On the 17th Benedek, commanding the Austrian army, gave orders for its march from Moravia to the neighbourhood of Josefstadt. Moltke had expected this and calculated that the Austrian movement could not be completed in time to enable Benedek with his whole army to attack either of the Prussian armies. On June 22 Moltke ordered both Prussian armies to advance into Bohemia and to seek to unite in the direction of Gitschin. The Austrians marched faster than Moltke expected, and might have opposed the Crown Prince with four or five corps; but Benedek's attention was centred on Prince Frederick Charles, and he interposed against the Crown Prince's advance four corps not under a common command, so that they were beaten in detail, as were also the Saxons and the Austrian corps with them, by Prince Frederick Charles. On July 1 Benedek collected his already shaken forces in a defensive position in front of Koniggratz. Moltke's two armies were now within a march of one another and of the enemy. On July 2 Frederick Charles, who had passed Gitschin, ordered his army to attack this position, whereupon Moltke, who had that day reached Gitschin from Berlin, instructed the Crown Prince, who was at Koniginhof, to advance with his whole force against the Austrian right flank. Next day the Austrian army was defeated in the greatest battle of the century.

Moltke now marched with the first army on Vienna. The Austrian Emperor then sued peace.

After the peace, the Prussian Diet voted Moltke the sum of £30,000, with which he bought the estate of Creisau, near Schweidnitz, in Silesia. *The Campaign of 1866 in Germany* (1867), produced under Moltke's personal supervision, was remarkable for its accuracy and reticence. On Dec. 24, 1868, Moltke's wife died at Berlin.

Franco-German War.—In 1570 suddenly came the war with France. The probability of such a war had occupied Moltke's attention almost continuously since 1857, and a series of memoirs is preserved in which from time to time he worked out and recorded his ideas as to the transport and arrangement of the Prussian or German forces for the opening of the campaign. The great successes of 1866 had strengthened Moltke's position, so that when the mobilization order of the Prussian and south German forces was issued (July 15, 1870) his plans were adopted without dispute, and five days later he was appointed "Chief of the general staff of the army at the headquarters of H.M. the King" for the duration of the war. This gave Moltke the right to issue in the king's name, though of course not without his approval, orders which were equivalent to royal commands. Moltke's plan was to assemble the whole army to the south of Mainz. If the French should disregard the neutrality of Belgium and Luxemburg, and advance on the line from Paris to Cologne or any other point on the Lower Rhine, the German army would be able to strike at their flank, while the Rhine itself, with the fortresses of Coblenz, Cologne and Wesel, would be a serious obstacle in their front. If the French should attempt to invade south Germany, an advance of the Germans up either bank of the Rhine would threaten their communications.

Moltke expected that the French would be compelled by the direction of their railways to collect the greater part of their army near Metz, and a smaller portion near Strasbourg. The German forces were grouped into three armies: the first of 60,000 men, under Steinmetz, on the Moselle below Trèves; the second of 131,000 men, under Prince Frederick Charles. round Homburg, with a reserve of 60,000 men behind it; the third under the Crown Prince of 130,000 men, at Landau. Three army corps amounting to 100,000 men were not reckoned upon in the first instance, as it was desirable to keep a considerable force in north-eastern Germany, in case Austria should make common cause with France. If, as seemed probable, the French should take the initiative before the German armies were ready, and for that purpose should advance from Metz in the direction of Mainz, Moltke would merely put back a few miles nearer to Mainz the points of debarcation from the railway of the troops of the second army. This measure was actually adopted, though the anticipated French invasion did not take place.

Moltke's plan of operations was that the three armies while advancing should make a right wheel, so that the first army on the right would reach the bank of the Moselle opposite Metz, while the second and third armies should push forward, the third army to defeat the French force near Strasbourg, and the second to strike the Moselle near Pont-à-Mousson. If the French army should be found during this advance in front of the second army, it would be attacked in front by the second army and in flank by the first or the third or both. If it should be found on or north of the line from Sarrebourg to Lunéville, it could still be attacked from two sides by the second and third armies in co-operation. The intention of the great right wheel was to attack the principal French army in such a direction as to drive it north and cut its communications with Paris. The fortress of Metz was to be observed, and the main German forces to march upon Paris.

This plan was carried out in its broad outlines. The battle of Worth was brought on prematurely, and therefore led, not to the capture of MacMahon's army, which was intended, but only to its total defeat and hasty retreat as far as Chblons. The battle of Spicheren was not intended by Moltke, who wished to keep Bazaine's army on the Saar till he could attack it with the second army in front and the first army on its left flank, while the third army was closing towards its rear. But these unintended or unexpected victories did not disconcert Moltke, who carried out his intended advance to Pont-à-Mousson, there crossed the Moselle with the first and second armies, which he then ordered to face north and wheel round in order to cut off Bazaine from Paris. But Frederick Charles, contrary to these instructions, directed the second army towards the Meuse and consequently found himself with only two corps facing the whole French army at Mars-la-Tour. The two corps, however, defeated Bazaine (August 16), who retreated to the position St. Privat-Gravelotte. Next day Moltke brought up the rest of the second army and on the 18th attacked Bazaine and drove him into the fortress of Metz. Moltke has been blamed for the last local attack at Gravelotte, in which there was a fruitless heavy loss, but it is now known that this attack was ordered by the king, and Moltke blamed himself for not having used his influence to prevent it.

During the night following the battle Moltke made his next decision. He left one army to invest Bazaine and Metz, and set out with the two others to march towards Paris, the more southerly one leading, so that when MacMahon's army should be found the main blow might be delivered from the south and MacMahon driven to the north. On Aug. 25 it was found that MacMahon was moving north-east for the relief of Bazaine. The moment Moltke was satisfied of the accuracy of his information, he ordered the German columns to turn their faces north instead of west. MacMahon's right wing was attacked at Beaumont while attempting to cross the Meuse, his advance necessarily abandoned, and his army with difficulty collected at Sedan. Here the two German armies were so brought up as completely to surround the French army, which on Sept. 1 was attacked and compelled to raise the white flag. After the capitulation of Sedan, Moltke resumed the advance on Paris, which was surrounded and invested. From this time his strategy is remarkable for its judicious economy of force, for he was wise enough never to attempt mare than was practicable with the means at his disposal. The surrender of Metz and of Paris was a question of time. In this Moltke was completely successful. Metz surrendered on Oct. 27, and on Jan. 28, 1871, an armistice was concluded at Paris and the war ended.

On Oct. 29, 1870, Moltke was created graf (count or earl) and on June 16, 1871. field marshal. After the war he superintended the preparation of its history, which was published between 1874 and 1881 by the great general staff. In 1888 he resigned his post as chief of the staff. In 1867 Moltke was elected to the North German Diet, and in 1871 to the Reichstag. His speeches, dealing mostly with military questions, were regarded as models of conciseness and relevancy. He died suddenly on April 24, 1891, and after a magnificent funeral ceremony at Berlin his remains were laid beside those of his wife in the chapel at Creisau.

As a strategist Moltke cannot be estimated by comparison with Frederick or Napoleon, because he had not the authority either of a king or of a commander-in-chief. While it is doubtful whether he can be convicted of any strategical errors, it seems beyond doubt that he never had to face a situation which placed any strain on his powers, for in the campaigns of 1866 and 1870 his decisions seemed to be made without the slightest effort.

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MBLTKE, HELMUTH JOHANNES LUDWIG VQN (1848–1916), German soldier, born in Gersdorf, Mecklenburg, May 23, 1848, was nephew of the famous Count von Moltke. Becoming an officer in 1870, in 1902 he commanded the 1st Division of the Guards Corps, in 1904 became quartermaster-general, and two years later was appointed chief of the general staff of the army. At the outbreak of the World War, although already old and in failing health, he became principal director of the German operations. His strategy, based partly on the plans bequeathed to him by Gen. von Schlieffen (*q.v.*), whose pupil he had been, was devised to meet the problem of a war on two fronts. It involved a concentration of forces on the right flank, which, pivoting on Metz, and driving forward against the line Dunkirk-Verdun, was to force the French army to give battle on a reversed front. In the West, the left flank was to be held back, the troops in Alsace were to withdraw behind the Rhine, while a minimum defence was to face Russia. Bold and simple as was this plan, it neither allowed for the swift mobilization of the Russians, **nor**

for the problem of a shifting front. Forced by circumstances to introduce modification into the original plan, Moltke appears to have been unwise in his alterations. He withdrew six divisions from the main army to send to the Russian front, failed to concentrate on the northeast and planned an offensive in place of a defensive in Lorraine. Thus the plans of Schlieffen were prevented from bearing full fruit. On Nov. 3, 1914, his health being seriously impaired, he was relieved of his post and died on June 18, 1916. The following works by him were published after his death: *Erinnerungen,* Briefe, *Dokumente, 1877–1916* (1922), *Aufzeichnungen, Briefe, Schriften, Reden* (1923).

MOLUCCAS or **SPICE ISLANDS.** a name which in its widest sense includes all the islands of the Malay archipelago (*q.v.*) between Celebes on the west, New Guinea on the east. Timor on the south and the open Pacific ocean on the north. They cover an area of approximately 28,766 sq.mi. and are scattered between 2° 43' N. and 8° 23' S. and 124° 22' and 135° E. They include: (1) the Moluccas proper or Ternate group, of which Halmahera is the largest; (2) the Batjan (Bachian) and Obi groups; (3) the Amboina group of which Ceram (Indonesian, Seram) and Buru are the largest; (4) the Banda Islands; (5) the southeastern islands, comprising the Tanimbar group, Babar, etc.; and (6) the Kai (Ewab) and the Aru Islands. The Moluccas form a province under a governor at Amboina.

The islands consist chiefly of crystalline schists and coralline limestones. overlaid by Jurassic! Cretaceous and Tertiary deposits. Ceram contains an oil field. Most of the islands are mountainous (more than 9,000 ft. in Ceram) and densely forested, but the Aru and Tanimbar groups are flat and swampy. The population in 1956 was estimated at 736,119, of mixed descent, including Javanese, Malay, Portuguese and Dutch. mingled with indigenous peoples. Islam is the chief religion except in Amboina which is mainly Christian. The staple food is sago and the chief occupations are hunting and fishing.

In some parts the evergreen rain forest, formerly covering most of the islands, has been cut down and the land cultivated. There are patches of open savanna and the coasts are fringed with mangrove swamps. Among valuable trees are sandalwood; the Amboyna pitch tree (*Agathis* alba) from which dammar gum is extracted, especially on Obi; and *Melaleuca leucadendron,* the source of cajeput oil, mainly distilled on Buru. The sago palm (*Metroxylon*) grows wild in swamps and is also cultivated: the nutmeg (Myristica *fragrans*) and clove (Eugenia *aromatica*) are natives, but though still grown extensively, they are less important economically than they were; coconuts have largely replaced spices. Other crops include rice, maize, pepper and fruits.

Land mammals, apart from bats, are very few. Cuscuses are common: the flying opossum is found on Aru. the babirusa of the Celebes on Buru and the crested baboon on Batjan, Buru and Sula. Wild pigs, a civet cat, a deer and shrews were all probably introduced. Bird life is profuse and brilliant with parrots. pigeons, brush turkeys and a bird of paradise. On Ceram there are cassowaries. Insect life is even richer and butterflies are remarkably beautiful. Fish and shellfish abound in great variety; trepang is a favourite food fish; pearl and other shells are traded.

The name Moluccas is said to be derived from the Arabic for "king." Argensola (1609) uses the forms islas *Malucas, Maluco,* and el *Maluco;* Coronel (1623), *islas* del *Moluco;* and Camoens, *Maluco.* After Magellan's passage round Cape Horn to the far east. the Spanish had laid claim to the Rloluccas under the treaty of Tordesilas (1494), but in 1528 they were bought out by the Portuguese, whose influence in the Moluccas was predominant until the arrival of the Dutch early in the 17th century. Finding the power of the sultan of Ternate too strong in the northern Moluccas. the Dutch concentrated on the southern islands, particularly Amboina and Banda. The Bungaya contract (1667) gave them an opening in the north and the friendship of the sultan of Ternate aided them immensely. In 1685 the Dutch declared all contracts with the sultan of Ternate void. took the northern Moluccas and New Guinea under their rule and. with the southern isles. gradually consolidated them into the Moluccas. The island group was occupied by the Japanese during World War II. When sovereignty passed into Indonesian hands in 1949, the Amboinese under their leader Soumokil refused to be incorporated in the Indonesian republic. They revolted on April 26, 1950, and proclaimed an independent republic of the South Moluccas. After fierce fighting on the island of Amboina the rising was quelled.

See H. A. Brouwer, *The Geology of the Netherlands East Indies* (1925); R. Kennedy, *Islands and Peoples of the Indies* (1943).

MOLY, a mysterious plant with magical powers described in Homer. Odyssey, x, 302–306 (Gr. *mōly*). Hermes pulls it up and gives it to Odysseus as a protection against the arts of Circe. It is further described as "having a black root and a flower like milk, and hard for mortals to pull up." R. M. Henry in Class. Rev. (Dec. 1906), p. 434, who illustrates the Homeric account by passages in the Paris and Leyden magical papyri, argues that moly is probably a magical name, derived perhaps from Phoenician or Egyptian sources, for a plant which cannot be certainly identified. The "difficulty of pulling up" the plant is caused by magic. In modern times the name has been applied to a species of onion (*Allium Moly*), a native of southern Europe, grown in borders and rock gardens for its bright yellow flowers.

MOLYBDENITE, a mineral consisting of molybdenum disulfide! MoS_2, containing 60% molybdenum. It is the chief source of molybdenum. which is used in the manufacture of special steels, such as tool steel, to which it imparts greater hardness and strength. The metal is used in the electrical industry: and certain compounds are used in chemistry, ceramics and dyeing.

hlolybdenite closely resembles graphite, has the same greasy feel and likewise is soft enough to mark paper. Both minerals have a layer structure and as a result have perfect basal cleavage and are usually foliated. The name comes from the Greek *molybdos* (lead), with which both graphite and molybdenite were confused. The latter was first identified by P. J. Hjelm, who in 1782 discovered the element molybdenum in this mineral. It is distinguished from graphite by its greater specific gravity (4.7), a bluish lead-gray colour and a greenish streak on glazed porcelain, in contrast with the grayish streak of graphite. Its common association with quartz or acidic rocks may also help distinguish it, for graphite is more commonly associated with metamorphosed limestone and basic rocks. Molybdenite is hexagonal, but the six-sided platy crystals are rare. It is commonly in disseminated plates or scales, which are flexible but not elastic. The lustre is bright metallic.

Molybdenite occurs in crystalline rocks. such as granites, pegmatite and schists, and also in quartz veins. It is fairly common in small quantities as one of the first minerals formed in high temperature veins? along with scheelite, wolframite, topaz and fluorite.

The United States has been the chief producer, usually accounting for more than 85% of the world's production. In the second half of the 20th century Colorado was the leading state, followed by Utah, Arizona. California and New Mexico. Xlinor production was in Canada, Norway and Turkey, and deposits were reported in the Federation of Rhodesia and Nyasaland and in Sierra Leone.

(L. S. RL.; X.)

MOLYBDENUM is a metallic element resembling steel in colour and having an unusually high melting point of about 2,610° C. (4,730° F.). It is one of the most important of the alloying elements used in steels. irons and certain nonferrous alloys. It is also one of the most commonly used of the refractory metals.

Molybdenum (symbol Mo, element number 42, atomic weight 95.95) is in Group VI B of the periodic system and is therefore related to chromium and tungsten. There are seven natural stable isotopes with mass numbers (in order of decreasing abundance) 98, 96, 92, 95, 100, 97, 94; several artificial radioactive isotopes (91, 93, 99. 101, 102, 105) are known. The arrangement of electrons in the unfilled N and O shells is $4s^2$, $4p^6$, $4d^5$, $5s^1$.

OCCURRENCE AND PRODUCTION

Molybdenum is not found free in nature. The only important production is from deposits containing the mineral molybdenite, MoS_2; however, some powellite—calcium tungstomolybdate, $Ca(Mo, W)O_4$—a secondary mineral of the scheelite group, is treated to recover molybdenum and deposits containing wulfenite,

lead molybdate, $PbMoO_4$, have been worked.

After World War I, uhen the usefulness of alloys containing molybdenum was recognized, the United States supplied about 90% of the world's production, most of nhich usually came from the Climax mine at Climax, Colo. The next largest source was the copper industry which obtains molybdenite concentrate as a by-product from several mines in the United States and Chile. Around the middle of the 20th century, world production of molybdenum in concentrates fluctuated from about 20,000,000 to 70,000,000 lb. a year.

At Climax. where the mine is operated primarily for the recovery of molybdenite concentrate, the ore may contain from 0.3% to 0.6% MoS_2. Separation of molybdenite concentrate is accomplished by crushing, fine grinding and oil flotation. Commercial concentrate contains about 80% to 95% MoS_2 on a dry basis.

The molybdenum sulfide in the concentrate is converted by roasting to molybdic oxide (MoO_3). There is no removal in this process of the siliceous gangue contained in the concentrate. The product may be referred to as technical molybdic oxide or roasted molybdenite concentrate.

Ferromolybdenum is produced from technical oxide by either thermite or electric furnace processes and usually contains between 55%–75% molybdenum. Molybdenum may be added to steel in the furnace in the form of technical oxide or ferromolybdenum. Ferromolybdenum is generally used for ladle additions to either steel or iron. Metallic molybdenum of high purity may be used in making the nonferrous alloys for high temperature service. See also METALLURGY.

CHARACTERISTICS AND USES

Metallic Molybdenum. — Molybdenum powder is produced by the hydrogen reduction of purified molybdic oxide or ammonium molybdate. Metal boats containing the oxide are pushed through heated tubes reaching a maximum temperature of about 1,050° C. (1,922° F.). The process is commonly carried out in two stages; the first step produces molybdenum dioxide at about 600° C. (1,112° F.) which is reduced to metal at 1,000° to 1,050° C. (1,832° to 1,922° F.) in the second stage. Conversion of powder to massive metal may be carried out by either of two methods, the powder metallurgy (*q.v.*) process developed about 1910 or the arc-casting process developed about 1944.

In the first process, the powder is compacted at room temperature into ingots or bars under pressures of about 10 to 20 tons per square inch. The compacts are sintered by heating in hydrogen or vacuum at 1,100° to 2,200° C. (2,012° to 3,992° F.).

In the arc-casting process, a partially sintered bar serves as a consumable electrode and is melted into a water-cooled mold usually made of copper. The electrode may be prefabricated or may be continuously pressed and sintered within the melting unit. The operation is carried out in a high vacuum or an atmosphere of purified inert gases. In this process, alloying elements can readily be incorporated by mixing them with the molybdenum powder from which the electrode is made.

Small pouder metallurgy compacts to be made into rod or wire may be worked by swaging or rolling, starting at about 1,300° C. (2,372° F.). After suitable reduction, wire may be made by drawing through carbide dies or, for finer sizes, through diamond dies. Arc-cast ingots may be broken down by extrusion at about 1.100° to 1,310° C. (2,012° to 2,390° F.) The extrusions may be rolled into bar products. For the production of plates and sheets, extrusions may be rolled or forged into sheet bars. They may also be used for the production of hand or die forgings.

Among the properties of metallic molybdenum responsible for its commercial use are its very high melting point, superior strength at high temperatures, high modulus of elasticity, high electrical and thermal conductivity, low coefficient of thermal expansion and relatively low absorption cross section for thermal neutrons. It is resistant to several common chemical solutions including hydrochloric, sulfuric, phosphoric and hydrofluoric acids under many conditions of concentration and temperature. It is attacked by oxidizing acids. molten oxidizing salts and fused alkalis. It is rapidly oxidized in air at temperatures above about ;00° C. (932° F.).

Metallic molybdenum has been widely used in electronic tubes for anodes, grids and support members. Rod or wire is used for heating elements in furnaces operating up to 1,700° C. (3,092° F.). Oxidation is avoided by using a reducing or inert atmosphere. Sprayed coatings of molybdenum make a firm bond to steel and some other metals. and show excellent resistance to wear. In the glass industry molybdenum has been used for resistance heating electrodes, stirring devices and wear parts, Molybdenum and its alloys have also been used for various parts of high-temperature engines. When excessive oxidation might be encountered, protective coatings are necessary.

Molybdenum as an Alloying Element. — In the 1890s, the use of *molybdenum* in steel was studied by various investigators Until about 1918, however, the commercial development of molybdenum steels was hindered by the high price and uncertain supply of molybdenum. The development of the mine at Climax and the experiences of steel fabricators with wartime molybdenum steels led to further development work and to the adoption in the 1920s of various molybdenum steels for peacetime purposes, notably by the automotive industry. In steels for automotive and other machine parts, molybdenum may be used as the principal alloying element or in conjunction with other elements, especially chromium and nickel.

In machine construction, alloy steel parts are generally hardened and tempered to increase their strength and resistance to wear. The principal reason for adding alloying elements is to make it possible to harden the parts by less rapid cooling, as by quenching in oil instead of water. The alloying elements are said to increase the hardenability of steel. Molybdenum is one of the most effective elements in this respect.

Molybdenum contributes to the toughness of quenched and tempered steels especially by helping to prevent the development of temper brittleness. This effect together with its contribution to hardenability has accounted for the use of molybdenum in many applications nhere maximum toughness is required as in armour plate and guns.

High-speed tool steels contain molybdenum or tungsten to develop the property known as red hardness, or ability to cut at a red heat. It has been known since about 1900 that one part by weight of molybdenum is substantially equivalent to tno parts of tungsten, but the commercial development of molybdenum high-speed steels began about 1934. Such steels contain molybdenum or molybdenum and tungsten, together with chromium and vanadium. Rfolybdenum is also used in other types of tool steel and is added to various types of stainless steel to further improve their resistance to certain kinds of corrosion Molybdenum increases the strength of steel at elevated temperatures and has been widely used, for example, in pipes, valves, forgings and fittings in superheated steam plants, in superheater tubing and in cracking-furnace tubes Molybdenum increases the strength, toughness and uniformity of gray iron (see CAST IRON), in which it is extensively used.

As in steel. molybdenum also increases the hardenability and elevated temperature strength of gray iron. Molybdenum cast iron has been used in chilled rolls and also in grain rolls cast in sand molds to increase resistance to breakage. chipping, heat checking and spalling. In automobile engines, molybdenum cast irons can be used in camshafts and tappets. Many of the nickel-base and cobalt-base alloys nhich have been developed for high temperature use as in gas turbine parts contain molybdenum to increase their high temperature strength. Molybdenum is also used in certain nickel-base alloys developed primarily for resistance to corrosion in chemical solutions. See also ALLOYS.

Compounds.—Molybdenum exhibits valences of +2, +3, +4, +5 and +6; it is considered zero valent in the carbonyl $Mo(CO)_6$. The most important compound is the trioxide, MoO_3, from which most of the knonn compounds containing the element can be prepared The oxide obtained by roasting molybdenite in air can be purified by sublimation, or pure oxide may be obtained by thermal decomposition of ammonium molybdate.

Molybdic oxide has found use as a catalyst. Molybdate chrome orange, a brilliant pigment of high covering power, may be made

with molybdic oxide or sodium molybdate. Na_2MoO_4, as a source of molybdenum; these compounds are also used in the production of molybdated lakes and toners. Ammonium molybdate is used in the production of molybdenum metal powder. in the preparation of catalysts and as an analytical reagent, especially for the determination of phosphorus. Molybdenum disulfide, MoS_2, of adequate purity for use as a lubricant can be prepared from regular molybdenite concentrate by further grinding and flotation or by leaching with hydrofluoric acid. It may be used as an additive to greases and oils or as a dry film or solid lubricant. The pentachloride, $MoCl_5$, may be prepared by the action of chlorine on molybdenum powder. It has been used as a chlorination catalyst.

Molybdenum has been proved an essential trace element in plant nutrition; in legumes, it assists bacteria in fixing nitrogen. Sodium molybdate or molybdenum trioxide may also be used (see FERTILIZERS AND MANURES: Secondary Elements). See also Index references under "Molybdenum" in the Index volume.

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MOLYNEUX. This historic English name came into the country from France at the time of the Norman Conquest through William de Molines (Moleyns, Molyneux), who obtained a grant of Sefton, in Lancashire, whence come the present earls of Sefton. His descendant Adam de Molyneux (Moleyns or Molins), who died in 1450, was bishop of Chichester and keeper of the privy seal; he n-as a son of Sir Richard Molyneux of Sefton, and uncle of the Sir Richard Molyneux (d. 1459), the Lancastrian favourite of Henry VI, whose descendant Richard Molyneux (1593–1636) was created in 1628 1st Viscount Molyneux of Maryborough, a title now merged in that of Sefton (created 1771).

Another Molyneux family of some importance is the Irish one, descended from Sir Thomas Molyneux (1531–97), Irish chancellor of the exchequer, who, born at Calais, settled in Ireland in 1576. He was the great-grandfather of Sir Thomas Molyneux, Bart. (1661–1733), a well-known physician and zoologist. and of William Molyneux (1656–98), the philosopher. astronomer and politician. the friend of Locke, and author of *Dioptrica nova* (1692), whose work on the legislative independence of Ireland (*The* Case *of* Ireland, etc., 1698) created a stir at the time. The latter's son Samuel (1689–1728) was also a well-known astronomer.

MOM. A system of signs invented by Njoya about 1900, and written by a small group in the Cameroons. Over 300 separate signs were first used; the progress from purely pictographic representation to syllabaries and alphabetic forms is notable.

MOMBASA, a town of Kenya protectorate, East Africa. and the chief port for Kenya colony, Uganda and northeastern Tanganyika, is built on a coralline island about 3 mi. long and $2\frac{1}{2}$ mi. wide, at the mouth of a deep arm of the Indian ocean. The population (Mombasa social survey census 1957) was 145.387 including 4.399 Europeans; the population of the 1948 census was 54.746. Municipal area. including mainland districts. $26\frac{1}{2}$ sq.mi. The climate is warm and equable, with a mean maximum temperature of 86° F. and a mean minimum of 74° F. February and March are the warmest months, June and July the coolest. The annual rainfall averages 47.65 in.; the driest months are January through March; the mean relative humidity is 75%. Coral headlands enclose sandy bays and the striking vegetation includes mango and fig trees, coconut palms, flamboyant, baobab, bougainvillea and oleander. On the east side of the island Mombasa old harbour serves dhows and coastal sailing vessels. On the west side Kilindini, the modern port. runs into the capacious harbourage of Port Reitz. Connections between island and mainland are by Nyali bridge and Makupa and Kipevu bridge-causeways; several ferries also carry vehicular and passenger traffic.

During the 1950s Mombasa developed from an old-fashioned harbour town into a thriving modern seaport. Most Arab-style houses have been replaced by multi-storied buildings. The commercial area is concentrated in the centre but the movement of shipping and mercantile offices has been toward Kilindini. An industrial area covering 52 ac. is fully developed at Shimanzi in the northwest; Changamwe, on the mainland across the Makupa causeway, and the most recent industrial district, contains an oil refinery.

The old town clustered around Mombasa old port is mainly occupied by Asian and Arab traders. The Portuguese relic Fort Jesus (1592). overlooking the old harbour, had been used as a prison since 1892 but in 1958 was handed over to the Kenya Royal National Parks administration for use as a museum. There are also Portuguese ruins of churches: watchtowers, blockhouses and remains of mosques. At the southeastern point of the island, government house and a golf club face the Indian ocean. Around a gardened square behind Fort Jesus are the treasury, municipal offices and head post office; near by stand the law courts and Mombasa club. Public buildings include Anglican and Roman Catholic cathedrals; mosques and temples; European, Asian. Arab and African schools; and hospitals. There are many hotels, clubs and cinemas, a theatre and a stadium.

The first train steamed from Mombasa to Lake Victoria in 1901. The rail terminus is in the centre of the island and the main line is carried by the Makupa causeway. The interterritorial East African Railways and Harbours administration maintains a daily service with up-country districts. Uganda and northern Tanganyika. Motor roads link the port with other parts of Kenya, and at Nairobi with the Cape-to-Cairo road. Local buses serve the town and all nearby points. From Port Reitz airport, about 6 mi. from the centre of the island. regular air services connect with transcontinental airlines at Nairobi and with other parts of East Africa. The landlocked port of Kilindini accommodates vessels of any size. Its first deep-water berth was built in 1926 and by the early 1960s it had 14, including those on the mainland at Kipevu. Passenger services connect the port with most parts of the world.

Mombasa is a market for the region's agricultural products, including coconuts, sisal, cotton, sugar, kapok. various fruits and vegetables. rice. maize and millet. The port handles the export of many of these and other goods such as coffee. minerals. soda ash, oilseed and cake. Industries include cement making, lime burning. coffee curing. brewing. machine shops. and the manufacture of glass. coconut oil, soap, aluminum ware and metal containers.

It is believed that Mombasa takes its name from Mombasa in Oman (Persian gulf). With the rise of Islam, Arabs established themselves on the East African coast and a Perso-Arabic settlement at Mombasa dates from about the 11th century. In 1331 the Arab traveler Ibn Batuta described it as "a large place," and in 1498 Vasco da Gama found it a seat of considerable commerce. The ruler of the city tried to entrap da Gama (or so the explorer thought) and with this began a series of Portuguese-Arab campaigns which gave full force to the island's Swahili name *Mvita* (war). The principal incidents were the capture and burning of the town by Francisco de Almeida (1505), Nunho da Cunha (1529) and Duarte de Rlenezes (1587), the revolt and flight (1631) of Yusuf ibn Hassan after massacring the Portuguese colony. and the three years' siege of Fort Jesus by the imam of Oman in 1696–98, ending in the expulsion of the Portuguese. From March 1728 to Nov. 1729 a Portuguese force from Goa once again held Mombasa, when they were finally driven out by Muscat Arabs.

In Dec. 1823 the ruling Mazrui family placed the city under British protection and in Feb. 1824. Lieut. J. J. Reitz was appointed commandant. He died soon after. The protectorate was never confirmed by the British government. The town was later captured by Seyyid Said of Oman who, after repeated attacks, obtained possession in 1837. Said made Zanzibar his capital and Mombasa became of secondary importance. A revolt against Zanzibar in 187j was put down with British assistance. In 1887 the town was handed over by the sultan of Zanzibar to the British for administration and it later became the capital of the East African protectorate (Kenya colony). In 1907 the seat of central government was removed to Nairobi. Mombasa became a municipality in 1928 and assumed council status in 1959; at which time it still formed part of the sultanate of Zanzibar and was included in Kenya protectorate as distinct from Kenya colony. (ED. R.)

MOMMSEN, THEODOR (1817–1903), German historian and archaeologist, was born on Nov. 30, 1817, at Garding, in

Schleswig. After being educated at Kiel he devoted himself to the study of Roman law and antiquities. In 1843 a grant from the Danish government enabled him to go to Italy, where he began his important investigation of Roman inscriptions. He collected the inscriptions of Samnium, and in 1852 published those of the kingdom of Naples. He was appointed in 1848 professor of civil law at Leipzig. His work there was interrupted by his political opinions. During 1848, when the extreme party was in the ascendant. Mommsen supported the monarchy. When the Revolution had spent its force and Beust executed his *coup d'état,* he protested, with many of his colleagues, against this act. In consequence he was dismissed from his professorship. Becoming professor at Zürich, Mommsen wrote exhaustive monographs on Roman Switzerland. and began to work on his *Roman History,* the three volumes of which appeared between 1854 and 1856 (8th Germ. ed. 1888–94, Eng. trans. in Everyman series, 4 vols. 1911).

In 1854 the Berlin academy made him chief editor of a *Corpus* of all extant Roman inscriptions and in order that he might carry on the work he was appointed in 1858 to a professorship at Berlin. The first volume appeared in 1861; five of the succeeding volumes he edited himself, and the whole mas executed under his supervision and with the cooperation of scholars whom he had trained. Mommsen also found time to write two larger works, the *History of the Roman Coinage* and the *Romisches Staatsrecht,* a profound analysis of Roman constitutional law, and *Romisches Strafrecht,* on Roman criminal jurisdiction. His *Roman Provinces* previously published in 1884 (Eng. trans. 2 vols. 1909) gives an interesting picture of social life under the empire. He was one of the founders of the *Preussische Jahrbiicher,* and for many years a member of the Prussian parliament.

Equally great as antiquary. jurist, political and social historian, Mommsen lived to see the time when among students of Roman history he had pupils, followers, critics, but no rivals. He combined the power of minute investigation with a singular faculty for bold generalization and the capacity for tracing out the effect of thought on political and social life. Mommsen died at Charlottenburg on Nov. 1, 1903.

In addition to the above, Mommsen's chief publications are: the *Roman Chronology to the Tinte of Caesar* (1858); his editions of the *Monumentum Ancyranum* and of the *Digest* in the *Corpus juris civilis,* and of the *Chronica* of Cassiodorus in *Monumenta Germaniae historica,* the *Auctores antiquissimi* section of which was under his supervision. Many of his pamphlets and articles have been collected under the title *Römische Forschungen.* His *Reden und Aufsätze* appeared in 1905 and his *Schriften* in 1905 foll.

MOMORDICA, a genus of annual or perennial vines belonging to the family Cucurbitaceae, natives of the tropics, especially Africa, and known in cultivation chiefly as hothouse plants. They are grown for their ornamental fleshy fruits, which are oblong to cylindrical in shape, orange to red in colour, prickly or warted externally, and burst when ripe. generally with elastic force. into irregular valves. M. *Balsamina,* known as balsam apple. is a very pretty annual, well adapted for trellises, etc., in tropical situations, as is also *M. Cliarantia,* the balsam pear, a somewhat larger species.

MOMOTIDAE: *see* MOTMOT.

MOMUS, in Greek mythology, the son of Night (*Nux*), the personihcation of censoriousness. He is frequently mentioned as a sort of licensed grumbler, finding fault with all that the gods do: hence the proverb "even Momus could not find fault" (Plat. *Rep.* 487A) to denote perfection. He appears very seldom in serious works (*Cypria,* frag. 1): a lost satyr-play of Sophocles bore his name. Lucian often introduces him, and he appears in a well known Xesopic fable.

MON, a historically significant minority people numbering in the 1960s about 350.000 in the eastern delta region of Burma and 65.000 in west central Thailand. now distinguishable from the Burmese only in language. The Mon were among the earliest Mongoloid people from west China who spread over the river lowlands of southeast Asia from the Irrawaddy delta to the Menam Chao Phya valley and south to the Kra isthmus. They are a remnant of the earliest known civilization of southeast Asia, having been exposed to Indian culture (Brahmanism) and Theravada Buddhism for more than a millennium prior to the arrival of Burmese and Thai. Principal ancient Mon sites in lower Burma were Thaton, Twante, Rangoon and Pegu. The 7th century centre of power was the kingdom of Dvaravati at Lopburi on the lower Menam, an offshoot of the Khmer empire. In the early 9th century the centre of Mon power shifted west to Pegu on the lower Sittang river. There were Mon connections with the great Buddhist centre at Kancheepuram (Madras). Southward-migrating Burmese took over the Mon irrigation of the Kyaukse area in central Burma and this dry zone became their key economic area (culture hearth). Conquest of Thaton in 1057 by Anawrata (Anuruddha), first king of Burma, was culturally decisive: Mon monks and scriptures of Theravada Buddhism were based at the Burmese capital, Pagan; Pali superseded Sanskrit as the language of sacred books; the Burmese adopted the Mon alphabet and Talaing became the Burmese name for Mon. Burmese were brought into direct contact with Indian influences and the way was opened for late 12th-century contact with Buddhist centres in Ceylon. Intermittent warfare for supremacy between the Mon of Pegu and Burmese to the north was the principal feature of 11th- to 18th-century Burma history. The Mon bore the brunt of 16th-century Burmese-Siamese struggles; their land was laid waste and their people were conscripted for forced labour or military service. Desperate Mon rebellions were met with savage reprisals, resulting in periodic migrations of the Mon to Siam. Short-lived independence for the Mon (1740–1757) ended with the Burmese siege and sack of Pegu and Mon subjugation. Those Mon who were not enslaved found refuge in Siam. Lower Burma became depopulated and famine-stricken, and, when the British arrived in 1824. had reverted to uncultivated waste.

See D. G. E. Hall, *The History of South-East Asia* (1955); and R. Halliday, *The Talaings* (1917). (W. L. TH.)

MONACO, a sovereign principality on the Mediterranean coast, 9 mi. E. of Nice, bounded on all sides by the French *département* of Alpes-Maritimes. Pop. (1961) 22.297, including 3,039 Monegasques, 12,869 French, 4,217 Italians and 598 British. Area .6 sq.mi.

The Phoenicians and later the Greeks had a temple on the Monaco headland dedicated to Heracles, whose local surname Monoecus may be derived from a pre-Indo-European root *mon-,* "raised site" or "rock." Recognized as a Genoese possession in 1162, it fell to the dissident Genoese Grimaldi in 1297. Confirmed in power in 1419, the Grimaldi usually allied themselves with France until 1524, when Augustin sided with the emperor Charles V. Honor6 I, Augustin's successor, was made marquis of Campagna and count of Canosa, and special privileges were granted. The *droit de mer,* or right to 2% of the value of the merchandise in ships passing within sight of the fortress, originated with the Genoese and had been confirmed by Charles VIII in 1497. It was confirmed again in the treaty of Péronne (1641), whereby Honor6 II re-allied his house with France, losing Canosa, etc., but becoming duke of the Valentinois. In 1731 Antoine I, Honoré's great-grandson, was succeeded by his daughter Louise Hippolyte, wife of Jacques de Goyon-Matignon, count of Torigny, who succeeded his wife and took the name of Grimaldi. In 1793 the national convention dispossessed the reigning family and annexed Llonaco to France. The treaty of Paris (1814) restored the family; that of Vienna (1815) put Monaco under the protection of Sardinia. In 1860 Nice was transferred to France. By the Franco-Monégasque treaty of Feb. 2, 1861, Monaco was restored to independent sovereignty.

In 1911 Prince Albert granted the principality a constitution. providing for a national council of 18 members, elected for four years by universal suffrage and *scrutin de liste.* Government is by a ministry assisted by a council of state, acting under the authority of the prince. Legislative power rests with the prince and the national council. On July 17, 1918, a new Franco-Monégasque treaty was signed. It contained a clause that in the event of the dynasty becoming extinct, Monaco would become an autonomous state under French protection. Albert was succeeded on June 26, 1922, by his son Louis II, who died May 9, 1949. He was succeeded by his grandson Rainier III (b. May 31, 1923), son of

the hereditary princess Charlotte Louise Juliette and of Prince Pierre, count de Polignac. On April 18–19, 1956. Rainier married Grace Patricia Kelly. U.S. motion-picture actress. A daughter, Caroline Louise Marguerite, was born on Jan. 23. 1957. and a son, Albert Xlexandre Louis Pierre. on March 14. 1958.

The territory of hlonaco is divided into three *quartier:* Monaco-Ville, pop. (1961) 1,774. the old settlement on the summit of a rocky headland defended by ramparts; La Condamine. pop. (1961) 11.007, on the west of the bay, a winter resort with manufactures of perfume and liqueurs; Monte Carlo, pop. (1961) 9.516. with its casino, pigeon shooting ground and hotels. Each commune is administered by a municipal authority. The judicial system, since 1819. has been based on the French. There is a court of first instance and a *juge de paix,* and by arrangement two Paris judges form a court of appeal. The bishopric dates from 1887. There is a semimilitary police force.

In the town of Monaco are the cathedral of St. Nicholas (on the site of the ancient churchj, the medieval Genoese and Renaissance palace and Prince Albert's oceanographic museum (1910). Another museum contains prehistoric exhibits from the grottoes near Mentone and Roman antiquities from La Turbie.

In 1861 François Blanc of Homburg obtained a jo-yr. concession to run gambling tables. This concession passed to a company and was subsequently extended. The Monégasques are forbidden access to the tables but are exempt from taxation.

See A. Smith, *M. and Monte Carlo* (1912); L. H. Labande, *Histoire de* la *Principauté de M.* (1934). (K. E. E.; X.)

MONAGAS, a state in eastern Venezuela, is bounded by the Orinoco river on the southeast, the Caño Mánama on the east, the San Juan river and the Gulf of Paria on the northeast. and the states of Sucre and Anzoategui on the north and west. Area 14.158 sq.mi. Pop. (1961) 243,028. Except for a coastal range on the north and marshes in the Orinoco delta area, Monagas is a land of savannas — typical llanos country. Cattle raising is dominant over most of the state, though the usual list of Venezuelan crops is grown in the northern uplands. Monagas has one of the largest oil-bearing areas in eastern Venezuela; among the principal fields are Campo Temblador, Campo Santa Barabara. Campo Jusepin and Campo Quiriquire. Pipelines connect the fields with the Caripito refinery and terminal. Maturín (pop. [1961] 53.445) is the state capital and chief trading centre. (L. We.)

MONAGHAN, a county of Ireland in the province of Ulster, bounded east by Xrmagh, southeast by Louth, south by Meath, southwest by Cavan. west by Fermanagh and north by Tyrone. The land area is 498.4 sq.mi. Pop. (1961) 47,077. The northwestern part is included in the great central plain of Ireland. but to the south and east the surface is irregular. The principal range is that of Slievebeagh, a barren tract extending into Fermanagh. The principal rivers are the Finn, rising near the centre of the county and passing into Fermanagh, and the Blackwater. which forms the boundary with Tyrone. The Ulster canal passes the towns of Monaghan and Clones. and was intended to afford communication between Lough Neagh and Lough Erne; it became derelict in the 1920s.

In geological structure the county drops from the Upper Carboniferous outlier of Slievebeagh in the northwest to a Carboniferous Limestone area toward Monaghan town; but south of this a Silurian area stretches across the Cavan and Armagh borders. At Carrickmacross, an outlier of Carboniferous Limestone, Coal Measures (with poor seams of coal) and Trias is encountered. Gypsum is extensively quarried in the Trias, and lead ore was formerly mined in many places in the Silurian area. The Triassic clay furnishes excellent bricks. Eskers or glacial ridges occur at several places. Limestone is abundant, and worked at small cost. Freestone and slates are quarried.

The district now called the County of Monaghan was included in the district of Uriel or Orgial, known in the times of Elizabeth I as Macmahon's country. It was made shire ground under its present name by Sir John Perrot in the reign of Elizabeth I. Near Clones are two large raths and there is a round tower there. as well as at Inishkeen. There are several Danish forts. The 6th-century abbey of Clones, once the seat of a bishopric, was rebuilt in the 14th century.

The soil is generally fertile where it rests on limestone, and there is also a mixed soil of deep clay. capable of high cultivation: but in the hilly regions a strong retentive clay prevails. which could be made productive only by careful draining and culture. Oats, potatoes, flax and turnips are the principal crops. The number of cattle. sheep, pigs, goats and poultry is well maintained. Leather. boots and shoes are the only manufactures of consequence. The Belfast and Clones line of the Great Northern railway crosses the county from northeast to west, and the Dundalk and Clones line runs from southeast to west, with branches to Carrickmacross and to Cootehill (County Cavan). Monaghan returns three members to *dail eireann.*

MONAGHAN, the county town of County Monaghan, Ire.. jj mi. S.W. of Belfast by road and 18 mi. S.W. of Armagh. Pop. (1961) 4,010. There is a modern (1862–92) Roman Catholic cathedral of St. Macartan for the diocese of Clogher. The town takes its name (*Muinechan,* the town of monks) from an early monastery. It was incorporated by James I. but was little more than a hamlet until the close of the 18th century.

MONA ISLAND is, a limestone shelf of 21 sq.mi. raised 1jo to 200 ft. out oi the Mona channel about 50 mi. S.W. of Puerto Rico. The island has nó permanent inhabitants. Guided missile installations and a lighthouse are maintained. There is a small landing strip. In spite of excellent beaches and good fishing. government attempts to develop the island as a tourist attraction had produced no results by the early 1960s. (T. G. Ms.)

MONAL (Monaul, Moonal. Impeyan Pheasant), a beautiful pheasant (*Lophophorus impejanus*) living 8,000 to 15,000 ft. up in the Himalayas from Afghanistan to Bhutan. The crested male has a shining green and blue body, gilded purple neck. white rump and short red-brown tail. Related species are found in northern Burma and Yunnan (L. *sclateri)* and in southeastern Kokonor and western Szechuan (L. *lhuysii*). *See* also Pheasant. (G. F. Ss.)

MONA MONKEY, a West African guenon (*q.v.*) of the genus *Cercopithecus.* The mona (*C. mona)* is characterized by the presence of a black band running from the eye to the ear. The general colour of the upper parts is black; with a pair of white spots near the tail, while a band across the forehead and the whole under surface are likewise white. *See* Primates.

MONARCHIANISM, a theological term designating the view taken by those Christians who. within the church. toward the end of the 2nd century and during the 3rd. opposed the doctrine of an independent personal subsistence of the Logos, and affirmed the sole deity of God the Father. The representatives of the extreme monotheistic view, which. while regarding Christ as Redeemer. clung tenaciously to the numerical unity of the Deity, were called monarchians, a term brought into general use by Tertullian. It is usual to speak of two kinds of monarchianism — the dynamistic (or adoptionist) and the modalistic (or Sabellian) — though the distinction cannot be carried through without some straining of the texts.

By monarchians of the dynamistic class Christ was held to be a mere man, miraculously conceived indeed. but constituted the Son of God simply by the infinitely high degree in which he had been filled with Divine wisdom and power. This view was taught at Rome about the end of the 2nd century by Theodotus, who was excommunicated by Victor, and at a later date by Artemon, excommunicated by Zephyrinus. About the year 260 it was again propounded within the Church by Paul of Samosata (*q.v.*).

Modalistic monarchianism, conceiving that the whole fullness of the Godhead dwelt in Christ. took exception to the "subordinatianism" of some church writers, and maintained that the names Father and Son were only different designations of the same subject, the one God. who "with reference to the relations in which He had previously stood to the world is called the Father, but in reference to His appearance in humanity is called the Son." It was first taught. in the interests of the "monarchia" of God, by Praxeas. a confessor from Asia Minor in Rome about 190, and was opposed by Tertullian in his well-known controversial tract. The same view—the "patripassian" as it was also

called, because it implied that God the Father had suffered on the cross—obtained fresh support in Rome about 215 from certain disciples of Noetus of Smyrna, who received a modified support from Calixtus I. For the subsequent history of modalistic monarchianism *see* SABELLIUS. *See* also ADOPTIONISM.

See A. Harnack, History of Dognza, vol. iii, pp. 1–118 (1897).

MONARCHY, strictly, the undivided sovereignty or rule of a single person. (Fr. *monarchie,* from Lat. *monarchia,* from the Gr. *monos* alone, *arche* rule.) Hence the term is applied to states in which the supreme authority is vested in a single person. the monarch; who in his own right is the permanent head of the state. The word has, however, outlived this original meaning, and is now used, when used at all, somewhat loosely of states ruled over by hereditary sovereigns, as distinct from republics with elected presidents; or for the "monarchical principle," as opposed to the republican.

The old idea of monarchy, *viz.* that of the prince as representing within the limits of his dominions the monarchy of God over all things. culminated in the 17th century in the extreme version of the doctrine of the divine right of kings, and was defined in the famous dictum of Louis XIV.: *L'état c'est* ***moi!*** The conception of monarchy was derived through Christianity from the theocracies of the East; it was the underlying principle of the medieval empire and also of the medieval papacy, the rule of the popes during the period of its greatest development being sometimes called "the papal monarchy." The monarchical principle was shaken to its foundations by the English revolution of 1688; it was shattered by the French revolution of 1789; and though it survives as a political force. more or less strongly, in many European countries, "monarchists." in the strict sense of the word, are everywhere a small and dwindling minority. To express the change phrases were invented which have come into general use, though involving a certain contradiction in terms *viz.* "limited" or "constitutional monarchy," as opposed to "absolute'! or "autocratic monarchy."

Finally, a distinction is drawn between "elective" and "hereditary" monarchies. Of the former class the most conspicuous was the Holy Roman Empire; but in Europe all monarchies were, within certain limits, originally elective; and, after the introduction of Christianity, the essential condition of the assumption of sovereign power was not so much kinship with the reigning family as the "sacring" by the divine authority of the church. The purely hereditary principle was of comparatively late growth, the outcome of obvious convenience, exalted under the influence of various forces into a religious or quasi-religious dogma. (See also GOVERNMENT and SOVEREIGNTY.)

MONASSIR (MONASIR), tribe of Semitic stock, living in the Nile valley between Birti and Dar Robatab. They are a prosperous, sedentary tribe, claim kinship with the Ababda, and speak Arabic, but are of mixed blood.

MONASTERY, the home of a religious community (see MONASTICISM). The word is commonly used only of houses of men, but in what follows houses of women religious, widely though not properly known as convents, will also be considered; a monastery ruled by an abbot is called an abbey.

The earliest Christian monastic communities inhabited groups of cells or huts collected about a common centre, which was usually the abode of some anchorite celebrated for superior holiness. Such, for example, was the case with the disciples of Anthony in the Egyptian Thebaid in the early 4th century. The monastery properly so-called came into existence a few years later when Pachomius, also in Egypt, established the cenobitic life, which rapidly spread to Syria and elsewhere. The Pachomian monks lived in separate huts, forming a religious hamlet. They had no refectory but ate their common meal reclining on strewn grass, often out-of-doors. By degrees order was introduced in the groups of huts, and they were arranged in lines like the tents in an encampment or the houses in a street. From this arrangement a line of single cells came to be known by the Greek word *laura,* meaning "lane" or "passage."

The necessity for defense from hostile attacks, economy of space and convenience of access from one part of the community to another by degrees dictated a more compact and orderly arrangement of the buildings of a monastic cenobium. Large piles of buildings were erected, with strong outside walls, within which all the necessary edifices were ranged round one or more open courts, often surrounded by cloisters, though very often also the buildings stood free inside the enclosure, with an ambulatory or colonnade running along the inner side of the wall. No fixed plan was adopted! but a usual Eastern arrangement may be seen in the plan of the convent of the Laura, on Mt. Athos in Greece.

When monasticism was introduced to the West, its local habitation took various forms in harmony with the social conditions and situation of the community. Thus Celtic monachism preferred a group of cells and small houses built of stones, such as may be seen on various sites in Ireland or in the excavations at Iona (Scot.) or Whitby (Yorkshire). In Latin lands the buildings were larger and more compact, but the site was often such as to make elaborate or regular planning difficult, as for instance in the upper monastery of Subiaco or that of Cava de' Tirreni northwest of Salerno in Italy.

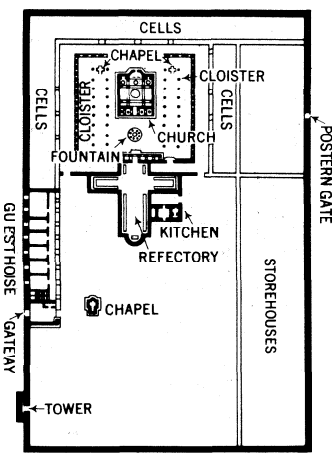


FIG. 1.—MONASTERY OF THE LAURA, MT. ATHOS, GREECE, FOUNDED IN 963

Monasticism in western Europe, as is well known, was progressively influenced by the rule of St. Benedict of Nursia, which was composed about A.D. 535–540 but was not widely followed before the end of the 7th century. Benedict in his early life had been familiar with the small, simple and almost casual buildings of the monasteries in the valleys and mountains of central Italy, and the home of his later life, where he wrote his rule, was the rugged hilltop of Monte Cassino. In the rule there is mention of an oratory, refectory, cells for monks and novices and quarters for guests; it is also laid down that all things necessary for the life of the monks should be contained within the enclosure, and water, a mill, a bakehouse and offices for all necessary crafts are specified, while the mention of a porter implies a wall and a single public entrance. No indication, however, is given of the size of the buildings or of their relation to each other, and there is also no mention of a cloister.

The cloister, soon to become the central feature of the monastic complex and used in some languages as a synonym for the whole monastery (as in Fr. *cloître* and Ger. Kloster), originated in northern Italy and was probably derived not, as was first suggested, from the court (atrium) of Roman domestic buildings but from the narthex (*q.v.*) or porticoed court at the west end of early basilica1 churches such as can still be seen at Sant'Ambrogio in Milan. When once this had been transferred to a position alongside the nave, with its eastern walk abutting on the transept of a cruciform church, it became the circulating area and the living room of the whole establishment, with ranges of buildings on the three vacant sides: to the east the dormitory, novitiate, warming house and latrines; to the south, farthest from the church, refectory and kitchens; to the west, storerooms and guest rooms, adjacent to the one exit to the outer court. This, the classical layout, is seen in almost all its essentials, and with all possible additions and elaborations needed in what was to be a kind of religious civic centre or county town, in the interesting document known as the plan of St. Gall (Switzerland) which was in fact almost certainly the "blueprint" of a model monastery circulated by Benedict of Aniane when he was acting as principal monastic reformer to the emperor Louis the Pious about 820. The buildings, with some exceptions, seem to have been of one story only, and possibly many of them were wooden.

Not all Benedictine abbeys, not even the greatest, had in practice all the appurtenances of the St. Gall plan, but almost all

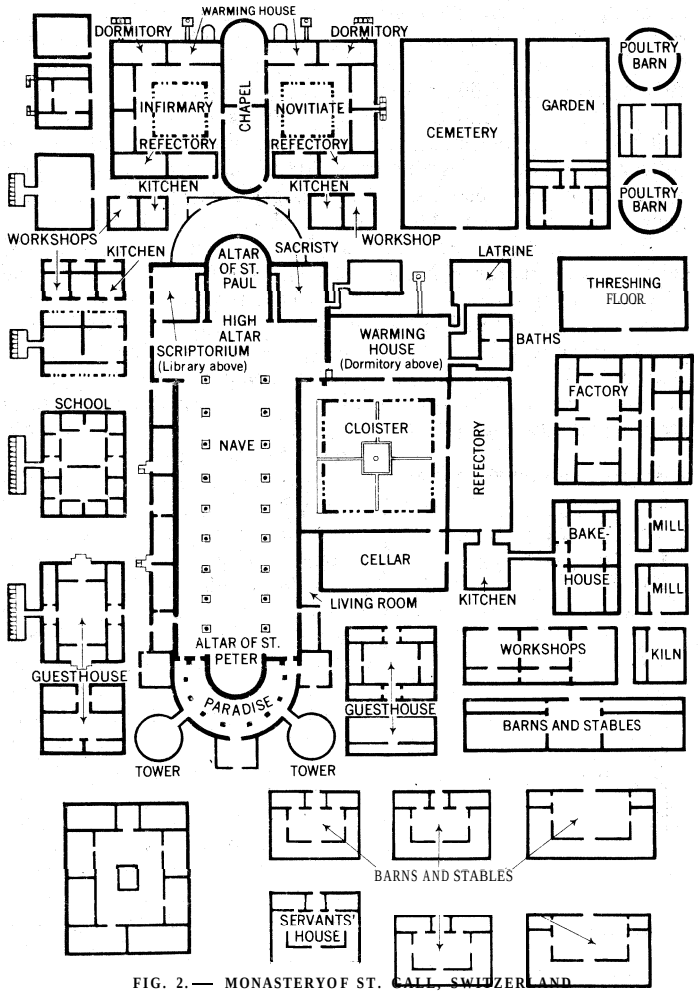


FIG. 2.— MONASTERYOF ST. GALL, SWITZERLAND

had, in one form or another, the four-sided cloister surrounded by the conventual buildings. In these, only two significant changes had been made in the centuries between Charlemagne and the religious revival of the 11th century The first was the addition of an assembly room (the chapter house) as an imposing architectural feature in the east range of buildings near the church; the second. perhaps not unconnected with this. mas the lifting of the dormitory (dorter) to first floor (US second story) level, with the consequent increase of available space below it on the ground floor Of the four walks of the cloister the quietest that alongside the nave of the church. was used as the place for daily work and study Whereas south of the Alps the cloister was normally sited north of the church to secure a maximum of shade and steady light north of the Alps the need for a maximum of lipht and warmth led to its transference to the south; nhere. however (as in England at Canterbury Bury St Edmunds and Gloucester), the ground to the south of the church was already occupied by churches or a graveyard, the planners had no hesitation in siting the cloister to the north.

In all monasteries the church. constructed on a scale that often had little apparent relation to the number of potential worshipers, was the principal architectural feature, and the multiplication of liturgical processions, of private Masses and often of popular shrines helped to lengthen the nave and multiply side chapels In addition, the church, whenever the architect had a free hand, occupied the highest point of the site.

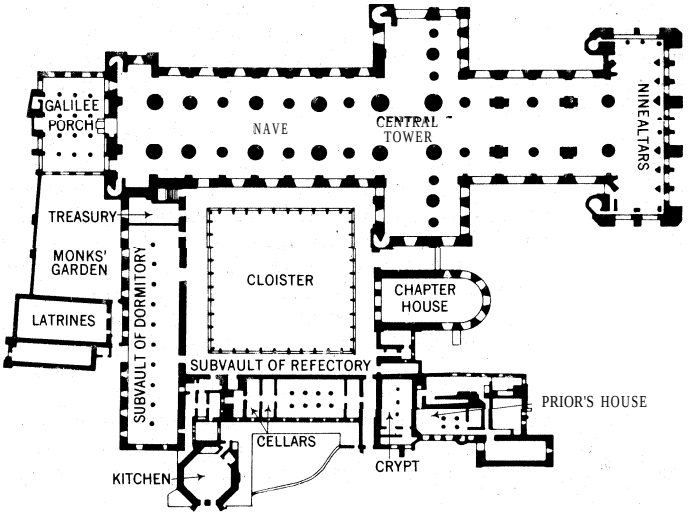
Round the cloister lay the sacristy, chapter house, treasury, novitiate and warming house, over which extended at first floor level the dorter. with "night" stairs giving direct access to the transept of the church and "day" stairs debouching in the cloister. At the end of the dorter and usually at right angles to it lay the rere-dorter or *necessarium* (latrines), a building of some size standing over the great drain Along the south walk lay the refectory (frater), with the kitchen at its southwest angle outside the cloister range To the :vest lay the cellarage and the cellarer's office with rooms for distinguished guests and (later) the abbot's chambers at first floor level.

Outside this nucleus lay two other blocks of buildings. To the southeast — that is, in the most secluded position — lay the infirmary, a monastery *in parvo* with a large hall containing beds, chapel. frater and often a small cloister and garden: to the west of the cloister lay an extension of the original scanty guest quarters. Beyond these. to the west of the cloister and church. lay the great court. bounded by a precinct wall, entered by a great gateway, and bordered by offices and stabling of every kind. It must, however. be remembered that Benedictine abbeys were often ancient foundations in cities or on an eminence (*e*g., Subiaco. Monte Cassino. Durham and Worcester) where the normal plan encountered hindrances, and radical modifications were often necessary.

It was not till the 14th century that a large room for books became common. Before that date, provision was made for books in presses against the wall of the cloister, and in particular against the wall adjoining the church, which, in a normal plan. would be the lightest. In Cistercian abbeys there was from the beginning a small book cupboard betaeen the church and the chapter house. Writing and illumination were done either in the north nalk of the cloister, where in the later centuries of the middle ages small studies or "carrels" were provided for individuals (as at Gloucester), or in a special room in or adjacent to the warming house (calefactory). *(See* LIBRARIES : *Medieval Period: Monastic Libraries.)*

Cluny.—Of all the monasteries of the west in the "Benedictine centuries" the abbey of Cluny in France was the largest and most celebrated. In the 12th century it housed a community of 400 to say nothing of the constant stream of Cluniac monks visiting the mother abbey and of guests and pilgrims, yet it was still able on occasion to receive the papal or royal court or even, as in 1245. both pope and king simultaneously. The church was by far the largest in Europe and remained so till the rebuilding of St. Peter's in Rome. Almost the whole complex of buildings disappeared between 1789 and 1814, during the revolutionary period, but a lengthy series of excavations, which were conducted by K. J. Conant under the auspices of the Mediaeval Academy of America, has made possible a reconstruction of the ground plan with some conception of the architectural style of the buildings. Cluny and its dependencies had no specific features of plan and differed from houses of similar size only in their magnificence of decoration.

Augustinian Canons and **Premonstratensians.**—These monasteries resembled those of the Benedictines, but the largest house of canons was no larger than a moderately sized abbey of

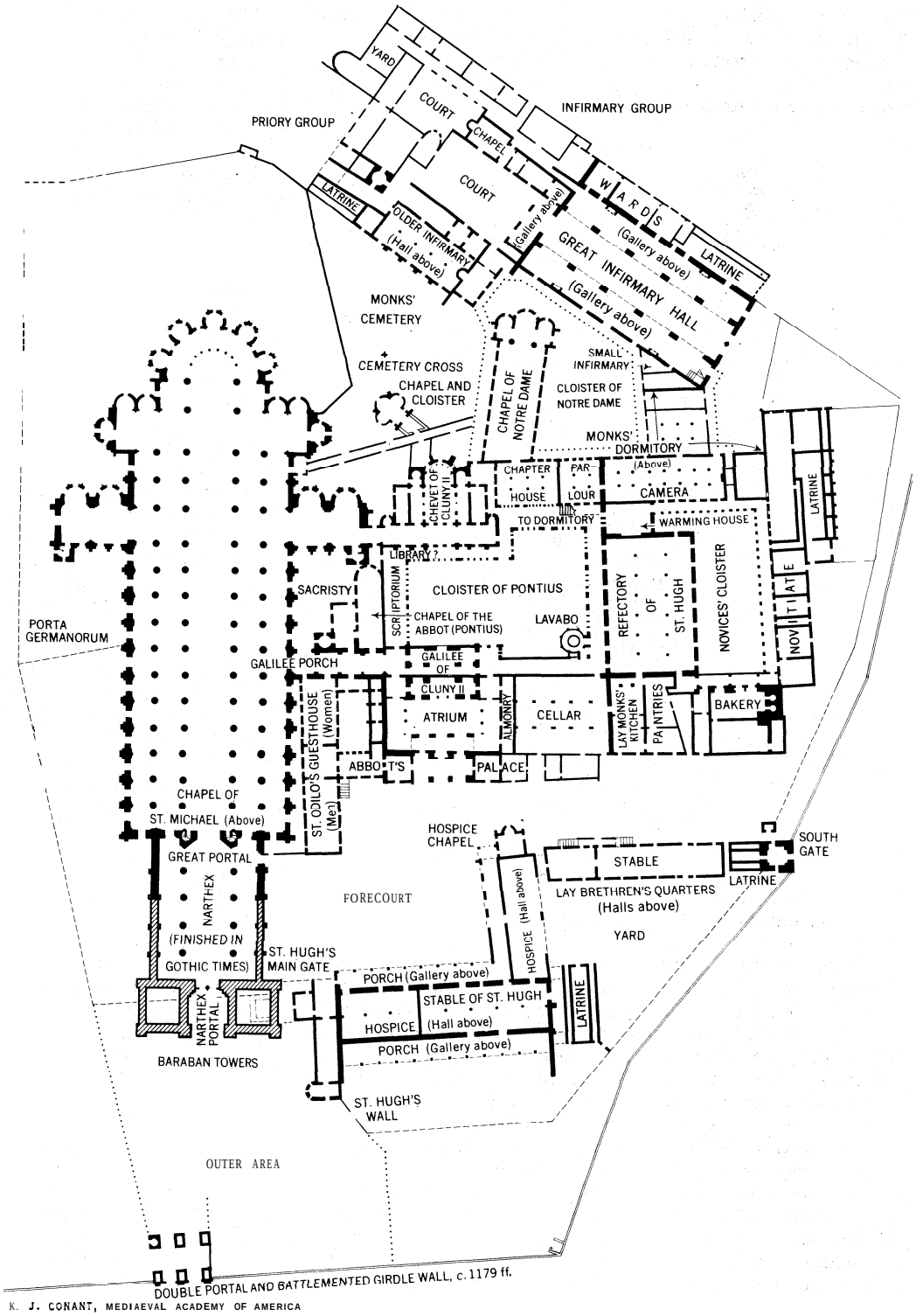


BY COURTESY OF THE BUILDER'

FIG. 3.— ABBEYOF DURHAM. ENGLAND. BEGUN *c.* 1071

monks, and the majority were small or even minute. As the canons rarely manned a cathedral (Carlisle is the only English instance'~ or a great city church (St. Mary Overy. now Southwark cathedral. London, is hardly an exception j they of ten planned on a small scale; if and when funds or numbers demanded or permitted enlargement they often found themselves without room for a south aisle of the church, the site being occupied by a walk of the cloister, or forced to dislocate the buildings of the eastern range to make way for an enlarged transept. They also frequently dispensed with the western range, closing the cloister garth with a curtain wall. The Premonstratensians in particular were very flexible in planning, and even their larger houses show great irregularity of siting, and displacements from the conventional order in the various apartments and slightly rhomboid or trapezoid cloisters are not unknown.

Cistercians.—A new era in planning and building began with the spread of the Cistercian order in the early decades of the 12th century. Four circumstances, out of the many new features of the order, helped to distinguish their abbeys from those of the older monks: they were constructed rapidly on virgin sites, with a free hand for planning; uniformity of layout was imposed by their constitutions; simplicity of style and decoration was likewise imposed: and provision had to be made for large numbers of lay brothers within the monastic enclosure. Their architects. within these limits, were further bound by two considerations, one of sentiment and one of utility: the high altar of the church must stand on the. highest point of the site, and provision must be made of a copious supply of water for sanitary purposes. a need which sometimes necessitated a northern site for the cloister to permit of drainage in that direction. Generally the apartments on the east and south range lay in the traditional positions, but when a Cistercian community increased greatly and it was necessary to enlarge the refectory lack of space in the south walk often led to the construction of a new frater at right angles to the line of cloister.



K. J. CONANT, MEDIAEVAL ACADEMY OF AMERICA

FIG. 4.—ABBEY OF CLUNY, FRANCE. AS OF 1157

As for the lay brothers, the Cistercians solved the problem by making use of the western range, largely otiose in Benedictine abbeys. This was still used for cellarage at ground level, but on the first floor a long dorter accommodated the brothers. while their refectory was sited on the ground floor of the range, which was extended to the south beyond the angle of the cloister garth. The kitchen, common to monks and brothers, was placed at the angle between the two fraters. The lay brothers had also an infirmary on a site to the southwest of the cloister. There were thus to all intents two monasteries in a single complex. For worship, the lay brothers used some of the western bays of the nave of the church, and often, to protect the monks in the cloister from disturbance, a long passage, known as the lane. within the western range led from the frater to the church, with a door into the nave aisle.

Mention has been made of the drainage; this, closely linked with the water supply, was a matter in which the Cistercians excelled. Their abbeys were always sited where a swiftly flowing stream ran, or could be conducted, through the buildings from

west to east, flushing the drains and carrying away the refuse. At some monasteries, such as Fountains in Yorkshire, the engineering and architectural devices are both ingenious and beautiful. Besides the flow for drainage, an entirely independent supply was available for drinking and washing throughout the buildings.

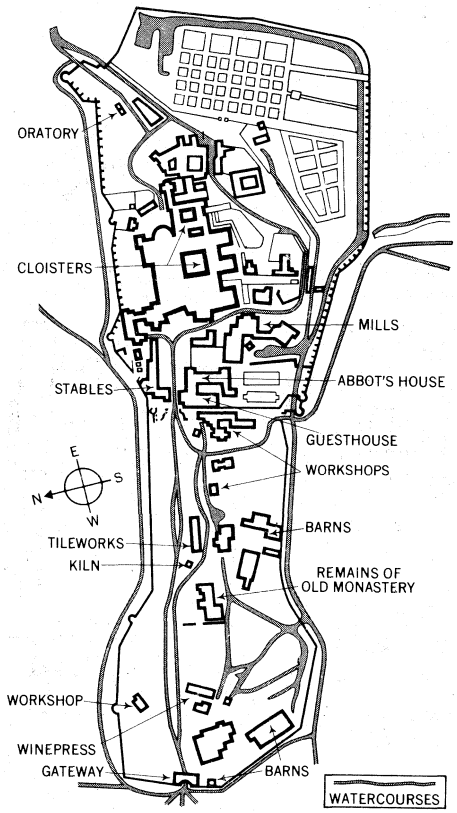


FIG. 5.— ABBEY OF CLAIRVAUX. FRANCE, FOUNDED IN 1115

This was often carried from a spring, at a distance from the abbey, by stone conduits or lead piping, and distributed round the cloisters where needed.

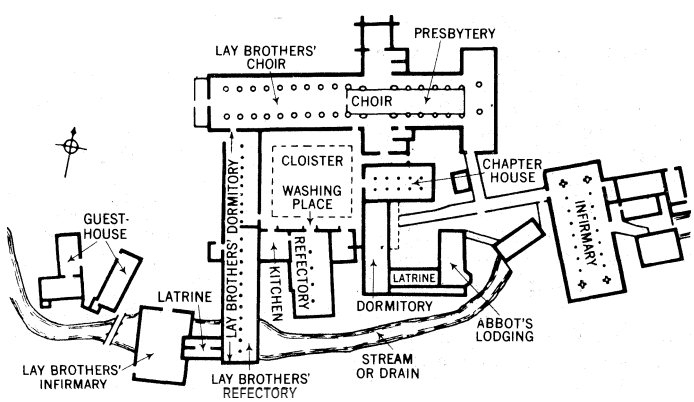
The uniformity of Cistercian planning strikes the most casual observer. While the materials used show great local differences, as may be seen, for example. by comparing Fountains and Rievaulx (Yorkshire) with Furness (Lancashire) or Dundrennan (Kirkcudbrightshire), the plans are almost identical. and it is only in a few small abbeys that never flourished in numbers and wealth. such as Kymmer in Wales. that the primitive simplicity of the earliest buildings was never given full development. .

Carthusians.— This religious order, which was in origin eremitical, always retained its character, though it domesticated the hermit's life to the extent of placing his cell within an architectural complex. The cloister garth. which was often of considerable size, was surrounded by the miniature houses of the brethren, each with its small garden plot. The church, often no more than a fair-sized chapel, adjoined the cloister on the side where the one means of egress led to the refectory, the prior's cell, the guesthouse and the outer gate. In early Charterhouses (the English corruption of the original Grande Chartreuse) the lay brothers lived in a group of buildings at some distance from the monks' cloister (*e.g.*, at Witham and Hinton in Somerset), but later, when urban Charterhouses became common. they were accommodated (as at the London Charterhouse) within the monastic enclosure. Normally, and in England universally, the buildings of a Charterhouse were modest, not to say mean. in size and in appearance (cf. the church and buildings at Mount Grace in Torkshire). but on the continent of Europe, as in Spain and Italy (*e.g.*, at Florence and Pavia) they were constructed by benefactors on a scale with materials of great magnificence. This. however, made no alteration to the solitude and simplicity of the individual Carthusian.

Mendicant Friars.— The orders of friars, poor by definition in the first century of their appearance, settled generally in towns in humble tenements given or lent to them by benefactors or the civic authorities. As time went on they, or their friends for them, constructed a permanent friary with a large church and the normal common rooms such as refectory and chapter room, but these were always on a small scale save at the most important houses in London and such academic houses of study as Oxford and Cambridge. This article is not concerned with the peculiarities of their church architecture. Access to the small cloister was customarily by means of a transit across the church, and the cloister was usually merely a corridor within the walls of the domestic buildings. As the sites of friaries were often valuable, the buildings disappeared rapidly at the dissolution of the monasteries, but exception must be made of a few friaries, especially of the Franciscans and Carmelites, which were situated in the open country. These followed, with some modifications, the normal plan of the small monastic house. The only large room, not found in monastic houses, was the school for lectures to the young members of the order.

Nuns.— The monasteries of women usually followed, on a smaller scale, the type of plan favoured by the men's branch of the order, though as the Cistercian nuns had no need to provide for lay brothers their houses showed none of the features peculiar to the White Monks. The Gilbertine order in England, which was one of nuns directed by a small group of canons, is an exception to this general rule. There the plan took the form of two similar monasteries, a greater (that of the nuns) and a less, separated by a church divided by a medial wall and accommodating both nuns and canons, all of whom had a view of the common high altar. An example of a large Gilbertine house can be seen at Watton, Yorkshire, where the whole plan was brought to light by Sir William H. St. John Hope in 1893–98.

Later Developments.— As the centuries passed, considerable modifications were made in the monastic buildings. almost all in the direction of greater comfort and individual privacy. Some of these changes reflected changing social conditions, while others were due to relaxation of the rule within the houses concerned. Chief among them was an increase in size and amenity in the accommodation provided for the abbot or prior. Originally merely a cell either in the western range (Benedictine:) or near the dorter (Cistercian), it grew into a substantial house, with dining hall, oratory and guest rooms either near the infirmary (Cistercian) or west of the cloister (Benedictine). In the later centuries of the middle ages these houses were probably the most fully developed specimens of domestic architecture and planning in existence, with comfortable rooms, heated by fires of coal and provided with facilities for washing, including piped water at first floor level. A similar tendency led to the multiplication of private chambers



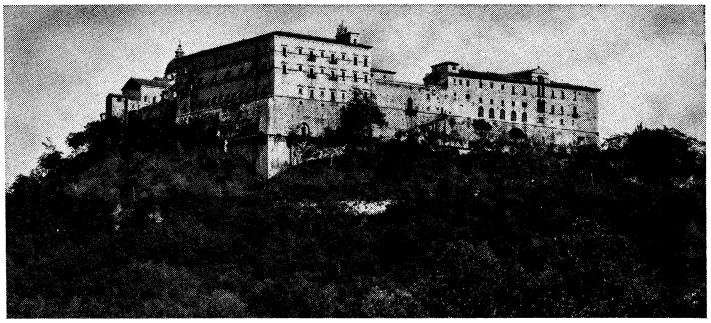
FROM DAVID KNOWLES AND J. K. ST. JOSEPH, "MONASTIC SITES FROM THE AIR," 1952; CAMBRIDGE UNIVERSITY PRESS

FIG. 6.— FOUNTAINS ABBEY. YORKSHIRE, ENGLAND, FOUNDED IN 1132

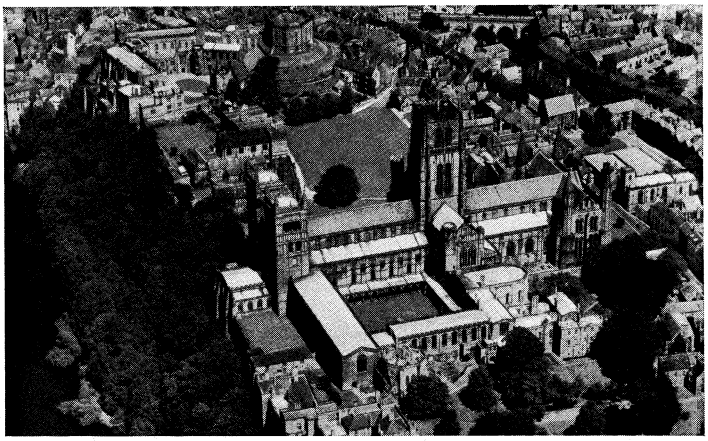
for the officials of the monastery and for doctors of theology, as well as for the sick and aged. Other developments were seen in the gatehouse, which in the late 14th century was often rebuilt, as at Thornton, Lincolnshire, on a scale of great splendour, and

MONASTERY

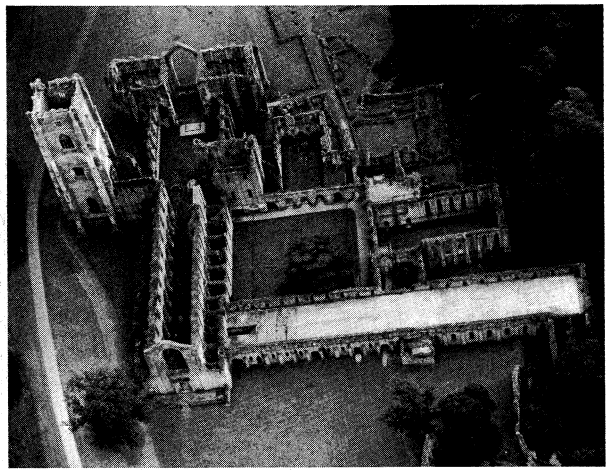
Galleries of the Greek Orthodox monastery of Simopetra on Mt. Athos, Greece. Founded during the 14th century



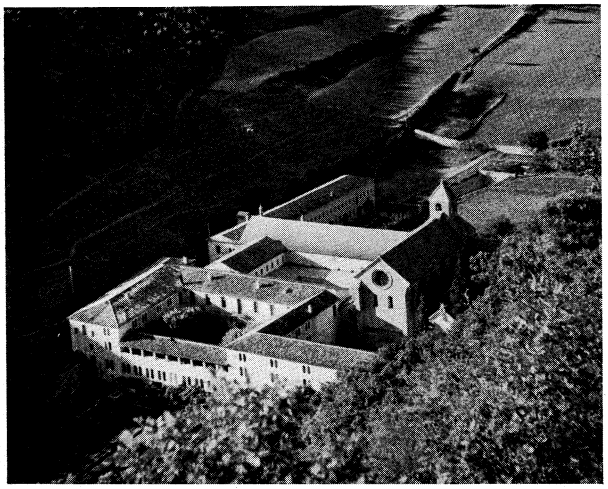
Benedictine monastery on Monte Cassino, Italy, as it appeared prior to World War II. Established by St. Benedict in 529



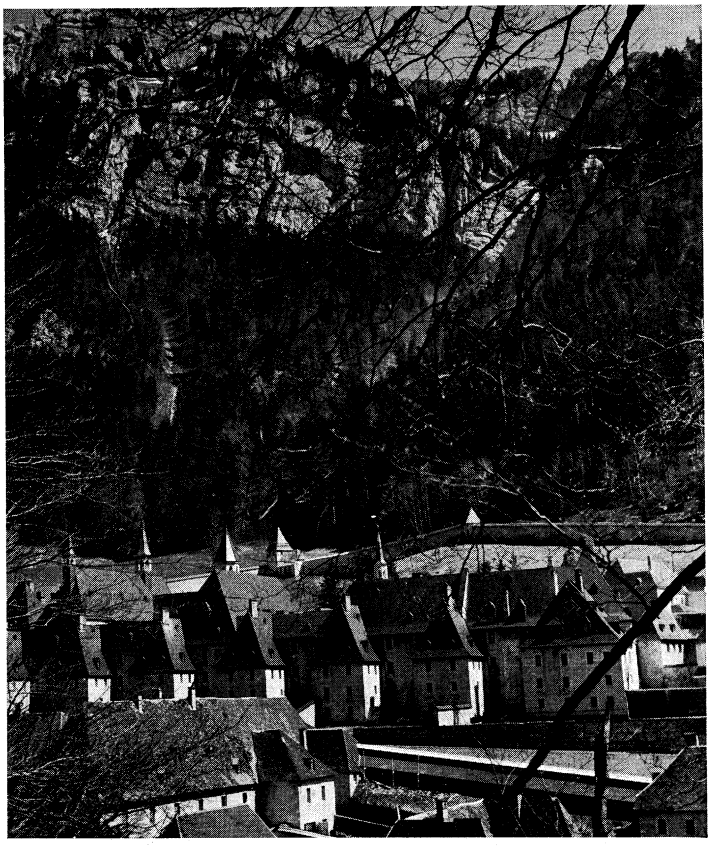
Cathedral priory, Durham, Eng. Founded by the Benedictine order in 1093



Ruins of Fountains abbey, Yorkshire, the best-preserved and most complete Cistercian house in England. Founded in 1132



Cistercian abbey of Sénanque, Vaucluse *département,* France. Simplicity of style characterized early Cistercian monasteries. Founded 1148

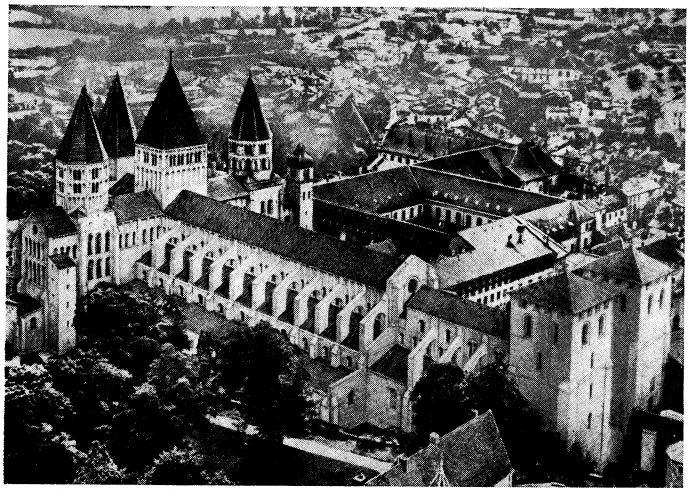


La Grande Chartreuse, Carthusian priory near Grenoble, France, founded in 1084 by St. Bruno. Most of the buildings date from the 14th century and later

MONASTERIES DATING FROM THE 6TH TO THE 17TH CENTURY

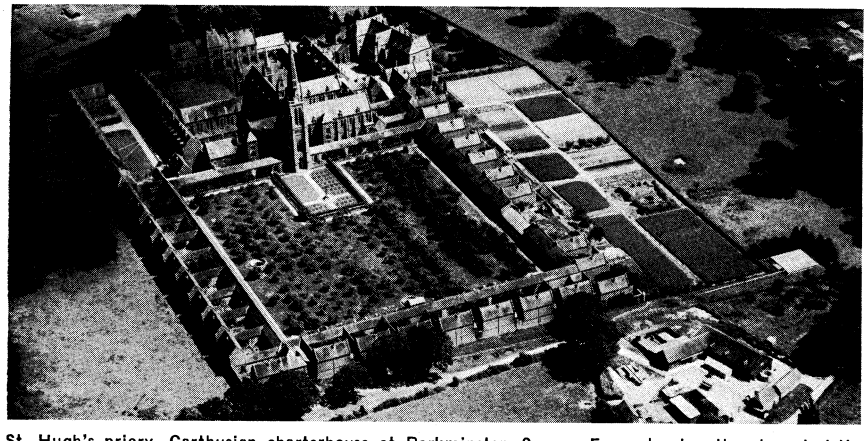
BY COURTESY OF (TOP LEFT) THE NATIONAL TOURIST ORGANIZATION OF GREECE: PHOTOGRAPHS (TOP RIGHT) MANSELL-ALINARI, (CENTRE RIGHT) AEROFILMS AND AERO PICTORIAL LTD., (CENTRE LEFT) FROM "MONASTIC SITES FROM THE AIR" BY DAVID KNOWLES AND J. K. ST. JOSEPH, UNIVERSITY PRESS, CAMBRIDGE, 1952, (BOTTOM LEFT) FROM "PROVENCE" PUBLISHED BY B. ARTHAUD, (BOTTOM RIGHT) KURT BLUM—RAPHO GUILLUMETTE

MONASTERY

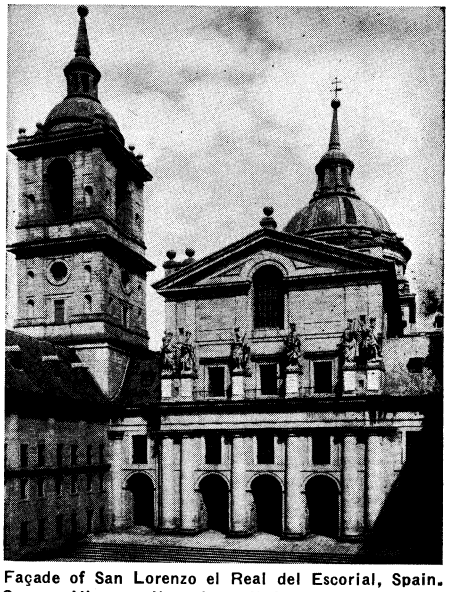


Benedictine abbey of **Cluny,** France, as it appeared about 1765. Buildings in left foreground are drawn. Founded in 910, most of the buildings were destroyed between 1789 and 1814

Ettal abbey in Bavaria, Germany. Established by the Benedictine order in 1300, it was rebuilt during the 18th century

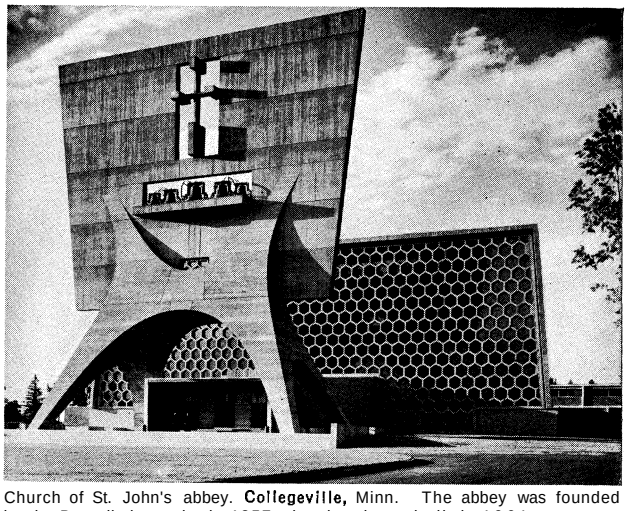


St. Hugh's priory, Carthusian charterhouse at Parkminster, Sussex, Eng., showing the characteristic Carthusian arrangement of small monks' houses surrounding the large cloister. Founded in 1883



Façade of San Lorenzo el Real del Escorial, Spain. Once a Hieronymite priory, it is now occupied by Augustinians. Begun 1563, completed 1584

Cloister and towers of the monastery of San Francisco, Quito, Ecuador. Founaed in 1538 by the Franciscan order



Church of St. John's abbey. **Collegeville,** Minn. The abbey was founded by the Benedictine order in 1857, the church was built in 1961

MONASTERIES OF EUROPE, SOUTH AMERICA AND THE UNITED STATES

BY COURTESY OF (TOP RIGHT) ROBERT LOBL, (BOTTOM RIGHT) ST JOHN'S ABBEY; PHOTOGRAPHS (TOP LEFT) K. J. CONANT, MEDIAEVAL ACADEMY OF AMERICA (CENTRE LEFT) FROM "MONASTIC SITES FROM THE AIR" BY DAVID KNOWLES AND J. K. ST. JOSEPH: UNIVERSITY PRESS, CAMBRIDGE. 1952, (CENTRE RIGHT) FOTO MAS, (BOTTOM LEFT) PAUL POPPER LTD.

in the library, which came into being as a large room with desks and presses either over the north walk of the cloister or between the chapter house and the church. From the 16th century onward the private cell became general. Even in the middle ages the monks had come to occupy a wainscoted study or carrel either in the cloister or in the dorter, as at Durham. Gradually the cubicle study became common; this in time developed into a small private room, and only the reformed Cistercians retained the common norkroom and dorter.

Post-Reformation Changes.— In the various reforms and revivals from the late 16th century onward the religious orders adopted the ruling styles in architecture, in which churches were sharply distinguished from domestic buildings of all kinds. These latter, in all the countries influenced by Renaissance architecture, became great masses of masonry with many stories and multiple fenestration arranged around a succession of quadrangles. Ecclesiastical institutions were indistinguishable from secular or private buildings of comparable size, and in almost every country such monasteries as remained in existence were clothed with thick layers of new buildings within which some of the old cloisters and rooms were embedded. Thus Cîteaux, Monte Cassino, Einsiedeln and the abbeys in the valley of the Danube (to name but a few) became monuments of Louis XIV or baroque architecture and the traditional monastic plan was submerged or ignored. The library grew in size and became a splendid apartment, seen at its fullest development in northern Italy, Bavaria and Austria.

In the course of the revival of monastic life that began in France in the middle of the 19th century, spread gradually throughout Europe and later extended to North America and elsewhere, a great variety was seen in the design and planning of monasteries. All save the Carthusians and reformed Cistercians have been affected by the substitution of corridors of private rooms or cells for the public dormitory Even in the case of the Cistercians the medieval layout had been so thoroughly overlaid that after the destruction at the time of the French Revolution the primitive plan fell into oblivion and the monasteries of the Trappists bear little resemblance to the medieval abbeys of the White Monks.

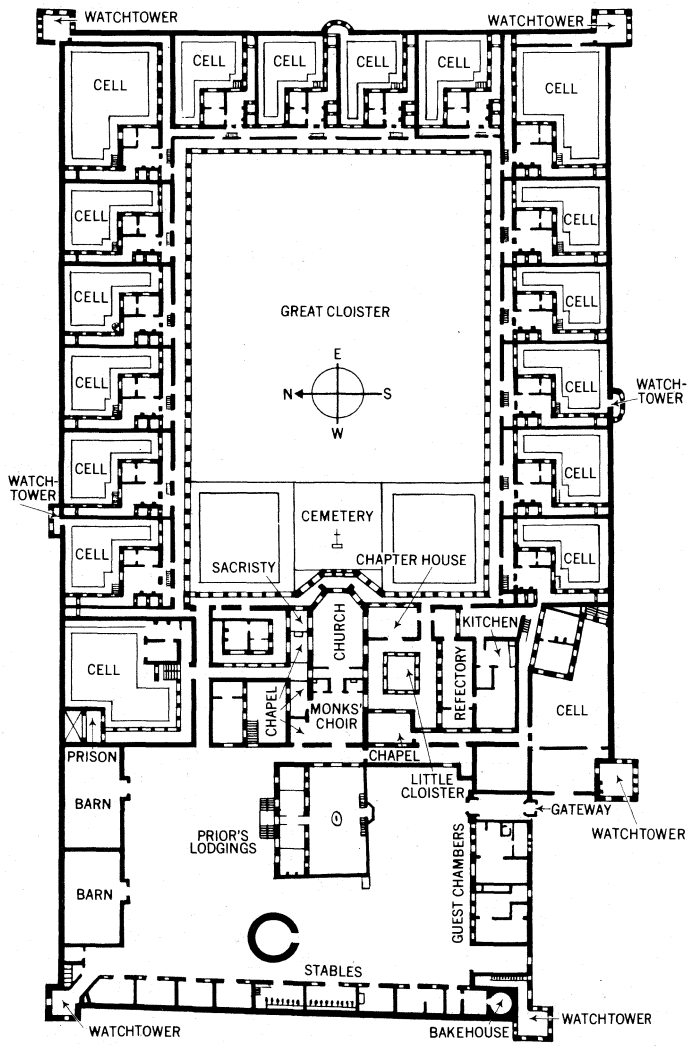


FIG. 7.— PLANFOR RECONSTRUCTION OF CARTHUSIAN MONASTERY OF PORT STE. MARIE. NEAR CLERMONT-FERRAND: FOUNDED 1219

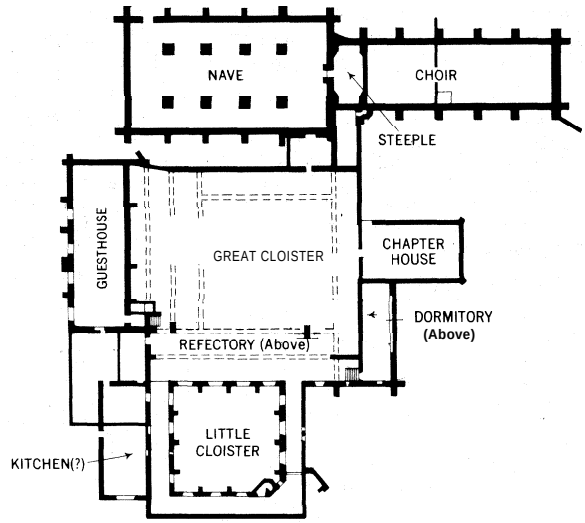


FIG. 8.— FRANCISCAN FRIARY. WALSINGHAM. ENGLAND. FOUNDED IN 1347

Similarly. Benedictine abbeys such as Solesmes in France were built with several stories of cells opening upon galleries and staircases. with the cloister merely a wide vaulted passage on the ground floor. Though the cloister and cloister parth have been usually retained, they now serve simply as a walking place; the cloister has lost its functional importance in the plan and is often covered by buildings; the dormitory has ceased to exist as an architectural feature. the library has continued to be an outstanding member of the plan and other buildings containing classrooms or lecture rooms and accommodation for pupils or students adjoin or surround the monastic nucleus of the complex. Such an establishment as for instance Ampleforth abbey in Yorkshire. which has the largest monastic community and houses the largest Roman Catholic boarding school in England. has developed in detached buildings on a sloping site and might well be taken from a distance to be simply a large educational or training establishment.

Other monasteries, both in Europe and America, such as St. Vincent's archabbey. Latrobe. Pa.. or St. Meinrad's, St. Meinrad, Ind.. show to the outer world lofty windowed façades that have nothing in them of the traditional monastic design. Few, even of modern Cistercian abbeys. have the simplicity of plan of those of the 12th century, and an abbey in full life and vigour. such as Gethsemani. Ry.. lies at the centre of offices and outbuildings that have disappeared from most medieval sites.

In the 19th and 20th centuries there were some reversions to medieval design. Architects and antiquaries such as Viollet-le-Duc in France and Sir William H. St. John Hope in England restored by research and excavation the primitive plans of the various orders, and where a monastery was built on a virgin site care sometimes was taken to preserve much of the traditional plan. Speaking generally, however, the modern Benedictine monastery. however impressive in size and in the extent of its satellite buildings. has little resemblance to its medieval predecessor save in the presence of a large church (often, architecturally speaking. a large chapel without transepts or aisles) and of an adjacent cloistered walk.

At the same time. the preservation and study of the abandoned or ruined abbeys of earlier times have made great advances in the British Isles and in France, and monastic sites are visited yearly by many thousands. In Great Britain the ministry of

works has rescued numerous monastic ruins from neglect or destruction and has surrounded them with a décor of green turf and taken every care to arrest further deterioration.

See also CLOISTER.

BIBLIOGRAPHY.—There is no authoritative general work. For Cistercian architecture M. Aubert, *Architecture cistercienne en France* (1947), is definitive, and on a smaller scale A R. Martin, *Franciscan Architecture in England* (1937). K. J. Conant, *Carolingian and Romanesque Archztecture, 800 to 1200* (1959) contains much on Cluniac arrangements. For a general sketch *see* also D. Knowles and K. St. Joseph, *Monastic Sites From the Air* (1952). (M. D. K.)

MONASTICISM, an ascetic system of living apart from the world (Gr. *μοναστής*, a monk, from *μόνος*, alone). Monasticism is the attempt to develop and regulate the exercise of asceticism and mysticism (*qq.v.*). It is by no means a creation of Christianity; long before the Christian era a highly organized monasticism existed in India and other parts of Asia.

BY COURTESY OF THE BRITISH MUSEUM

A FRANCISCAN NUN

(1). Pre-Christian *Monasticism*.—Greek asceticism and mysticism seem never to have produced a monastic system; but among the Jews, both in Judaea and in Alexandria, this development took place. In Judaea the Essenes before the time of Christ lived a fully organized monastic life (see Schiirer, *Jewish* People, ii, §30); the same is true in regard to the Therapeutae, who lived near Alexandria.

A general sketch of pre-Christian asceticism and monasticism, with indication of the chief authorities, is given in O. Zöckler's *Askese und Mönchtum*, pp. 32–135 (1897). This account is epitomized by J. O. Hannay, *Spirit and Origin of Christian Monasticism*, app. i (1903); the view now common among scholars is there maintained that these pre-Christian realizations of the monastic idea had no influence on the rise and development of Christian monasticism. For later findings, *see* de Labriolle, in Fliche-Martin, *Histoire de l'Eglise*, iii, 299–369 (1936).

(2). Beginnings of *Christian Monasticism*.—The practice of asceticism asserted itself at an early date in Christian life: men and women abstained from marriage, from flesh meat, from the use of intoxicating drink, and devoted themselves to prayer, religious exercises and works of charity (S. Schiwietz, Das *morgenländische Mönchtum*, pt. i. 1904; J. O. Hannay, *op. cit.*, ch. 2, 3). In Egypt, at the middle of the 3rd century, it was the custom for such ascetics to live in solitary retirement in the neighbourhood of the towns and villages. This was the manner of life which St. Anthony (*q.v.*) began to lead, c. 270; but after 15 years he withdrew to a deserted fort on the east bank of the Nile, opposite the Fayum. For 20 years he lived a solitary liie until would-be disciples called on him to guide them. There are reasons for doubting whether Anthony was actually the first Christian hermit (see E. C. Butler, *Lausiac* History of *Palladius*, p. 230, 1898), but an isolated case does not invalidate the 4th-century tradition that Anthony mas the father of Christian monasticism.

(3). St. Anthony's *Monachism*.—The form of monastic life directly derived from St. Anthony was the type that prevailed in middle and northern Egypt up to the middle of the 5th century. The chief authorities for the study of this type of monastic life are the Vita *Antonii* (probably by Athanasius), the *Historia monachorum* (ed. by E. Preuschen), the Historica Lausiaca of Palladius (ed, by E. C. Butler)—these works are to be found in Latin in Rosweyd's *Vitae Patrum* (*Migne*, Patrol. Lat., lxxiii, lxxiv)—and the writings of Cassian (English translation by Gibson in "Xicene and Post-Nicene Library").

Antonian monachism grew out of the purely eremitical life, and it retained many of the characteristic features inherited from its origin. The party of travellers whose journey in 394 is narrated in the *Historia* monachorum found at the chief towns along the Nile, from Lycopolis (Assiut or Siut) to Alexandria, and in the deserts that fringed the river, monastic habitations, sometimes of hermits, sometimes of several monks living together.

(4). St. *Pachomius' Monachism*.—Very different was the type of monastic life that prevailed in the more southerly parts of Egypt. There, at Tabennisi near Dendera in the year 323, St. Rachomius (*q.v.*) established the first Christian cenobium, or monastery properly so called (see P. Ladeuze, *Cénobitisme Pakhomien*, 1898; Schiwietz, op. *cit.*, pt. ii, §§ 12–16; E, C. Butler, *op. cit.*, pt. i, p. 234, pt. ii, notes 48, 49, 54, 59). Before his death in 346 Pachomius had established nine monasteries of men and one of women, and after his death other foundations continued to be made in all parts of Egypt, but especially in the south and in Abyssinia. Palladius tells us that (*c.* 410) the Pachomian or Tabennesiot monks numbered about 7,000. The life was fully cenobitical, regulated in all details by minute rules and with prayers and meals in common. Work was done for its own sake, not merely for an occupation, thus marking a new departure in the monastic ideal. St. Pachomius not only inaugurated Christian cenobitical liie, but he also was responsible for the creation of the first "religious order."

The Coptic abbot Shenout governed on similar lines the great "white monastery," and the ruins survive near Akhmim. It remained purely Coptic, with no infiltration of Greek ideas or influence (see J. Leipoldt, *Schenulte* von *Atripe*, 1903). Egyptian monachism began to wane after 500, and following the Mohammedan occupation continued to decline.

(5). *Oriental Monachism*.—The monastic institute was imported early in the 4th century from Egypt into Syria. The most celebrated was the life of the stylites or pillar hermits (see SIMEON STYLITES). Monastic life there tended to revert to the eremitical form, and to this day Syrian and Armenian monks are to be found dwelling in caverns and desert places and given up nholly to the practice of austerity and contemplation (see E. C. Butler, *Lausiac* History of Palladius, pt. i, p. 239). Before the close of the 4th century monachism spread into Persia, Babylonia and Arabia.

(6). Basilian and Greek *Monachism*.—Though Eustathius of Sebaste was the first to introduce the monastic life within the confines of Greek Christianity in Asia Minor (c. 340), it was St. Basil who adapted it to Greek and European ideas and needs. St Basil's standards have remained the standards of Greek and Slavonic monasticism.

(7). *Early* Western *Monachism*.—The knowledge of the monastic life was carried to western Europe by St. Athanasius, who in 340 went to Rome accompanied by tuo monks. Monasticism soon became common in Rome and throughout Italy, and before long spread to Gaul and to northern Africa (see E. C. Butler, *op. cit.*, pt. i, p. 245; also Hannay, *op. cit.*, ch. 7).

(8). St. *Benedict's Monachism*.—St. Benedict (c. 500) effected a permanently working adaptation of the monastic ideal and life to the conditions of western races. The life was to be self-denying and hard, but not one of any great austerity (see BENEDICT, SAINT; and E. C. Butler, Benedictine *Monachism*). The individual monk was sunk in the community, whose corporate life he had to live. St. Benedict's rule was a new creation in monastic history (see F. A. Gasquet. Sketch of Monastic Constitutional History). St. Benedict defines his monastery as "a school of the service of the Lord" (Reg., *Prol.*). The great act of service is the public common celebration of the canonical office, the "work of God" he calls it, to which "nothing is to be preferred" (Reg. *c.* 43). The rest of the day is filled up with a round of work and reading. Work (and in St. Benedict's time it was predominantly field work) took a more important place in the life than was the case under St. Pachomius or St. Basil, occupying notably more time than the church services. St. Benedict introduced. too, the idea of law and order, of rule binding on the abbot no less than on the monks; thus he reduced almost to a vanishing point the element of arbitrariness found in the earlier rules. Lastly he introduced the idea of stability, whereby monk and community were bound to each other for life.

BY COURTESY OF THE BRITISH MUSEUM

A BENEDICTINE MONK

THE BENEDICTINE RULE

(9). Western *Monachism* in the Early Middle Ages.—Soon the Benedictine form of monastic life became the only one in Western Europe (see BENEDICTINES). The only serious rival was the Irish rule of Columban. The beginnings of Celtic monachism are obscure: When, however, Irish monachism emerges. into the full light of history, it was in its manifestations closely akin to the Egyptian, or even to the Syrian type: there was the same love of the eremitical life, the same craving after bodily austerities of an extraordinary kind, the same individualistic piety. The Irish monks were great missioners in the north of England and the northern and central parts of Europe, and in the course of the 7th century the Irish rule of St. Columban and the Roman rule of St. Benedict met in the monasteries in central Europe that had been founded by Columban and his Irish monks. The Benedictine rule supplanted the Irish so inevitably that the personnel ceased to be Irish, that even in St. Columban's onn monastery of Luxeuil his rule was no longer observed, and by Charlemagne's time Benedictinism was predominant except in Spain, where traces of other rules survived. During the 7th and 8th centuries the Benedictine houses were the chief instrument in the christianizing and civilizing and educating of the Teutonic races.

(10). *Offshoots and Modifications* of Benedictine *Monachism.*—As previously stated, St. Pachomius's monasteries formed an order—a curious anticipation of what six centuries later was to become the vogue in Western monasticism. The Benedictine houses, before Cluny, never coalesced in this way; even when the system of national congregations was introduced, they were but loose federations of autonomous abbeys: although the convenient expression "Benedictine order" is frequently used, the Benedictines do not form an order in the proper sense of the word. But with the 10th century we reach the period of orders, and it is on this line that all subsequent developments in Western monasticism have run. The first order was that of Cluny, founded in 910 (see CLUNY).

The chief offshoot from the Benedictine institute was the Cistercians (c. 1100); their ground idea was to return to the letter of St. Benedict's rule (see CISTERCIANS).

Towards the end of the 10th century and during the 11th a strong tendency set in to revert to the eremitical life, probably owing to the example of the Greek monks, who at this time entered Sicily and south Italy in great numbers This tendency produced the orders of the Camaldulians or Camaldolese (c. 975) in Italy, and in France the Grandmontines (1076) and Carthusians (1084), all leading practically eremitical lives, and assembling ordinarily only for the church services. The Vallombrosians (1038) near Florence maintained a cenobitical life, but eliminated every element of Benedictine life that was not devoted to pure contemplation. At Fontevrault (founded in 1092) the special feature was the system of "double monasteries" *i.e.,* neighbouring, but rigorously separated, monasteries of men and of women.

(11). *New Kinds* of *Religious Orders.*—A new form was that of the canons regular or Augustinian canons (*q* v.) who about the year 1060 arose out of the older semi-monastic canonical institute, and lived according to the so-called "Rule of St. Xugustine." The essential difference between monks and regular canons may be explained as follows: monks, whether hermits or cenobites, are men who live a certain kind of life for its own sake; external works, either temporal or spiritual. are accidental. But canons regular were in virtue of their origin essentially clerics, and their common life, monastery rule, and the rest, were something additional grafted on to their proper clerical state.

Two special kinds of orders arose out of the religious wars waged by Christendom against the Mohammedans in the Holy Land and in Spain: (1) the military orders: the Knights Hospitailers of St. John and the Knights Templars. both at the beginning of the 12th century, and the Teutonic Knights at its close; (2) the orders of Ransom, whose object was to free Christian prisoners and slaves from captivity under the Mohammedans, the members being bound by vow even to offer themselves in exchange; such orders were the Trinitarians (*q.v.*) founded in 1198, and the order of Our Lady of Ransom (de Mercede), founded by St. Peter Nolasco in 1223; both were under the Augustinian rule.

RISE OF MENDICANT ORDERS

At the beginning of the 13th century arose the series of great mendicant orders Their nature and work and the needs that called them into being are explained in the article MENDICANT MOVEMENT AND ORDERS and in the separate articles on ST. FRANCIS OF ASSISI and FRANCISCANS (1210), ST. DOMINIC and DOMIKICASS (I21j), CARMELITES (I245) AUGUSTINIAN HERMITS (1256)—these were the four great orders of mendicant friars—to them were added, in 1487, the Servites (*q.v.*) founded in 1233. Among monks and canons regular each monastery has its fixed community The friar, however, does not belong to any particular house, but to the province or order. In the monk attachment to his own monastery is a virtue; in the friar detachment is the ideal. The monk, or the canon, normally exercises his influence on the world in and through his community, not as an individual but as a member of a corporate body. The friar's sphere of work is normally outside his convent, and he works and influences directly and as an individual. Here too should be mentioned St, Francis's great creation, the Tertiaries (*q.v.*) or devout men and women living in the world, who while continuing their family life and their ordinary avocations followed a certain rule of life, giving themselves up to more than ordinary prayer and the pursuit of good works, and abstaining from amusements of a worldly kind.

(12). The Religious Orders in *the* Later *Middle* Ages.—The 13th century was the heyday of monasticism in the West; the mendicant orders were in their first fervour and enthusiasm and the great abbeys of Benedictines, Cistercians and Augustinian canons reflected the results of the religious reform and revival associated with Hildebrand's name. Under the Benedictine rule were formed the new congregations or orders of Silvestrines (1231), Celestines (c. 1260) and Olivetans (1319; *qq.v.*). But towards the end of the century a period of decline set in, which ran its course in increasing volume throughout the 14th century. A great wave of secularity rolled over the Church, engulfing the religious orders with the rest. The great schism was reflected in the mendicant orders which were divided into two obediences, to the destruction of discipline. The great wealth of the old monastic orders exposed them, especially in France and Italy, to the vicious system of commendation, whereby a bishop, an ecclesiastic, or even a layman was appointed "commendatory abbot" of a monastery, merely for the purpose of drawing the revenues (see ABBOT); the monasteries were often deprived even of necessary maintenance, the communities dwindled, and regular observance became impossible. In the German lands, the lowest level was touched, and the writings of the Augustinian canon Johann Busch and of the Benedictine abbot Trithemius reveal a state of things in the first half of the 15th century that urgently called for reform. The first move in this direction was made in the Netherlands and north Germany under the influence of Gerhard Groot (*q v.*) and issued in the formation of the Windesheim congregation of Augustinian canons and the secular congregation of Brethren of the Common Life (*q.v.*) founded *c.* 1384, both of which became centres of religious revival. During the first half of the 15th century numerous and effective efforts at reform were initiated in all the orders without exception. and in every part of Europe. These movements, promoted bv the councils of Constance and Basle, partook of the spirit of the time and were characterized by an extreme austerity of life a certain hardness of spirit, and a sort of police regulation easily understandable at a time of reaction from grave abuses. At this time arose the Hieronymites founded in 13'75, under the Augustinian rule, the Observants (1415) among the Franciscans (*q.v.*), and the Minims (founded *c.* 1460 by St. Francis of Paola, *q.v.*), whose programme was to outdo the Minors or Franciscans. The Refor-

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A DOMINICAN NUN, THIRD ORDER OF ST. DOMINIC

mation destroyed the monasteries in northern Europe and crippled those in central Europe. But a tide of reaction soon began to flow.

MODERN TIMES

(13). The Modern Orders.—During the Reformation period there sprang up to meet the needs of the time, a new kind of religious order, called Regular Clerks. These are religious orders in the full sense of the word, as the members take the solemn religious vows. Regular clerks are by their institute clerics and priests, and they are devoted to some particular work or works as their own special object—as education, the preaching of missions and retreats, or the going on missions to the heathen. They carry still further the tendencies that differentiate the friars from the monks; and have commonly given up the choral celebrations of the canonical office, which had been maintained by the friars.

Of regular clerks by far the most important are the Jesuits (see JESUS, SOCIETY OF), founded in 1540; there are also the Theatines (founded 1524 by St. Cajetan and Caraffa, afterwards Paul IV); the Barnabites (founded 1530, by St. Antonio Zaccaria) and others (see Max Heimbucher, *Orden u.* Kongregationen [1934] II, pp. 96–340). Strictly speaking, the "religious congregations" should be distinguished from the orders of regular clerks, the difference being that in the former the vows, though taken for life, are only "simple vows" and more easily dispensable by authority; but the character and work of the two institutes are very similar. The chief of these congregations are the Passionists (founded by St. Paul of the Cross, 1725) and the Redemptorists (founded by St. Alfonsus Liguori, 1749), both dedicated to giving missions and retreats. The Christian Brothers, devoted to primary education, founded by St. Jean Baptiste de la Salle in 1679, are not in orders (Heimbucher, *op. cit.* pp. 433–444).

Besides the religious congregations there are a number of "secular congregations," composed of secular priests living together under temporary vows and free to leave at will; the following deserve mention: Oblates of St. Charles (founded by St. Charles Borromeo, 1578); Oratorians (founded by St. Philip Neri, c. 1570); the French Oratory (founded by Cardinal Berulle, 1613), a similar but distinct institution, which produced a number of scholars of the highest distinction—Thomassin, Morin, Malebranche, Richard Simon, Juénin, Lebrun, Masillon, and others; Lazarists (founded by St. Vincent de Paul, 1624); Sulpicians (founded by M. Olier, 1642), and a vast number of others, including several for the mission to the heathen (see Heimbucher *op. cit.* pp. 560–637).

During the period under review, from the Reformation to the French Revolution, the old orders went on alongside the new, and many notable revivals and congregations arose among them: the most noteworthy were the Capuchins (*q.v.*) among the Franciscans (1528); the Discalced Carmelites (*q.v.*) of St. Teresa and St. John of the Cross (1562); the Trappists (*q.v.*) among the Cistercians (1663); and most famous of all, the Maurists (*q.v.*) among the Benedictines of France (1621).

(14). The *Religious* Orders in Recent Times.—At the end of the 18th century and the opening of the 19th the religious orders received a succession of blows in those countries in which they had survived the Reformation. The Jesuits were suppressed by Pope Clement XIV. in 1773, and restored by Pius VII. in 1814. As the result of the ecclesiastical policy of the emperor Joseph II. nearly all religious houses of all kinds were suppressed throughout the Austrian dominions (1780). The French Revolution swept them out of France and caused the secularization of the great majority in Central Europe and Italy. In Portugal and Spain they were dissolved in 1834–35; in Italy in 1866; in the Prussian dominions in 1871. The last half of the 19th century, and more especially the last quarter, witnessed a remarkable revival of vitality and growth in most of the older orders in nearly every country of western Europe, and besides an extraordinary number of new congregations, devoted to works of every sort, were founded in the 19th century: Heimbucher (*op. cit.* pp. 505–637) gives a list of scores of these new congregations, for women and men. In the new countries, especially in the United States and Australia, but also in South Africa, orders and congregations of all kinds are most thriving. The chief set-back has come again in France, where, by the Association Laws of 1903, the religious orders have nearly all been suppressed and expelled and their property confiscated. Many religious returned to France after World War I.

WOMEN'S PART

(15). The *Nuns.*—In all ages women, hardly less than men, have played their part in monasticism. In the earliest Christian times the veiled virgins formed a grade or order apart, more formally separated from the community than were the male ascetics. There is reason for believing that there were organized convents for women before there were any for men; for when St. Anthony left the world in 270 to embrace the ascetic life, the *Vita* says he placed his sister in a nunnery (παρθενών). We learn from Palladius that by the end of the 4th century nunneries were numerous all over Egypt, and. they existed also in Palestine, in Italy and in Africa—in fact throughout the Christian world. It is a curious coincidence that the sister of each of the three great cenobitical founders, Pachomius, Basil and Benedict, was a nun and ruled a community of nuns according to an adaptation of her brother's rule for monks. In the West the Benedictine nuns played a great part in the Christian settlement of north-western Europe. As the various monastic and mendicant orders arose, a female branch was in most cases formed alongside of the order; the canonesses, and hermitesses and Dominicanesses, and Franciscan nuns, or Poor Clares (*q.v.*). Then there were the "double orders" of Sempringham (see GILBERT OF SEMPRINGHAM, ST.) and Fontevrault, in which the nuns were the predominant or even the dominant element. Of the modern orders of men only a few include nuns. The great majority of these modern congregations of women follow the Augustinian rule, supplemented by special constitutions or by-laws; such are the Brigittines, the Ursulines and the Visitation nuns: others follow the rule of the third order of the Franciscans or other mendicants (see TERTIARIES). In early times nuns could go out of their enclosure on occasion; but in the later middle ages, up to the Council of Trent, the tendency was to keep them more and more strictly confined within their convent precincts. In 1609 an English lady, Mary Ward, founded at Munich the "Institute of Mary," the nuns of which were not bound to enclosure. St. Vincent de Paul soon followed; in 1633 he established the Sisters of Charity, bound only by yearly voms, and wholly given up to works of charity—chiefly nursing in hospitals and in the homes of the poor, and primary education in poor schools.

BY COURTESY OF THE BRITISH MUSEUM

A MONK OF THE CARTHUSIAN ORDER

The nuns belonging to the older orders tend to the contemplative idea, and they still find recruits in sufficient numbers, in spite of the modern rush to the active congregations. These latter exist in wondrous number and variety, exercising every imaginable form of good work.

See also references under "Monasticism" in the Index volume.

For monasticism generally *see* Hélyot, *Histoire des ordres réligieux* (1714–1719; other editions 1721, 1792, 1838); Max Heimbucher, *Die Orden und Kongregationen der katholischen Kirche,* 3rd ed., 1933–1934, 2 vol.; Leclerc, art. "Cénobitisme" in *Dictionnaire d'Archéologie et de Liturgie;* and for first 10 sections, E. C. Butler, *Benedictine Monachism;* Berlière, *L'ordre monastique des origines au XIIe siècle.*

MONAZITE, a mineral consisting of the phosphate of the cerium and lanthanum group of rare-earth elements including neodymium. Small and variable amounts of thorium. 2%–12%, and of yttrium are usually also present. The world's supply of thorium (*q.v.*) was very largely obtained from monazite. Thorium is converted by neutron bombardment into a fissionable isotope of uranium and can be employed in atomic power reactors; the oxide thoria formerly was used on a large scale for the manufacture of mantles for incandescent gas lighting. The cerium (*q.v.*) is used for chemical and ceramic applications. and alloyed with iron it

forms the sparking flints of automatic lighters.

Monazite is of wide distribution as minute crystals in granites and gneisses, being present in very small quantity as an accessory constituent of these rocks. By powdering the rock and washing away the lighter minerals in a stream of water, the heavy minerals (zircon. rutile. magnetite, garnet, monazite, ilmenite, etc.) may be collected. This separation has been effected naturally by the weathering and disintegration of the rocks and the accumulation of the heavier minerals in the beds of streams. Under these conditions monazite has been found as rounded grains in alluvial gold washings and as a constituent of the black-sand fraction of beach and, river sands. It also occurs in geologically old placer deposits (cemented conglomerates), as in the Witwatersrand, U. of S. Af., and the Black hills of South Dakota. Large masses of monazite are found in pegmatite veins, as in Madagascar. Quebec and North Carolina (where a crystal weighing 59 lb. was found). Vein deposits of massive granular monazite are known in San Bernardino county. Calif., and the van Rhynsdorp district, Cape Province, U. of S. Af.

Important commercial deposits of monazite are found in the beach sands of Travancore in southwestern India. in the states of Espirito Santo and Bahia, Braz.. in New South Wales and Queensland, and in Ceylon. In the United States, monazite deposits are found in Florida. the Appalachian region. Idaho and Montana. The crude sands. known as monazite sands, usually are first concentrated by washing, and the monazite and other minerals are then separated magnetically.

The composition of monazite is represented by the formula $(Ce,La,Nd)PO_4$; thorium is—present as thoria (ThO_2). Crystals of monazite belong in the monoclinic system. and are usually flattened parallel to the orthopinacoid. The large crystals from pegmatites usually are reddish brown, dull and opaque. and simple in form, while the small, translucent honey-yellow crystals from the Alps are bounded by numerous bright faces. The hardness is 5.5 and the specific gravity 5.1–5.2. *See* also **RARE** EARTHS.

(CL. F.)

MONBODDO, JAMES BURNETT, LORD (1714–1799), Scottish jurist. an eccentric but imaginative writer on natural history and the origins of society, was born at Monboddo. Kincardineshire. A classical scholar, he studied at Aberdeen and Edinburgh. He was made a lord of session in 1767 with the title of Lord Monboddo.

In his *Antient Metaphysics* (1779–99), Monboddo conceived man as gradually elevating himself from an animal condition to a state in which mind acts independently of body. In *The Origin and Progress of Language* (1773–92), he related man to the orangutan. His speculations were an odd jumble of insight and fancy with some curious points of contact with Darwinism. He died on May 26, 1799.

Boswell's *Life of Johnson* gives an account of Johnson's visit to Burnert at Monboddo, and is full of references to the natural contemporary view of a man who thought that the human species could be related to apes.

See W. Knight, *Lord Monboddo and Some of His Contemporaries* (1900); *A.* O. Lovejoy, *Essays in the History of Ideas* (1948).

MONCEY, BON ADRIEN JEANNOT DE, DUKE OF CONEGLIANO (1754–1842), marshal of France. the son of a lawyer, was born at Besançon on July 31, 1754. He received a commission in the army in 1778. Moncey won great distinction in the campaigns of 1793 and 1794 on the Spanish frontier *(see* FRENCH REVOLUTIONARY WARS), rising in a few months to become commander in chief of the army of the western Pyrénées. After this he was employed in the highest commands until 1799, when the government. suspecting him of royalist views, dismissed him. But the *coup d'état* of 18 *Brumaire* brought him back to the active list, and in Napoleon's Italian campaign of 1800 he led a corps from Switzerland into Italy. In 1801 Napoleon made him inspector general of gendarmerie, created him a marshal of France in 1804. and in 1808 he received the title of duke of Conegliano. In 1808 Moncey was sent to Spain in command of an army corps. He took a leading part in the emperor's campaign on the Ebro and in the second siege of Saragossa in 1809. He refused to serve in the invasion of Russia. When, however. France nas invaded (1814) Marshal Moncey reappeared in the field and fought the last battle for Paris. He remained neutral during the Hundred Days but after Waterloo was jailed for refusing to take part in the court-martial of Ney, and lost his marshalate. He was reinstated in 1816. His last active service was as a commander of an army corps in nar uith Spain, 1823. He died April 20, 1842.

MONCTON, a city and port in Westmoreland county, N.B., Canada. 89 mi. N.E. of Saint John by rail, at the head of navigation on the Petitcodiac river, the seat of the workshops and offices of the Canadian National railway. It is a central point on the Trans-Canada Air Lines, connecting with Montreal, Halifax, Sydney and St. john's (Nfd.). Pop. (1961) 43,840. It has large stove and clothing factories, furniture and hardware rnanufacturies, engine and boiler works and a lumber trade.

MOND, LUDWIG (1839–1909), British chemist and industrialist who perfected the Solvay ammonia-soda process of making alkali and devised a process for the extraction of nickel. was born at Cassel. Ger , March 7. 1839. After studying at Marburg under H. Kolbe and at Heidelberg under R. Bunsen, and holding several industrial positions in Germany he went to England in 1862 and became associated with a well-known alkali manufacturer at Widnes. where he elaborated the practical application of a method he had patented for recovering the sulfur lost as calcium sulfide in the black ash waste of the Leblanc alkali process, which he introduced into some 30 works in England and France. He became a naturalized British subject in 1880 In 1873 he entered into partnership nith Sir John Tomlinson Brunner (1842–1919), and thus founded the great chemical manufacturing firm of Brunner. Mond and Co They began to make alkali by the Solvay ammonia-soda process, which process was significantly improved by Mond. About 1879 Mond began experiments in the economical utilization of fuel and his efforts led him to the system (patented 1883) of making the producer gas known by his name. "Mond gas." Further, he worked out a gas battery.

His discovery of nickel carbonyl made possible a successful process for the extraction of nickel from its ores. nhich involved the finding, acquisition and development of mines in Canada. the elaboration of new and suitable smelting operations there and the invention of highly specialized apparatus for the refining works in Wales.

Mond was elected a fellow of the Royal society in 1891. A liberal contributor to the purposes of research, he founded in 1896 the Davy-Faraday Research laboratory in connection with the Royal institution. He was a notable art collector, most of his paintings being bequeathed to the National gallery. He died in London on Dec. 11, 1909.

See Carl Langer in *Berichte der deutschen chem. Gesellschaft,* p. 3665 (1911), which contains a list of his papers; J. P. Richter, *The Mond Collection,* 2 vol. (1910), describes his art collection.

MONDINO DE'LUZZI (DE LUICCI, DEI LUZZI MUNDINUS) (1270?–1326), Italian physician and the founder of modern anatomy. He reintroduced the study of body structure from human dissections after this practice had been abandoned for about 1,700 years. Born in Bologna in the latter part of the 13th century. he received his medical training in the famed university of that city. After graduation he taught and studied anatomy and surgery at his alma mater while carrying on active practice in both medicine and surgery. He died at Bologna in 1326.

Anatomy. previous to Mondino's time, was taught from the books of Galen and occasionally from the dissection of pigs or monkeys. It nas Mondino's great service that he revived the practice of human dissection for study as well as student demonstration. His *Anothomia* mas written in 1316 and became the standard text on the subject for more than 200 years. It was first printed in Pavia in 1478 and went through about 40 editions. In this book, the teachings of Galen are perpetuated with no attempt to challenge or change them. It instructs the student in the technique of dissection as well as in the description of the parts. Adaptation of structure to function, morbid changes and even therapeutic, suggestions are added tu the anatomical descriptions.

Mondino wrote other books on medicine and surgery and commentaries on Hippocrates and Galen, but his assured place in the history of medicine rests upon his classic little treatise on anatomy and upon the initiation of human dissection upon which it is based.

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MONDRIAN, PIET (PIET CORNELIS MONDRIAAN) (1872–1944), Dutch painter, critically regarded as one of the purest nonobjective painters, was born in Amersfoort on March 7, 1872. He received early instruction at home from his father, who was an amateur painter, and then attended the Amsterdam Academy of Fine Arts for three years. He achieved moderate success with his early landscapes, which emphasized mass and absence of detail, but in later years he drifted away from traditional techniques and began to explore the realm of abstractions. In 1910 he moved to Paris, where he came under the influence of French cubists. He developed an antipathy for curved lines, and his compositions were notable for their vertical and horizontal lines, which formed crosses and rectangles. In 1914, with Theo van Doesburg, he founded the Dutch de Stijl group of painters and architects, with whom he worked in the Netherlands for the next six years. On his return to Paris in 1920 he explained "neoplasticism" in a published report. Three years later he formed the nucleus of an abstractionist group. He left Paris for London at the start of World War II, and went to the U.S. in 1940. He died in New York city on Feb. 1, 1944.

Mondrian's influence may be felt in European architecture and in general trends in design. His pictures hang in museums in New York, Philadelphia and Buffalo and at Yale university, as well as in Amsterdam, The Hague, Dresden and Hanover. In 1943 the Museum of Modern Art in New York city acquired his composition entitled "Broadway Boogie-Woogie," which became a source of controversy in professional circles; his "Composition in White, Black and Red" also is there. A representative showing of his work was held at the Museum of Modern Art in 1945.

MONEL METAL, the trade-marked name of a copper-nickel alloy developed in 1905. The alloy contains about 67% nickel, 28% copper and 2% iron, together with small amounts of carbon, manganese and silicon, and is made directly from the copper-nickel ores of Sudbury, Ont., by roasting the copper-nickel converter matte (see NICKEL) and reducing the resulting oxide to metal with charcoal.

The alloy is nickel-white in colour. Its distinguishing characteristics are rustproofness and corrosion resistance, its ready manufacture by all usual methods and its satisfactory mechanical properties. Its corrosion rate is low in moist atmosphere, fresh and sea water, solutions of most organic salts, alkalis and of all except nitric and other strongly oxidizing acids. Very corrosive solutions, such as those of ferric salts, of sulfurous acid, of the free halogens, attack it appreciably.

The alloy is quite malleable, both hot and cold, and machinable. It is readily melted and cast. It can be forged, rolled, machined, drawn and welded, and in consequence is readily fabricated and is available in a variety of commercial forms. Some of the important characteristics of monel metal are: density. 8.80; melting range (about), 1,345°–1,375° C.; modulus of elasticity, 25,000,000 lb. per square inch; tensile strength (hot rolled), 90,000 lb. per square inch; tensile strength (cold rolled), 100,000 to 150,000 lb. per square inch; elongation (hot rolled), 50%; Brinell hardness (hot rolled), 150; thermal expansion (25°–100° C.), .000014 per 1° C.; electrical resistivity, 42.5 microhms per cubic centimetre; magnetic permeability (100 Gauss), 10–15; forging and rolling temperature range, 940"–1,240°·C.

MONET, CLAUDE (1840–1926), French painter, a leader in the practice of open-air painting and one of the chief founders of Impressionism, was born in Paris on Nov. 14, 1840. The family moved to Le Havre about five years after. As a child, he much preferred excursions by the sea to the schoolroom, where he drew cartoons of his teachers. By the age of 15 he had gained a local reputation and a small income as a caricaturist; but it was not until meeting Eugène Boudin, the marine painter from Honfleur, that he began painting the sea and sky he so much loved.

Monet first visited Paris in 1859–60, where he was impressed by the paintings of Charles Daubigny and Constant Troyon. To his family's annoyance, he refused to enroll in the École des Beaux-Arts, but frequented the haunts of the advanced artists and worked at the Académie Suisse, where he met Camille Pissarro. This informal training was interrupted by a call to military service in Algeria. He was excited by the African light and colour, but returned to his family's home in Sainte-Adresse (near Le Havre) in 1862 because of illness. Again he painted the sea with Boudin, and met the Dutch marine painter Johann Jongkind. Later that year, and in 1863, he continued his study in Paris, this time with the academician Charles Gleyre, in whose atelier he met Frédéric Bazille, Alfred Sisley and Auguste Renoir. After disagreements with their master, the group departed for the forest of Fontainebleau where, two years later! at Chailly, Monet was to paint one of his best known early works, "The Picnic" ("Déjeuner sur l'Herbe"), in the spirit of Edouard Manet and Gustave Courbet, both of whom he already knew and admired. It was also during this period—sometime between 1858 and 1871—that Monet discovered Japanese prints, the decorative flatness of which was to play such an important role in the development of modern painting in France.

By 1872 Monet's direction was clear. He had settled in the Seine village of Argenteuil with his wife Camille and his five-year-old son Jean. His painting was already mature, and he had met his future dealer, Durand-Ruel. He had battled with changing outdoor light at Le Havre and Honfleur, in England and Holland, on the Seine and in the forest. He was also known for figure and still-life painting. In 1867, moreover, he had finished a huge figure composition, the "Women in the Garden," entirely in the open air. During his London visit (1870–71) he had seen the outdoor oil studies of John Constable and the romantic landscapes of J. M. W. Turner. He may have known James Whistler's early "Nocturnes." By 1874 Monet's radical art had become both a rallying point and a focus of attack; his "Impression," when shown in the first large exhibition of the expanding group of insurgent painters, caused them all to be labeled by the press, in derision, as Impressionists.

During the 1870s the river, rather than the sea, became Monet's primary subject. Already in 1868 he had begun the sequence of impressions of the Seine which formed a major part of his work before 1900. At Argenteuil, and later at Vétheuil, he constantly sought a more-direct perceptual response to the changing appearances of nature, thus breaking sharply with the studio-conceived landscape painting of the past. In the 1880s, after Camille's death, he painted both the river and the seacoast, striving to reconcile first impressions with colour harmony, expressive manipulation of pigment and composition. Monet moved to his final home at Giverny with his second wife, Alice Hoschedé, in 1883. It was there, after 1890, that he systematized his method of developing several studies of the same motif in series, changing canvases with the light or as his interest shifted. These "series" were usually dated, and often exhibited, in groups: "Poplars" (1890–91), "Haystacks" (1891), "Rouen Cathedrals" (1894), "Mornings on the Seine" (1896–97), "Scenes of the River Thames" (1899–1904), "Venice" (1908), etc. The most renowned of the works identified with Giverny, however: were those of the unique "water garden" which Monet had created by diverting the tiny Epte river. Before long paintings of water lilies, irises, weeping willows and his Japanese bridge could be found in most of the major art collections and museums of the world along with his other famous works. The last years, though hampered by failing eyesight, were almost entirely devoted to these "water landscapes." During World War I, encouraged by his friend Georges Clemenceau, Monet planned a gift to the French government. He died, on Dec. 5, 1926, before it was completed; but the following spring a series of large paintings of the garden were finally installed in two oval rooms in the Orangerie of the Tuileries.

See also PAINTING: France: *19th* Century: *Monet* and *Impressionism;* IMPRESSIONISM.

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MONETA, ERNESTO TEODORO (1833–1918), Italian newspaperman and publicist. was born in Milan on Sept. 20, 1833. In 1848, when a boy of 15, he participated in the insurrection of the people of Milan against the Austrians. usually known as *Le Cinque Giornate.* After the Austrian victory in the resulting war of 1848–49 against Piedmont. he was compelled to expatriate and moved to Piedmont where he attended the military academy of Ivrea.

In 1859. when war again broke out between Piedmont and Austria, he enlisted with four brothers in a corps of mountain troops organized by Giuseppe Garibaldi. The folloning year he participated in the liberation of southern Italy arid fought at the battle of Volturno (1860). After the proclamation of the kingdom of Italy (1861) he joined the regular army and in 1866 fought at the battle of Custoza against the Austrians. In 1867 he resigned from the army and became the editor in chief of *Il Secolo,* a democratic nenspaper published in Milan, and continued in that position until 1896.

The suffering he witnessed during his military life deeply impressed Moneta and prompted him to seek means to atoid further wars. About 1887 he founded in Milan the *Società internazionale per la pace: Unione Lombarda* along the lines of the International Peace society organized in England by Hodgson Pratt. The *Unione* sponsored disarmament, the establishment of a League of Nations. and the settlement of international disputes by means of arbitration.

For the dissemination of those ideas. Moneta started in 1898 the publication in Milan of a periodical. *La Vita internazionale,* to which several Italian and foreign pacifists contributed In 1906 he presided at the International Peace conference in Milan and the folloning year he shared the Nobel prize in recognition of his services to the cause of universal peace.

A man of sincere faith and lofty ideals, Moneta was neither a deep thinker nor a great writer, Moneta, however, repeatedly pointed out that while he was opposed to warmongers, he was not milling to sacrifice his ideals of justice to the desire for peace. In 1911 he wholeheartedly supported the impending Italian occupation of Libya on the ground that it nould open to civilization a territory which was being laid waste by Tu-key's backward and corrupted rule. Again. in 1915, he advocated Italy's intervention in World War I for the purpose of fighting the aggressive and imperialistic designs of the Central Powers. He died in Milan on Feb 10. 1918. (A P. Sr)

MONETARY AGREEMENT, an agreement between countries concerning monetary matters of common interest to them. A special form of monetary agreement is that by which two or more countries adopt a common regulation of their currencies and thus create a monetary union.

An outstanding example was the Latin Monetary union founded in 1865 that embraced France. Belgium Snitzerland, Italy and later Greece. Each country kept its own nomenclature for its currency France Belgium and Snitzerland terming their monetary unit the franc, Italy the lira. Greece the drachma In 1873. because of the depreciation of silver. all the members of the union agreed to limit the coinage of new silver five-franc pieces, thus dropping the double standard of gold and silver to which they originally adhered, and placing their currency virtually upon the gold standard All public offices of the member states nere obliged to accept the union currency in payment. Subsidiary currency (silver token money ranging irom 20 centimes to 2 francs) rernained national, *i.e.,* was not union currency, nor were bank notes recognized as such. World War I broke up the Latin Monetary union in fact. if not in name

Another important monetary union of the same type was the Scandinavian union, comprising Sneden, Norway and Denmark. There the national monetary units had a common name, the krone. or krona. The union was formed betneen Sneden and Denmark in 1873 and Norway joined tno years later. The monetary union among the Scandinavian countries nas much closer than that among the Latin countries. It embraced all subsidiary currency issued by the participant countries. The foreign exchange quotations were discontinued and the whole region could be considered, so far as monetary matters were concerned, as one country. During World War I the union broke up *de facto,* and was never revived. *See* also INTERNATIONAL PAYMENTS; STERLING AREA; INTERNATIONAL MONETARY FUND.

MONETARY UNIT, the standard unit of value of a national currency (*q.v.*). For individual monetary units *see* BOLÍVAR; 'DINAR; DOLLAR; DRACHMA; ESCUDO; FLORIN; FRANC; GUINEA; GULDEN; KRONE; LEV; LIRA; MARK; PEXNY; PESETA; PESO; POUND STERLING; RIAL; ROLBLE; RUPEE; SHEKEL; SHILLING; SOL; TAEL; YEN; ZLOTY; etc.

MONEY. Money is the medium in which prices are expressed, debts discharged, goods and services paid for, and bank reserves held. When used in the sense of the money supply, the term is synonymous with circulating medium and may be regarded as comprising demand deposits and common money or currency (*q.v.*); *i.e.,* paper money issued by the government, bank notes and coins. The term is used still more broadly to embrace money which does not enter into hand-to-hand circulation. This applies to the standard money, often gold, which may, be held as a basic monetary reserve without at any time entering into general circulation. In the United States it includes gold certificates which constitute the legal reserves of the federal reserve banks. The term may even be extended to include abstract units which have been employed at different times for stating certain prices, the best known example being the guinea which is still used in England for stating certain types of monetary payments. The expression "near-money" was coined to identify certain types of liquid assets, such as time deposits and short-term government obligations, which are regarded as possessing some of the important characteristics of money and as having significant effects on the working of the monetary system.

The difficulty of arriving at a single clear-cut definition of money has led to identifying money in terms of the functions it performs. The British economist Ralph G. Hawtrey stated that: "Money is one of those concepts which, like a teaspoon or an umbrella, but unlike an earthquake or a buttercup, are definable primarily by the use or purpose which they serve."[1] Alternatively, it may be said that money is anything, regardless of its physical or legal characteristics, which customarily and principally performs certain specified functions.

The functions of money (upon which definition depends) are closely interrelated, but it is nevertheless useful to differentiate among them. The most familiar is that of medium of exchange, whereby goods and services are paid for and debts and other contracts discharged. Money is also the unit of account, in which records are kept, costs computed, and values compared. It is a means of stating the prices of goods and services and expressing debts. salary and wage agreements, rents, insurance obligations, and innumerable other contracts. The third major function of money is to serve as a reserve of ready purchasing power. Money is the only completely liquid asset. Ownership of a cash balance in the form of currency or demand deposits makes it possible to act quickly in matters calling for the payment of money. The convenience and other benefits conferred by the possession of ready cash are entirely different from the more or less pathological considerations that motivate the miser.

Certain functions of money which were of major importance at one time declined, while other functions became more important, and entirely new functions arose. The use of money as a store of value was important in earlier societies but became of relatively little consequence in more advanced economies. People now prefer to store values in savings deposits, insurance policies or securities where the unit-of-account function of money (particularly as a standard of deferred payments) is of primary concern. With the rise of commercial banking and central banking came a corresponding increase in the importance of the use of money as reserves of the banking system.

[1] Ralph G. Hawtrey, *Currency and Credit,* Longmans, Green and Co. (New York, 1928).

Money is unique among economic goods; it is usually regarded not as wealth (though gold or other commodity money should be included as part of wealth) but as a device for exchanging and measuring wealth. An increase in the quantity of money in a country does not necessarily constitute an increase in the country's wealth. More money would result in higher prices or greater liquidity but would not necessarily, except possibly through some roundabout process, mean greater wealth. Money is neither a production good nor a consumption good. It is sometimes given the rather abstract title of "numeraire," something used for counting or relating other things. As such there is no satisfactory means of stating the value of money (its price or what it exchanges for) other than by means of index numbers (*q.v.*) of prices. Changes in the value of money are shown as the reciprocal of percentage deviations of the index from some established base. A rise of 100% in the index number of prices would signify that the value of money—*i.e.*, its purchasing power—had fallen by one-half.

Origin and Development of Money.—Scores, perhaps hundreds, of different objects have served as money at one time or another. including such things as slaves, gunpowder and the jawbones of pigs. Perhaps the heaviest money ever used was the stone money of the island of Yap in the South Pacific, and the lightest, the feather money of the Sew Hebrides. For centuries. salt money circulated among the natives of Ethiopia without being supplanted by the gold or silver coins of the traders with whom the Ethiopians came in contact.

At one time it was thought that particular types of money came into existence as a result of the most generally bartered economic good gradually coming to serve as a common medium of exchange. Such an explanation is hard to reconcile with the adoption of a great many of the monetary types known to history. The ox of Homeric Greece (pekus, from which comes the word pecuniary), the elephant of Ceylon. or the skull money used in Borneo during the 19th century can scarcely have served widely as a medium. of exchange. On the other hand, it is easy to suppose that oxen or elephants may have been used as a basis for comparing the wealth of persons or tribes, and from that they have become the standard for measuring other values as well. Human skulls enjoyed unique prestige in the social system of Borneo; it became customary to relate pigs or palm nuts to this highly regarded unit when comparing their values for purposes of actual exchange. In this way, skulls served as the standard and pigs and palm nuts as the medium of exchange. just as in western societies gold has served as the standard and coins and paper money as the medium of exchange.

Money is to be thought of as having originated out of religious and social custom rather than directly out of barter. Commodities which later came to be important as a standard of value or medium of exchange seem first to have been important as ransom, bride price, ceremonial offering, or means of ostentation. The application to economic ends generally developed out of the earlier discharge of religious. legal and ritualistic uses.

Early money was often some useful substance. In the evolution of the money material there seems to have been a tendency to move from the more useful substance to the less useful and more ornamental. The popularity of gold and silver, two of the most ornamental of metals. attests to the close relation between money and ornamentation. So also does the frequent use of coins as ornaments and the issuance of coins with holes in them to facilitate stringing. Terms associated with monetary units were once generally related to bases of measurement. Drachma meant handful (originally a handful of iron nails); pound. livra, lira and ruble were terms of actual metallic weight.

In contrast with terms such as pecuniary, drachma and pound, which reflect the commodity origins of money, are the words note and bill which relate to debt. The step from terms denoting physical assets to terms indicating debt is of great significance in the history of monetary development. It reflects the transition from predominantly commodity money to predominantly debt money. At first, debt money retained a link with the past in the form of legal and other connections with a commodity base such as gold or silver; thus the bank note was originally a promise to pay some sort of asset (*i.e.*, commodity) money. In many modern countries, however, debt money stands alone without any pretense to commodity backing or to convertibility into any form of asset money. Debt money has assumed a variety of forms, of which demand deposits (so-called cheque-book money) are now the most common.

Resort to the use of debt money removed the basis of the automatic regulation of the money supply by means of market changes affecting a commodity used as money. As long as the monetary structure was directly tied to gold or silver the volume of money was limited by the physical character of the money substance. Changes in the amount of money in circulation' were subject to influences from the side of the money material. Although it would be possible to devise a system of debt money which would operate automatically. the effect of the spread of debt money was to lessen the influence of automatic forces and to increase the importance of monetary management and control throughout the world. Because the character of the money itself does not establish effective limits to its issue, the prevention of abuse in the issuance of debt money depends upon the exercise of due restraint by the issuing authority. The satisfactory functioning of noncommodity money is dependent on strength and responsibility of the government and reasonable stability of economic conditions. Such notable instances of monetary breakdown as occurred in Germany in the middle 1920s and in China, Greece and Hungary in the middle 1940s resulted when these requirements were not fulfilled.

Commodity standards embodied a technique of monetary regulation and control. Abandonment of commodity standards and subordination of automatic influences, even where the link with some metallic base remained, contributed to the devising of substitute procedures for governing monetary behaviour. These included an expansion in the number and powers of central banks and. most notable of all, the establishment of the International Monetary fund (*q.v.*) at the end of World War II. If the functioning of these alternative techniques left considerable to be desired, the same could also be said of the methods employed earlier.

Monetary Standards.—The type of money which serves as the basis for the monetary system of a country and to which other kinds of money are customarily related, through convertibility or otherwise, is known as standard money. The effect of adopting a particular monetary standard is to make that the basis for measuring value in the same sense that the adoption of the foot or the pound establishes it as the basis of measuring distance or weight. It is to be noted, however, that monetary standards have never provided a unit of measurement comparable with these others from the standpoint of uniformity and constancy. Monetary standards are of two main types, commodity standards and noncommodity or paper standards.

The most widely known commodity standard is gold. The general principles of the gold standard apply to any commodity standard, whether monometallic or not. The essence of the gold standard is maintenance of equality between the value of the domestic currency unit and a stipulated amount of gold. The various provisions for establishing and maintaining the gold standard are to be regarded as means to this end. The international gold standard exists when countries maintain convertibility between currency and gold and allow the free export and import of gold. With these provisions in effect the domestic currency unit will be equal in value to a given weight of gold in world markets.

Various types of gold standard have existed at one time or another, differing primarily with respect to the provisions governing convertibility between currency and gold. The gold coin standard was common until World War I and in some countries until the depression of the 1930s. Under this standard, currency is convertible into gold at the initiative of anyone and for quantities as small as the smallest gold coin available. Under the gold bullion standard, currency and gold are convertible only in large amounts. Convertibility may be further restricted, as by providing that currency will be redeemed only at the initiative of specified groups such as foreign central banks. The gold exchange standard exists where currency is convertible not into gold

coin or bullion but into drafts payable in the currency of some country which is on the gold standard. Because this provision will presumably result in equality between a unit of domestic currency and a given weight of gold, the gold exchange standard is to be regarded as a true form of the gold standard.

As a result of the events of the 1930s, government officials in various countries were given unusual powers in connection with the administration of the gold standard. At one time discretionary provisions of this character would have been considered incompatible with a true gold standard. Certain of the discretionary features were subsequently removed but it remained customary to speak of the modified gold standard in contrast with the traditional gold standard such as formerly existed.

Bimetallism exists when tno metals are standard money, each at a fixed price in terms of the domestic currency unit (and therefore, of course, at a fixed ratio in terms of one another). Bimetallism using gold and silver was widely adopted in the 19th century but its success was far from uniform, partly because different countries attempted to maintain legal ratios which were incompatible with one another. Proposed commodity standards include symmetallism and composite commodity reserve money. Under symmetallism the monetary standard would consist of two or more metals exchangeable at a fixed price in terms of the domestic currency unit when combined in legally fixed proportions. Composite commodity reserve money would differ from symmetallisin in that the standard unit would comprise not only metals but an assorted group of staple commodities. The aim of the various compound standards is to improve on the gold standard by extending the general principles of monometallism to a broader commodity base.

Under a paper standard, currency is not convertible on fixed terms into any specific commodity or combination of commodities. The paper standard is said to be controlled if transactions involving foreign exchange, and therefore exchange rates in terms of foreign currencies, are strictly regulated. Degrees of control may vary greatly; sometimes multiple exchange rates are maintained, with different quotations for different types of transaction. A free paper standard differs from the controlled in that transactions involving foreign exchange are relatively unrestricted and exchange rates are allowed to fluctuate. The authorities may undertake, however, to exercise a steadying influence on exchange rates, as through the operations of an exchange stabilization fund.

Circulating Medium. — Money as a medium of exchange consists of currency and demand deposits at commercial banks against which cheques are drawn. The use of bank deposits for effecting current payments largely superseded the use of bank notes and became especially far advanced in Anglo-Saxon countries. In the United States the issue of circulating notes by commercial banks was narrowly restricted after 1866 and prohibited after 1936; only the federal reserve banks now have the privilege of note issue. A similar monopoly was given to the Bank of England much earlier.

The chief distinction between bank notes and demand deposits lies in their physical form. Bank notes are engraved or printed certificates made out for designated amounts; demand deposits consist merely of book entries acknowledging the bank's commitment to pay currency upon demand. Deposits circulate by means of cheques made out on printed forms for amounts and at times which are determined according to the convenience of the depositor. Bank notes are looked upon as just another kind of paper money, whereas the public is hardly conscious of the fact that deposits are money. The difference, though superficial, largely accounts for the fact that the issue of bank notes was strictly regulated and then taken away from commercial banks entirely, but the privilege of providing circulating medium in the form of demand deposits has been accorded with relative freedom.

An explanation of the process whereby the operations of commercial banks result in the creation of circulating medium is part of the theory of banking (*q.v.*). It is sufficient to say that banks are responsible for by far the largest part of the money supply in terms both of monetary value and of payments effected.

Throughout the world the volume of circulating medium has expanded at a more rapid rate than population or physical volume of business. In 1900 currency and demand deposits in the United States amounted to $52 per capita; 50 years later it was more than 14 times as great. The total, particularly of deposits, tended to decline in depressions. It expanded greatly during wars, with currency growing at a faster rate than deposits. The aggregate of circulating medium is governed by forces largely outside the control of individuals. The proportions which are held in the form of deposits and currency, respectively, and the particular denominations of currency held, however, are almost wholly determined by the actions of individuals. Increases or decreases in the amount of currency outstanding or of any particular denomination are largely automatic. The commercial banks, the central bank and the treasury are at any given moment merely the agents through which the preference of individuals is expressed.

Meaning of **the** Value of Money. — It is customary to express the value of money in terms of what it will buy. Because money is used to purchase an endless variety of things it is necessary to resort to some suitable index of prices as a measure of changes in purchasing power. Different indexes may be chosen as representative of the purchasing power in different uses or for different groups of people. A rise in the index signifies that a given sum of money will command fewer things than before, and a fall in the index signifies that it will command more. If the index were to rise from 100 to 200 it would mean that the same amount would buy only half as much; conversely, a decline from 100 to 50 would signify that it would buy twice as much as before. Thus it is said that the value of money varies inversely with the price index. Neither the value of money nor the level of prices is to be regarded as changing because of a change in the other. Causality between changes in the value of money and movements of the price index is not involved; they are simply alternative ways of expressing the same idea.

Value of money is most commonly used in the sense just described, that of purchasing pomer over goods and services. It is necessary, however, to distinguish certain other meanings. The expression may refer to the value of money in terms of some standard money substance. Thus the mint parity that exists under the gold standard is the official value of the currency in terms of the standard commodity, gold. The reference in the U.S. constitution to congress's pomer to regulate the value of money uses value of money in this sense. Again, value of money may relate to the price of the monetary unit of one country in terms of the unit of another country. This is what is meant by saying that the pound is worth so many dollars and cents.

The interest rate is sometimes referred to as the price of money but this usage is open to the objection that what is priced is not the money itself but its use for a period of time (usually a year). This price is more nearly analogous therefore to ordinary rent, which is the price charged for the use of real property for a period of time such as a year. To criticize the propriety of identifying the interest rate with the "price" of money is not to deny, however, that interest may be an important factor in the operation of the monetary system.

A number of different terms are applied to changes in the value of the monetary unit. Inflation refers to a substantial rise in the price level; *i.e.*, a decline in the purchasing power of money in terms of goods and services. By depreciation is ordinarily meant a decline in the quoted value of one monetary unit in terms of another or of some monetary standard such as gold. Devaluation signifies the taking of formal action to set a new and lower official quotation of one currency in terms of other currencies or of gold or other standard metal.

Source **of** the Value **of** Money. — Because money came into existence as a result of certain valuable commodities assuming money functions, it was natural enough that value in the commodity use should have been looked upon as the source of value in the money use. The value of commodity money was explained in terms of the value of the commodity used as money; the value of money which had ceased to be convertible into gold or some other commodity was explained in terms of the prospect of future

redemption in some valuable commodity. As long as commodity money was predominantly used, this conception of the source of the value remained common. After the collapse of the international gold standard in the decade of the 1930s, however, much of the world continued year after year to employ money which had no commodity value, was convertible into no money commodity, and had no prospect of future convertibility. Yet in many countries the money continued to maintain its value as successfully as when it had been attached to some commodity base.

When a person accepts a piece of money he does not stop to consider whether it is convertible into gold or has gold reserves behind it; nor does he take account of the fact that the government has declared it to be legal tender. If he were to analyze his motives he would at once realize that he is willing to accept money in exchange for things of value because he has no doubt that he will be able to pass the money on to others in the same way. Thus the value of money is a reflection of the value of the goods and services which the users of money find that they can get for it when they choose to pass it on to others. It is not directly dependent on the money substance or on government authority.

This explanation of the source of money value has been criticized as involving circular reasoning on the ground that it amounts to saying that "money is accepted because it is accepted." Instead of this being a valid criticism, it is precisely the point that is being made: to explain the value which money has it is necessary to introduce acceptability; *i.e.,* behaviour. How the social behaviour or custom that lies behind the ready acceptance of money came into existence in the first place is a separate question and one that relates to the origin of'money rather than its value. The explanation has likewise been attacked as making money merely a reckoning device, similar, for example, to poker chips. This observation is also to be regarded as a rough approximation rather than a valid criticism: money is indeed a means of reckoning—a "numeraire." In the case of money, as of poker chips, the value which a given unit possesses results from the fact that it will be accepted at that value by others. Where the acceptance of poker chips is limited and temporary, however, that is not the case with money.

The commodity feature may conceivably have a bearing on the source of the value of money through affecting its acceptability. This consideration is likely to be important, as has been noted, in the origin of money. Similarly, the action of government in making money legal tender may influence its general acceptance. Once money has become established, however, the absence of these features seems to have little effect on the acceptability of money and therefore on its value. Instead, the principal reason for basing money on some valuable commodity is then that this provision is believed to afford a necessary safeguard against over-issue. Either the commodity aspect or governmental authority is to be regarded as part of the possible technique of determining the quantity of money, not as a precondition of money's having value.

Causes of Change in the Value of Money.—Monetary theorists have long been occupied with the question of what causes the value of money to change. The problem to be explained is why changes take place in the general level of prices. If we think of a collection of economic goods which have been selected as representative of what people spend their money for, the question is why it takes sometimes more and sometimes fewer dollars to buy this aggregate of economic goods.

Changes in the value of money are most commonly explained, especially in the United States, in terms of the transactions form of the quantity theory of money. The formula used in discussing the quantity theory is derived from the self-evident fact that what is sold is equal in value to what is given in payment. Thus the quantity of goods (including securities) and services traded (T) multiplied by their average price (P) is equal to the quantity of money (M) multiplied by the number of times the money is used (V) during the period. This is the so-called equation of exchange—the total value of what is bought (PT) is equal to the total value of the money payments made (MV); *i.e.*, $PT = MV$ or $P = MV/T$.

There are statistical difficulties in actually applying the equation of exchange. Conceptually, however, it is a simple statement of identity and it is not to be confused with the quantity theory of money. This theory results only when certain assumptions are introduced with respect to the factors in the equation of exchange. The most important such assumption is that P is passive; *i.e.,* is determined by and not determinant of the quantities M, V and T. The theory then amounts to saying that the value of money changes inversely with and as a result of changes in the quantity of money and its rate of use, and directly with changes in the volume of trade.

Formerly there was a tendency to assume that V and T were relatively stable and therefore that the value of money could be regarded as varying inversely with the quantity of money alone. Considerable importance is now attached to changes in V and T, especially the former. The emphasis on M is regarded as being justified only for major inflations and then only approximately.

Another form of the quantity theory of money (usually known as the cash-balance form) which has been particularly popular in Great Britain replaces the quantities V and T with k and R where R represents real income and k the proportion of R which the public desires to hold command over in the form of money. The equation $P = M/kR$ amounts to saying that the value of money as measured by the goods and services entering into real income varies inversely with and as a result of changes in the amount of money and directly with the desire of the public to hold resources in the form of money. The quantity k is similar to though not quite the same as the reciprocal of V. This form of the quantity theory has the advantage of emphasizing psychological influences through k, but in general has much the same shortcomings as the transactions formulation of the theory.

Theories such as the foregoing are designed to account in general terms for significant changes in the purchasing power of money. When it comes to a consideration of more specific factors, it is to be noted that major price rises have been associated primarily with war. Serious inflation has seldom occurred in peacetime except as a direct aftermath of war. The financial burdens arising out of war typically result in strong pressures toward expansion of the circulating medium and in a weakening of the power of governments to resist these pressures.

Money and the Level of Business Activity.—Partly as a result of the depressed conditions of the 1930s, the main interest of monetary theorists shifted to the relation of the operation of the monetary system to the level of business activity. This reorientation of monetary theory was signalized by the publication in 1936 of the *General Theory of Employment, Interest and Money,* by John Maynard Keynes. Formerly, money had been discussed chiefly in relation to its usefulness in facilitating production, exchange and the division of labour generally and to its effect on changes in the price level. Thereafter much greater attention was devoted to the bearing of money payments on levels of employment and economic output. The focus of attention shifted from money stocks to money flows. The theory of money came to be more closely integrated with general economic theory.

The assumption underlying this newer approach was that the level of business activity is determined by total effective demand. Total effective demand is defined as aggregate monetary expenditures for final products. Changes in the level of business activity are then explained in terms of factors governing the total volume of expenditures.

Implicit in the total spendings analysis is the conception that at any given time there is some ideal level of monetary spending at which the economy would be fully employed with no tendency for prices to change in an inflationary or deflationary manner. Below this ideal level there would presumably be a tendency toward deflation accompanied by falling prices and an increase in unemployment and idle capacity. Above the ideal level there would be a tendency toward inflation. Even though the ideal level of spending is not statistically determinable, it constitutes a point of reference for purposes of analysis. An approximation to the ideal level of spending by the community is presumed to be a necessary condition for the attainment of full employment.

The idea of a flow of money payments through the economy is basic to the total spendings approach. Payments are necessarily two-sided—whenever someone pays, someone receives. It is no

less true — and this is the application that is given much attention in periods of depression — that when someone does not pay, someone does not receive. Income resulting from the expenditures of others becomes available for further spending. If it is in fact spent it thereby generates income for still others. Income is quantitatively the largest source of funds spent. Special importance attaches to the determination and disposition of income in relation to the flow of money payments through the economy.

Funds available for spending may also be derived from two other sources. One of these consists of existing balances of currency and demand deposits, and possibly also the conversion of time deposits, government securities, and certain other kinds of relatively liquid assets. Such reserves of cash and other liquid assets have presumably been accumulated out of past income. The final possible source of funds available for spending is newly created money, of which demand deposits resulting from an expansion of bank lending and investing are ordinarily the best example.

All income originates in expenditure, and expenditure on new goods and services necessarily generates income; in fact, income and expenditure are the same thing viewed respectively from the standpoint of receivers and payers. It follows that total income in one period must be equal to total expenditures incurred at the same time. In this gross sense, total income is bound to be sufficient to pay, at prices corresponding to the costs incurred in producing them, for all the final goods produced. This is what is meant by saying that any level of production is potentially self-financing at the existing level of prices. In other words, if all incomes generated by a given volume of production were spent on what was produced, they would exactly cover the costs (*i.e.*, expenditures) incurred in producing. In that simple fact lies the answer to the recurrent fear of a chronic lack of purchasing power sufficient to pay, at prices which will cover costs of production, for what society produces.

The difficulty with this line of reasoning. of course, is that incomes are not necessarily all spent. It is true enough that expenditure arising out of production creates adequate potential purchasing power in the form of the incomes which it generates. But only the actual exercise of this purchasing power can translate the potential demand into effective demand. If all spending were just equal to income, the flow of money payments would continue at a constant level. Incomes would be generated in each successive spending period in exactly the same amounts as in the preceding period. Presumably, current production of final products entering the market would be fully absorbed. There is no assurance, however, either that income will all be spent or that expenditure out of income will not be supplemented by the spending of funds drawn from one of the other sources, namely. liquid assets or newly created money. Thus it is possible for expenditure to be greater or less than income in the preceding period, and therefore for total effective demand to increase or decrease and business activity to tend to rise or fall.

The question that arises next is why aggregate spending, *i.e.*, total effective demand, may exceed or fall short of the ideal level that is necessary in order to achieve full employment without inflation. The answer, it is said, lies in various factors or combinations of factors affecting the flow of money payments. One of the most important of these is liquidity preference. As was noted above, money is the only completely liquid asset. The anticipated advantages of holding resources in the form of money vary chiefly because of uncertainty concerning the future. An increase in the preference of the community for liquidity (*i.e.*, for holding resources in highly liquid form) tvould tend to reduce the flow of money payments and therefore total effective demand. It will be seen that this reasoning vie s money as being desired for itself, because of the quality of liquidity which it possesses, and not merely as something to be exchanged as soon as possible for other economic goods.

Directly related to liquidity preference is the rate of interest, which Keynesians defined as the price demanded for parting with liquidity. The rate of interest was assumed to be determined by two factors — the community's liquidity preference and the amount of money in existence. A change in the rate of interest because of either or both of these factors would raise or lower the cost of borrowing for investment purposes. Thus it would tend to alter the volume of investment (*i.e.*, expenditures on final goods to be added to capital) and thereby to alter the flow of money payments and total effective demand.

The relations of saving to investment occupy a position of great importance in monetary theory directed toward explaining how levels of business activity are determined. The issues, partly technical and partly terminological, are involved. It is sufficient to say here that the inclinations of the public with respect to current saving and investment greatly affect the volume of money payments which governs the level of business activity.

Saving is generally regarded as being primarily determined by, rather than a determinant of, the prevailing level of income. Changes in investment are looked upon as ordinarily the principal immediate factor contributing to variations in total effective demand. The great strategic importance of investment rests partly on the autonomous influences which may originate with it and partly on the extent to which it can be made the object of governmental policies such as those designed to bring about changes in interest rates, the money supply and public works.

Total monetary expenditures may also be described as originating with the three classes of spenders — consumers, investors and government. At one time it was customary to concentrate attention on the first two categories only, but in most countries of the world governmental expenditures had assumed such large proportions by the middle of the 20th century as to warrant separate consideration. Changes in the volume of spending by the government are likely to have a decisive effect on total effective demand in time of war and may remain significantly high even in peacetime. 'Spending by consumers is much the largest element in aggregate demand. One of the principal modifications of earlier Keynesian monetary theory was to attach greater importance to possible changes in the volume of consumption expenditures. Great importance, though perhaps not so great as at first, continues to be ascribed to spending by investors, with changes in inventories being looked upon as the most significant element contributing to short-run fluctuations in the volume of investment. The level of total effective demand depends on the combined spending by all three groups — consumers, investors and government — rather than on changes in spending by any one of them alone.

The quantity theory of money and the total spendings approach constitute the two principal guides to monetary policy. They are to be regarded as supplementing one another rather than as being in conflict. To some extent they can be directed toward the solution of similar problems, but for the most part the quantity theory tends to be applied to policies relating to price movements, especially inflation, and the total spendings approach to policies relating to fluctuations in business activity.

Monetary Policy. — Monetary policy ordinarily refers to measures employed by the central bank of a country to influence the quantity or use of money for the purpose of promoting economic stability. Monetary policy also may be directed toward other ends such as financing war or facilitating recovery from a business depression. The concept may embrace other policies which affect monetary relationships; *e.g.*, the issue of fiat money (inconvertible currency) and regulation of foreign exchange rates.

Monetary policy is distinguished from fiscal policy, even though the latter may be directed toward similar ends. Fiscal policy includes taxation, public works expenditures and management of the public debt where these measures are carried out with a view to influencing business activity. With the enlarged scale of treasury operations, fiscal policy assumed greatly increased importance. In the division of functions between monetary policy and fiscal policy, monetary policy is often looked upon as being the more effective of the two in combating inflation, and fiscal policy in overcoming deflation. One of the major problems of monetary policy is that of integrating it with fiscal policy. The two are to be regarded not as alternatives but as complementing one another. Complete independence of the central bank and the treasury is impracticable; the activities of the one inevitably involve those

of the other so that the problem of relationships between them is one of co-ordinating the activities of each with those of the other.

The principal instruments of monetary policy may be classified into the two categories of general and selective controls. The general instruments of control in the U.S. include the discount rate, open market operations. and changes in reserve requirements. The discount rate was usually looked upon as most important until the decade of the 1920s, and open market operations as most important after that time. Instruments in this category are general in the sense that they are directed toward influencing the volume and use of money and credit without regard to any particular use or class of user. The selective instruments, on the other hand, are designed to control the use of money and credit in particular areas; *e.g.,* the stock market, instalment sales, real estate and possibly inventories. While any of the instruments of monetary policy is presumed to alter the market compared with what it would be in the complete absence of control, the general instruments are less open to criticism on the grounds of interfering with the freedom of adjustments through the operation of market forces.

At one time, monetary policy was thought of primarily in terms of maintaining a fixed relationship betneen doniestic currency and a given weight of gold or what amounts to the same thing, an approximately constant exchange value in terms of other currencies on the gold standard. After World War I, considerable interest was attached to the idea of maintaining stability in the value of money as measured in terms of some standard index number of prices. Later the goal of monetary stability assumed broader proportion: it came to be thought of in the sense of a high level of business activity (with due allowance for growth).

The great difficulty with monetary policy lies in the fact that the various possible aims such as those just mentioned, each of which is likely to be economically desirable in itself. may come into conflict with one another. The authorities are certain to be confronted with the necessity of choosing from among various desirable goals. The problem is one of effecting a balance among objectives, even though the price of making progress in one direction is to fall a little shorter in some other direction. Flexibility is essential since objectives which were appropriate at one time may cease to be suitable under changed circumstances.

One of the unresolved questions is that of "rules *vs.* authorities in monetary policy." It is argued on the one hand that the monetary authorities should have wide discretion in meeting problems as they arise, and on the other that an attempt should be made to lay down a framework of rules designed to produce the results desired while at the same time permitting individuals to operate freely without the threat of unpredictable interference by the authorities. The issue is largely the historic one of government by men or government by laws. A solution turns partly on the possibility of central bankers adapting themselves wisely to changing economic conditions, partly on the possibility of discovering a sufficiently definite and lasting framework of monetary rules.

A further question closely related to the preceding is that of secrecy or publicity in the conduct of monetary policy. It is not easy to determine how far central banks should go in indicating what their future policies will be. Is it better to establish certain rules and criteria indicating when monetary controls would be strengthened or relaxed. or would that tie the hands of the authorities unduly and perhaps commit them to actions which might prove undesirable under circumstances presently unforeseen? The issue of secrecy or publicity is not to be divorced from the nature of the policies that would be announced. Full knowledge of the exact nature of future policy is impossible, if only because it is certain to change with changing conditions. But this is not to deny the usefulness of indicating the eeneral outlines of monetary policy for the guidance of central bankers as well as the public.

The task of monetary policy, including the balancing of different and potentially conflicting objectives. has become more complex but at the same time the means at the disposal of the monetary and fiscal authorities have become more numerous and. in total, more powerful. This fact gives rise to the problem already noted of effectively integrating monetary policy with fiscal policy. It also involves the problem of co-ordinating the various instruments of monetary control — the general controls with the selective and one general or selective measure with another. A satisfactory solution of the problems of integration and co-ordination nould open the way, despite the greater difficulty of the task, to more comprehensive and effective monetary policy than was possible under former conditions.

International Aspects. — The international role of money is an extension of the place it occupies and the functi ons it performs within a country. The ideal is that, through such means as the adjustment of foreign exchange rates and changes in the money supply, appropriate relationships may be established between the price levels of different countries with the expectation that thereupon the demand and supply of foreign exchange will be equalized automatically and the balance of international payments maintained in equilibrium. The criterion of such an ideal equilibrium is the preservation of a high degree of freedom for individuals to exercise their choice in international economic relations without creating monetary disturbances through excessive drain of monetary reserves, flights of capital, or inflationary or deflationary pressure on prices.

Because of the quantitative importance of international trade and its responsiveness to price differences, price-level adjustments occupy a strategic place in international monetary affairs. It is to be noted, however, that money and monetary policy may also exert an important influence on the level of interest rates in different countries, the movement of short-term and long-term capital, changes in business activity, and other economic developments. Domestic and international policies are closely related. Experience after World Wars I and II clearly indicated that unless domestic budgets are brought under a reasonable degree of control there could be little hope of solving the problem of the international balance of payments.

There are two principal methods of bringing the price level of one country into adjustment with the levels in other countries. The method of the international gold standard is that prices should be subjected to pressures calculated to bring them in line. while exchange rates are allowed to remain approximately constant. The method of "free" inconvertible paper currencies is to bring about the adjustment by changes in exchange rates, nhile price levels are allowed to remain more or less stable. The gold standard method seeks to make price levels conform to established exchange rate relationships; the paper standard method seeks to make exchange rates conform to prevailing price levels.

Under the international gold standard, exchange rates were anchored to the mint par of exchange; *i.e.,* the ratio of the pure gold content of one monetary unit to the pure gold content of the other. Exchange rates could fluctuate on either side of the mint par by no more than the cost of transferring gold from the mint of one country (or similar place oi redemption) to the mint of the other country. These limits are known as the gold shipping points. Whenever the exchange rate moved to one of the gold points. gold reserves would move from the country whose price level was too high to the country whose price level was too low. This uould tend to bring about a contraction of circulating medium in the country where prices mere high and an expansion of circulating medium in the other country. This in turn would presumably bring their price levels into proper adjustment. Supplementary influences, as by nay of changes in incomes and interest rates, were expected to facilitate the entire process.

Under a system of free paper currencies, exchange rates are regarded as being anchored to what is techriically known as "purchasing power parity." This is a much less definite point than that which the gold standard provided; it represents a relationship which theoretically will equalize the purchasing power of the two currencies over goods and can be calculated by comparing changes in price level indexes from some base year.

In actual practice neither method of price level adjustment worked as perfectly as the description might suggest. The drain of gold reserves sometimes had an unsettling effect on public psychology and might even aggravate the existing disequilibrium in the balance of international payments by leading to hoarding or to

flights of capital. In addition, countries losing or gaining reserves did not always adjust circulating medium in the manner that was expected of them. Likewise, under paper standard conditions. the foreign exchange value of paper currencies sometimes exhibited erratic fluctuations which, far from serving any useful purpose in effecting an orderly adjustment of supply and demand, might have just the opposite tendency.

The International Rfonetary fund was established at the end of World War II as an alternative to either a gold standard or a paper standard system. The international gold standard was regarded as having contributed to the spread of depression and as likely to interfere with the success of full-employment policies. Free paper standards were associated in the public mind with inflation and with disorder in the foreign exchange markets.

The fund undertook to promote exchange rate stability by facilitating the adjustment of minor fluctuations in the demand and supply of ioreipn exchange and to permit orderly changes in exchange rates when fundamental disequilibrium in international balances oi payments arises. The bulk of ioreign exchange transactions are handled through ordinary channels. Operations involving the fund are carried out between the fund on the one side and the treasuries, central banks or similar agencies of member countries on the other side. Member countries are allowed to draw on the iund to meet temporary shortages of ioreign exchange. each member country having an assigned quota within which it must stay. Payments in and out of the fund because of short-run variations in the demand and supply of foreign exchange operate in substantially the same manner as the various exchange stabilization funds which have been set up at different times on a more local basis.

It was hoped that the International Monetary fund would bring about the removal of direct controls over foreign exchange operations, hold exchange rate changes within narrow limits, and permit the early restoration of convertibility among the various national currencies. That these expectations mere not realized may be attributed more to the seriousness of balance of payments difficulties in the years after World War II than to any defects apparent in the fund. (See also BANKING; BILL OF EXCHANGE; CHECK; CURRENCY; DOLLAR; INFLATION AND DEFLATION; MONEY MARKET; QUANTITY THEORY OF MONEY; TRADE CYCLE; etc.) (C. R. WY.)

MONEY, MEDIEVAL. The Roman monetary system as reorganized by Constantine the Great included reduction of the weight of the gold coin *solidus* to $\frac{1}{72}$ of the Roman *libra* (pound; about 4.55 grams of pure gold). This system was inherited by the Byzantine empire and copied by the western barbaric rulers. For centuries after the reform the Byzantine *solidus* (also called *nomisma*, *bezant* or, later, *hyperperon*) continued to be struck regularly and remained the main medium of exchange in both international trade and domestic transactions involving large sums. enjoying an incomparable prestige throughout the Mediterranean area. Silver and copper coins continued to be used in local and petty trade. In the west the social and economic disturbances that followed the barbaric invasions progressively disrupted the monetary system inherited from Rome. The economy shifted toward a natural domestic economy where monetary units were increasingly used as units of account rather than means of payment.

The appearance of the Moslems in the Mediterranean did not immediately produce a change in the monetary situation. In the early period of their expansion they continued to use Byzantine and Persian coins. Caliph Abd-el-Malek established an independent Moslem bimetallic monetary system whose two basic units were the silver *dirhem* and the gold *dinar* which broke the monopoly of the Byzantine *solidus* in the Mediterranean and even gained in prestige outside the Moslem border.

From this period there were three monetary areas: the Byzantine, the Moslem and the western European, which was in a state of general disorganization. An important step in restoring order to the monetary affairs of western Europe was a set of reforms launched by the Carolingians. In their final cast, these reforms consisted of the establishment of silver monometallism, the increase of the pound-weight from about 325 to about 410 grams and the adoption of a new monetary unit: called after the old Roman *denarius*. The latter was a silver penny. 240 of which were cut from a pound-weight of silver (one penny contained about 1.7 grams of silver). For roughly three centuries the penny remained the only official denomination coined by western mints. Since the Roman era prices and debts had usually been expressed in terms of *solidi* (shillings), which were still the unit of account at the time of the Carolingian reforms. In the final stage of these reforms it was determined that the *solidus* was to be equivalent to 12 of the new monetary units (penny). The relationship, therefore. of 1 *libra* = 20 *solidi* = 240 *denari* emerged: these equivalents were to remain the basis of the European monetary system until the French Revolution. Of the three elements, only the penny was an actual coin when the reform was introduced; shilling referred to an old coin no longer in use; and the pound was simply a measure of weight. However. the use of only one denomination proved cumbersome and people began to use the equivalents 1:20:240 for reckoning.

From the 8th century, apart from a few unimportant exceptions, the west did not strike gold coins. The only gold pieces used in international trade were the Moslem *dinar* and the Byzantine *solidus*. Both gold coins displayed an extraordinary ability to remain intrinsically stable in their weight and fineness until the beginning of the 11th century; other coins did not display similar long-run stability. In a manner of speaking, in each of the two empires. Moslem and Byzantine, two monetary systems coexisted side by side: one, of considerable stability, based on gold coins and used for international transactions; the other, unstable. based on silver and other metals.

The universal law that seems to make every unit of money lose its value with the passage of time worked throughout the Middle Ages. The progressive lowering of the value of currency took in practice the form of debasement; *i.e.*, reduction in either weight or fineness of coins or both. Debasement was particularly frequent and intense in the case of silver coins, but it did not proceed at the same rate in the various countries: in some it was rather violent and considerable: in others mild and slow. The penny. which originally had been the same throughout Europe, eventually acquired different values in the various regions. The continuous and uneven debasement of the penny meant a reduction in the value of its abstract accounting multiples, shillings and pounds.

For many generations economists and historians interpreted currency debasement as a case of royal falsification of money, clipping or wearing of coins; however, a more complex set of factors must be sought to explain the secular debasement of currency. Among these are long-run increases in the demand for money in the face of relatively inelastic supplies of precious metals. pressures of entrepreneurial groups, deficits in the balance of payments and budgetary deficits.

With the long-term economic expansion in Europe a monetary system of virtually only one local denomination, itself plagued by constant debasement, was becoming increasingly unwieldy and impractical: a need for larger denominations arose. In the 12th century, Venice issued a coin worth 24 pennies; in 1252 Genoa and Florence coined a gold piece. The gold coins of Florence (*fiorino*) and Genoa (*genoino*) represented a piece of pure gold of the weight of 3.53 grams. The example was quickly taken up by other Italian and European states and from the middle of the 13th century to the end of the Middle Ages the *fiorino* and the Venetian *ducato* enjoyed the highest reputation: they became the international currencies *par excellence*. Throughout western Europe the emission of a coinage in gold became common and with it the monometallism inaugurated by the Carolingians was finally ended.

Generally speaking. the gold coins of Byzantium and the Moslem empire, and later the gold coins of western Europe, were used as international currencies. Every effort was made to maintain their fineness and weight, yet the fact that they remained generally stable while the silver pieces were progressively debased complicated the monetary structure of many countries. This created social conflicts and the problems of so-called internal exchange rate movements that represented one of the tangled aspects of monetary policy in the Middle Ages.

In order to evaluate the economic implications of secular debasement it should be stressed that debasement did not necessarily coincide with inflation. Throughout the Middle Ages the supply of silver and gold was quite inelastic, causing deflationary pressures that were partly offset by the debasements of silver

coins. In point of fact, prices expressed in local currencies did not generally increase proportionately (reciprocally) to the debasement of the currencies themselves. Toward the end of the 15th century. discoveries of great silver deposits in Saxony, Bohemia and Tyrol permitted an increase in the supply of big silver coins. In particular. the *testoni* and the *thaler* were introduced. *Testoni* were first struck in Milan and Venice; *thalers* in St. Joachimsthal in Bohemia in 1519.

Aside from metallic currency the monetary systems of the Middle Ages included bank money or circulating credit. Credit developed considerably after the 11th century, especially in the Italian trading centres; there. early ,developments in banking practices and the letter of exchange made credit an important monetary medium. Transfer banks (*banchi di scritta)* were in operation in the centres of international trade (Constantinople. Venice, Genoa. Florence and Bruges) to facilitate payments through transfer orders. Although the refinement of banking techniques made great progress, quantitatively the most important kind of credit involved delayed payments. This type of transaction allowed a more efficient use of the stock of metallic money and enjoyed a widespread diffusion in the Middle Ages.

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MONEY, QUANTITY THEORY OF: **see** QUANTITY THEORY OF MONEY.

MONEY-LENDING. Exacting a charge for borrowed goods or services was foreign to the mores of community life in primitive societies. Loans were primarily to relieve distress and the accepted custom was to expect no more than repayment in kind.

With the beginning of trade and commerce and the introduction of money. the practice grew of making a charge for a loan of money. This charge was originally called usury (*q.v.*). Ever since. protecting borrowers in necessitous circumstances against the avidity of lenders has been a constant concern of the state.

Until the Mosaic position was formulated, a charge for loans was treated as a civil matter. Abuses by moneylenders were condemned as harmful to the temporal welfare of the state. In Hebraic and Christian dogma. usury became a matter of ecclesiastical concern. Taking advantage of the necessitous circumstances of a member of the same community was frowned upon and all usury on loans for consumption purposes was condemned and prohibited. The great moral influence of the Bible projected the scriptural injunction against usury through the centuries. Nevertheless, the growing need of commerce for money and credit in production forced a re-evaluation of the usury concept over the ages. The canonist doctrine on usury gave way to secular lams that recognized situations in which the lender had a legitimate title to a charge for a loan.

Europe. — By the end of the 15th century. statutory maximum rates began to appear. These distinguished between interest and usury. Interest is the charge for a loan of money permitted by law; usury is a charge in excess of the legal maximum. By the statute of Henry VIII. England in 1541 legalized the taking of interest at a rate of 10%. Within a few years this law was repealed by Edward VI but it was re-enacted several years later by Elizabeth I. The rate was reduced to 8% in 1624, to 6% in 1660 and to 5% in 1713. Setting a specific number as a socially acceptable rate draws a quantitive line of demarcation between legal and illegal transactions. This numerical pattern was picked up by the American colonies. noting. in effect, that any rate of charge beyond a certain number is usurious and illegal. This number was different for the several colonies.

Meanwhile an able line of thinkers, prominent among whom were Robert Jaques Turgot of France (1775) and Jeremy Bentham of England (1787), attacked the basic idea of legal control over interest rates. By 1867 their teachings had led to the abandonment of all control over interest rates in England and in most of the countries of Europe. The states that succeeded the American colonies, with three or four exceptions, continued to impose a statutory maximum rate of interest. Exaction of more interest than such a maximum was a simple test of unfairness in a loan contract

Repeal of the statutory maximum interest rate in England left unsolved the question of the fairness of the rate charged in particular transactions Through innumerable cases of abuse and extortion, particularly in personal loans, the courts groped their way to a method of providing relief when the transaction was harsh or unconscionable. They finally found a qualitative rather than a quantitive way to do so by a decision in 1886 that established the power of chancery to reopen any interest transaction to relieve a borrower of excessive interest and in other ways to soften the terms of an offensive contract

This power to recast an objectionable contract in the interest of equity was subsequently incorporated in the Money-Lenders act of 1900. As rewritten and amended in 1927, the Money-Lenders act provides that a transaction shall, unless the contrary is proved, be deemed harsh and unconscionable if interest exceeds 48% a year. This number is not a statutory maximum in the sense of U.S. laws, it is merely a convenient guidepost. If satisfied that the rate charged, though not exceeding 48%, is excessive the court may at any time reopen the transaction and relieve an oppressed borrower from payment of any sum in excess of what the court considers reasonable. If the excess payment has already been made, the court may order a refund. On the other hand, the courts may find justified interest rates in excess of 48% and they have, on occasion, approved rates of 100% and more on loans.

Sources of consumer credit other than licensed moneylenders governed by the Money-Lenders act in England include unlicensed lenders, check traders, pawnbrokers and the indirect types of financing known as credit sales and hire purchase. Unlicensed lenders deal with the poorest risks who cannot get credit elsewhere. Transactions are informal without a written contract. The lender may be a "hip pocket" operator without a specific address at which he carries on business. Rates are 100% per year and up. A common rate is 1*s.* for £1 for one week or until the borrower's next payday.

Check traders issue checks to approved persons. The checks are accepted in payment for goods purchased in designated stores, the check trader taking a discount from the merchant. This method of borrowing is popular among working people in the industrial areas. Check traders make weekly collections from customers.

Pawnbrokers in England have been in business for centuries. They trace their ancestry to the hlontes Pietatis founded in the 15th century by the Franciscans to aid needy small borrowers who could turn to no other resource for help. Money was lent on pawns pledged as security and a small sum was demanded in return. payable each month: to meet administrative expenses. In the early years the average rate ranged from 1% to 5% a month. In some European countries the Montes subsequently became state institutions. The English Pawnbroking act of 1872 allowed a charge of up to 25% a year on loans of £2 or less, and a rate of 20% a year on larger loans. A small ticket fee and a small valuation fee are also allowed.

Indirect financing is either through credit sales where title is passed immediately or through hire purchase where title is retained until hiring charges have been satisfactorily paid for a specified period of time. The English I-lire Purchase act of 1938 was designed to give the maximum amount of protection to the small installment buyer. It applies to contracts of £50 or less in the case of motor vehicles, £100 or less for all other commodities except live stock where the limit is £500.

Although installment trading in Great Britain goes back over a century, the system has enjoyed popularity with the masses only since World War I. It was helped by the development of hire purchase or finance companies. At first the banks stayed aloof from this development, subsequently, they participated by buying into hire purchase companies. Finally. in 1958, British banks, for the first time, began to offer to depositors personal loans without security for any reasonable purpose in amounts from £50 to £500. The effective rate is about 10% with repayment monthly over a period of 6 to 24 months. The German banks followed

similarly in 1959 with loans of 300 to 2,000 DM.

See Franklin W. Ryan, *Usury and Usury Laws* (1924); Bernard W. Dempsey, *Interest and Usury* (1943).

United States.—General interest and usury statutes of the several states often authorize two rates of interest on loans: a legal rate that an obligation will bear in the absence of an agreement for a different rate; and a contract or maximum rate that may be charged by written agreement. In the second half of the 20th century, legal rates were as follows: 4% in North Dakota; 5% in Illinois, Iowa, Louisiana, Michigan and Wisconsin; 6% in 40 states; and 7% in California, Georgia, Nevada and Wyoming. Colorado, Maine, Massachusetts and New Hampshire had no maximum contract rates; Rhode Island had fixed 30% on loans of more than $50; 10 states had set the contract rate the same as the legal rate; and the remaining states allowed a contract rate which was from 1% to 6% above the legal rate.

Colorado, Maine, Massachusetts and New Hampshire prescribed no penalty for usury. In other states penalties for usury varied from forfeiture of interest or excessive interest to forfeiture of three times excessive interest or twice total interest; or made the loan void; or imposed a fine, imprisonment or both.

In Delaware, Maryland, Minnesota, Missouri, New Jersey, New Mexico, Ohio, New York, Pennsylvania, South Carolina, West Virginia and Wisconsin, corporations may not interpose the defense of usury but may defend or sue to rescind the contract if legality is negated by fraud, *ultra vires* acts (acts outside its objects) or impossibility of performance

Commissions, brokerage or legal fees, which when bona fide are legitimate, are sometimes perverted by lenders to cloak spurious charges to evade statutory rates.

Usury statutes had been written with the businessman in mind rather than the consumer. As the United States became industrialized and workers concentrated in cities, granting credit to consumers changed from the informal accommodations of colonial days to legalistic written contracts payable in installments to conform with weekly and monthly pay envelopes.

By the beginning of the 20th century changes in the economy had created an acute need for sources where workers could obtain small loans to meet emergencies in family life. Such loans could not be made profitably to workers at usury or contract rates; thus no legitimate capital was available for consumer use. When a consumer needs several hundred dollars to take care of an emergency or opportunity. relief rather than money cost is paramount. Such situations open the door to loan "sharks" who flout the law and charge exorbitant rates. Shocking abuses finally stirred the social conscience into devising various ways to meet the legitimate loan needs of workers.

Three different approaches were formulated into law within a period of three years. Each law permitted a rate higher than that allowed by the general interest and usury statute.

The credit union approach in 1909 is the co-operative one of members in a homogeneous group—such as employees in one company—contributing to a common pool from which loans are made to members in need. Overhead is low because space, time and effort are contributed by employer and employees; rates are generally 1% per month.

The loan and investment approach (Morris plan, 1910) follows the traditional bank method for business loans. The borrower contracts for a term loan at the statutory rate and agrees to make periodic deposits or buy an investment certificate on the installment plan. Deposits or the paid-up certificate are sufficient to liquidate the loan at maturity. The economic effect of the dual transaction is to double the contract rate and to make the effective rate 16% to 24% per annum.

The third approach is based on the economic principle that adequate capital in the hands of responsible businessmen can only be attracted if a rate is permitted that yields a reasonable profit over cost. This type of legislation in the several states follows a pattern formulated by the Russell Sage foundation in a model small loan law. which requires verification of fitness and character of the lender. licensing, supervision and annual reports; imposes severe penalties for infractions; sets a maximum loan; and permits a rate of 2% to 3.5% per month on the unpaid principal balance on the smallest loans and graduated lower rates of charge on the larger loans. Lenders are called small loan companies, licensed lenders or consumer finance companies.

An indirect type of financing developed through sales finance companies that buy, at a discount from dealers, notes given by consumers in connection with time-payment purchases, which they are unable or unwilling to pay in a lump sum. Effective rates in the early 1960s ran from 12% to 24%. In the late 1930s commercial banks also became heavily engaged in consumer credit, at effective rates of 7% to 14%. *See* also BANKING.

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MONEY MARKET. This term embraces that part of the machinery of a financial centre concerned with the provision of credit of short duration, as distinct from long-term loans or permanent capital. It comprises, chiefly, the banks, which make advances for short periods; the discount houses, which buy and sell bills of exchange and treasury bills and other short-term government obligations; and the accepting houses or merchant banks, which, with the banks, provide trade with first-class bills by putting their name to them for a small commission. But dealers in bullion and foreign exchange and those firms on stock exchanges which deal largely in government securities also form part of the money market. The term discount market is used to describe the money market in the narrower sense, *i.e.*, discount houses, banks and merchant banks.

At the centre of the system stands the central bank, which derives its power and prestige from acting as banker to the government and the other banks. In London this is, of course, the Bank of England, which until 1946 was peculiar as a central bank in that it was a private corporation, nominally independent of government control, whereas in other countries it is usual for the government, through power to appoint part of the board or through ownership of part of the capital, to have a direct influence over the operations of the central bank.

By the Bank of England act, 1946, however, ownership of the bank passed to the state which compulsorily purchased from the existing stockholders the capital of the joint-stock company owning the bank. The court of directors and the governor and deputy governors previously appointed by the stockholders were now nominated by the prime minister but in other respects the nationalization of the bank did not make a great deal of difference for in the later years of its private ownership it had co-operated so closely with the treasury that it could almost be regarded as a department of state. This development began in World War I, became accentuated when Britain left the gold standard in 1931 and culminated during World War II.

In peacetime the main function of the Bank of England is to regulate the volume of money or purchasing power in the hands of the public in such a way as best to promote the prosperity of the country. In wartime the overriding consideration is the government's borrowing policy: the volume of money must be so controlled as to facilitate the financing of the war. In either case the procedure is the same. If the central bank makes an advance or if it purchases securities, the amount of the advance or the purchase appears in the form of a credit in the bank's ledgers against which the government (or some other customer of the bank) can draw cheques. The cheques are paid into their banks by the contractors and others who receive them; and the operation thus increases the amount of "cash in hand and at the Bank of England" held by the other banks and so widens the foundations on which they build their credit operations. The same increase in purchasing power is effected whenever a central bank makes an advance to any kind of borrower and its power to widen the basis of credit, when moderately exercised, gives great elasticity to the monetary systems of those countries in which it has been highly developed.

When a country is on the gold standard, the freedom of a central bank to expand credit is subject to a more or less automatic check, since undue expansion is likely to lead to a drain on the

central bank's gold reserves. In Britain the Bank of England was not permitted to issue notes (above a certain line) except against a pound for pound holding of gold. This system was regarded as unduly rigid and as exposing the country to monetary crises brought about by withdrawals of gold for export resulting from deflationary action on the part of foreign countries. It was abandoned in 1931 and thereafter notes were not convertible into gold. (The obligation imposed on the bank by the Bank Charter act of 1844 to pay its notes in gold coin ceased to have effect on the restoration of the gold standard after World War I in 1925. It was succeeded by an obligation to pay notes in gold bullion provided this was required for export purposes, but this obligation lapsed in 1931.)

With an international gold standard in force, no special control of foreign exchanges is required. Each country regulates its currency and credit policy in such a way as to preserve a sufficient reserve of gold. The foreign exchanges—the external values of the individual currencies—are then automatically fixed within small limits. But under an inconvertible paper standard the external value of a country's currency—its foreign exchanges—will be subject to wide variations.

Theoretically and in the long run this value will be determined, as under the gold standard. by the amount of currency (including in this term both legal tender currency and bank money) in circulation. But with the automatic checks of the gold standard absent, big fluctuations in value are likely to be brought about, as experience has amply demonstrated, by speculation.

This had led to the establishment in Britain and other countries of special funds—in Britain called the exchange equilization account—operating in the foreign exchange markets with a view to limiting undue fluctuations in the exchange value of the currency of the country in question. Nevertheless, control of the exchanges as well as domestic economic prosperity can be ultimately ensured only by control of the volume of money circulating—in other words, by expansion or contraction of credit.

International Monetary Fund.—At the end of World War II great hopes were entertained that an organization known as the International Monetary fund set up on the recommendation of the international conference of experts held at Bretton Woods, N.H., in 1944, would contribute greatly to the stabilization of foreign exchanges. The constitution of the fund provided for international consultation and collaboration with a view to promoting exchange stability, facilitating multilateral trading throughout the world, and checking disequilibrium in the balances of international payments between the member countries.

With these objects in view it was provided that each member country should pay into the fund, partly in gold and partly in its own currency, a quota based on the size of its prewar trade and other considerations. Any country whose payments account was in deficit (*i.e.,* broadly speaking, whose imports exceeded its exports) could obtain temporary credit from the fund up to an amount dependent on its quota, in virtue of the power of the fund (within specified limits) to sell to any member in exchange for its own currency the currency of any other member. This provided a new means by which countries in deficit on current account could obtain temporary credit. Another provision, regarded as revolutionary at the time of the formation of the fund, placed upon creditor countries (countries currently exporting more than they were importing) the duty of doing all they could to bring their payments accounts into balance.

Members also pledged themselves not to change the parity value of their currencies without the sanction of the fund. But it could hardly be claimed that the fund had been outstandingly successful in achieving the objects for which it was formed. This must be put down mainly to the failure of many member countries. in the stresses first of the aftermath of World War II and then of the rearmament periods during the Korean mar, to maintain control over their domestic price and credit systems and so finally to eliminate inflationary pressures.

Expansion and Contraction of Credit.—This is achieved either by what are called open market operations or by varying the price of credit by means of changes in the bank rate, or by the two methods in combination. The central bank expands credit by making advances to the money market or by buying bills or securities from it, thus giving those to whom it lends or from whom it buys the power to draw cheques on it, which they can pay into their banks. It contracts credit by selling bills or securities or by borrowing from the discount houses and other large dealers in money.

Alternatively, the central bank can lower or raise its rate of discount at which it buys bills of exchange and its rate for advances, which in England has usually been $\frac{1}{2}\%$ higher. By making changes in its official rate it affects the general price of credit throughout the country, because the other banks base on bank rate the rates that they allow to depositors and the rates at which they make advances to their borrowing customers. A rise in bank rate thus makes credit dearer to all who are engaged in business and so tends to induce them to reduce their commitments by selling commodities or securities which they are carrying on borrowed money: a lower level of prices is thus produced which stimulates exports and reduces imports and tends to turn the foreign exchanges in favour of London. A fall in bank rate, correspondingly, makes credit cheaper to business men and so tempts them to increase their purchases of conimodities or securities and to borrow additional funds for the purpose. This leads to a higher level of prices, stimulates imports and discourages exports and tends (unless of course foreign central banks are simultaneously lowering their bank rates) to turn the foreign exchanges against London.

The bank rate used to be the main method of monetary control. Between 1932 and 1951 this method was largely in abeyance, the bank rate being maintained continuously at 2% save for a few weeks at the beginning of World War II. But in Nov 1951 the bank rate was raised to $2\frac{1}{2}\%$ as part of a new and more restrictive policy of monetary control and in March 1952 to 4%.

Before it was fully developed as a central bank, the Bank of England acted as banker, in competition with the commercial banks, to business and other private firms. Later, as a matter of central banking principle, it ceased to deal with private customers and. like the federal reserve banks in the United States, confined itself to doing business mith the government, the banks, including many foreign central banks, and discount and other financial houses.

The Bank of England rarely deals direct with the joint-stock banks and its open market credit operations mainly take the form of buying or selling treasury bills or other bills of exchange from or to the discount houses or of buying or selling government securities on the stock exchange or in the money market. Nevertheless, such operations immediately affect the credit system of the country as a whole. The discount houses and other firms with whom the bank conducts its open market operations all have accounts with the joint-stock or commercial banks. A firm which receives a cheque from the Bank of England for bills or securities bought by the bank pays it into a joint-stock bank, which thus finds its balance at the Bank of England strengthened. A firm which gives the Bank of England a cheque for bills or securities bought from it draws the cheque on a joint-stock bank, which thus finds its balance at the Bank of England diminished.

The joint-stock banks normally try to maintain a constant ratio of about 8% between their cash (Bank of England balance plus legal tender) and their deposits. If their cash rises they try to find new borrowers or they buy additional securities: if their cash falls they must. in order to preserve the cash ratio, call in loans from their borrowing customers or sell securities. The business community at large thus at once discovers that the banks are inclined to be more willing lenders or, on the other hand, that they are insisting on repayment of outstanding advances. In the latter event borrowers have no option but to comply, since the banks can otherwise sell the assets which they hold as security for the advances. But no trader or industrialist can be compelled to borrow from his bank unless he wants to. So in times of extreme business depression and uncertainty it may happen that the Bank of England's open market policy fails. for the time being at least, to achieve its object of stimulating trade ac-

tivity. This was the case in the severe trade slump of 1929 and the following years, when what has been described as a credit deadlock supervened. On the other hand, if the central bank is sufficiently determined it can always check the development of an unhealthy boom and an excessive rise in prices—except of course when this is due. as in wartime, to unavoidable and continuous government borrowing.

Under a properly administered system of credit control no special control of the legal tender currency circulation is necessary. Under a gold standard it is essential to limit the circulation of paper currency in accordance with the gold reserves in hand, since the notes are convertible into gold on demand. Credit policy must therefore conform to the amount of the circulation. But under an inconvertible paper standard it is the volume of credit which must determine the amount of the circulation, since the owner of a bank deposit must always be permitted to convert it into legal tender if he desires. In Britain the issue of additional bank notes is, since the abandonment of the gold standard, made, on the application of the Bank of England, by the treasury, which gives it consent by a "treasury minute," which is subsequently presented to parliament.

Since the evolution of the system by which the banks can grant credits. which, being transferred by cheque from one to another, increase the total of deposits which they handle, a magical and unlimited power of creating purchasing power is often attributed to them. But in practical fact this power is limited in many countries by law—as in the United States, where the banks are obliged to maintain a certain proportion between cash and liabilities. Even in England, where notwithstanding the inclusion in the Bank of England act, 1946, of certain legal powers of "direction" the banks are generally left free to conduct their business as their prudence and experience impel them, they are, as already stated, always careful to maintain a proportion between cash and liabilities such as is required by safety and banking conventions. Moreover, as has been shown, the policy of the commercial banks is closely affected by that of the Bank of England in virtue of its power to determine the amount of bank cash, while ultimately it is the treasury, to which the Bank of England must defer, which regulates the credit-granting power of the banks.

At times when a country's financial position is abundantly strong, the commercial banks, with a comfortable margin between them and the possibility of stringency, have a good deal of latitude in the conduct of their business. The theory that the banks exercise a despotic tyranny over industry and by their distribution of credit decide what is and what is not to be produced is largely a delusion. In spite of amalgamations, competition among them is so keen that they cannot (subject to government regulation or request) afford to refuse any solvent customer the accommodation to which his position entitles him; and their dependence on public confidence is so complete and so vital, that they dare not make advances unless they have reasonable confidence that they will be repaid. In granting credits the only question that they can consider is whether the customer's obligation is likely to be met—in other words whether he is going to use the money in some enterprise which will pay, by satisfying some public demand; and so it is public demand, well or ill exercised, which finally decides who is to get credit and not the banker, who merely interprets it.

Loans and Advances, by which the banks foster production and trade, used to be the most important item in the assets which they hold and are now exceeded only by the investments item. At the same time they are the least liquid of their resources, because though nominally recoverable on demand or at short notice, they cannot be called in at times of stringency without inflicting serious inconvenience on customers whose solvency the banks would be most reluctant to endanger. It is thus on the other items in their assets that the banks have to rely, in order to secure that liquid position which is the ideal of prudent banking. Their holding of legal tender cash and cash at the central bank is their first line of defense and after that come the loans at call and short notice which they make to the discount houses. for financing the stock of bills of exchange carried by the latter, and (in normal peace conditions) to the stock exchange for financing securities that have not yet found a home or are being carried by speculators for the rise. Stock exchange loans are rather less liquid than the loans to discount houses which run from day to day or for a week. It is on these last that the banks, as has been shown, rely at times of seasonal pressure to reinforce their cash holding, calling them in and so obliging the discount houses to produce fresh credit by borrowing from the central bank. The banks' holding of bills of exchange is another highly liquid item because they can arrange so as always to have a certain proportion falling due day by day or any date they may anticipate pressure. Bills of exchange drawn against commodities of general consumption and accepted by banks and firms (see MERCHANT BANKERS) of first-rate standing are the most liquid of investments because they do not have to be sold but are paid when due; and treasury bills which now form so large a part of the stock-in-trade of the discount market, have the same advantages with government security added. During World War II the British government adopted the system of borrowing direct from the banks on treasury deposit receipts. These receipts form another liquid asset for the banks, the treasury deposits being repayable in six months besides being callable at any time by the banks if the money is required to subscribe (on their own or their customers' account) for new government loans. The banks' investments—now the largest item among their assets'—are usually confined to government stocks and other gilt-edged securities.

(See also the articles BANKING; BILL OF EXCHANGE; CHECK; MERCHANT BANKERS; MONEY; and the bibliographies attached thereto.) (H. WIT.; O. **R. H.)**

THE NEW YORK MONEY MARKET

The focus of the American money market is New York city. There are other subsidiary money centres such as Chicago, St. Louis and San Francisco, but the facilities of these secondary markets are not sufficiently extensive to attract a large volume of funds. The growth of a money market is conditioned not only by the opportunities that it offers for the profitable employment of funds but equally by the facility with which it permits their release. New York offers large possibilities in both directions. Security operations in New York require enormous sums. Flotations of new securities on a large scale for governmental and large private business corporations are handled by New York houses. The annual offering of new securities at mid-20th century reached from $8,000,000,000 to $12,000,000,000. Between the initiation of such new issues and their final absorption by investors large sums are needed by the officiating bankers, and such sums are normally borrowed. Speculative operations in stocks and bonds in the New York market conducted usually on a marginal basis likewise require great sums.

New York is also the bill and commercial paper market of the country. Dealers in these instruments have their headquarters in New York city. They buy them as fast as they are created, paying for them mostly with borrowed money, reselling them to any bank, firm or individual having free funds to invest. After the 1920s, however, this market declined greatly in relative importance. Short-term U.S. government paper, issued in enormous amounts by the treasury to finance war and defense needs, came to supply the stock-in-trade of the money market.

Foreign Exchange Market.—The U.S. foreign exchange market is also centred in New York city. New York banks and banking houses have large foreign departments. They have branches, agencies, offices or correspondents in the chief centres of the world. Most interior banks do not have a large enough foreign business to justify the organization of an independent foreign department. Hence for their foreign business they rely on their New York correspondents. The disturbances of international trade and investment resulting from depression and World War II greatly narrowed the scope of the foreign exchange market, however. Monetary and exchange controls and bulk commodity buying by governments instead of by private traders restricted the volume of operations. Brokers declined to a sixth of their prewar number.

Canada, Cuba, Switzerland and Mexico allowed considerable freedom in exchange trading in their currencies at mid-century. Other countries were applying strict controls. The result was that an increasing proportion of U.S. international business was being financed in terms of U. S. dollars.

New York's position of leadership in manufacturing and commerce contributes to its financial leadership. It is not only the chief manufacturing city of the country but also the principal port, the leading city in wholesale distribution, and the centre of the printing and publishing trades. Large sums are constantly needed in New York to finance its manufactures, its domestic and foreign commerce and its output of newspapers, magazines and books.

Structure of the New York Money Market. — The foundation of the money market is naturally the federal reserve system. This system holds the monetary reserves of the country. It supplies currency when there is need for it. As treasury agent it supplies gold for export and makes imports of gold available for domestic credit operations. The main dealings of the federal reserve banks are with member banks and with the government. They also carry accounts for the Export-Import bank, the International Monetary fund, the International Bank for Reconstruction and Development, for other U.S. government financial institutions and for foreign governments and central banks, and for exchange and check collection purposes, for domestic, nonmember banks. They may also engage in open-market operations in bankers' acceptances and in governmental securities. The active conduct of affairs on the supply side of the money market is, however, primarily the affair of the local national and state banks and trust companies. Through their purchases of government and other securities the insurance companies also pour large sums into the market.

Related Agencies. — Mention must be made of the related agencies. Since United States government securities constitute the principal stock-in-trade of the New York money market, the dealers in these securities should receive first mention. There are also the dealers in acceptances and the commercial paper houses. There are factoring companies and discount houses which finance accounts receivable and instalment paper and there are a few individuals who function as intermediaries between borrowers and lenders.

On the demand side of the market the alignment is equally diverse. First may be mentioned the stock exchange brokers who finance their customers' marginal operations. From 50% to 80% of the funds needed by the brokers for this purpose are obtained through time loans from the banks. On the demand side also are arrayed the bond and security dealers. They not only arrange for financing new issues but also carry on extensive over-the-counter bond trading.

Next are the acceptance dealers and the commercial paper houses. They too have to borrow in order to carry their lines of paper pending its final sale to the ultimate purchaser. Finance companies of various kinds also play a considerable role in the market. They handle instalment or conditional sales paper arising in sundry fields. They finance the dealers in automobiles, pianos, radios, television sets and numerous other articles sold in the U.S. on the instalment plan.

Lastly may be mentioned the host of other corporations, firms and individuals who require funds. These borrow to some extent on stock-exchange collateral, on the security of warehouse receipts covering the great staples or on some other satisfactory form of property. The prevailing U.S. practice in such firm or individual borrowing, however, is based upon the extension of unsecured "lines" of credit involving the use of the single-name promissory note.

Operation of the New York Market. — Down to the collapse of the stock market in 1929 the most sensitive element in the money market was the call loan. Call loans were made principally on stock-exchange collateral, although to some extent also on bankers' acceptances and other acceptable security. In times of great speculative activity the amounts involved ran to billions of dollars. But call loans virtually disappeared as an active factor in the money market, brokers relying on time loans to meet their needs. Bankers' acceptances and commercial paper continued to find their way into the market but not in impressive amounts. On June 30, 1951, for example, there were $425,000,000 of bankers acceptances outstanding and $331,000,000 of commercial paper. On the same date the insured commercial banks of the country held $3,819,000,000 in U.S. treasury bills, $3,111,000,000 in treasury certificates of indebtedness and $14,762,000,000 in treasury notes. It is these short-term issues of the treasury which supply the basis for the bulk of operations in the money market. Not only do they give rise to frequent refunding operations by the treasury but they also appear in large turnover operations each day. They constitute the liquid assets in the money market which permit the banks and other investors to make quick readjustments in their positions. The liquidity of government securities was greatly stimulated by legal provisions which permit member banks to borrow from the reserve banks, using such securities as collateral and which further permit the reserve banks themselves to buy and sell these governmental issues as considerations of policy may warrant.

The Treasury. — The part played by U.S. treasury issues as the liquid-asset-reliance in the money market affords some indication of the overpowering significance of treasury operations as a whole. For the 1951 fiscal year, for example, the net receipts of the treasury were $48,143,000,000 and the budget expenditures mere $44,633,000,000. Because of the effect on bank reserves, the ebb and flow of these enormous sums have a heavy impact on the money market, sometimes tending to deplete such reserves and at other times, when large government disbursements are made, tending to augment them. The rates at which the treasury offers its issues tends also to be controlling. During World War II, in the interest of war finance, the federal reserve banks rediscounted treasury paper for their member banks at favourable rates and also bought at par in the open market long-time government bonds when the price threatened to go below that level. Since the treasury's interest was served by low money rates. and it adjusted its issues accordingly, there developed an inflationary expansion of bank credit which the federal reserve system was powerless to control. In time this gave rise to serious protests In 1947 the federal reserve system withdrew its low rediscount rate for treasury paper, but not until 1951, after rather warm debate behind the scenes and in the public press, was an agreement effected under which money rates were more freely permitted to find a level determined by the competitive processes of the market.

The Securities Market in the United States also plays an important role in money-market procedure. Besides their loans to brokers and dealers, banks became heavy purchasers of securities, such investments outrunning total loans. Business firms and individuals invest temporarily idle working capital in bonds and even in stock, relying on the fact that, subsequently, when such capital is again required for ordinary business operations, these investments can be promptly sold.

U.S. Banking Abroad. — The development of U.S. banking abroad also affects the domestic money market. American banks are purchasers of foreign bills and in other mays as nell lead funds in foreign centre?. In normal times there is a considerable shifting of funds back and forth from one international market to another according to the competitive lure of the respective discount rates and the state of the exchanges In like manner foreign banks buy U S bills and carry heavy New York balances. These operations swell the flow and ebb of funds in New York.

Procedure in the New York market is very flexible. Through the effective clearing and transfer system operated by the federal reserve banks large sums can be rapidly shifted to and from New York. A slackening of demand for funds in the interior thus leads quickly to their transfer to New York where they can be profitably loaned or invested An increased interior demand for funds is similarly accompanied by a rapid withdrawal from New I'ork. The New York market may thus be regarded as the great national money shock absorber

Federal Reserve System. — The federal reserve system plays an important part in this procedure. As pressure develops in the

money market member banks may borrow from or rediscount paper at the reserve banks.

Additional reserve funds are also supplied to market indirectly through treasury disbursements and through open market purchases by the reserve system of acceptance and government securities.

Supervision.— The federal reserve system, like other central banks is, at least to some extent, in a position to supervise and ssfeguard the money market. The reserve system cannot control operations in detail. The member banks must assume full responsibility for their loans and investments. But through the control of final reserves, of margin requirements in security speculation and of the discount rate, the reserve system may determine the conditions under which member banks can get funds for further expansion.

Through its open-market operations and with co-operative debt management by the treasury it can also directly influence the volume of reserve bank credit available. Although there are 12 independent reserve banks, the important open market operations are conducted mainly through the New York market by a committee representing the system as a whole. Similarly, the exercise of its supervisory powers by the board of governors has tended to give unity in discount procedure. The reserve system thus acts as the foundation of the money market, and as its supervisor and protector. (E. E. A.; X.)

See John T. Madden *et al., Money Market Primer* (1948); *M.* F. Joliffe, *United States as a Financial Centre, 1919–1933* (1935).

MONEY ORDER is the term used for an order on the issuer to pay a certain sum of money upon demand to the person named in the money order. Money orders are widely used for the safe, fast and convenient transmission of small sums of money. The buyer pays the issuer the amount of the money order plus a service charge. Money orders are a generally accepted means of payment because of the unquestionable ability of the issuer to exchange the money order for cash upon demand.

Money orders are issued by sovereign governments (usually postal authorities), banks and other qualified institutions. These issuers compete on the basis of service and convenience rather than in terms of the cost of their services.

In the United Kingdom, postal authorities themselves first issued money orders in 1838. These were sold for amounts up to 40*s*. ($5.60); larger sums could be remitted by buying several such postal money orders. Approximately £200,000,000 ($560,000,000) a year was remitted by this means in the second half of the 20th century.

In the United States the postal money order system was started in 1864 and modernized in 1951. The maximum amount of a single postal money order was set at $100. Annual sales of these money orders, which in the second half of the 20th century ran about $6,000,000,000 each year, were larger than the sales of bank and nonbank issuers.

American Express company, which began issuing money orders in 1882. is the largest nonbank issuer of money orders. American Express money orders are used in most parts of the world. Telegraph companies also provide money order services.

See American Bankers Association, *Money Order Services* (1956). (*R.* M. S)

MONFALCONE, a town, province of Trieste, Friuli-Venezia Giulia, Italy, 20 mi. N W of Trieste by rail. Pop. (1951) 24,160. It has shipbuilding yards and produces sodium carbonate and refines oils. About 1 mi. from the castle of Duino, 5 mi. to the southeast, the Timavo (anc. *Timavur)* emerges from its subterranean course of more than 25 mi. from the caves of S. Canziano by three different exits in normal times, and by seven in flood time. (Virgil, *Aeneid,* i. 244 speaks of nine.) This natural phenomenon had naturally attracted the attention of the ancients, and their writings are full of allusions to it; there has, it appears, been little change since ancient times.

See The *Year's Work in Classical Studies,* 117, 118 (1925–26).

MONFORTE or MONTFORTE DE LEMOS, a town of northwestern Spain, in the province of Lugo. on the Cabe, a small right-hand tributary of the Sil, and at the junction of the railways from Tuy and Astorga to Corunna.

The town is built on a hill surmounted by a ruined medieval citadel. Monforte has soap factories and linen weaving. There is trade in livestock.

Pop. (1950) 22.131 (mun.).

MONGE, GASPARD (1746–1818), French mathematician, the inventor of descriptive geometry, was born at Beaune on May 10, 1746. He was educated at the college of the Oratorians at Beaune and at their college at Lyons, where at 16 he was made a teacher of physics. Returning to Beaune for a vacation, he made a large-scale plan of the town, inventing the methods of observation and constructing the necessary instruments; the plan was presented to the town and preserved in the library. An officer of engineers who saw it wrote to recommend Monge to the commandant of the military school at Mézières. He was received as a draftsman and pupil in the practical school attached to that institution; the school itself was of too aristocratic a character to allow his admission to it.

His manual skill was duly appreciated: "I was a thousand times tempted," he said long afterward, "to tear up my drawings in disgust at the esteem in which they were held, as if I had been good for nothing better." An opportunity, however, presented itself when Monge was required to work out from data supplied to him the gun emplacement of a proposed fortress. At that time such an operation could be performed only by a long arithmetical process, but Monge, substituting for this a geometrical method, obtained the result so quickly that the commandant at first refused to receive it. Upon examination the value of the discovery was recognized and the method adopted. It was considered so valuable that it long was guarded as a military secret.

Continuing his researches, Monge arrived at that general method of the application of geometry to the arts of construction that later became known as descriptive geometry.

In 1768 Monge became professor of mathematics and in 1771 professor of physics at Mézières; in 1780 he was appointed to a chair of hydraulics at the Lyceum in Paris (held by him together with his appointments at Mézières) and was received as a member of the Académie; his intimate friendship with C. L. Berthollet began at this time. In 1783, quitting Mézières, he was, on the death of É. Bézout, appointed examiner of naval candidates.

Monge wrote various mathematical and physical papers. Among these may be noticed the memoir "Sur la théorie des déblais et des remblais" (1781), which, while giving a remarkably elegant investigation in regard to the problem of earthwork referred to in the title, establishes in connection with it his capital discovery of the curves of curvature of a surface. Monge's memoir gives the ordinary differential equation of the curves of curvature and establishes the general theory; the application to the particular case of the ellipsoid was first made by him in a later paper in 1795.

In 1792 Monge became minister of marine, but he remained so only until 1793. He accompanied Napoleon on the Egyptian expedition. When the committee of public safety made an appeal to the savants to assist in producing the *matériel* required for the defense of the republic, he applied himself nholly to these operations and distinguished himself by his indefatigable activity. He wrote at this time his *Description* de *l'art de fabriquer les canons* and his *Avis aux ouvviers en fer sur la fabrication de l'acier.*

Monge took an active part in the measures for the establishment of the normal school (which existed only during the first four months of the year 1795) and of the École Polytechnique and was at each of them professor for descriptive geometry. His later mathematical papers were published (1794–1816) in the *Journal* and the *Corvespondance* of the polytechnic school.

On the formation of the senate' he was appointed a member of that body, with the title of count of Péluse. On the fall of Napoleon he was deprived, as a Bonapartist, of all his honours and excluded from the list of members of the reconstituted institute. He died at Paris on July 28. 1818.

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de Gaspard Monge (1951); P. V. Aubry, *Monge, le savant ami de Napoleon Bonaparte* (1954). (O. Oe.)

MONGHYR, a town and district in the Bhagalpur division of Bihar, India. The town is 77 mi. E.S.E. of Patna, on the right bank of the Ganges and on a short spur-line from Jamalpur on the main Patna-Calcutta line of the Eastern railway. A ferry connects it with Monghyr Ghat on the other side of the river and also on a short spur of the Benares-Dinajpur line of the North-Eastern railway. Pop. (1951) 74,348.

Monghyr, which appears under the form of Mudgagiri in an inscription of the 9th century A.D., was a place of military importance under the Mohammedans and frequently the seat of local governors or commandants. Shah Shuja built himself a palace there and in 1761 Nawab Kasim Ali moved his capital there from Murshidabad. The walls and ramparts of the fort are still standing. The fort dates back beyond 1580, when it was repaired by Todar Mal, Akbar's general and governor. Inside it is the tomb of an unknown saint erected in 1497. The house of Gurghin Khan, the Armenian general of Kasim Ali, stands on a small hill 3 mi. east of the town. Monghyr was captured by the British in 1763, and it was there that, three years later, Clive quelled "the White Mutiny" of the European officers of the army.

Monghyr was formerly famous for its manufactures of firearms, swords and iron articles of every kind. Its chief industry is the manufacture of cigarettes.

MONGHYR DISTRICT has an area of 3,975 sq.mi. The Ganges divides it into two parts. The northern, intersected by the Burhi Gandak and the Tiljuga (Kamla, Kareha?, two tributaries of the Ganges, is a flat, closely cultivated country, subject to inundations. There are many marshes, of which the largest is the Kabar Tal (7 sq.mi.). To the south of the Ganges the country is dry and much less fertile, and irrigation is necessary. Some ranges of hills and isolated plains occur in this part of the district. The chief are thk Kharagpur hills with a length of 20 mi. and an average breadth of 24 mi. which rise at Maruk to 1,628 ft. above sea level, and the Gidheswar (or Gidhaur) hills, which cover about 80 sq.mi. At Jamalpur (pop., 1951, 44,172), 6 mi. from Monghyr, are railway engineering workshops. Slate is quarried in the Kharagpur hills. Pop. of district (1951) 2,849,127.

MONGOL CAMPAIGNS. This article deals with the military methods of the Mongols during their great period of conquest, and illustrates it by an outline of the chief campaigns in that brief but unparalleled span of 30 years wherein they overran the Asiatic and European continents from the Yellow sea to the Baltic and the Adriatic.

If we study a physical map of Asia and Europe, we can trace a vast belt of open and level territory, though of varying altitudes, which stretches from the Yellow sea in the Far East to the Baltic sea and the Danube in the West. This chain of plains and plateaux is practically unwooded, and only broken by a few well-defined mountain ranges. It is the trough of the world's migrations, the path by which the great racial invasions have come to Europe and to China. Along it have passed the transcontinental routes of commerce, from the early caravans to the Siberian railway. But in even greater volume has it been the channel for armies, for it offers few obstacles to movement, and there uniquely the paramount principle of mobility has full rein.

In the centre of the continent lies the Mongolian plateau, barred by lofty and inaccessible Tibet from the fertile plains of India, but with comparatively easy access to the rich fields of China to the East, and of Western Turkistan and Russia to the West. This bare, bleak enclosure is the birthplace of the Turco-Mongol race, and the conditions of their environment have given the race their special characteristics. The European peoples became seafarers by reason of their lengthy coastlines and close touch with the sea. The Mongolian peoples became horsemen because constant and far-reaching land movement was necessary to obtain pasturage, and a warlike race because the barrenness of the land and the resulting migrations brought them into repeated conflict with other tribes and peoples. Long before the days of Jenghiz Khan, this lateral expansion of the Turco-Mongol race, and their pressure on the peoples who lay to the west, had produced barbarian invasions which overran Europe and overthrew the Roman empire, culminating in the invasions of the Huns.

Organization and **Equipment.**—Fuller knowledge has dispelled the excuse of mediaeval historians that the Mongol victories were due to an overwhelming superiority of numbers. Quality rather than quantity was the secret of their amazingly rapid sequence of successes. Alone of all the armies of their time had they grasped the essentials of strategy, while their tactical *mechanism* was so perfect that the higher conceptions of tactics were unnecessary.

The supreme command was in the hands of the emperor; but once the plan was decided upon, the subordinate generals executed the actual operations without interference, and with but the rarest communication with the supreme command. The nominal command of the various armies was held by royal princes, but the actual control was exercised by generals of experience, of whom the most famous were Chépé and Sabutai in the western campaigns, and Mukhuli in China.

The organization of the army was on a decimal basis. The strongest unit was the touman, a division of 10,000 troops, which could act as an independent force. The army was made up by a temporary grouping of toumans, generally three. Each touman was composed of 10 regiments of 1,000 men, and each regiment of 10 squadrons, and that again was divided into 10 troops of 10 men apiece. In addition there was a touman *d'élite,* the guard, which usually formed a general reserve in the hands of the commander-in-chief. There were also various formations of auxiliary troops.

For their protective equipment the Mongols had an armour of tanned hide in four pieces, composed of overlapping plates, which were lacquered to prevent humidity. The shield was only used when on sentry duty. Their weapons comprised a lance, a curved sabre with sharpened point, suitable either for cutting or thrusting, and two bows—one for shooting from horseback, and the other, for greater precision, when on foot. They had three quivers, each with a different calibre of arrows for the various ranges. One class could penetrate armour, and the other was suitable against unprotected troops. In addition, their light artillery consisted of various missile-throwing machines, mangonels, and catapults. These were taken to pieces, and formed a pack-artillery. They could fire rapidly and accurately, could go anywhere, and were adequate for open fighting.

Every trooper carried a complete set of tools, individual camp-kettle, and iron ration, for his own maintenance and subsistence in the field. He had also a water-tight bag in which he carried a change of clothes, and which could be inflated for crossing rivers.

Tactics.—The tactics of the Mongol army were rigid in conception, without the possibility of wide variation, but flexible in execution. They were built up on a definite framework of tactical moves, so that they resembled an applied battle drill. The analogy is further heightened by the fact that the different manoeuvres were directed by signals, so that the delays and upsets caused by orders and messages were obviated. The result of these battle drill tactics was seen in an amazing perfection and rapidity of execution. The Mongol force was a machine which worked like clockwork, and this very mobility made it irresistible to troops far more strongly armed and numerous.

The battle formation was comprised of five ranks, the squadrons being separated by wide intervals. The troops in the two front ranks wore complete armour, with sword and lance, and their horses also were armoured. The three rear ranks wore no armour, and their weapons were the bow and the javelin. From these latter were thrown out mounted skirmishers or light troops, who harassed the enemy as he advanced. Later, as the two forces drew near each other, the rear ranks advanced through the intervals in the front ranks, and poured a deadly hail of arrows and javelins on the enemy. Then, when they had disorganized the enemy ranks, they retired into the intervals, and the front ranks charged to deliver the decisive blow. It was a perfect combination of fire and shock tactics, the missile-weapon troops firing and disorganizing the enemy ready for the

shock troops to complete his overthrow.

Their continuous run of victories, usually over superior numbers, were achieved in defiance of most of the canons on which European armies, of the present equally with the past, have based their systems Nor can these successes be discounted in the way that is common when discussing victories over Asiatic troops, who are regarded as lacking the staying power, discipline, and equipment of European soldiers. Sabutai's warriors proved themselves more than a match for the men-at-arms of mediaeval Europe, who had superiority both of numbers and armour. The Mongol tactics were never to close with the adversary until he was weakened and disorganized by fire. If charged by the heavy European cavalry, they never let themselves be drawn into a clash, but dispersed on a signal, rallied by signal at a distance, and again assailed the enemy with fire, repeating the process until the enemy was "unhinged" and the way paved for a decisive charge. Thus they proved that mobility is the basis of tactics, as of strategy; that lightly armed troops can beat more heavily armed ones if their mobility is sufficiently superior

Another canon that they violated was that mobile troops, such as cavalry, must needs rest on a stable infantry base. Although cavalry was the decisive arm alike of Alexander and Hannibal, it formed merely the mobile wings hinged on an essentially protective infantry centre, which was the pivot on which it manoeuvred. The prime feature of the Mongol military system was therefore its simplicity, due to the use of a single arm, in contrast to the inevitably complex organization of a combination of several arms which has always characterized European armies. In this way the Mongols solved the ever-difficult problem of co-operation between arms which had radically different qualities and limitations. The single arm they used was that which possessed the highest degree of mobility, and in this lay the secret of their unbroken run of victory. At such local points where greater "locomobility" was needed than mounted troops could achieve, a proportion of the troops were temporarily dismounted and fought on foot

Invasion of China.—The career of the founder of the Mongol power, Jenghiz Khan, is recounted in the article upon him. After he had established his overlordship over the nomads of the Mongolian steppes, his first major campaigns were in the conquest of the Kin empire in China, 1211–14. He had previously loaned the emperor troops and thereby gained an intimate knowledge of the country and conditions within the Great Wall.

The first invasion, of 1211, was probably not made in much strength. It passed through the wall without difficulty, one of the entrances being opened by treachery, and dispersed the advanced forces of the empire. Then one of the Kin armies was trapped in hill country which it knew less well than the invaders, and Chépé's touman, making a night march round and on to its rear, broke it up. But as the invaders penetrated deeper they found the fortified cities an almost insuperable obstacle both to their methods and to their small numbers, and, in face of the growing strength of the enemy forces, withdrew in the autumn. Next spring this invasion was renewed and this time Jenghiz Khan appears to have used Taitong-Fu as a bait, in the same way as Bonaparte used the fortress of Mantua in 1796—to draw on and annihilate the successive armies which came to its relief. But the reduction of fortified cities remained an obstruction until the campaign of 1214. Then a vast concentric advance by three armies, the centre one moving on to the sea in the rear of Yen-Kin, the Kin capital, brought about such a demoralization that the emperor fled to the south and the chaos in his dominions enabled the Mongols to subdue the disorganized fragments. Leaving his general Mukhuli in control in China Jenghiz Khan himself returned to Karakorum. With his borders now firmly established as far as the river barrier of the Hoang-Ho, his base was secure for an advance towards the west. Here lay the rich and fertile empire of the Shah of Khwarizm (Karismian empire), which embraced what is to-day Turkistan, Persia, and northern India. The Shah's intrigues, combined with Jenghiz Khan's desire for expansion, brought about a conflict, the signal for which was the Shah's folly in putting to death the envoys of Jenghiz.

Invasion of **Turkistan.**—Like all the Mongol campaigns, the invasion of Turkistan was prepared by the employment of an extensive spy system, combining propaganda among the enemy peoples with a remarkable service of information to the Mongol command. The Shah mobilized all his vassal States, but like Napoleon's opponents in the disposition of his forces he adopted the fatal cordon system. By stringing out his forces in packets all along the line of the Syr Daria, he made himself weak everywhere and restricted himself to a purely defensive rôle.

Then, early in 1220, Jenghiz Khan struck his opening blow, a shrewdly conceived diversion. Chépé, with two toumans, had passed by the southern route from Kashgar into Fergana, and was advancing on Khojent, which covered the southern end of the Syr Daria line. Thus Chépé directly threatened the Shah's right flank, as well as Samarkand and Bukhara, which lay beyond —the two centres of his power. It was a dagger pointing at the heart of the enemy. The Shah reinforced the Syr Daria line, and concentrated some 40,000 at Bukhara, and also at Samarkand. Against this Karismian total of some 200,000 men the Mongols had probably about 150,000 in the invading armies.

Jenghiz Khan had distributed his main striking force into three armies, two under his sons Juji and Jagatai. While Chépé was striking his first blows in Fergana, the three armies which formed the main force traversed a northern route by the Dzungarian Gate, and in February suddenly debouched on the left flank of the Syr Daria line. The two armies of Juji and Jagatai turned south from Otrar, clearing the line of the Syr Daria, capturing the fortresses, and working towards Chépé's detachment, which, after taking Khojent, was seeking to join hands with them. Then, like a thunder-clap, as the Shah's attention was fixed to his front, the news reached him that Jenghiz Khan with his mass of manoeuvre had appeared on his left rear, and was almost at the gates of Bukhara.

This army of 40.000 men, under Jenghiz Khan himself, had followed in the wake of Juji's and Jagatai's armies, crossed the Syr Daria at Otrar, and then disappeared. Masked by the armies of the two princes, its arrival on the scene had passed almost unnoticed. Having crossed the Syr Daria, it vanished into the immense desert of Kizyl-kum. By this dramatic venture of 40,000 to 50,000 men, and even more horses, across a desert, Jenghiz Khan appears to have gained complete secrecy until the moment when he debouched at the southern end and was almost on the top of Bukhara—in rear of the Shah's armies! At one blow the Shah's whole line was turned, and his communications severed with his more distant westerly States, whose forces had still to arrive. Demoraljzed, the Shah fled and left the garrison of Bukhara to its fate.

Jenghiz Khan captured Bukhara, and then turned east towards Samarkand. Meanwhile, the armies of the princes had joined hands with Chépé, and were converging on Samarkand. The doomed last stronghold of the Karismian power was caught between the hammer of the princes and the anvil of Jenghiz Khan himself, and soon fell. In the brief space of five months Jenghiz Khan had overthrown the mighty Rarismian empire, and opened the gateway to the west, towards Russia and towards Europe.

The enemy armies crushed, Jenghiz Khan despatched Sabutai and Chépé westwards in pursuit of the Shah and to open up the path to further conquests. The Shah's son, Jelaladdin, still held out in the south for a time, and then crossed the Indus. Jenghiz followed him up, and in 1221 sent an expedition to Delhi, which took nominal possession of the country that his successors were to hold in reality. Jenghiz devoted his remaining years until his death to consolidating his mighty empire, which stretched from Korea to the Persian gulf.

Invasion of **Russia.**—Sabutai and Chépé, after accomplishing their mission of pursuit, asked permission for an advance towards the Kiptchak country—*i.e.,* southern Russia. The suggestion found favour with the emperor, and in six months they had advanced as far as Tiflis, crushing the kingdom of Georgia. In the spring of 1221 they pressed on into south Russia as far as the basin of the Donetz. Everywhere they established a stable

military and civil administration. Further, they organized an elaborate system of information to discover the weak points and rivalries of Europe. In this they found the Venetians quite willing to sacrifice the interests of Christian Europe in order to gain an advantage over their great trading rivals, the Genoese. In return for Mongol help in ousting the Genoese trade-centres in the Crimea, the Venetians acted as part of the intelligence service of the Mongols.

In 1223, however, Sabutai and Chépé were recalled by Jenghiz Khan, and returned by the northern end of the Caspian sea. Schemes of European conquest were suspended for a generation owing to the death of Jenghiz Khan in 1227. Disputes over the succession, for which Jenghiz had designated his second surviving son Ogdai, retarded further expansion to the West. Jenghiz Khan had called to his aid, in the administration of the immense newly gained empire, Yeliu Chutsai, a statesman of the former Kin empire. The natural result was to give a Chinese complexion to the policy of the Mongol empire, and to discourage adventures in Europe. But eventually Sabutai's scheme for the invasion of the West came to the front once more. The ground had already been prepared for it by his network of spies and propagandists.

It is probable that the invading force did not number more than 150,000 men, even when it set out, and that as a result of the losses in the preliminary campaigns and the detachments left to guard the communications with the East, little more than 100,000 took part in the Polish and Hungarian campaigns. The troops themselves came plainly from China, as the occupiers of the former Karismian empire were needed for events there. The horses only could be provided from south Russia, which had been organized as a vast remount depot.

In 1239 Central Russia was subdued as far as Moscow, and security was assured to the rear and communications of the invaders. The real objective was Hungary, for its people were the only branch of the Turco-Mongol race who still remained outside the authority of Jenghiz Khan's successors. But the neighbouring powers concerted, if not combined, to resist the invasion. They included Poland, Bohemia, and the Holy Roman empire, to which Hungary acted as a bulwark. With these powers were arrayed the German military orders, whose mission it was to be the outposts of the West against the heathen.

Szydlow and Liegnitz.—In Jan. 1241 Sabutai, with the prince Batu as his nominal superior, concentrated the Mongol forces in the region Lemberg-Przemysl. His intention was to force the passes of the Carpathian barrier, and to march on the Hungarian capital, Gran. But whilst he thus made his main effort against the principal enemy, it was necessary to assure security against interference from the others. An advance into Hungary, with the Poles and Germans ready to fall on his right flank, would be hazardous. It was necessary to crush these threats to his flank, and to ward off any premature intervention from Austria (the empire) or Bohemia. The tremendous victories of Szydlow in Poland and Liegnitz in Silesia have caused some historians to imagine that the Mongol purpose was a general conquest of Europe. But it was no part of Sabutai's strategy to advance into the hilly and wooded regions of western Europe, where the Mongolian horsemen would be at a disadvantage, and their system of tactics unsuitable to the country. The plain of Hungary was his goal, and he kept to it unswervingly.

He divided his force into four armies. Three of these he assigned to the main operation, and the fourth he used to achieve his secondary object—the removal of the danger on his right flank. This army, under Kaidu, moved first, as had Chépé's detachment into Fergana. At the beginning of March 1241 it crossed the Vistula at Sandomir. Then it fell upon the Polish armies of Boleslas and Miecislas at Szydlow and crushed them. Kaidu swept on at hurricane speed, took Cracow, and then Breslau; on April 8 he met at Liegnitz the German forces under Duke Henry of Silesia, together with the orders of the Templars and Hospitallers, and the remains of the Polish troops. A day's march to the south was the army of King Wenceslas of Bohemia. The Mongols, who were inferior in numbers to the troops of Duke Henry, struck on April g before the allied armies could effect a junction, and inflicted a terrible disaster. In less than a month the Mongols had covered some 400 miles, fought two decisive battles, taken four great cities, and conquered Poland and Silesia from the Vistula to the borders of Saxony.

Advance into Hungary.— But while they had been fulfilling this mission of security, Sabutai had wiped out the Hungarian army. He advanced into Hungary in thsee columns, of which the two flank columns traversed the circumference of an elongated circle, while he himself with the central mass started later and went through the diameter Thus he set up his forces in a close-linked and secure system with true economy of force, as was later the Napoleonic method. The dates of departure and the routes were evidently so arranged that the three columns should converge and join hands on the Danube near the Hungarian capital, where the main enemy forces were likely to be met.

The central mass—the last to move—forced the pass of Ruska on March 12, and advanced by the valley of the Theiss to the Danube near Gran. Rarely, if ever, in history has the speed of its advance been approached. Sabutai's advanced guard arrived at the Danube on the 15th, and Sabutai himself with the main body came up two days later. Within a fortnight all three armies had assembled, and Sabutai confronted Bela of Hungary, whose army lay across the Danube.

At this moment, however, Kaidu's detachment had yet to fight the battle of Liegnitz, and Sabutai would be uncertain of the situation as regards the other enemy armies. Moreover, it would have been difficult for him to force the crossings of the river under the eyes of the enemy, nor would it have been wise to fight a decisive battle with the Danube at his back. Hence he executed a true strategic retreat towards his base at Munkacz, luring on his enemy away from the protection of the Danube and the chance of reinforcement. The retirement was carried out slowly, taking six days to reach the Sajo river, half the distance, Then suddenly he delivered his crushing surprise blow. In the night he crossed the Sajo, and at daybreak he struck. By midday the Hungarian army ceased to exist, Bela was in flight, and more than 70,000 of his men were left dead on the battlefield.

For this battle we have accounts sufficiently reliable to grasp the Mongol tactics. Contemporary observers were impressed, above all, by two features: first, the speed, silence, and mechanical perfection of their evolutions carried out by signals with the black-and-white flags of the squadrons; second, the deadliness of their fire. Their opponents, in the words of a chronicler, "fell to the right and left like the leaves of winter." The armies of the middle ages, until the English archers in the next century, relied almost entirely on shock tactics. But the Mongols, as Plano Carpini says, "wounded and killed men and horses, and only when the men and horses are worn down by the arrows, do they come to close quarters."

After this holocaust, Hungary was occupied without further fighting. There was no attempt to push farther into Europe, apart from one reconnaissance into Austria. But at the end of the year Ogdai died at Karakorum, and the princes were all eager to compete for the succession. As a result the Mongol armies and their leaders decided to return east. The evacuation of Hungary was carried out systematically and without interference, and Europe, wondering at its deliverance, began to enshroud both the causes of its defeats and the strength of its conquerors in a cloud of legend.

(B. H. L. H.)

MONGOLIA, the name given to a vast tableland in central Asia, the traditional home country of the Mongol peoples and now divided into two distinct cultural and political entities, Inner Mongolia, an autonomous region *(ch'u)* of the Chinese People's Republic (see MONGOLIA. INNER), and Outer Mongolian People's Republic (*q.v.*). The later stages of the political evolution and the significance of the present situation can most easily be appreciated in the light of the physical geography of the country, its natural divisions and their respective orientation.

Mongolia in the physical sense is essentially a plateau varying from 3.000 to 5,000 ft. in altitude and composed of granites, gneisses and crystalline schists of Archaean and Primary Age. It is bordered on the northwest by the extensive mountain complex

of the Altai, Tannu-ola and Sayan groups, and on the northeast by the Transbaikalian highlands. On the southeast it is separated from the plain of north China by a belt of pronounced scarps whose continuation northward in the high faulted scarp of the Great Khingan delimits the plateau on the side of Manchuria. On the southwest it abuts against the lofty Nan-shan. the outermost of the great chains which enclose the Tibetan plateau. Only on the west, already outside Mongolia, does the tableland sink to lower levels in the Jungarian depression and the Tarim basin on either side of the Tien-shan. Physiographically Mongolia falls into three clearly marked divisions:

1. The central or Gobi region (see also under GOBI), on the whole the lowest and most uniform portion of the plateau. It forms an elongated shallow depression within the plateau. Isolated and neathered hill ranges of low altitude characterize the surface of Gobi, which is generally covered with gravel, sand or even marked by bare rock. Rivers are absent save on the northern margin where the Kerulen drains an area really foreign to Gobi—an area of mountains and valleys constituting the first outliers of the Yablonoi mountain system of Transbaikalia.

2. The northwestern mountain complex which has been compared in its character with the Bohemian block in Europe. It is in the nature of an uplifted massif enclosed by mountain ranges (Altai, Khangai, Sayan) in places marked by faulting. It may even be the counterpart, on a smaller scale. of the Tibetan plateau. The general level of the valleys in this region is about 3,000–4,500 ft. above sea level. The whole is well drained by rivers.

3. Southeastern Mongolia, on the inner or Chinese side of the Gobi, is like the northwest in being much more diversified in character than the central porticn of the plateau. It contains an outer and an inner series of chains. The outer series forms parallel ranges (Suma-Khada, Ta-tsing-shan, Khara-narin-uia and others). The inner series is made up of denuded fold chains partly within the line of the Great Wall (in the neighbourhood of Kalgan) and forms the frontier zone between Mongolia and the alluvial plain of north China. Between these two series is an intermediate zone of lower elevation and this is economically the vital part of Inner Mongolia.

Differences in Climate and Vegetation.—The differences here noted between the three maior regions of the Mongolian tableland are further accentuated-on climatic and vegetational grounds. The plateau as a whole is naturally characterized by dryness and great seasonal range of temperature, *i.e.*, "continentality." During the winter half year the Asiatic high-pressure system is centred over the northern edge of the plateau, while pressure is lowest in June, July and August. The whole area is one of outflowing winter and inflowing summer winds. The latter come from two main directions: west or northwest affecting Outer Mongolia, and southeast (monsoonal) affecting Inner Mongolia. The difference in mean temperature between the northwest and southeast of the plateau is considerable, amounting to about 20° F. on the average of the year. But the contrast is much greater in winter than in summer when the temperature is relatively uniform over the whole area. The Altai-Sayan mountain complex in the northwest partakes essentially of the Siberian climatic regime; the winter cold and annual range of temperature are here at their maximum. The total annual rainfall (including heavy snowfall) averages 10–20 in., but coming as it does from the west is not of the monsoonal type. Winds are probably not so strong or frequent as in Gobi, for Ulan Bator (on the edge of the region) is reported to have calms on 40% of the days in the year. It has a mean January temperature of −15° F. and a mean July temperature of 64° F. (tempered by altitude) showing an abnormal range. The average annual rainfall there is between 9 and 10 in., which is less than that of the northwest as a whole. The Gobi represents the classic example of a region with an extreme or continental climate. Winds blow unimpeded almost all the year round, mainly from the northwest. The rainfall is almost negligible in the real Gobi; the dryness is due to the fact that rain-bearing southerly winds have deposited their moisture on the successive high marginal ridges which border the plateau on the southeast.

On the other hand the Pacific influence is reflected in the climate of Inner Mongolia which more than any other part of the plateau is definitely affected by the monsoonal regime of summer. In the winter half year winds are predominantly from the northwest bringing extreme cold; while dust storms arising in Gobi are a common feature. The summer monsoon from the southeast brings the rains, averaging from 10 to 15 in. annually along the plateau edge, beyond which they rapidly die away.

The vegetational conditions correspond closely to these contrasts of climate. The northwest has Siberian affinities. On both sides of the Sayan are dense forests of larch, cedar, pine and deciduous woods characteristic of the Siberian flora. These decrease to their southern limits on the northern slopes (only) of the Khangai and Tannu-ola. With this exception the surface of this lofty mountain complex is marked by prairie land, furnishing excellent pasture in the wide basinlike valleys or plains. The rivers of the Ienissei basin are abundantly stocked with fish and the meadowland of the floor of the basin affords very rich pasture; the area also contains valuable mineral deposits and is capable of supporting a larger population. From the Tannu-ola southward, the treeless zone extends to the unforested Altai; the gravel surface generally yields dry prairie land.

The Gobi division, as a whole, must be regarded rather as a poor steppeland than desert proper. On its northern limits around the Kerulen river, high mountains bearing larch and spruce woods alternate with river valleys which afford areas of good pasture. Steppes succeed southward. merging into the Shamo or Gobi proper which is barren of vegetation save in spring and early summer. Physiographically, climatically and vegetationally Gobi is a very real divide between Inner and Outer Mongolia, whose affinities in a physical sense are with China proper and Siberia respectively.

The description of Inner Mongolia as a "land of high grasses" implies its pastoral wealth, but much of it has also potentia! agricultural value. This is particularly true of the fertile zone from the Ala-shan along the alluvial course of the Hwang-ho to the northeast of Kalgan, *i.e.*, along the intermediate belt between the plateau edge and the series of ridges within the Great Wall. The Ordos is a region of stunted steppe vegetation, but the In-shan series of mountain ridges (*i.e.*, the plateau edge) contains well-watered and sheltered valleys yielding an abundant vegetation.

ANTHROPOLOGY

The terms "Mongol" and "Mongolian" have been very much abused because of the fame of Jenghiz and Kublai Khan and are, indeed, often applied to all the inhabitants of the far east. Mongol should, however, be limited to a purely linguistic and national sense and should include only the speakers of Mongol languages, who are connected to a certain extent culturally and often only distinguished from their cousins, the Turks, by difference of language. Physically, although probably to a large extent Armenoid, they have come into contact with a variety of other stocks which have considerably modified the original type, which varies from district to district. Within historical times the Mongols have wandered far and wide over an area which has always been thinly populated. On the other hand, among nomads over a large area there is apt to be less divergence of type than in a settled population of relatively greater density. These two different aspects will serve to explain their remarkable homogeneity which appears in spite of local differences. The political history of the Mongols as an entity begins with Jenghiz Khan, whose father was the ruler of a few clans. Jenghiz was born about 1162 "with a piece of clotted blood in his hand." His horoscope foretold a bloody career, and the prophet in this case did not lie. He succeeded in binding the Mongols into a loose political organization, which in its original form did not survive his death, but the fruits of his military genius were sufficient to carry the Mongol horsemen over most of Asia and as far into Europe as Austria and Hungary. Under Kublai Khan the Mongols conquered China and held it for a brief period. Their political history has, however, always been of varied fortunes; they have advanced westward and southward, and they have retired again. In the 17th century Inner Mongolia, one of the most typical Mongol countries, was cultivated by the Chinese, and the Chi-

nese in fairly recent times have once more invaded with the plow this virgin prairie land. "the country of the long grass." (See MONGOLS.)

Racially. these slow movements are probably more important than the greater cataclysmic invasions of the Mongol armies. The Chinese, being sedentary agriculturists, definitely establish their racial type wherever they settle. The nomad Mongol, with his perpetual movement, makes tremendous incursions, but probably because of the smallness of his numbers in relation to the area occupied does not permanently establish his type where there is racial competition from people who settle a small area with a denser population. The Mongols may be conveniently divided into two main groups: the western Mongols or Oirats (incorrectly called Eleuts) to whom the Kalmucks belong, and the eastern Mongols, inhabiting Inner and Outer Mongolia. The Buriats (Buryats; *q.v.*) in Siberia are a subdivision of the eastern Mongols.

Social Organization. — The Mongol social organization of recent times has been somewhat complicated because of its dual nature, which is partly ecclesiastical, partly military (among the shamanist Mongols the ecclesiastical organization does not. of course exist, and their social system is similar to that of the Siberian Turks). The lay population is divided into three classes, the free nomads (Xrat), the serfs (Khamjilga) and the nobles (Taiji) to certain families of whom the hereditary princes (Jassak) belong. The clergy include the higher clergy (that is. the living Buddhas, who are chosen at birth as "reincarnations," and the lamas, who must obtain the permission of their overlords before taking the vows) and the ecclesiastical serfs, who are presented by their chiefs to monasteries. The clergy are celibate, and at least in Inner Mongolia about two males out of three take vows. The laity are organized for the most part on a military basis, the religious being excused from service.

The unit of organization is the *bak* or group, a small conglomeration of tents on the steppe, governed by an elected elder. A number of groups form a squadron (Sumu, literally "arrow"), and several squadrons constitute a banner (Khoshun) led by its hereditary prince, usually the eldest son of the last prince, although certain princes. known as "seal-less" princes, and some nobles have no banner. The adult males are also organized into troops of horsemen and the latter into regiments. The prince has complete control over the persons of his subjects, although to a certain extent the old steppe law has been modified by the Chinese in their territories. Its first and foremost principle is military; disobedience to the khan or his subordinates is immediately punished by death. Otherwise crimes are punished by a payment, usually in kind — cattle, sheep or camels — to the sufferer or his group. The banners are grouped together into a confederacy, which forms part of the heritage of a single princely house and was formerly ruled by the ancestor of all the princes who now hold the more or less independent banners which compose it. The Manchus somewhat modified this system by introducing leagues with elected princes, managing to secure the election of their nominee. Most of these confederacies corresponded to already existing confederacies.

The mode of life is intimately associated with geographical conditions. The food quest is limited practically entirely to the products of their herds (chiefly of sheep). Mongols have two types of houses. The travelling tent is a simple ridge pole tent, covered with dark cotton cloth. The more permanent tent or yurt consists of a lattice framework standing upright to about a man's height, on top of which is a sloping frame which forms the roof; a space is left open at the top to allow the smoke to escape. The whole frame. roof and sides, is covered by thick felts and anchored by ropes thrown over the whole structure. The *yurt* can be dismantled in about half an hour. The Mongol village consists of a small collection of tents, usually situated in a subsidiary valley, to be near wells in the main valley but protected from the great winds of the plains. The village usually possesses some sort of corral to protect the weaker animals from wolves. Another important feature is the great pyramid of dried dung which in this treeless country takes the place of wood for burning. The flocks supply milk, mutton. wool, skins and, as a by-product of the milk, a simple fermented liquor made of mare s milk (*airik;* in Turkic, *kumyss*) and a distilled alcoholic beverage called *arkhi.* Huge shaggy and very fierce dogs effectually keep off stray marauders and wolves and act as scavengers, eating up all the bodies of dead animals. The sheep are kept near the village both because they are looked after by the children and because their droppings are so valuable. The pony herds are kept farther away. The Mongols almost live in the saddle, riding upright and shifting the weight from one leg to the other. The ponies in immediate use are kept tied up near the village, one especially fast and carefully trained beast being always at hand to act as the "lassoo" pony. When a beast is wanted from the herd, a rider mounted on this pony takes a rod with a noose at the end, picks out the beast he wants to take, rides up and drops the noose over its head, tightens the noose and plays it as a fisherman, riding it round in circles till it gives in. The lassoo pony must be sufficiently fast to keep a neck ahead of any pony to be captured. The horsemanship of the Mongols can be best judged by the ride of one of their best men, who did the 1,500 mi. from Jibhalanta to Peking in eight days, changing ponies at each of the posting places; 15 mi. or so apart, which used to be kept up along the imperial routes. Any man on a pony picked out of the herd will think nothing of doing 100 mi. in one day. Along the trade routes camels are used. usually as pack animals, but sometimes for draught; elsewhere, however, the pony is the indispensable associate of the Mongols. They do a good deal of trading and thereby supply additions, such as grain and sugar and tea, to the products of their herds. In the taiga region. where game is more easily approached, many of the men are hunters. The craft of silverwork is rather highly developed. Every married woman wears an elaborate headdress of silver and stones, worked by the Mongols themselves. Although modern rifles have been introduced into Mongolia, their national weapon, which is still used ceremonially, is a bow made of horn backed by sinew. It is overstrung, *i.e.,* in making the bow it is so moulded that the belly of the bow when unstrung is directed backward, instead of forward as it is when the bow is strung.

Religion. — Apart from the immigrant Chinese, two types of religion are prevalent in this region. shamanism and Buddhism. The former is the original religion of the Mongols. Although Buddhism began to spread in central Asia long before Jenghiz Khan, he was still a shamanist. In the 12th century two important Mongolian tribes, the Naimans and the Kereits, were Christians, their faith being the Nestorian Christianity. This disappeared, however, almost with no trace left. Buddhism made good progress under Kublai Khan. During the period of the internal feuds following the expulsion of the Mongols from China (1368), the number of Buddhists decreased considerably and large portions of the population returned to shamanism. At the end oi the 16th century Buddhism regained its lost position and during the 17th century the population of Outer Mongolia, the Buriats and the Kalmucks, became Buddhists. Buddhism in Mongolia is similar to that in Tibet (*q.v.*) and presents no special local features. There are, however. certain local differences of interest. The lamaseries form the only permanent habitations in this land of nomads, but the lamas are not confined to their convents, and in practice large numbers of them are wanderers. The older shamanistic religion exists side by side with the higher and more orthodox faith. Among a pastoral people the Buddhist objection to the destruction of life cannot exist, and the slaughter of animals, and even their actual sacrifice, an idea entirely repugnant to Buddhist ideals, forms an important part of many Mongol ceremonies, including that of marriage. Over much of Mongolia there are ancient *obos* or stone pyramids, placed in honour of the spirits — especially on conspicuous, rocky outcrops. Ceremonies take place at these *obos* at intervals. In the remoter districts shamanistic rites still take place. usually toward nightfall. A fire is lit outside the tent, and animals are sacrificed. The chief performer, man or woman, begins by reciting traditional spells and gradually works into a hysterical condition, during which he may see visions, and finally falls unconscious on the ground. There are still professional shamans among the Buriats and in Outer Mongolia.

The general features of the mode of life of the inhabitants of Mongolia contrasted very strongly with that of their most inti-

mate neighbours, the Chinese, as recently as in the early 1900s. They entirely lacked any real form of cohesion, and though the Mongol princes were at times able to combine and conquer immense territories, the death of the khan was usually the signal for the breakup of his dynasty. Their life can be seen probably most typically in the region south of Gobi, a region which at various times has been given over to Chinese agriculturists, in the Ming dynasty, for instance. The Chinese have pushed many miles beyond the wall, into a country which is suited naturally to pastoral nomadism, and though the nomad cannot exist when the agriculturist has passed by, any slight change in environment which compels the agriculturalist to retire results in the land returning once more to pasture. A factor accelerating and increasing the Chinese colonization of Inner Mongolia is the railroad construction. By the early 1950s several railroads traversed Inner Mongolia, contributing much to the integration of Inner Mongolia in the economic and political system of China. This resulted in a considerable influx of Chinese settlers constantly increasing from year to year.

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HISTORY

From very early times the Mongolian plateau was inhabited by nomadic groups but the term Mongol is comparatively late. Its earliest mention is in the annals of the Chinese T'ang dynasty (618–907) where reference is made to the *mong-ku* invaders. The original homeland of the historic Mongols was the area between the Onon and Kerulen rivers southeast of Lake Baikal whence they extended their conquests (see MONGOLS) until their power reached its zenith in the vast empire of Kublai Khan (13th century). The breakup of their empire and the fall of this dynasty (the Yiian) in China were followed by disintegration in Mongolia, where independent communities under separate chiefs came into existence. Soon aftenvard the Manchu dynasty was established in China and, following the policy adopted by the Han and T'ang dynasties, set about the task of controlling the critical steppelands of the interior. The Mongol tribes whose lands were adjacent to the northern frontier of China early submitted but the more remote Khalkha and Kalmuck tribes beyond the Gobi desert were not brought under control until the reign of K'ang-hsi (1661–1721) or even later. Hence the distinction between Inner Mongolia and Outer Mongolia (the area later included in the Mongolian People's Republic) was foreshadowed at this period. In 1689, at the Congress of Dolonor, Mongolia accepted Manchu rule, and for more than tno centuries the entire area was a dependency of the Manchu empire. But immediately after the fall of the Manchus in the Revolution of 1911, the northern Mongol princes expelled the Chinese officials at Urga (now Ulan Bator) and declared their independence under the rule of the Living Buddha. The political distinction between Outer and Inner Mongolia then finally emerged and corresponded essentially to the natural divisions distinguished on physlcal grounds. The arid, almost empty nastes of the central Gobi separate the two relatively fertile marginal areas to the north and south which form the cores of the two divisions, the one orientated toward Siberia, the other toward China. In outlook, in political status. in the composition of their populations and in the trend of their economic developments, these two divisions are quite distinct and the term "Mongolia" used in a political or even in an ethnic sense has little significance save in relation to the northern republic.

Inner Mongolia comprises a broad belt adjacent to the northern border of China from south Manchuria on the east to Kansu on the west. Its northern boundary against Outer Mongolia runs through the heart of the desert to the Great Khingan. Its eastern boundary with Manchuria extends beyond the Khingan and runs southeastward almost to the coast of the Gulf of Liao-tung to include the broken eastern extension of the plateau. The boundary is parallel to the coast for a considerable distance, leaving to Manchuria only a narrow sill traversed by the main route from Peking (Peiping) to Mukden. Opposite Shanhai-kman ("the Gate between mountain and sea") it turns west to follow the line of the Great Wall along the scarplands northwest of Peking. Much of this eastern portion of Inner Mongolia. known as Jehol, is drained toward and geographically related to Manchuria. From Kalgan the southern boundary follows the outermost scarp along the Great Wall and traverses the Ordos plateau, crossing both arms of the gigantic loop of the Hwang-ho (Yellow river). Finally it runs northwest into the desert, forming in this western section the northern border of the Kansu corridor.

The outstanding features of Inner Mongolia are the progressive development of Chinese influence and the replacement of nomadism by agriculture and pastoral farming. In the 17th century there were few Chinese outside the Great Wall, nor did the early Manchu emperors encourage emigration. But the dynasty in its later years, inspired bv fear of Tawanese pressure from the east and Russian pressure from the north, adopted the Chinese policy of colonization and of direct control of the Mongol tribal organizations through Chinese officials. The establishment of the republic was followed by a complete political reorganization of Inner Mongolia, bringing it into integral relationship with China proper. With the addition of the portions of the provinces of Chihli and Shansi which lay to the north of the Great Wall there were formed in 1914 the three administrative areas of Jehol, Chahar and Suiyiian (with capital cities at Jehol, Kalgan and Kweihwa. respectively) while the semidesert region of the extreme west was constituted the military district of Sitao and placed under the control of Kansu. Shortly afterward the revolution which terminated the tsarist regime destroyed Russian influence in the south and allowed the policy of active Chinese assimilation to proceed unchecked.

By 1929 Jehol. Chahar. Suiyiian and Sitao (enlarged to become Ningsia [Ninghsia]) had been incorporated as four provinces of China. Chinese colonization proceeded apace until by 1933 the only land that remained free from Chinese settlement was a portion of northern Chahar where the Silingol league under Prince Teh maintained a precarious autonomy. A Mongol Autonomous Political council set up in 1934 under Chinese auspices clashed in 1936 with a similar Mongol regime in Chahar which had been promoted by the Japanese. Conflict between rival movements was, however, brought to an end when both Chahar and Suiyiian were invaded by the Kwantung army in 1937 and the Japanese forced the establishment of three autonomous governments—of Chanan (south Chahar), Suiyiian and Chinpei (north Shansi)—under a federal council which subsequently (19.39) became the Federated Autonomous government of Mongolia, known by the abbreviated title of "Mengchiang." The nominal suzerainty of "Mengchiang" remained with China, or rather with the so-called National government established at Nanking. but the Japanese by their treaty with that government of 1940 retained the right to station armed forces indefinitely in the area and were its de ***facfo*** masters. After the end of World War II in the far east Inner Mongolia again became part and parcel of China, although it still seemed to enjoy a sort of autonomy under the Chinese Communist regime. But whatever may be the shifting fortunes of Mongol autonomy, the overriding fact is that Inner Mongolia is, in both economic and ethnic character, an extension of China to the northwest. The population of former "Mengchiang" is about 5,500,000. Of these less than 500 000 are Mongols, and the remainder consists almost entirely of Chinese whose main occupation is agriculture in all areas suited to it. Chief among these areas are the valleys and terraces along the route of the Peking-Suiyuan railway and the alluvial lands around the northern bend of the Hwang-ho which embraces in the north of Ordos a valuable agricultural plain known as the Ho-tou.

In these districts the population is overwhelmingly Chinese, and nomadism has practically disappeared.

There is but little intermixture of Mongols and Chinese, for

where the Chinese farmer arrives with his spade the Mongo! withdraws with his herd. Only in very exceptional cases does the Mongol adopt agriculture. Two entirely different economic systems are in conflict, and the herder has generally given way to the peasant. But much of Inner Mongolia is better adapted for animal rearing than for any other economic use, and the Mongols, with improved methods, may yet find their place in the new regime. From time immemorial China has been a great market for Mongolian ponies, and the demand has in recent years been raised by military needs and the increase of horse racing in the big cities, which has led some of the Mongol herd owners to take an interest in systematic breeding. With the support of the chiefs an important experiment in dairy farming on modern lines but adapted to Mongol methods wa5 made in Chahar with considerable success, and Kalgan, Peking and Tientsin are increasingly important as markets for pastoral products of all kinds. The agriculture carried on by the Chinese colonists (who are so far mainly Muslims), or by the large class of seasonal workers from Shansi. is naturally of the type characteristic of North China—oats, wheat, buckwheat, millet, rapeseed, kaoliang, sesame and beans being the principal crops. The low rainfall makes tillage without irrigation somewhat precarious, but in some districts irrigation is possible on quite a large scale. notably in the Wuyüan district of Suiyuan. There around the northwestern angle of the great Yellow river bend, an extensive system of irrigation canals between the present course and a deserted channel to the north has converted over 150.000 ac. of arid land into productive fields. Elsewhere irrigation must mainly depend on wells and storage of water in the mountains In the nonirrigated lands, dependent upon rainfall. mixed farming, combining stock raising with the cultivation of the soil, has been strongly urged upon the Chinese settlers, whose natural inclination is to rely exclusively on their crops. It is noteworthy that afforestation has been actively promoted by the authorities in former Chahar and Suiyuan. In the aggregate there is a considerable number of small-scale industries, mainly based upon pastoral products. They include the manufacture of rough woolen cloths and rugs, the preparation of felt, furs and leather, soap factories in which the acrid Mongolian "butter" is used and papermaking from hemp ropes Kalgan is the chief emporium of the skin and fur trade and the main collecting and distributing centre for Inner Mongolia. (See KALGAN.) Peking and Tientsin are the two chief external markets Wool has been the chief foreign export.

Transport in Inner Mongolia is still mainly dependent upon camels, horses and oxcarts, using the ancient caravan tracks, but motor and rail traffic is steadily increasing Motor roads were constructed by soldier colonists. The construction of the Peking-Kalgan-Suiyuan railway in the 1920s was also of great value in the development of Inner Mongolia and is noteworthy as having been entirely constructed and maintained by Chinese capital and engineers. It followed the ancient caravan route up the historic Nankow pass and tapped not only eome of the richest agricultural and pastoral lands but also a mineral district of considerable value. It was pushed westward as far as Pao-t'ou, on the northern bend of the Yellow river. See also CHAHAR; NINGSIA; SUIYÜAN.

Outer Mongolia or the Mongolian People's Republic.— The proclamation of the independence of Outer Mongolia and the expulsion of Chinese officials by the Mongol princes assembled at Urga after the fall of the Manchu dynasty in 1911 have been already noticed. Since then the country has passed through many political vicissitudes and has been the scene of more than one revolution. In 1924 occurred the death of the last Khutukhtu or Living Buddha, the theocratic ruler of the country, who claimed to be the incarnation of a disciple of Buddha. It was almost immediately followed by a revolution fostered by agents of the Soviet Russian power. which was then actively pursuing the policy of recovering control of the central and eastern Asiatic lands formerly belonging to or within the sphere of influence of the tsarist empire. The Mongol revolution of 1924 established the Mongolian People's Republic and in November of that year a constitution was promulgated in the name of the First Great khural (People's assembly). The present constitution was adopted in 1940 and arnended in 1952.

Political authority is in fact exercised by the Mongolian People's Revolutionary party. the nucleus of which mas formed in 1920 of young Mongols who had received Soviet training. Its pattern is that of the Communist party, and real power is exercised by a small party caucus. The governmental organs follow the Soviet model and are in practice subordinated to party control. The regime is in theory republican, the constitution providing that there shall be no president at the head of the state "all supreme power being vested in the Great Assembly of the People and in the government elected by it." This national assembly. the Great khural, meets once in three years and elects a small khural for a term of three years. The latter convenes once a year. The small khural elects a presidium, which has full powers between sessions of the khurals, and being composed mainly of members of the People's Revolutionary party is the organ through which the party controls the government of the state. The National assembly is elected by provincial and urban councils, themselves elected by councils of smaller administrative units The administrative units, in ascending order of size, are the traditional groups known as the bag, the *somon*, the *khoshun* and the *aymag* (of which latter there are 18). together with the three urban governments of Ulan Bator, Choybalsan and Siihe Baatar. The social and economic aims of the Revolutionary party can be best understood in the light of previous conditions in Mongolia The penetration of Chinese influence under the Manchu empire had tended to destroy the solidarity of the Mongols, and the use of firearms by surrounding peoples tended to reduce their martial prestige.

The influence of Tibetan lamaism was debilitating, since it produced a large class of monastery-dwelling lama-priests, who by playing upon the superstitions of the people secured for themselves a great part of the uealth of the country. It moreover diminished the martial qualities of the Mongols by creating a large sedentary and unproductive class. Population declined. partly through celibacy but more through the spread of venereal disease. The influence of the Chinese traders was on the whole disruptive, since the Mongols got heavily into their debt. Ail these circumstances combined to depress the condition of the tribesmen and to put into the hands of the lamas and the princes wealth and power which they abused. The People's Revolutionary party therefore aimed at depriving the lamas and princes of their influence and redistributing the wealth of the country among the ordinary tribesmen. Its platform as announced in the early days of the revolution called for the abolition of the theocratic regime, the separation of church and state, a unified economic policy under state control and ownership of land and natural resources by the people. At first the party used drastic methods of confiscation but. after a series of uprisings in which large portions of the population and even units of the People's army participated (1932), later became somewhat more conciliatory, especially toward the church. It has endeavoured to combat lamaism by popular education and propaganda and by building up the party's own strength, especially through its hold on the army, which is evidently an efficient force, recruited largely from the Revolutionary Union of Youth (Revsomol) which stemmed from the Communist Youth International All Mongol adults who are self-supporting and over 18 years of age have the franchise. with the exception of prisoners in jail. The army takes part in electing the National assembly.

The country is largely pastoral and there are few areas suitable for agriculture, since even where the soil is fertile tillage frequently produces erosion. Mining (gold and coal) has been developed, and at the Nalaikha coal field (said to have a reserve of 500,000,000 tons) several thousand miners are employed—a startling development for a nomadic people. The mines are connected with Ulan Bator by a narrow-gauge railway of about 20 mi. The railway from Ulan Bator to Ulan Ude on the Trans-Siberian line was completed in 1949. Though the old caravan routes are still used and transport is mainly by horse, camel or oxcart, a great length of roads suitable for motor vehicles has been constructed, some being mere tracks across the steppes,

others being surfaced and graded. There is an international airport at Ulan Bator. Foreign trade. which is monopolized by the state. is entirely with the U.S.S.R. Exports consist of wool, skins, furs, horn, horses, salt and some gold. The imports are chiefly foodstuffs. textiles and building materials. The old trade route from Ulan Bator to Kalgan has become very important as the shortest way from Siberia to Communist China.

The external relations of Outer Mongolia, both political and economic, are in fact almost exclusively with the Soviet Union. The independence of the Mongolian People's Republic was acknowledged by the Nationalist Chinese government in 1946. This officially put an end to Chinese sovereignty over Outer Mongolia which had had no practical meaning, the republic being a Soviet satellite. To resist Japanese pressure, the U.S.S.R. and Outer Mongolia reached an understanding in 1934, which was in March 1936 embodied in a protocol of mutual assistance providing for military aid in the event of any threatened attack. Later, in 1939, a border dispute arose between Outer Mongolia and "Manchukuo," which developed into armed conflict in the area under dispute. the district of Nomonhan where the frontiers of Manchuria (Hsingan), Inner Mongolia (Chahar j and Outer Mongolia meet. Japanese and "Manchukuo" forces clashed with Soviet and Outer Mongol troops and in Sept. 1939 a crushing defeat was inflicted by a powerfully armed mechanized Soviet force upon the Japanese, who lost 18,000 men and were ejected from the territory in dispute. After an armistice the discussions of a mixed boundary commission dragged on until Oct. 1941, when an agreement was at last reached, no doubt because the U.S.S.R. and Japan had meanwhile found it desirable to conclude a pact of neutrality in April 1941. This pact remained in force until Aug. 9, 1945, when the Soviet Union, in fulfillment of its obligations under the Yalta agreement declared war upon Japan. The Mongolian People's Republic, under its mutual assistance pact with the U.S.S.R., also declared war and sent an army of 80,000 against the Japanese. The Mongols defeated the Japanese in Kalgan and Dolon-Nor, invaded the province of Jehol and reached the Liaotung peninsula.

The Mongolian People's Republic is bounded on the northwest by the high crests which form the buttress ranges of the plateau and extend from the Xltai through the Sayan mountains—essentially a natural frontier. The boundary then passes well to the south of Lake Baikal, cutting across the Selenga-Orkhon and Kerulen river systems which orientate this northeastern section of Mongolia toward Transbaikalia. Its short eastern boundary, abutting on Manchuria, lies to the west of the Great Khingan. The southern boundary with Inner Mongolia follows the centre of the Gobi. The total area of the state is 592.664 sq.mi., but the productive regions are concentrated in the north near the Siberian frontier. where the grassland becomes richer and grades into forest on the mountain slopes. In contrast to Inner Mongolia the population is essentially Mongol, comprising two principal tribal groups: the Oirats in the west and Khalkhas in the east. These are the purest and most typical of the Mongols, but the Buriat iribes of Transbaikalia, although mixed with other racial elements, are closely related to them and form another point of contact with the Russian sphere. The differences between the Khalkha, Kalmuck and Buriat dialects are comparatively small (*see* A. N. J. Whymant, *A Mongolian Grammar* [1946]). There is a relatively large Mongol literature. Lama-Buddhism is everywhere the popular religion. It gradually replaced shamanism from the time when Kublai Khan adopted Buddhism and instituted the Dalai Lama as the head of the Tibetan and Mongolian Buddhists; and its spread was encouraged by the Manchu emperors as a convenient instrument for taming the wild Mongol nature. Buddhism indeed appreciably changed the habits and outlook of the Mongols as a whole, converting a race of virile warriors into inoffensive and generally indolent herdsmen. Their potential military strength was further sapped by the Manchu policy of weakening the original tribal organization and bringing it under the control of their officials. The revival of military training and association with the Soviet regime have again altered the bias of the national character. The Mongols were formerly the classical example of pure nomads, but, as part of the general change in their mode of life induced by the Manchu policy of restricting tribal organizations to fixed areas: they have in large part settled down, although seasonal movement between winter and summer pastures by individual families is still common. It is the avowed policy of the government to foster industries, and some local development has taken place in the towns, but the flocks and herds remain the chief source of wealth.

Industries.—Mongolia is often reported to be rich in minerals, but there is little exact knowledge of the nature and extent of these resources, except in areas which have already been exploited because of suitable transport facilities. These are for the most part in Inner Mongolia. Coal is mined in fair quantities in former Chahar, Suiyüan and Ningsia. For the transport of Suiyiian coal the Japanese constructed an extension of the Peking-Suiyüan railway from the former railhead at Pao-t'ou, northward in the direction of Pailingmiao (an old caravan halt on the route from Outer Mongolia). Perhaps the most important mineral deposits worked in Inner Mongolia are the Pai-yün-o-po iron-ore field north of Pao-t'ou and the coking-coal mines of Shik-kuai-kou, to the northeast.

The coal of Outer Mongolia is mostly brown coal of low quality but there are mines, in addition to those at Nalaikha, near Choibalsan Tawan-Tolgoi and Man-chu-li; coal of fairly good quality occurs in Tannu Tuva. The richest mineral provinces appear to be in the Siberian borderlands, including Tannu Tuva (see TUVA).

While the industrial potential of Mongolia in general has been much exaggerated and while its economic future probably lies mainly in the direction of improved sheep and cattle raising, the economic significance of the Chahar iron deposits cannot be overlooked, not only because of their high quality but also because of their proximity to the great coal reserves of Shansi and the abundant coking coal available at Kaiping close to the Hopei seaboard. This conjunction of basic materials with land and sea transport facilities makes the south Chahar-north Hopei area most suitable for the development of large-scale heavy industry and presages its economic and strategic importance irrespective of its political future.

Population. — The total Mongol population is not accurately known. It is scattered over the great Mongolian plateau which covers some 1,500,000 sq.mi. and includes, in addition to the Khalkha, Oirat and other Mongols within the political boundaries of the Mongolian People's Republic and Inner Mongolia, probably 2,000,000 Mongols in the Jehol and Hsingan provinces; considerable Mongol eiements in the Chinese provinces of Chinghai, Sinkiang and northern Kansu; and the Buriat Mongols of Transbaikalia. Their total number is said to be about 3,000,000, of whom the majority inhabit Inner Mongolia and Manchuria, while the Mongolian People's Republic accounts for about 845,500.

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(P.M. R.; K. S.L.; N.N.P.)

EXPLORATIONS

The existence of an Asiatic centre of origin or homeland where ancestral types of mammalian life developed millions of years ago and apread westward to Europe and eastward to America had long been a matter of purely palaeontological theory. In 1900 Prof. Henry Fairfield Osborn, president of the American Museum of Natural History, New York, summarized his conviction of the truth of the theory and plotted on a map the regions in which he believed the great orders of mammals had originated. *(Science,* April 13. 1900, p. 567.) His belief was entirely based upon inductive reasoning, for the fossil history of Asia was unknown.

Central Asian Expeditions.— This theory was responsible for the original conception of the central Asiatic expeditions. After ten years of zoological work in various parts of Asia, plans took shape to test the theory by scientific exploration of the little known central Asian plateau. The main problem was to discover the geologic and palaeontologic history of central Asia; to find whether or not it had been the nursery of many of the dominant groups of animals, including the human race; and to reconstruct its past climate; vegetation and general physical conditions, particularly in relation to the evolution of man. It was necessary that a group of specialists be taken into central Asia *together* in order that the knowledge of each man might supplement that of his colleagues. Probably no archaeologist could have dated the culture and unravelled the story of the dune dwellers, a prehistoric race which was discovered, without the assistance of other scientists. This was indeed the first expedition of such magnitude to employ these methods. The fossil history of central Asia was completely unknown. The British had made some discoveries of importance in India. In China fossil teeth and bones had long been sold for medicine and a few had been studied by English and German scientists. Some interesting and important finds had been made in Java. Persia and Asiatic Russia. But these all came from the edge of the interior continent. Literally, the only fossils known from the central Asian plateau were a few "rhinoceros" teeth discovered by the Russian explorer. V. A. Obruchev, in 1894–96.

The 1925 expedition of 40 men comprised the following branches of science: palaeontology, geology, palaeobotany, archaeology, topography. zoology and photography. The foreign staff included 12 Americans and 2 British; in the native staff there were 26 Chinese and Mongols. some being highly trained assistants. With so many branches of science represented it was improbable that all the men could find work in the same place at the same time. Therefore, the expedition was divided into four units, each with a car complete with its own driver, interpreter, cook and camp gear; any unit could leave the base camp and maintain itself independently for several weeks if necessary, As a matter of fact the expedition was almost continually divided except on long marches to new localities; frequently there were four camps from 20 mi. to 100 mi. apart.

General Survey.— It became evident that the first season must be devoted to a general survey of several thousand miles of country to locate and appraise its value for the special purposes of the expedition without attempting exhaustive work in any of them. The next year could then be one of intensive study, the amount of time to be devoted to each locality could be carefully planned in advance, and the staff adjusted accordingly. Since the main object of the expedition was to test the theory of central Asia as the chief theatre of mammalian evolution and distribution, palaeontology was most important during 1922–23.

Contrary to expectations, rich fossil deposits were discovered immediately. Four days after starting in 1922 it was found that the main trail between Kalgan, China, and Urga (Ulan Bator), the capital of Mongolia. which had been traversed by several geologists, runs directly through three rich fossil beds—one Oligocene and one Eocene, of the age of mammals, and one Cretaceous, of the age of reptiles: The palaeontological work of the expedition, which was carried on under the direction of Walter Granger, "revealed the high central Asiatic plateau as the home of most of the terrestrial dinosaurian reptiles of Upper Jurassic and of Cretaceous Lime. In brief, these discoveries establish Mongolia as a chief center of northern terrestrial life-history from the close of the Jurassic time to the close of Pleistocene time" (Osborn).

Since the middle of the age of reptiles, Mongolia has been continuously a high, dry continent. As a result, fossils "revealed especially the hitherto unknown high continental life of Cretaceous and Tertiary times" and showed that Gobia. as Grabau had named this ancient central Asian continent, was then sparsely forested, with limited rain supply and luxuriant with life, although it is now one of the most arid and inhospitable regions of the world. It was "extremely favourable to the evolution of reptiles, mammals, insects and plants hitherto known only along the Cretaceous shorelines of Europe and the Cretaceous seaborders of the center of America" (Osborn).

Dinosaur Eggs.—Among the several thousand fossil specimens obtained it is difficult to select those of first importance scientifically. but in popular interest the dinosaur eggs stand foremost. These were discovered among dinosaur remains in a rich deposit almost in the centre of Mongolia near a well known to the Mongols as *Shabarakh Ussu*, the "Place of the Muddy Waters." The beds consist of fine red sandstone of Upper Cretaceous age and are extremely rich in skulls and skeletons of a hitherto unknown dinosaur, *Protoceratops Andrewsi*. Bits of shell were discovered in 1922 but were not recognized as dinosaurian. The following year, on July 13. George Olaen found the first complete eggs. Three had broken out of a small sandstone ledge and lay exposed. Other shell fragments were partially embedded in the rock; just under the shelf were the projecting ends of two more eggs. Subsequently the block was found to contain 13 eggs in two layers lying with the large ends pointing towdrd the centre, exactly as they had been left by the dinosaur when she covered them with sand for the last time millions of years ago. The skeleton of a small dinosaur was found, lying 4 in. above the eggs in the loose sediment on top of the rock The specimen represented a toothless species. *Oviraptor philoceratops*. It is possible that this little dinosaur existed by feeding on the eggs of its relatives and was about to rob the nest when it was buried by a sudden sandstorm The eggs first discovered are 8 in. long by 7 in, around. They are rather more elongate than those of modern reptiles and differ greatly in shape from the eggs of any known bird, living or fossil. The dry country and the loose, extremely fine sand probably explain how such delicate objects as eggs were so beautifully preserved. After they had been deposited in a shallow "nest" scooped out of the sand the dinosaur covered them with a thin layer of sediment and left them to be hatched by the warmth of the sun. In a sudden windstorm, many feet of sand might have been heaped upon the eggs. Air and sun thus mere cut off and incubation abruptly ceased. The weight of sediment eventually cracked the shells and the liquid contents ran out. Simultaneously the fine sand sifted into the interior forming the solid cores which are present in all the specimens. The loose sediment of the entire region was eventually consolidated into red sandstone, the matrix in which all the eggs are enclosed. Two of those from the original discovery were somewhat broken, exposing the delicate skeletons of embryonic dinosaurs.

The **Baluchitherium.**—Another discovery, second only in popular interest to the dinosaur eggs, was the skull and parts of the skeleton of the gigantic hornless rhinoceros *Baluchitherium*, the largest land mammal known to have existed. An almost complete skull was discovered in Mongolia in 1922, and in 1925 were

found the four legs and feet of another individual that evidently had been trapped in quicksand and buried alive. It is estimated that the *Baluchitherium* stood 18 ft. high at the shoulders, that it was about 27 ft. long and that with its prehensile upper lip it could pull down tree branches 22 ft. in the air.

Geology and Climate.—The structure of the Mongolian plateau consists of two great series of formations, separated by a proiound unconformity. Those below the unconformity form a floor of ancient complex rock upon which the later sediments rest; many of these are fossil bearing. An enormous granite batholith or underlying floor supports the inference that valuable mineral deposits are more likely to be found about the margins of the batholith than in the area of broad exposure. The region has a basinlike character. There have been several mountain-making periods, several erosion periods and several revivals of volcanism.

The Gobi is essentially a rock desert with a very thin veneer of shifting sand and much bare rock. Interpretation of the strata indicates that. this region has been continuously a continental area since early Mesozoic times; the sediments deposited since are all of continental type and not marine, being either fluvial, lacustrine or aeolian.

This region has been arid and semiarid in its climatic habit for many millions of years. There is no indication that the regions ever experienced glaciation. In Pleistocene time, glacial epochs were represented in the Gobi region by changes to more humid climate, and interglacial epochs by return to desert conditions. The close of the glacial period and the beginning of recent time were marked by a change from comparative humidity to the desert climate of today. But even in recent time the climate has not been uniform; neither has the curve of change been smooth. There have been smaller changes within the longer cycles. Even within the last great arid cycle there have been epochs when the Gobi region was comparatively fruitful and could support a numerous population, separated by other epochs of more strictly desert habit and difficult conditions for animal life.

Archaeological Work.—Because caves and rock shelters, so common in Europe, are virtually nonexistent in Mongolia, archaeological work there is particularly difficult. Nevertheless, from near Kalgan to the outlying ranges of the Altai mountains more or less superficial traces of two prehistoric cultures were discovered. In sight of the Altai, where workable artifact materials such as jasper, chalcedony and agate were abundant, there are evidences of long-standing occupation. In the Gobi desert were found five cultural horizons, not including the living Mongols. The most recent in age were monuments consisting of rectangular and circular rock enclosures, from 3 to 150 ft. across. Most of these are burial places and several contained skeletal remains of a brachycephalic people. In one grave, N. C. Nelson discovered a skeleton with its head lying on a saddle, bows and arrows tipped with iron, bits of fabric and iron saddle trimmings. Near the graves were frequently pictographs pecked on the face of the rock. These represent human beings, camels, horses, cattle, stags, antelopes, ibexes and mountain sheep; the stag is now absent there.

The meagre data do not warrant any precise conclusions about this interesting culture but it seems probable that it is an expansion of the remarkable mound culture of Bronze and Iron Age times uncovered by Russian investigations in the Upper Yenesei country. As such its Mongolian antiquity can scarcely exceed 2,000 years.

The **"Dune** Dwellers."—An important archaeological discovery was a culture camp near the eastern spur of the Altai mountains within half a mile of the dinosaur egg beds. In fact, these primitive artisans used for necklace ornaments the broken shells of dinosaur eggs as well as those of *Struthiolithus,* the giant ostrich of the Stone Age of Mongolia. No human fossils were found, but it is established that the Stone Age tribes spread over the borders of the Gobi desert region during the Ice Age, establishing their workshops near large lakes bordering the Altai mountains. These Neolithic and Mesolithic people were named by Nelson the "dune dwellers" or the "Shabarakh culture" because of the occurrence of their artifacts in old, dead and indurated sand deposits called the "Shabarakh formation."

In 1912 Col. P. K. Kozlov discovered "the dead city" Kara Khoto on the Egiin Gol and found a huge library of books and manuscripts in Hsi-Hsia, a language related to Tibetan and extinct since the 14th century. (R. C. AN.; N. N. P.; X)

MONGOLIA, INNER, an autonomous region (ch'ii) of the Chinese People's Republic, lies in northeastern China adjoining the Mongolian People's Republic. Its traditional nomadism has been replaced in the 20th century by agriculture and pastoral farming, largely due to Chinese influence.

In 1636, after the Manchus had succeeded in building an empire in northeastern China, they included in it southern Mongolia. In 1644 a Manchu prince became the first emperor of China of the Manchu or Ch'ing dynasty, and from that time southern Mongolia was known as Inner Mongolia, as opposed to northern or Outer Mongolia, which remained independent. In 1691 Emperor K'ang Hsi subjugated Outer Mongolia also but the division of Mongolia into two parts remained.

Up to the end of the 18th century Chinese colonization of Outer Mongolia was strictly forbidden, but it made a considerable advance in Inner Mongolia. At the time of the Chinese revolution of 1911, which brought about the fall of the Manchu dynasty, there were more Chinese than Mongols in Inner Mongolia. As Outer Mongolia became autonomous under tsarist Russian protection, the Chinese republican government concentrated on the defense of Inner Mongolia against possible insurrections, and stationed about 10.000 Chinese troops at Kalgan (q v.). In 1914, revolts of Mongol *arats* (livestock breeders) broke out in various places, particularly in the region of Dolon-nor.

The events of 1921 in Outer Mongolia, which led to the establishment there of a *de facto* independent state, exerted an influence in Inner Mongolia. A Mongolian People's Revolutionary party was formed and the first session was held at Kalgan in 1925. The anti-Communist reaction in China in 1927 resulted in the execution of two leaders of this party, known as To Sung-nien and Li Yu-chih, and the party went underground.

When the Japanese seized Manchuria in 1931 and in the next year organized there the puppet state of Manchoukuo, they also exploited the anti-Chinese sentiments of the Mongolian princes. In 1939 they created in the western part of Manchoukuo a Mongolian "state" headed by Prince Teh (Teh Wang) and in 1943 they included in it other Mongol-populated parts of northeast China and called it the Sinan or Khingan autonomous province of Manchoukuo.

The Japanese defeat in 1945 was followed by a Chinese civil war and the conquest of all continental China by the Communists. In Nov. 1945 a meeting of people's delegates from western Inner Mongolia, held at Kalgan, set up a committee to work for the autonomy of Inner Mongolia. In Jan. 1946 a meeting of people's representatives of eastern Inner Mongolia took place at Gegen Sume, 25 mi. E. of Ulanhot (Wangyehmiao) and organized the autonomous government of Eastern Mongolia. A joint conference of representatives of eastern and western Inner Mongolia, held in March–April 1946 at Chengte (Jehol), set up the joint committee of the autonomy movement of Inner Mongolia under the veteran Communist Ulanfu (Yiin Tse). In May 1946 the autonomous government of Eastern Mongolia was disbanded by the people's representatives of that state, meeting in extraordinary session at Ulanhot, and a Khingan provincial democratic government was set up. A joint meeting of the people's representatives of Inner Mongolia, held from April 23 to May 2, 1947, at Ulanhot, proclaimed the autonomy of the Mongolian districts of northeast China and Inner Mongolia within the boundaries of a free democratic China, under the title of Inner Mongolia. The autonomous democratic government of Inner Mongolia was formed on May 1, 1947, and Ulanfu was elected president. In July 1947 a provincial committee of the Communist party of China in Inner Mongolia was established, with Ulanfu as its president.

At first the autonomous region comprised the lands that were formerly part of Heilungkiang, Liaohsi, Jehol and Chahar provinces, with a population (1951 est.) of 2,322,000. In June 1954, as a result of changes in the administrative organization of the Chinese People's Republic. the province of Suiyuan (*q.v.*) was included in the Mongolian autonomous region, with an additional population of 2,670,000 (1951 est.). The area of the enlarged autonomous region thus amounted to 454,633 sq.mi. and its population was 7,338,000 in 1953 and estimated to be 9,200,000 in 1957. According to a 1954 estimate, however, there were in China only 1,462,956 Mongols, mostly in the Mongolian autonomous region and in the former Ningsia (q v.) province. This figure suggested that the proportion of Mongols in the Mongolian autonomous region was no more than 23%. In 1954 the capital of the autonomous region was moved from Ulanhot to Huhehot (formerly Kweisui), till then the chief town of Suiyiian. *See* also MONGOLIA; MONGOLIAN PEOPLE'S REPUBLIC; MONGOLS; CHINA.

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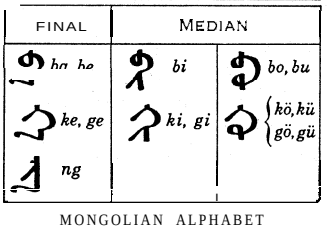
MONGOLIA, OUTER: *see* MONGOLIAN PEOPLE'S REPUBLIC.

MONGOLIAN LANGUAGE. The Mongolian language

consists of a group of dialects, spoken in various parts of Central Asia, which are related to other Altaic languages, such as Turkic (Turkish, Uzbek, Kazakh), Manchu-Tungus (Manchu, Goldi, Evenki), and Korean. Mongolian languages are divided into two main groups: western Mongolian, or Oirat, particularly Kalmuck; and eastern Mongolian, which includes Ordos, Kharchin, Chakhar, Buryat and Khalkha. Between World Wars I and II about 3,500,000 Mongols were living in various parts of Asia. In 1953 there were approximately 1,500,000 Mongols in Inner Mongolia. Buryat Mongolian is spoken by about 300,000 persons around Lake Baykal. Mogol, which is spoken in Afghanistan, Monguor, which is spoken in Kansu province, and Dagur, which is spoken in Manchuria, contain many archaic features. About 1,500,000 persons understand Khalkha-Mongolian easily.

The pronunciation of Mongolian is comparatively simple. A characteristic feature is the existence of both long vowels and short vowels, *i.e., der* ("pillow") and *deer* ("above"), *toso* ("butter") and *tooso* ("dust"), *khana* ("wall") and *Khaana?* ("where?"). Another basic feature is called vowel harmony, the essence of which is that a single word may contain either back vowels only *(a, o, u)* or front vowels only *(e, o, ü)*. Initial accent is a common feature in the pronunciation of most words.

Mongolian is an agglutinative language group; the use to which a word is put is indicated by means of suffixes (endings). Verbs have about 30 possible formative suffixes, and nouns have seven regular declensional suffixes. In declensions the suffixes are the same for all nouns, modified only by the requirements of vowel harmony. Note the following example: *gar* (nominative "hand"), *gariin* ("of the hand"), *garta* ("in the hand"), *gariig* (accusative 'hand"), *garaas* ("from the hand"), *garaar* ("by means of the hand"), *gartay* ("along with the hand"). Each suffix has only one function, *e.g.*, Khalkha *akhanartan* ("to his elder brother"): *akha* ("elder brother"), *-nar* (a plural suffix), *-ta* (dative suffix), and *-n* (possessive ending "his"). There are no prepositions but only postpositions, *e.g., uula deer* ("on the mountain"): *uula* ("mountain") and *deer* ("on"); *usan dotoro* ("in the water"): *usan* ("water") and *dotoro* ("in"); *tšinii orondo* ("instead of you"): *tšinii* (genitive "of you") and *orondo* ("instead"). Mongolian has no grammatical gender, and there is little distinction in form between the use of words as nouns or adjectives.



MONGOLIAN ALPHABET

[1] Used only in first syllable; [2] used before vowels; [3] used before consonants; [4] used only in foreign words

The syntax is characterized by a strict word order. The verb is the last element in a sentence or clause. Note the following sentences: *aawa namaig surguulid yawuulawa* ("father sent me to school"), *aawa* ("father"), *namaig* ("me"), *surguuli* ("school"), *-d* (dative suffix), *yaw-* ("to go"), *-uul* (causative suffix), and *-awa* (past tense suffix); *tši yawawal bi haniladz' yawayii* ("if you go, I'll go with you"), *tši* ("you"), *yawa-* ("to go"), *-wal* (conditional suffix), *bi* ("I"), *hanila-* ("to accompany"), *-di* (auxiliary verb suffix), *yawa-* ("to go"), and *-yii* (voluntative suffix); *Ulaan Baatart suusaar onoodor tawan dfil boldz' baina* ("it is now five years since he has been living in Ulan Bator"), *Ulaan Baatar* ("Ulan Bator"), *-t* (dative suffix), *suu-* ("to reside"), *-saar* (subsequent time suffix), *onoodor* ("today"), *tawan* ("five"), *džil* ("year"), *bol-* ("to become"), *-di* (auxiliary verb suffix), *bai* ("to be"): and *-na* (present tense suffix).

The Mongolian alphabet was received from the Uighurs, a Turkic people, in the 13th century. The latter took it from the Sogdians, an Iranian people. The Sogdian alphabet was an adaptation of a Semitic alphabet (Aramaic). The Mongolian alphabet was written vertically downward. After 1941 the Cyrillic alphabet was introduced into the Mongolian People's Republic (Outer Mongolia). It contains additional letters to indicate the front vowel sounds ü and ö. It is now the official alphabet in the Mongolian People's Republic.

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(F. H. BK.)

MONGOLIAN LITERATURE begins with the *Secret History of the Mongols,* an imperial chronicle dealing with the life and times of Genghis Khan and his successors. written A.D. 1240.

Üligers, orally transmitted epic stories in verse, form the bulk of native literary expression. Highly stylized, they relate adventures of legendary heroes and villains. In spite of their great length (sometimes more than 20.000 lines), they are recited from memory by bards. Like the *Iliad,* the *Aeneid* and other epics, they are genuine artistic creations. The verses alliterate in couplets or quatrains. are seven or eight syllables long and are characterized by parallelism. Much phraseology is common to many epic poems. Besides Genghis Khan, there are heroes such as Erintsen Mergen, Engke Bolod Khan and Geser Khan (the last of Tibetan origin). The villain of epics is the many-headed monster, the *manggus,* whom the hero always defeats.

Historical chronicles represent another important form of indigenous literature. Usually beginning with the creation of the world from primordial elements, they attempt to link the Indian and Tibetan rulers into the house of Genghis Khan. Such are the *Altan Tobchi* ("The Golden Button"), composed about 1604 and giving a world history down to Ligdan Khan (1604–34), and another *Altan Tobchi* of about 100 years later. The *Erdeni-yin Tobcki* ("The Jeweled Button") became known in the west as early as 1829 when a Russian savant, I. J. Schmidt, published it in Mongolian with a German translation and commentary. It is by Sagang Sechen.

Mongolian literature was profoundly influenced by the introduction of Buddhism around the end of the 1500s. Earlier surviving works (on stone or paper) are mostly official documents. No oral epics were written down until the late 1880s. The advent of Buddhism evoked translations of its sacred writings and related works. A Buddhist canonical collection, the *Kanjur* (comprising the *szitras* and *vinaya* of the Tripiṭaka), was translated and printed in 1635 in 108 volumes; the *Tanjur,* containing canonical commentary and noncanonical works in its 225 volumes, followed in 1741. Two especially \veil-known sermons *(szitras)* of Buddha are the "Golden Beam" *(Altan Gerel)* and the "White Lotus" *(Chagan Lingqua),* best called by their Sanskrit names, *Suvarnaprabhāsa* and *Saddharmapuṇḍarīka.* However, none of

these works is indigenous.

The religious but nondogmatic birth stories (Sanskrit *Jātaka*) deal with Buddha's meritorious deeds, and like the parables of Christianity illustrate religious truths. Best-known is the *Üliger-iin* dalai ("The Sea of Stories"). Translations of other Indian fables are the "Tales of the Vampire" (Siddhi *Kür*) and the "Saga of King Vikramāditya" (Mongolian *Bigarmijid*).

In the 18th and 19th centuries Chinese traders brought from China many Mongolian translations of Chinese novels of enchantment and romance, including the *San-kuo* chih and others.

In the early 20th century T. Zhamtsarano, a Russian-educated Buriat writer and intellectual, founded the short-lived Mongolian newspaper *Shine Toli* ("The New Rlirror"). He also translated some western authors, such as Edgar Allan Poe, Jules Verne and H. G. Wells. The outstanding modern writer is Damdin Surun. After the establishment of the Mongolian People's Republic in 1924, a body of realistic literature patterned on Soviet models emerged, and the old tales are rapidly being forgotten.

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MONGOLIAN PEOPLE'S REPUBLIC, formerly known as Outer Mongolia, is an independent state in eastern central Asia bounded on the north by the Russian Soviet Federated Socialist Republic, U.S.S.R., and on the east, south and southwest by the Chinese People's Republic. Area 591,119 sq.mi. Pop. (1956 est.) 815,500. For physical geography and early history see MONGOLIA; for the people see MONGOLS; see also CHINA.

Mongolian Autonomy Proclaimed.— In the endeavour to transform the greater part of Mongolia into a buffer state between Russia and China, the Russian tsarist diplomacy backed the autonomist tendencies of Mongolian princes and lamas. This policy succeeded because the Mongols feared Chinese colonization of their lands. The new Mongol nationalism looked abroad for support and found that only Russia was interested in giving it. On Aug. 4, 1911 (new style). the tsarist government decided "to play an active part in the Mongolian question." Early in November the general commanding the Irkutsk military district delivered 15.000 rifles, 7,000,000 cartridges and 15,000 sabres to Mongolian princes. On Nov. 18, three months before the abdication of the emperor of China and the proclamation of the Chinese republic. the Living Buddha of Urga (Ulan Bator) was proclaimed *bogdo* khan of Outer hfongolia. A government was set up and a military force of 20,000 was trained by Russian officers and noncommissioned officers of Russian Mongol (or Buryat) nationality. Tsarist Russia, however, did its best to prevent the Mongolian state from having diplomatic relations with any foreign power and to circumscribe Mongolian territorial aspirations toward Inner Mongolia, Barga in Manchuria, or Urianghai (Tannu Tuva), a region whose Turkic-speaking population was under Russian protection.

In the summer of 1912 Ivan Korostovetz, former Russian minister to Peking, was sent to Urga to negotiate a Russo-Mongolian treaty. On Nov. 3 (N.S.) he signed a treaty with Sain Noyan Khan, the Rlongolian prime minister, which proclaimed that "the old relations between hfongolia and China were at an end," but did not recognize the full independence of Mongolia. For all practical purposes the treaty created a de facto Russian protectorate in Outer Mongolia.

Autonomy Abolished.— The fall of the tsarist régime in 1917 caused the temporary abolition by China of Mongolian autonomy. As soon as it learned of the success of the Communist revolution in Russia, the Mongolian government closed the Russo-Mongolian frontier and refused to receive a Soviet representative in Urga. In Oct. 1919 Gen. Hsü Shu-tseng, formal representative of the central Chinese government but actually an agent of the pro-Japanese Anfu party then in power in northern China, arrived at Urga. With 6,000 Chinese soldiers at his disposal, he presented the Mongolian government with a 36-hour ultimatum demanding the abolition of autonomy. The government accepted, and a petition to restore the old relations was signed, though not by the Living Buddha. On Nov. 22, the president of the Chinese republic accepted the petition, agreeing to preserve the dignity of *bogdo* khan, the title assumed by the Living Buddha eight years before, but declaring all treaties concluded between Russia and Mongolia null and void. The Mongolian army was disarmed.

The Chinese success was, however, of short duration. In Oct. 1920 Mongolia was invaded by a White Russian force of 5,000 horsemen (Russian and Buryat) commanded by Baron Roman von Ungern-Sternberg, a soldier of fortune who declared himself for the idea of Pan-Mongolism. He occupied Urga on Feb. 3, 1921, but not for long. Since the end of 1919 there had existed in Urga two secret Mongolian groups plotting for independence and a new social order: one led by Suhe Baator (1893–1923) and Danzan Khorlo, officers of the first national Mongolian force, and the other by Khorloghiyin Choybalsan (1895–1952), a Communist sympathizer. On Soviet advice the two groups merged in 1920 to form a Mongolian People's party. On March 13, 1921, the new party established a revolutionary provisional government in Kyakhta, on the Russian side of the frontier. In June a Soviet army, with Mongolian units under Siihe Baator, defeated Ungern and on July 6 entered Urga. A national government headed by Lama Bodo was formed, while the Living Buddha was invited to limit his activities to religious affairs.

Autonomy Restored.— On Nov. 5,1921, Lama Bodo and G. V. Chicherin, the Soviet people's commissar for foreign affairs, signed a Soviet-Rlongolian treaty of friendship in Moscow. This recognized Outer Mongolia as an independent state and omitted all mention of its relations with China. At the same time a northwestern corner of Outer Mongolia, the Uriankhai, was proclaimed the independent republic of Tannu Tuva under Soviet protection. In April 1922 the Soviet political police claimed to have discovered that the head of the Mongolian government was a "Chinese spy"; Bodo was arrested and shot (Aug. 30) with 15 other "pro-Chinese plotters."

Events in Mongolia, however, did not divert the Soviet leadership from their concern with developments in China, and from 1921 they made every effort to increase their influence there. On May 31, 1924, a Soviet-Chinese agreement, signed by L. Karakhan, Soviet ambassador, and Wellington Koo, Chinese foreign minister, recognized China's sovereignty over Outer Mongolia and promised the withdrawal of Soviet troops. "We recognize the Mongolian People's Republic as part of the Chinese republic," commented Chicherin, "but we recognize also its autonomy in so far-reaching a sense that we regard it not only as independent of China in its internal affairs, but also as capable of pursuing its foreign policy independently."

Meanwhile, on May 20, 1924, the Living Buddha had died in Urga, and no new "incarnation" was permitted. On Aug. 4 the third congress of the Mongolian People's party opened in Urga, at which Danzan Khorlo, the commander in chief of the Mongolian army, made an "anti-Russian" speech. He was arrested, sentenced to death and shot as a "Japanese spy." (His friend Siihe Baator had died on Feb. 22, 1923, believed poisoned by the "enemies of the people.") The third congress prepared a draft of a new Mongolian constitution and changed the name of the party to the Mongolian People's Revolutionary party. On Nov. 26, 1924, the great people's khural (parliament) voted the new constitution and changed the name of Urga into Ulan Bator (*q.v.*), meaning Red Hero. At the beginning of 1925 Soviet troops were withdrawn from Mongolia.

Soviet-Mongolian Alliance.— China was too absorbed by its internal troubles to do anything about its theoretically recovered sovereignty over Outer Mongolia. In 1931 an entirely new situation was created by the Japanese invasion of Manchuria. In the same year Choybalsan joined the Mongolian government as foreign minister. On Nov. 27, 1934, Gendung, the prime minister, and Choybalsan concluded an agreement with M. M. Litvinov,

the Soviet people's commissar for foreign affairs, which amounted, though not explicitly. to a Soviet-Mongolian military alliance. Soon afterward Gendung was killed as a "Japanese spy" and Choybalsan became prime minister. On March 12, 1936, a formal treaty of alliance was signed at Ulan Bator between the U.S S R. and Mongolia, and Soviet armed forces reoccupied the territory of the sister republic. On July 7, 1937, Japan began the invasion of China and in the following month General Demid. commander in chief of the Mongolian army, died from poisoning in the train on his way to Moscow. He was succeeded by Choybalsan, who was made general and later marshal.

The Soviet-Mongolian alliance was implemented by the Soviet forces in the summer of 1939 when a Japanese army under Lt.-Gen. Kamatsubara attempted to invade eastern Mongolia. On the Soviet-Mongolian side General G. K. Zhukov had at his disposal a stronger force, and the principal battle was fought (Aug. 20–31) on the Khalkhin gol (river). The Soviet-Xlongolian forces lost 9.824 dead while the Japanese losses (according to Soviet sources) were about 25,000 killed. Hostilities ended on Sept. 15 and four days later a mixed commission was set up to define the frontier between Mongolia and Manchuria.

Independence Proclaimed. — Henceforward the U.S.S R. was firmly established in Mongolia. The situation was recognized (in a secret agreement disclosed on March 24, 1947) not only by Great Britain and the United States at Yalta (Feb. 11. 1945). but also by Nationalist China (Aug. 14, 1945). with the face-saving formula of a plebiscite. This took place on Oct. 20, 1945. The world was told that 487,409 citizens of the Mongolian People's Republic, *i.e.,* 98.4% of those entitled to vote: had gone to the polls and not a single vote mas cast against independence. On Jan, 5, 1916, Nationalist China officially recognized the independence of the Mongolian People's Republic and on Feb. 27 a new Soviet-Mongolian treaty of alliance was signed. In 1946 the government applied for admission to the United Nations (*q.v.*) but was rejected the following year because it had not exchanged diplomatic representatives with other UN members except the U.S.S.R. Only in April 1950 was Mongolia permitted to establish diplomatic relations with other "people's republics." On Sept. 28, 1952, Yumzhaghiyin Tsedenbal, chairman of' the Mongolian council of ministers, arrived in Peking. The following day Mao Tse-tung (who in 1936 had expressed his hope of seeing Outer Mongolia as a part of the Chinese federation) received the head of the Mongolian government, the first to visit the Chinese capital officially. On July 31, 1954, Chou En-lai, the prime minister of the Chinese People's Republic. visited Ulan Bator. This, too. was the first visit of a Chinese statesman to Outer Mongolia since it had ceased to be part of China.

Sandaiched between two great powers, the Mongols were successful in establishing their independence. By 1960, outside the 11 countries of the Socialist camp, only Burma. Cambodia. Cuba, India, Indonesia. Nepal and Yugoslavia had established diplomatic relations with Mongolia. Admission to the UN and establishment of normal relations with the United States and Great Britain were the main objects of Mongolian foreign policy.

POPULATION

About 91% of the inhabitants of the Mongolian People's Republic are Mongols. Two-thirds of them speak the Khalkha-Mongolian language, while the Oirat-Mongolian dialect is used in the western provinces. In the west also there are Turkic-speaking minorities (Kazakhs and Cighurs). A certain number of Russians; mainly advisers, technicians and skilled workers, and about 20,000 Chinese. rnostly workers, live in the towns. In 1925 the total population was estimated at 651,700 and in 1956 at 845,500. (Up to 1960 no census had ever been taken.) Before 1921 the Mongolian population was slowly dying out. Its increase within the frontiers of the hlongolian People's Republic is explained by the improvement of health measures and a decrease in venereal diseases. which were formerly widespread. In 1958 the natural increase of population was said to be 30.3 per 1,000, seven times more than in 1940.

Urbanization of the country has progressed. Ulan Bator, the capital. had 164.000 inhabitants in 1959, the town of Choybalsan 10.900, Jirgalanta (Hobdo) 5,800, Tsetserlig 9,000 and Sühe Baatar had 12,000.

Religion. — Lamaistic Buddhism, influenced by and in competition with native shamanism, was until the revolution the state religion in Mongolia. The Living Buddha of Urga, sometimes described as Khutukhtu (saint), was both religious head and national leader and was recognized as such by the Mongolian princes. although this was resented by the hlanchu dynasty. The Living Buddha had the largest number of *shabinar* or serfs. At the beginning of the 20th century it was estimated that their total number was 150,000. This meant that together with about 150,000 lamas (including 40.000 living permanently in 747 monasteries), about half of the population was directly under religious jurisdiction After the death of the last Living Buddha in 1924 this situation began to change. Officially, freedom of religion prevails, but by the mid-20th century Lamaism was subject to restriction and control. The majority of monasteries had been destroyed or turned to secular uses. A few former temples of historic and artistic value had been transformed into museums. The Gandan monastery in Ulan Bator and four other temples had re-established their religious function, and in 1959 the Mongol capital had a few dozen lamas.

GOVERNMENT AND ADMINISTRATION

The first constitution of 1924 was replaced by that of June 30, 1940, slightly amended in 1949 and 1952. By this, "the Mongolian People's Republic is an independent state of *arats* (livestock breeders). workers and intelligentsia, who have abolished the imperialist and feudal yoke, ensuring a noncapitalist approach to the development of the country to pave the way to the Socialism of the future." All the land and its natural resources belong to the people and private ownership of them is forbidden. but the right of citizens to private ownership of livestock, agricultural implements, houses, yurts (tents), incomes and savings. as well as the right of inheritance of private property. "is protected by law."

The republic consists of 18 *aymags* (regions) subdivided into *somons* (districts). The capital city of Ulan Bator is an independent administrative unit. (See Table.)

The highest organ of state authority is the great people's khural composed of deputies elected for three years on the basis of one for every 2,500 of the population, with universal franchise from the age of 18. The first general election took place on June 10, 1951. There were 295 constituencies in which 489.031 citizens recorded their votes (99.9% of the electorate); 487,358 voted for official candidates.

Administrative Aymags (Divisions) of the Mongolian People's Republic (1959)

Aymags	Chief cities
Tob (Tub) or Central	Dzun-modo
Hentey (Kentei)	Öndör Haan (Undur-Khan)
Doronod (Choybalsan)	Choybalsan (Choibalsan!
Suhe Baatar Sukhe-Bator)	Barun-Urt
Dorono Gobi or East Gobi'	Sayn Shanda (Sain-Shand)
Dunda Gobi or Middle Gobi	Mandal-Gobi
Ömönö Gobi (Umnu) or South Gobi	Dalan Dzadagad
Ara Hangay (Ara Khangai)	Tsetserlig (Tselserlik)
Bayan Hongor (Bayan-Khongor)	Bayan Hongor
Gobi Altay (Gobi-Altai)	Yusan-Bulak
Hobdo Kobdo)	Jirgalanta
Bayan Ölögey (Bayan-Ulegei)	Ölögey (Ulegei)
Ubsa Sur (Ubsu Hur)	Ulaan Goom (Clangom)
Dzabhan (Dzabkhan)	Jibhalanta (Ulyassutai)
Höbsögöl (Khubsugul)	Mörön (Muren)
Bulagan (Bulgan)	Bulagan tBulgan!
Öbör Hangay (Ubur Khangai)	Arbay Hesre (Arbai Khere)
Selenge	Sühe Baator

Regular sessions of the great people's khural are convened once a year. Between the sessions the presidium of the khural assumes the function of the highest state authority. The great khural appoints the council or' ministers. There are local khurals in the city of Ulan Bator and in every aymag and *somon.* Justice is administered by the supreme court of the republic, by the city court of Ulan Bator and by the aymag courts.

There is only one political party, the Mongolian People's Revolutionary (Communist) party. From 1940 Tsedenbal was the

parly's first secretary, combining this post with that of prime minister from 1952, when Choybalsan died (Jan. 26). In April 1954 he was succeeded as the party's first secretary by Dashiyin Damba, but in Nov. 1958 he again assumed the first secretaryship without abandoning the premiership. In March 1959, Damba, accused of conservatism, was dismissed from the party's politburo, together with five other members of this body.

Education.— Great strides have been made in combating illiteracy. In 1921 there existed in the entire country only one school with 50 pupils (excluding, of course, the lamaistic schools in the monasteries). In 1959 there were more than 400 schools for general education with about 117,000 pupils, the great majority being four-year schools, compulsory and free of charge for all children between the ages of 8 and 12. In the towns there were 31 seven-year and 24 ten-year schools, 15 vocational schools and 6 institutions of higher education, including the Mongolian State university which was opened in 1942 and had 2,500 students in 1959. It was claimed that by 1951 illiteracy had practically disappeared. In 1941 the government of the republic replaced the old Mongolian alphabet by one based on the Cyrillic, and the old Mongolian numerals by Arabic.

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ECONOMY

Pastoral pursuits still formed the livelihood of more than 80% of the population by mid-20th century, while from 70%–80% of the commodity production and more than 80% of the total exports derived from animal products. The total number of domestic stock in 1918 was only 12,700,000. This had risen to 27,500,000 in 1941. However, evidences of deteriorated ranges indicated that perhaps this number resulted in overcrowding of the grasslands. Efforts to increase numbers further have been unsuccessful, partly because of heavy annual stock losses from wolf attacks, diseases, droughts and severe winters. The winters of 1941–42 and 1944–45 resulted in such losses that total livestock numbers in 1947 were only 21,000,000. In 1956 the total fell short of the planned increase by 933,000 head and numbered 24,440.000. The distribution of types was as follows: sheep, 13,290,000; goats, 5,820,000; cattle, 2,090,000; camels, 851,000; and horses, 2,390,000. No other land on earth has so high a number of livestock per capita—about 24 for each person.

Most Mongols are *arats* or private owners of flocks and herds who follow their animals from one pasture land to another. The practice of providing fodder for winter feeding has been extensively introduced by the Russians. In 1956 an estimated total of 1.700.000 tons of hay was reported to have been gathered for winter use.

Cultivation is severely limited by low rainfall and a short growing season. The Mongols traditionally have abhorred agriculture and have generally left it to be carried on by Chinese and Russians. Approximately 175,000 ac. were under cultivation in 1912 but with decreased Chinese influence in the 1920s and 1930s this total fell to between 25,000 and 50,000 ac. Russian pressure during World War II resulted in the cultivation by 1944 of over 197.000 ac. distributed as follows among the major crops: wheat and rye, 87,450 ac.; oats, 43,960 ac.; barley, 40,500 ac.; millet, 18,280 ac.; and legumes and garden products, 8,150 ac. With the end of the war the total acreage declined and by 1947 was less than half the 1944 total. Thereafter Soviet prodding brought the total up to 207,854 ac. by 1956. Most of this land is state operated and is concentrated in the valleys of the Selenga, Orkhon and Onon rivers. Some of the crop land is irrigated.

Minerals found in the Mongolian People's Republic include non-coking brown coal extracted from seven mines at Nalaikha whose annual production in 1956 was between 40,000 and 60,000 tons. These figures were scheduled to be doubled with the opening of a new large mine in 1957. Coal is carried by rail to Ulan Bator where it is used for heat, electric power and light. Other coal deposits are being exploited near Choybalsan and at four other localities. Another source at Tawan-Tolgoi on the Trans-Mongolian railroad in the eastern Gobi also gave promise of future importance. Total coal production for the country in 1956 was 343,000 tons and production plans called for 637,000 tons in 1960.

Oil fields were found in the Sayn-Shanda region in the eastern Gobi district and were said to supply a significant part of Mongol oil requirements. Other important minerals were copper, lead, zinc, silver, gold, manganese, antimony, wolfram, tin, mercury, graphite and sulfur. Salt mas extracted and limestone processed for cement and lime. **A** Soviet-Mongol agency had charge of all mineral development until 1957 when control and investments were turned over to the Mongol state on condition that the latter was to amortize its debt to the Soviet Union in 30 years.

Industry, mining, transport, trade and professions (excluding the armed forces) in 1954 employed an estimated 90,000 persons, the bulk of these being Mongols. Industries are primarily concerned with animal products such as meat, fur and butter. In 1950 some 500 food-processing enterprises were said to be producing 44.8% of the country's industrial output.

Before 1921, Chinese merchants monopolized most of Mongolia's trade. By 1931 a Soviet trade agency, Stormong. had taken over the monopoly. External trade was later monopolized by Mongol state agencies. In internal trade, however, some 53% was handled by Mongol co-operatives in 1948, while state agencies handled 40%. Wool and live animals each comprised 30% of the exports. The north-south railroad through the capital was opened in Jan. 1956, connecting Peking with Siberia. A spur line runs south to Choybalsan from the Trans-Siberian railroad near the Manchurian border. Motor highways run roughly east-west through the middle of the country from Man-chu-li to the Soviet border at Kosch Agatsch, as well as north-south through the capital from the Soviet border to Dalan Dzadagad. A network of telephone and telegraph lines connects important places and there are also radio stations and airfields.

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MONGOLOID, a term used to designate one of the hypothetical major racial stocks or ethnic divisions of mankind, the others being Caucasoid and Negroid (see NEGRO). Mongoloids are supposed to resemble, in one way or another, the Mongols (*q.v.*). The use of the word as a racial designation implies that such resemblances are of a biological, hereditary nature rather than linguistic or cultural. In the narrower sense the name Mongoloid is applied only to those peoples who, like the Chinese, Japanese and their neighbours, are most like the Mongols. By extension, however, it has been applied to other populations which are supposed to be related to them. Such populations include the American Indians and the Indonesians or Malayans. Even such groups as the Lapps and Polynesians are thought, by many authorities, to be partially Mongoloid in ancestry.

Physical Characteristics.— It has long been apparent that differences exist in the typical appearance of members of different tribes and nations. The extent to which these differences are due to genetic rather than environmental causes has been much debated, but the fact that there are differences in appearance is obvious. Almost all natives of the countries of eastern Asia, for instance, have dark eyes, very dark coarse straight hair, and skin which, being less florid than that of Europeans, ranges in shade from pale ivory to deep yellow-brown. Their facial features are molded more smoothly than those of Europeans or Africans, and facial hair is scanty in both sexes, so that the difference between men and women in this respect is minimized. The cheekbones jut forward, neither the chin nor the brow ridges are prominent, and the bridge of the nose is rather low. In a large majority of individuals the eye appears to slant, because a fold of skin covers

the inner edge of the eyelid. The body tends to be stocky, with relatively short legs, and body hair is almost absent even among men, while among women the breasts are usually rather small.

In southeast Asia, and even more in Indonesia, the inhabitants tend to be shorter and slighter in build. The average skin colour is darker, the lips fuller, the nose broader. Men, at least, are less likely to have the epicanthic eye fold; women are more likely to have larger breasts. Wavy hair is less uncommon. The resemblance to the Chinese and Japanese is, however, quite obvious. Among American Indians, in contrast, a great range of intertribal variation is found. Typically, women have a closer resemblance to the peoples of eastern Asia than do men, for the latter, among many tribes, have high-bridged noses, prominent brow ridges and marked angularity in features generally. Facial and body hair is very scant, but baldness and even graying of hair with age are rare. The skin colour may be pale but is commonly even darker than among the peoples of Indonesia. A closer examination shows that American Indians resemble the peoples of eastern Asia, but differ from most other peoples, in the high frequency among them of shovel-shaped incisor teeth, a counterclockwise lambdoidal hair whorl, the Inca bone at the back of the skull and arches rather than whorls in the fingerprints. It is probable that these characters, like hair and eye pigmentation and hair quantity, are altered very little by environmental effects, which makes them much more useful as criteria of ancestral relationship. Indeed, since races are populations which differ in the relative frequencies of genes, there would be no assurance that the Mongoloids are a racial stock unless it could be demonstrated that their similarities, and the ways in which they differ from other ethnic groups, are genetically based. *(See* also FACE; HAIR.)

Blood Types and Biochemistry.— Knowledge of the mode of inheritance of human characteristics is mcst inadequate, but enough has been learned, especially in the field of serology, to make it possible to say that Mongoloid populations, whether in America or Asia, have a very low frequency of the allele for bloodtype A, in the ABO series, of the alleles for the blood types known as R^o, D^u, and negative in the Rh series, and lack the alleles for the abnormal hemoglobins which lead to sicklemia or thalassemia. These same populations have a rather low to very low frequency of the alleles for blood types N and Duffy negative, for red green colour blindness and for absence of the palmaris longus muscle (in the forearm), as contrasted with other human populations. Only among Mongoloid populations can the allele for the blood factor Diego be demonstrated to exist. Studies of characters of which the mode of inheritance is known are in general agreement with previous studies and serve to define more precisely the characteristics which unite Mongoloid populations.

Such studies have also served to define the differences between various populations of Mongoloid origin. American Indians, for instance, apparently lack the alleles for blood types B, A, and Rh negative completely; and even A_1, with the exception of a few tribes, is a rare allele. Very few tribes seem to possess the allele for type R^o, but many possess an especially high frequency of R^2, in the Rh series. Japanese, as contrasted with Chinese, have a lower frequency of B and of R^o alleles, but a higher frequency of the allele for the peroneus tertius, one of the anterior muscles of the lower leg. The greater frequency of hair on the lower legs of the Japanese as contrasted with the Chinese suggest further genetic differences between these two populations. These are, however, minor as compared to the differences between the Asian Mongoloid and the American Indian populations.

Ecology.— Ecological adaptation would appear to offer the most plausible explanation for some, but by no means all, of the features which distinguish Mongoloid from non-Mongoloid populations. Stocky build, short limbs, facial hairlessness and the general conformation of the face should provide advantages to a well-clothed arctic hunter; and it is true that these characteristics are found most frequently among those populations, such as the Eskimo and the Tungus, which inhabit the coldest areas of Siberia and North America. Adaptation to a lack of iodine in central Asia has been advanced as an explanation of the type and distribution of hair and of the high frequency of round headedness. There certainly seems to be a high correlation between average weight and climate, and some correlation between nose breadth and climate, among the various Mongoloid populations. Paedomorphism, or the retention into adult life of youthful characteristics, has been suggested as an explanation for such traits of the Asian Mongoloids as their short legs, lack of hirsuteness, lack of facial angularity and the small size of the female breast. It should be noted that none of these conjectures are mutually exclusive.

Archaeology.— It must also be noted that paucity of archaeological evidence prevents us from knowing for how long a period the characteristics of Mongoloids have been distinctive. The earliest skeletal remains from the Americas resemble those of the Indians of historic times, but they are not very early. *Sinanthropus,* who lived in north China during the second interglacial period, had shovel-shaped incisors, but he was anything but paedomorphic and is not even regarded as a member of the species *Homo sapiens,* to which all living races belong. Among a group of much later inhabitants of this same locality, one only, a female, resembles a typical Mongoloid. The earliest skulls from Japan, more recent in date, bear some resemblance to those of modern Japanese; and by the time of the Neolithic period, skeletal remains from China appear to be those of Chinese. In Indonesia, crania like those of the modern inhabitants seem to be relatively recent.

About one-third of the living inhabitants of the world are members of one or another of the Mongoloid populations. At the time of the discovery of America by the Europeans the proportion was probably greater. Historical and archaeological evidence both indicate that there has been a continuous drift of peoples from the general area of northern China to the south for thousands of years, as well as sporadic movements to the west and into the Pacific. Archaeological and genetic evidence indicate that the movement of tribes or bands into America took place much earlier, and for the most part before the Asian Mongoloids had evolved all of their present characteristics.

See also ANTHROPOLOGY: *Physical;* RACES OF MANKIND.

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MONGOLS, the name of one of the chief ethnographical divisions of Asiatic peoples *(see* also TURKS OR TURKIC PEOPLES). The early history of the blongols, like that of all central-Asian tribes, is obscure. Even the meaning of the name "Mongol" is a disputed point, though a general consent is given to Schott's etymology of the word from *mong,* meaning brave. From the earliest and scanty notice we have of the Mongols in the history of the T'ang dynasty of China (A.D. 619–690), and in works of later times, it appears that their original camping-grounds were along the courses of the Kerulen, Upper Nonni and Argun rivers. But in the absence of all historical particulars of their origin, legend, as is usual, has been busy with their early years. The Mongol historian, Sanang Setsen, gives currency to the rnyth that they sprang from a blue wolf; and the soberest story on record is that their ancestor Budantsar was miraculously conceived of a Mongol widow. By craft and violence Budantsar gained the chieftainship over a tribe living in the neighbourhood of his mother's tent, and thus left a heritage to his son. Varying fortunes attended the descendants of Budantsar, but on the whole their power gradually increased, until Yesukai, the father of Jenghiz Khan, who was eighth in descent from Budantsar, made his authority felt over a considerable area. For the extension of Mongoi dominion under his son *see* JENGHIZ KHAN.

Ogdai Khan.— Over the whole of the vast region stretching from the banks of the Dnieper to the China Sea, Jenghiz Khan set his second surviving son Ogotai, or Ogdai, as khagan, or chief khan, while to the family of his deceased eldest son, Juji, he assigned the country from Kayalik and Khwarizm to the borders of Bulgar and Saksin "where'er the hoofs of Mongol horse had tramped"; to Jagatai, his eldest surviving son, the territory from the borders of the Uighur country to Bukhārā; while Tulē, the youngest, received charge of the home country of the Mongols,

the care of the imperial encampment and family, and of the archives of the State. The appointment of Ogdai as his successor, being contrary to the usual Mongol custom of primogeniture, caused some bitterness among the followers of Jagatai, but Ogdai was finally led to the throne by his dispossessed brother amid the plaudits of the assembled Mongols. Once fairly on the throne he set himself vigorously to follow up the conquests won by his father. At the head of a large army he marched southwards into China to complete the ruin of the Kin dynasty, which had already been so rudely shaken, while at the same time Tulē advanced into the province of Honan from the side of Shensi. Against this combined attack the Kin troops made a vigorous stand, but the skill and courage of the Mongols bore down every opposition, and over a hecatomb of slaughtered foes they captured Kai-fêng Fu, the capital of their enemies. From Kai-fêng Fu the emperor fled to Ju-ning Fu, whither the Mongols quickly followed. After sustaining a siege for some weeks, and enduring all the horrors of starvation, the garrison submitted to the Mongols, and at the same time the emperor committed suicide by hanging. Thus fell in 1234 the Kin or "golden" dynasty, which had ruled over the northern portion of China for more than a century.

His first essay in extending the empire in the fertile provinces of China meeting with such success, Ogdai remembered the obligation laid upon him by his father's conquests in Western Asia. Jelāl-ed-din had been driven into India when Jenghiz annexed Khwarizm, but he had returned with the support of the sultan of Delhi, reconquered his own domain and advanced westward to Tiflis and Kelat. Ogdai sent 300,000 men into Khwarizm; they marched so rapidly upon the foe that the advance-guards reached Amid (Jelāl-ed-dīn's retreat) before that monarch had any idea of their approach. Accompanied by a few followers, Jelāl-ed-dīn fled to the Kurdish mountains, where he was basely murdered by a peasant. The primary object of the Mongol invasion was thus accomplished; and, unchecked and almost unopposed, they overran the districts of Diarbekr, Mesopotamia, Erbil and Kelat, and then advanced upon Azerbaijan. In the following year (1236) they invaded Georgia and Great Armenia, committing frightful atrocities. Tiflis was among the cities captured by assault, and Kars was surrendered at their approach. Meanwhile in 1235, Ogdai despatched three armies in as many directions. One was directed against Korea, one against the Sung dynasty, which ruled over the provinces of China south of the Yangtsze Kiang, and the third was sent westward under Batu into eastern Europe.

With irresistible vigour and astonishing speed the Mongols made their way through the forests of Penza and Tambov, and appeared before the "beautiful city" of Ryazan. For five days they discharged a ceaseless 'storm of shot from their balistas, and, having made a breach in the defences, carried the city by assault on Dec. 21, 1237. Moscow, at this time a place of little importance, next fell to the invaders, who then advanced against Vladimir, which at length succumbed. A dire fate overtook the inhabitants of Kozelsk, near Kaluga, where, in revenge for a partial defeat inflicted on a Mongol force, the followers of Batu held so terrible a "carnival of death" that the city was renamed by its captors Mobalig, "the city of woe." With the tide of victory thus strong in their favour the Mongols advanced against Kiev, "the mother of cities," and carried it by assault. The inevitable massacre followed and the city was razed to the ground.

Victorious and always advancing, the Mongols, having desolated this portion of Russia, moved on in two divisions, one under Batu into Hungary, and the other under Baidar and Kaidu into Poland. Without a check, Batu marched to the neighbourhood of Budapest, where the whole force of the kingdom was arrayed to resist him. While the careless Hungarians were sleeping, Batu launched his attack. Panic-stricken and helpless, they fled in all directions, followed by their merciless foe; the roads for two days' journey from the field of battle were strewn with corpses. The king, Bēla IV., was saved by the fleetness of his horse, though closely pursued by a body of Mongols, who followed at his heels as far as the coast of the Adriatic, burning and destroying everything in their way. Meanwhile Batu captured Budapest, and on Christmas day 1241, having crossed the Danube on the ice, took Esztergom by assault. While Batu had been thus triumphing, the force under Baidar and Kaidu had carried fire and sword into Poland. While laying waste the country they received the announcement of the death of Ogdai, and at the same time a summons for Batu to return eastwards into Mongolia.

While his lieutenants had been thus carrying his arms in all directions, Ogdai had been giving himself up to ignoble ease and licentiousness which ended in his death on Dec. 11, 1241. He was succeeded by his son Kuyuk, who reigned only seven years. On the death of Kuyuk, dissensions which had been for a long time smouldering between the houses of Ogdai and Jagatai broke out into open war, and after the short and disputed reigns of Kaidu and Chapai, grandsons of Ogdai, the lordship passed away for ever from the house of Ogdai. It did not go, however, to the house of Jagatai, but to that of Tulē.

Mangu Khan and **Hulagu.**—On July 1, 1251, Mangu, the eldest son of Tulē, and nephew to Ogdai, was elected khagan. With perfect impartiality, Mangu showed tolerance to the Christians, Mohammedans and Buddhists among his subjects although Shamanism was recognized as the State religion. Two years after his accession his court was visited by Rubruquis (*q.v.*) and other Christian monks, who were hospitably received. The description given by Rubruquis of the khagan's palace at Karakorum shows how wide was the interval which separated him from the nomad, tent-living life of his forefathers. On his accession complaints reached Mangu that dissensions had broken out in the province of Persia, and he therefore sent a force under the command of his brother Hulagu to punish the Ismailites or Assassins (*q.v.*), who were held to be the cause of the disorder. Marching by Samarkand and Karshi, Hulagu crossed the Oxus and advanced by way of Balkh into the province of Kuhistan or Kohistan. The terror of the Mongol name induced Rukneddin Gurshah II, the chief of the Assassins, to deprecate temporarily the wrath of Hulagu by offers of submission, but Rukneddin having been killed, 1256, Hulagu marched across the snowy mountains in the direction of Baghdad to attack the last Abbasid caliph and his Seljuk protectors. On arriving before the town he demanded its surrender. This being refused, he laid siege to the walls in the usual destructive Mongol fashion, and at length, finding resistance hopeless, the caliph was induced to give himself up and to open the gates to his enemies. On Feb. 15, 1258, the Mongols entered the walls and sacked the city (see CALIPHATE ad *fin.*). While at Baghdad Hulagu gave his astronomer, Nāsir ed-din, permission to build an observatory, which, splendidly furnished with armillary spheres and astrolabes, was erected at Maragha. The fall of Baghdad was almost contemporaneous with the end of the Seljuks of Konia as an independent power, though their actual destruction did not take place until 1308 (see SELJUKS).

The Mongol invasion resulted in a famine which desolated 'Iraq-Arabi, Mesopotamia, Syria and Rūm. The Mongols did not starve with the people but went forward through Syria. Aleppo was sacked, Damascus surrendered (1260) and Hulagu was meditating the capture of Jerusalem to restore it to the Christians when news of Mangu's death reached him and he returned to Mongolia leaving Kitboga in command of his Syrian forces.

Hitherto a vassal of Mangu, as is shown by his striking coins bearing the name of Mangu as well as his own, Hulagu was now recognized as ruler of the conquered provinces. He assumed the title of ilkhan, and, although acknowledging the khagan as supreme lord, was practically independent. The title of ilkhan was that borne by his successors, who ruled over Persia for about a century (*v. infra*, "The Ilkhans of Persia").

While Hulagu was prosecuting these conquests in western Asia, Mangu and his next brother Kublai were pursuing a like course in southern China. Southward they even advanced into Tong-king, and westward they carried their arms over the frontier into Tibet. Under the wise command of Kublai all indiscriminate massacres were forbidden, and probably for the first time in Mongol history the inhabitants and garrisons of captured cities were treated with humanity. While carrying on the war in the province of Szechwan Mangu was seized with an attack of dysentery, which proved fatal after a few days' illness. His body was carried into Mongolia on

the backs of two asses, and, in pursuance of the custom of slaughtering everyone encountered on the way, 20,000 persons were, according to Marco Polo, put to the sword.

At the Kuriltai, or assembly of notables, which was held at Shang-tu after the death of Mangu, his brother Kublai (see KUBLAI KHAN) was elected khagan. For 35 years he sat on the Mongol throne, and at his death in 1294, in his 79th year, he was succeeded by his son Timur Khan (or Uldsheitu Khan, Chinese, Yuen-chêng). During this reign the division between the Ogdai and Jagatai families and that of the ruling khagan was healed. Uldsheitu was succeeded by his nephew Khaissan, who died in Feb. 1311, after a short reign, and at the early age of 31. His nephew and successor, Buyantu (Chinese, Yen-tsung), was a man of considerable culture, and substantially patronized Chinese literature. Among other benefits which he conferred on letters he rescued the celebrated inscription-bearing "stone-drums," which are commonly said to be of the Chou period (1122–249 B.C.), from the decay and ruin to which they were left by the last emperor of the Kin dynasty, and placed them in the gateway of the temple of Confucius at Peking, where they now stand. After a reign of nine years, Buyantu was succeeded by his son Gegen (Chinese, Ying-tsung), who perished in 1323 by the knife of an assassin. Yissun Timur (Chinese, Tai-ting-ti), who was the next sovereign, devoted himself mainly to the administration of his empire. He divided China, which until that time had been apportioned into 12 provinces, into 18 provinces, and rearranged the system of State granaries, which had fallen into disorder. His court was visited by Friar Odoric (*q.v.*), who gives a minute description of the palace and its inhabitants.

FROM HENRY YULE, "BOOK OF SER MARCO POLO (JOHN MURRAY)

KUBLAI KHAN (A.D. 1216–1294), FROM A CHINESE ENGRAVING

The following years were years of great natural and political convulsions. In 1355 a Buddhist priest named Chu Yuan-chang became so impressed with the misery of his countrymen that he threw off his vestments and enrolled himself in the rebel army. His military genius soon raised him to the position of a leader, and with extraordinary success he overcame with his rude levies the trained legions of the Mongol emperor. While unable to defeat or check the rebels in the central provinces, Toghon Timur Khan was also called upon to face a rebellion in Korea. Nor were his arms more fortunate in the north than in the south. Toghon Timur, by a hasty flight, escaped from his enemies and sought safety on the shores of the Dolon-nor in Mongolia. For a time the western provinces of China continued to hold out against the rebels, but with the flight of Toghon Timur the Mongol troops lost heart, and in 1368 the ex-Buddhist priest ascended the throne as the first sovereign of the Ming or "Bright" dynasty, under the title of Hung-wu.

Thus ended the sovereignty of the house of Jenghiz Khan in China. Brave and hardy the Mongols have always shown themselves to be; but the capacity for consolidating the fruits of victory, for establishing a settled form of government, and for gaining the allegiance of the conquered peoples, has invariably been wanting in them.

Not content with having recovered China, the emperor Hung-wu sent an army of 400,000 men into Mongolia in pursuit of the forces which yet remained to the khagan. Even on their own ground the disheartened Mongols failed in their resistance to the Chinese, and at all points suffered disaster. Meanwhile Toghon Timur, who did not long survive his defeat, was succeeded in the khaganate by Biliktu Khan, who again, in 1379, was followed by Ussakhal Khan During the reign of this last prince the Chinese again invaded Mongolia, and inflicted a crushing defeat on the khan's forces in the neighbourhood of Lake Buyur This defeat was the final ruin of the eastern branch of the Mongols. who from this time surrendered the supremacy to the western division of the tribe. At first the Keraits or Torgod, as in the early days before Jenghiz Khan rose to power, exercised lordship over the eastern Mongols, but from these the supremacy passed to the Oirad, who for 50 years treated them as vassals. Notwithstanding their subjection, however, the Keraits still preserved the imperial line. Gradually, however, the Mongol tribes broke away from all governing centres, and established scattered communities with as many chiefs over the whole of eastern Mongolia. The discredit of having finally disintegrated the tribe is generally attached to Lingdan Khan (1604–34).

The Chakhars.—By this time the Mongols had recovered from the disaster suffered at the hands of the first Ming ruler. Driven to the north they retired to the banks of the Kerulen, their original home, but as the Chinese became weaker on the frontier they pushed southward and occupied the Ordos country. The Mongol royal family and their immediate surroundings occupied the Chakhar country to the north-west of the Ordos territory, where they became eventually subjugated by the Manchus who overthrew the Ming dynasty in 1644. At times the old vigour and strength seemed to return to the tribe, and we read of successful expeditions being made by the Ordos Mongols into Tibet, and even of invasions into China. The relations with Tibet thus inaugurated brought about a rapid spread of Buddhism among the Mongolians, and in the beginning of the 17th century a Dalai Lama was born among them. In 1625 Toba, one of the sons of Bushuktu Jinung Khan, went on a pilgrimage to the Dalai Lama, and brought back with him a copy of the Tanjur to be translated into Mongolian, as the Kanjur had already been.

Several of the tribes who had originally migrated with those who finally settled in the Ordos territory, finding the country to be so inhospitable, moved farther eastward into richer pastures. Among these were the Tumeds, one of whose chiefs, Altan Khan (Chinese, Yen-ta), is famous in later Mongol history for the power he acquired During the 16th century he carried on continuous warfare with China. and on peace being made (1571) he was made a prince of the empire. He was as successful also in Tibet, and he brought back Lama prisoners who spread Lamaism through all the Tumeds. Altan died in 1584 and was succeeded by his son Senge Dugureng Timur.

The Khalkha Mongols.—North of the Gobi desert live the Eastern and Western Khalkhas. In the early 17th century the Russians sent an embassy to the khan persuading him to acknowledge allegiance to the tsar. The allegiance was lightly sworn and lightly thrown off, and when the Russians attacked the Khirghiz the Mongols aided the latter. In spite of submission to Russia the Mongols had no protection against Chinese attacks on the south and the Manchus demanded Mongol submission in their turn. When the Kalmucks begdn to menace them the Khalkhas claimed Chinese protection, and the emperor K'ang-hsi invited all the Khalkha chiefs to meet him on the plain of Dolon-nor. This ceremony resulted in the absorption of the Khalkhas into the Chinese race.

The Torgod.—During the Kin dynasty of China the Keraits, as has been pointed out, were for a time supreme in Mongolia, and it was during that period that one of the earliest recognized sovereigns, Merghus Buyuruk Khan, sat on the throne. A grandson of Merghus was the celebrated Wang Khan, who was sometimes the ally and sometimes the enemy of Jenghiz Khan, and has also been identified as the Prester John of early western writers. In war he was almost invariably unfortunate, and it was with no great difficulty, therefore, that his brother Ki Wang detached the greater pdrt of the Kerait tribes from his banner and founded the Torgod chieftainship, named probably from the country where they settled themselves. Their history for several centuries consists of nothing but a succession of wars with the tribes on either side of them, and it was not until 1672, when Ayuka Khan opened relations with the Russians, that the country obtained an even temporarily settled existence. It was necessary, from the position of the territory, to conciliate either the Russians or the Turks. Frequent invasion from the north led to complaints of the tsar's government and friendly relations with the Krim Khan. Ayuka fought his way to Kazan and, having exacted full vengeance, made

peace with Russia, confirmed in 1722 at a conference with Peter the Great at Astrakhan. Ayuka was shortly succeeded by his son, Cheren Donduk, whose patent to the throne from the Dalai Lama did not protect him from the plots of his nephew, Donduk Ombo, who drove his uncle to St. Petersburg and seized the throne. Donduk Ombo governed wisely and with vigour, and was succeeded by Donduk Taishi, who went to Moscow to attend the coronation of the Empress Elizabeth and to swear fealty to the Russians. He was succeeded by his son Ubasha, who, in the war between his two powerful neighbours in 1769 and 1770, gave valuable assistance to the Russians. He determined to migrate eastward with his people, and on Jan. 5, 1771, he began his march with 70,000 families. In vain the Russians attempted to recall the fugitives, who, in spite of infinite hardships, after a journey of eight months reached the province of Ili, where they were welcomed by the Chinese authorities. Food for a year's consumption was supplied to each family; and land, money and cattle were freely distributed. It is believed that 300,000 persons survived to receive the hospitality of the Chinese. The Torgod prospered, but lost their individuality in absorption into the Chinese race.

The **Kalmucks.**—Among the Mongol chiefs who rose to fame during the rule of the Ming dynasty of China was Toghon, the Kalmuck khan, who, taking advantage of the state of confusion which reigned among the tribes of Mongolia, established for himself an empire in north-western Asia. He died in 1444 and was succeeded by his son, Yi-hsien, who was vigorous and ambitious. He attacked China and took the emperor (Chêng-t'ung) prisoner. Subsequent defeats made him open negotiations for the restoration of Chêng-t'ung. After Yi-hsien's death the Kalmucks lost much of their power in eastern Asia but still ravaged the Russian borders. In the 17th century Galdan restored some of their authority; taking advantage of a quarrel between the Black and White Mountaineers of Kashgar, he overran Little Bukhārā and left a viceroy there, with his capital at Yarkand. He made an alliance with China and then attacked the Khalkhas, but K'ang-hsi decided to support the Khalkhas. The Chinese marched into Mongolia and met Galdan's forces at Chao-modo where they routed them utterly. For a time Galdan strove to turn the tables on the Chinese but he died in the field, unsuccessful. Tsi-wang Arabtan, his successor, weakened his power by a dispute with the Russians over Little Bukhārā, said to be rich in gold. Peter the Great determined to force his way into the country and to oppose him the Kalmucks assembled in force. Tsi-wang's successor, Amursama, was appointed by the Chinese emperor K'ien Lung, who called him khan of the Kalmucks, and chief of Dzungaria (*q.v.*). But the real power was vested in Chinese commissioners, and Amursama revolted, dispersed the garrisons stationed in Ili and took Palikun. K'ien Lung sent a large force against the rebel and drove him into Siberia where he died of smallpox. China again absorbed a Mongol tribe, vying with Russia, her chief competitor in Mongol affairs. The Buriats, who occupied much territory on both sides of Lake Baikal, were not absorbed although they became "Russians."

The House of **Jagatai.**—The dominions given by Jenghiz Khan to his son Jagatai were involved in the quarrels between Kaidu and Kublai for the khaganate, but at the beginning of the 14th century Dua, a great-great-grandson of Jagatai, made himself undisputed lord of the whole region. Shortly after Dua's death the Mongols of eastern Turkistan, descendants of those who had favoured the pretensions of Kaidu to be khagan, separated from their western brethren and chose a son of Dua as their khan. Henceforth the Jagatais were divided into two dynasties, the western reigning at Samarkand, the eastern first at Kashgar and later at Yarkand and Aksu. Kazan (1343–46) was the last independent khan of the western Jagatais; thereafter power fell into the hands of amirs, who, however, continued to place a titular khan on the throne. In 1360 Toghluk-Timur, a grandson of Dua and khan of the eastern Jagatais (the kingdom called by the Persian historians Mogolistan), invaded the territories of the western Jagatais. About this time Timur (*q.v.*), otherwise Timur-i-leng (Tamerlane), a young amir at the court of the western Jagatais, allied himself with the leaders who had dethroned Kazan, and after the death of Toghluk-Timur became by right of conquest khan of both sections of the Jagatais. After Timur's death the two sections again divided, while a third kingdom, Ferghana, was held by the Timurids (descendants of Timur). At the beginning of the 16th century all three dynasties were swept away by Mohammed Shaibani, head of the Uzbeg Mongols (v. *infra,* "Uzbegs").

The Ilkhans of Persia.—The empire of the ilkhans established by Hulagu lasted nominally until 1353, but after the death of the ilkhan Abu Said in 1335 the real power was divided between five petty dynasties which had been formed out of the provinces conquered by Hulagu. Meantime Islam had made great progress among the Mongols, the third ilkhan, Nikudar Ahmed (reigned 1281–84), having embraced that faith. Upon the western frontiers of their empire bordering on the Syrian possessions of Egypt there was frequent intercourse, sometimes friendly, sometimes warlike, between the ilkhans and the sultans of Egypt (*q.v.*). Of the petty dynasties which supplanted that of Hulagu, one known as the Jelairids held Baghdad until about 1400. Another dynasty which reigned in Azerbaijan was overthrown in 1355 by the western Kipchaks (see below, *Golden* Horde). Between 1369 and 1400 Timur had made himself master of the greater part of Persia and established there a second Mongol dynasty, which in turn gave place to that of the Ak Kuyunli (see PERSIA).

The Golden Horde.--Of the Mongol tribes who became entirely subject to Russia the principal are those of the Crimea, of Kazan, and Astrakhan; of these the Tatars of Kazan are the truest representatives of the Golden Horde or western Kipchaks, who originally formed the subjects of Batu and Orda. Batu fixed his headquarters on the Volga, and there set up his golden tent from which the horde acquired its name. In 1255 Batu died and was succeeded by his brother, Bereke Khan. During the reign of this sovereign the exactions which were demanded from the Russian Christians by the Mongols aroused the Christian world against the barbarian conquerors, and at the command of Pope Alexander IV. a general crusade was preached against them. The crusaders, lacking unity, were surprised when a Tatar host, led by Nogai and Tulabagha, appeared in Poland. After a rapid and triumphant march the invaders took and destroyed Cracow, and thence advanced as far as Bythom (Beuthen) in Oppeln, from which point they eventually retired, carrying with them a crowd of Christian slaves.

From this time the Mongols became an important factor in European politics. They corresponded and treated with the European sovereigns, and intermarried with royal families. Hulagu married a daughter of Michael Palaeologus; Toktu Khan took as his wife Maria, the daughter of Andronicus II.; and to Nogai Michael betrothed his daughter Irene. Toktu, the second khan in succession to Bereke, is the first Mongol ruler of whom we hear as having struck coins. Those issued during his reign bear the mint marks of Sarai, New Sarai, Bulgar, Ukek, Khwarizm, Krim, Jullad and Madjarui, and vary in date from 1291 to 1312.

The adoption of Islam by the rulers of the Golden Horde drew closer the relations of the Mongols with Constantinople and Egypt. Nāṣir, ruler of Egypt, sent to demand in marriage a princess of the house of Jenghiz Khan. At first his request was refused by the proud Mongols, but the present of a million gold dinars, besides a number of horses and suits of armour, resulted in a princess landing at Alexandria in regal state in 1319. With that religious toleration common to his race, Uzbeg Khan, having married one princess to Nāṣir, gave another in marriage to George the prince of Moscow. Uzbeg protected the Russian churches within his frontiers, and put his seal to his new religious views by marrying a daughter of the Greek emperor, Andronicus III. He died in 1340, after a reign of 28 years. His coins were struck at Sarai, Khwarizm, Mokshi, Bulgar, Azak and Krim, and are dated from 1313 to 1340. His son and successor, Tinibeg Khan, after a reign of only a few months, was murdered by his brother, Janibeg Khan, who usurped his throne, which was snatched from him by violence in 1357. As he lay ill on his return from a successful expedition against Persia he was murdered by his son Berdibeg, who, in his turn was, after a short reign, murdered by his son Kulpa. With the death of Berdibeg the fortunes of the Gclden Horde began

rapidly to decline. *See* also article **Golden Horde.**

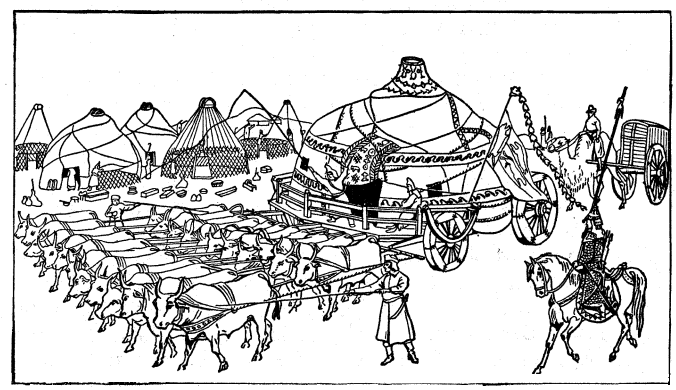
The White Horde or Eastern Kipchak.—While the power of the Golden Horde was dwindling away, the White Horde or Eastern Kipchak, which was the inheritance of the elder branch of the family of Juji, remained vigorous and prosperous. The descendants of Orda, Batu's elder brother, maintained much of the simplicity and vigour of their nomad ancestors, and the throne descended from father to son with undiminished authority until the reign of Urus Khan (1360). Khan Tuli Khoja paid with his life for his temerity in opposing the political plans of his connection with Urus Khan. Toktamish, the son of the murdered man, fled at the news of his father's death and sought refuge at the court of Timur, who received him with honour and at once agreed to espouse his cause. With this intention he despatched a force against Urus Khan, and gained some advantage over him, but, while fitting out another army to make a fresh attack, news reached him of the death of Urus.

He was followed on the throne by his two sons, Tuktakia and Timur Malik, each in turn; the first reigned but for a few weeks, and the second was killed in a battle against Toktamish, the son of his father's enemy. Toktamish seized the throne (1378), not only of Eastern Kipchak but also of the Golden Horde, over which his arms had at the same time proved victorious. He reigned as Nāṣir ed-din Jetal el Mahmud Ghujas Toktamish. His demands for tribute from the Russian princes met with refusal, and Toktamish therefore at once marched an army into Russia. Having captured Serpukhov, he advanced on Moscow. On Aug. 23, 1382, his troops appeared before the doomed city, and a general slaughter followed. The same pitiless fate overtook Vladimir, Zvenigorod, Yuriev, Mozhaisk and Dimitrov. With better fortune, the inhabitants of Pereslavl and Kolomna escaped with their lives from the troops of Toktamish, but at the expense of their cities, which were burned to the ground. Flushed with success, Toktamish demanded from his patron Timur the restoration of Khwarizm, which had fallen into the hands of the latter at a period when disorder reigned in the Golden Horde. On Timur's refusal Toktamish marched an army of 90,000 men against Tabriz. After a siege of eight days the city was taken by assault and ruthlessly ravaged. In the meantime Timur was collecting forces to punish his rebellious protégé. When his plans were fully matured, he advanced upon Old Urgenj and captured it. More merciful than Toktamish, he transported the inhabitants to Samarkand, but in order to mark his anger against the rebellious city he levelled it with the ground and sowed barley on the site where it had stood. On the banks of the Oxus he encountered his enemy, and after a bloody battle completely routed the Kipchaks, who fled in confusion. A lull followed this victory, but in 1390 Timur again took the field. After a considerable delay, owing to an illness which overtook Timur, his troops arrived at Kara Saman. Here envoys arrived from Toktamish bearing presents and a message asking pardon for his past conduct; but Timur was inexorable. He marched forward month after month through the Kipchak country in pursuit of Toktamish. At last, on June 18, he overtook him at Kandurcha, in the country of the Bulgars, and at once forced him to an engagement. For three days the battle lasted, and finally the Kipchaks were completely routed and fled in all directions.

Toktamish, though defeated, was not subdued, and in 1395 Timur found it necessary again to undertake a campaign against him. This time the armies met upon the Terek, and after a fiercely contested battle the Kipchaks again fled in confusion. Timur, threatened by the advancing autumn, gave up further pursuit, and retired with a vast booty of gold ingots, silver bars, pieces of Antioch linen and of the embroidered cloth of Russia, etc. On his homeward march southwards he arrived before Azak, which was then the entrepôt where the merchants of the east and west exchanged their wares. In vain the natives, with the Egyptian, Venetian, Genoese, Catalan and Basque inhabitants, besought him to spare the city. Circassia and Georgia next felt his iron heel, and the fastnesses of the central Caucasus were one and all destroyed. Timur rested for a time in luxurious splendour and then marched against and utterly destroyed Astrakhan. Sarai was similarly treated and Timur having destroyed the empire of Toktarnish for the second time returned home.

The Krim Tatars.—The power in the hands of the successors of Toktamish never revived after the last campaign of Timur. They were constantly engaged in wars with the Russians and the Krim Tatars, with whom the Russians had allied themselves, and by degrees their empire decayed, until, on the seizure and death of Ahmad Khan at the beginning of the 16th century, the domination of the Golden Horde came to an end.

The fate which thus overtook the Golden Horde was destined to be shared by all the western branches of the great Mongol family. The khans of Kazan and Kasimov had already in 1552 succumbed to the growing power of Russia, and the Krim Tatars were next to fall under the same yoke. In 1453 Constantinople had been taken by the Osmanli Turks, who, having quarrelled with the Genoese merchants who monopolized the trade on the Black sea, sent an expedition into the Crimea to punish the presumptuous traders. The po er which had captured Constantinople was not likely to be held in check by any forces at the disposal of the Genoese, and without any serious opposition Kaffa, Sudak, Balaklava and Inkerman fell before the troops of the sultan Mohammed. It was plain that, situated as the Crimea was, between the two great powers of Russia and Turkey, it must of necessity fall under the direction of one of them. Which it should be was decided by the invasion of the Turks, who restored Mengli Girai, the deposed khan, to the throne and virtually converted the khanate into a dependency of Constantinople. But though under the tutelage of Turkey, Mengli Girai, whose leading policy seems to have been the desire to strengthen himself against the khans of the Golden Horde, formed a close alliance with the grand-prince Ivan of Russia. Mohammed Girai Khan in 1521 marched an army northwards until, after having devastated the country, massacred the people, and desecrated the churches on his route, he arrived at the heights of Vorobiev overlooking Moscow. A treaty was arranged by which the grand-prince Basil undertook to pay a perpetual tribute to the Krim khans. Before long, however, a contention arose over the khanate of Kazan, recovered by the Mongols and lost again to Russia together with Astrakhan in 1555. The sultan, however, declined to accept this condition of things as final, and instigated Devlet Girai, the Krim khan, to attempt their recovery. On arriving before Moscow walls the latter found a large Russian force occupying the suburbs. With these, however, he was saved from an encounter, for just as his foremost men approached the town a fire broke out, which, in consequence of the high wind



FROM HENRY YULE, "BOOK OF SER MARCO POLO" (JOHN MURRAY)

MEDIAEVAL TATAR HUTS AND WAGONS. A PAVILION OF WANDS. COVERED WITH CLOTH, IS SHOWN; ERECTED ON A LARGE WAGON DRAWN BY 22 OXEN

blowing at the time, spread with frightful rapidity and in the space of six hours destroyed all the churches, palaces and houses, with the exception of the Kremlin, within a compass of 30 miles. Another invasion of Russia, a few years later (1572), was not so fortunate for the Mongols, who suffered a severe defeat near Molodi, 50 versts from Moscow. A campaign against Persia made a diversion in the wars which were constantly waged between the Krim khan and the Russians, Cossacks and Poles. So hardly were these last pressed by their pertinacious enemies in 1649 that they bound themselves by treaty to pay an annual subsidy to the khan.

But the fortunes of war were not always on the side of the Tatars, and with the advent of Peter the Great to the Russian throne the power of the Krim Mongols began to decline. In 1696 the tsar, supported by a large Cossack force under Mazeppa, took the field against Selim Girai Khan, and gained such successes that the latter was compelled to cede Azov to him. By a turn of the wheel of fortune the khan had the satisfaction in 1711 of having it restored to him by treaty; but this was the last real success that attended the Tatar arms. In 1735 the Russians in their turn invaded the Crimea, captured the celebrated lines of Perekop, and ravaged Bakhchi-sarai, the capital. In 1783 the Krim, together with the eastern portion of the land of the Nogais, became absorbed into the Russian province of Taurida.

The **Uzbegs.**—The Uzbegs on the destruction of the Golden Horde, assumed an important position on the east of the Caspian sea. The founder of their greatness was the khan Abulkhair, who reigned in the 15th century, and who consolidated a power out of a number of small clans. Shaibani Khan, his grandson, proved himself a worthy successor, and by him Babur (*q.v.*), the Timurid khan of Ferghana, who afterwards founded the Mogul empire in India, was driven from his ancestral dominions. In 1500 he inflicted a severe defeat on Baber's forces, and captured Samarkand, Herat and Kandahar. By these and other conquests he became possessed of all the country between the Oxus and the Jaxartes, of Ferghana, Khwarizm and Hissar, as well as of the territory of Tashkent from Kashgar to the frontiers of China. In the following year, by a dashing exploit, Baber recovered Samarkand, only to lose it again a few months later. During several succeeding years Shaibani's arms proved victorious in many fields of battle, and but for an indiscreet outrage on the territories of the shah of Persia he might have left behind him a powerful empire. The anger, however, of Shah Ismail roused against him a force before which he was destined to fall. The two armies met in the neighbourhood of Merv, where, after a desperate encounter, the Uzbegs were completely defeated. Shaibani, with a few followers, sought refuge in a cattle-pound. But finding no exit on the farther side, the refugees tried to leap their horses over the wall. In this attempt Shaibani was killed (1510). After this defeat the Uzbegs withdrew across the Oxus and abandoned Khurāsān. Farther east the news aroused Baber to renewed activity, and before long he re-occupied Samarkand and the province "beyond the river," which had been dominated by the Uzbegs for nine years. But though the Uzbegs were defeated they were by no means crushed, and ere long we find their khans reigning, now at Samarkand, and now at Bukhārā. As time advanced and European powers began to encroach more and more into Asia, the history of the khanates ceases to be confined to the internecine struggles of rival khans. Even Bukhārā was not beyond the reach of Russian ambition and English diplomacy. Several European envoys found their way thither during the first half of the 19th century, and the murder of Stoddart and Conolly in 1842 forms a melancholy episode in British relations with that fanatical capital. With the absorption of the khanate of Bukhārā and the capture of Khiva by the Russians the individual history of the Mongol tribes in central Asia comes to an end, and their name has left its imprint only on the dreary stretch of Chinese-owned country from Manchuria to the Altai mountains, and to the equally unattractive country in the neighbourhood of the Koko-nor. The Mongols have become scattered nomads engaged in agriculture and caravan trading, and are now for the most part indistinguishable from the Chinese who surround them everywhere.

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(R. K. D.; A. N. J. W.)

MONGOOSE, the name applied to weasel-like carnivores of the subfamily Herpestinae (*see* CARNIVORE), widely distributed in Asia and Africa, with a single species in southern Spain. The Indian mongoose is smaller than the Egyptian animal, with fur of a brownish grey colour, the hairs being largely white-ringed, while the cheeks and throat are more or less reddish. It is especially serviceable in India as a serpent killer, destroying not only the eggs and young of these creatures but killing the most venomous adult snakes. The mongoose is not immune to the snake's poison, falling a victim as rapidly as any other animal when bitten. By its agility and quickness of eye, it avoids the fangs of the snake while fixing its own teeth in the back of the reptile's neck.

LEWIS WAYNE WALKER FROM THE NATIONAL AUDUBON SOCIETY

INDIAN MONGOOSE (HERPESTES), INTRODUCED INTO THE WEST INDIES TO CONTROL VENOMOUS SNAKES AND RODENTS

Moreover, when excited, the mongoose erects its long stiff hair, and it must be difficult for a snake to drive its fangs through this and the thick skin which all the members of the genus possess.

The mongoose is equally dexterous in killing rats and other vermin.

For the effects of the introduction of the mongoose into Jamaica, *see* F. Finn, *Wild Animals of Yesterday and To-day,* 1st ed., London.

MONIS, JUDAH (1683–1764), Hebrew scholar and instructor at Harvard college, published the first Hebrew grammar in the American colonies (*Dickdook Leshon Gnebreet: A Grammar of the Hebrew Tongue,* 1735).

Said to have been of Italian origin, he lived in Jamaica and New York city, reportedly serving as a rabbi in both places. In 1720 he was awarded a master of arts degree from Harvard and in 1722, after his conversion to Christianity and public baptism, was appointed a teacher there with the new rank of instructor. On March 27, 1722, the day of his baptism, he delivered a speech which was later published in that year with two other essays by Monis on religion under the title *Three Discourses . . . The Truth, The Whole Truth, and, Nothing But the Truth. . . .*

For more than 35 years he remained at Harvard. He continued to recognize the seventh day of the week as the Sabbath although he eventually became a member of the First Church of Cambridge and professed his belief in Christianity.

He died in Massachusetts on April 25, 1764

MONISM: *see* PLURALISM AND MONISM.

MONITION, or ADMONITION, in English ecclesiastical law, an order requiring or admonishing the person complained of to do something specified in the monition, or appear and show cause to the contrary, "under pain of the law and penalty thereof." It is the lightest form of ecclesiastical censure.

MONITOR, NAVAL, a type of warship designed originally for use in shallow harbours and rivers for the blockade of the Confederate states, 1861–65. A minimum draft was essential and protection against gunfire from enemy artillery or fixed fortifications was necessary. The need for pointing guns at a target when the ship could not be maneuvered led to the revolving turret.

John Ericsson designed a vessel that met the essential specifications and suggested the name "Monitor." The dramatic battle between the "Monitor" and the "Merrimack" on March 9, 1862, caught the attention of the world and resulted in the building of many similar vessels for the U.S. navy. Unfortunately many errors were made in evaluating the genuine merits, capabilities and limitations of the monitor type.

The original "Monitor" conformed to the essential specifications, as noted above. but the ship was not seaworthy. While enroute from New York to Chesapeake bay for her famous battle, the "Monitor" almost sank on two occasions. She went to sea again in Dec. 1862, in tow of the "Rhode Island," and sank off Cape Hatteras with a loss of 4 officers and 12 men.

It is not strange that a new type should have serious defects; that is the rule and not the exception in engineering and shipbuilding developments. But the qualities and capabilities of the "Monitor" became an untouchable subject with the secretary of

the navy, Gideon Welles, and the assistant secretary. G. V. Fox. Suggestions for modifications and improvements in the monitor type were suppressed; the officers recommending alterations were rebuked and accused of opposition to progress. Welles convinced himself that he had an invincible weapon in the monitor type and considered that any contrary opinion was disloyalty to the Union.

The climax was the attempt to capture Charleston, S.C., with a squadron of monitors. Adm. Samuel Francis du Pont made the effort against his better judgment and was replaced in the command by Adm. John Dahlgren. who also failed. The Union squadron was saved from destruction only because the Confederates handled the defenses badly. Before du Pont attacked Charleston with nine monitors. John Ericsson wrote to Fox a letter of warning and protest in which he said, "A single shot will sink a ship, while 100 rounds will not silence a fort. . . ." Naval officers had been saying that the monitors were never designed to fight against forts. In fact, no naval vessels ever were designed for such a purpose.

Many vessels of the monitor type of various sizes were begun soon after the battle of March 9, 1862, and a number of these vessels were used successfully in the blockade of Confederate ports and related naval operations. Along with the building of these successful monitors. however, about 20 others were built which were found to be almost completely lacking in buoyancy when completed. These 20 monitors were useless. One consequence of the controversies over the monitor type was that no other navy built monitors until World War I, and those built at that time for the British, as well as for other navies, were designed for a different purpose. For many years after the Civil War the U.S. navy retained monitors of that period. Six monitors with two turrets each were built and placed in commission between 1891 and 1896. These ships displaced 4.000 to 6,000 tons and carried four 10-in. or 12-in. guns. Four later monitors were commissioned in 1902 and 1903, each carrying two 12-in. guns. with a displacement of 3,356 tons, and with a speed of 12 knots. These vessels "Ozark," "Tonopah." "Tallahassee,!' and "Cheyenne," mere the last monitors of the U.S. navy. Before and during World War I they served as submarine tenders. They were scrapped in 1922.

In 191j and 1916 British monitors of 6.000 and 8.000 tons, mounting 15-in. and 18-in. guns, were built for use along the Belgian coast, in the Dardanelles, in the Suez canal and in the Adriatic. The larger vessels of this type were 405 ft. long. had an 88-ft. beam and an 11-ft. draft. There were about 20 small monitors, of 400 tons. with draft of 6 ft. The British navy built monitors for World War II use. "Roberts." completed in 1941, and "Abercrombie," in 1943. They mounted two 1j-in. guns each. and displaced about 8.000 tons. In 1957 the Russian and Rumanian navies employed monitors designed for river use; they were small vessels with a draft of 6 ft.

The development of the monitor type by the U.S. navy was one of the most significant factors in the defeat of the Confederacy. The Union monitors were important for what they did between 1862 and 1865; they were even more important for what they could have done if any European power had attempted to break the blockade of the Southern ports.

Monitors are classed as powerful, seagoing river gunboats. River gunboats have a shallow draft and relatively heavy guns for use against troops. artillery, towns or other gunboats. The river gunboats of the Cnion navy in the American Civil War were especially useful and effective. For many years squadrons of gunboats were maintained on the Yangtze river, China, by the Royal and U.S. navies for the protection of their citizens and national vessels. *See* FLEET. NAVAL.

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"MONITOR" AND "MERRIMACK," BATTLE OF, a naval engagement notable as the first duel between ironclad men of war, and chiefly memorable in the annals of the American Civil War because of the dramatic contrast between the news of the spectacular successes of the "Merrimack" on March 8, 1862, and her failure to defeat the little "Monitor." next day. The events of the first day thrilled the South, and appeared to mean that the blockade of the Confederacy would be broken if nor destroyed. while the conflict between the ironclads was generally interpreted as a victory for the "Monitor," and produced feelings of combined relief and exultation in the North. The battle, on March 9, 1862, was in fact indecisive, and had little or no influence on the course of the war, but it is difficult to exaggerate the profound effect on morale that was produced in both sections. The secretary of war, Edwin M. Stanton, was almost hysterical on March 9 before the battle. and he sent telegrams to governors of Northern states and mayors of seaport cities urging them to prepare defenses against the "Merrimack." He did his best to create a feeling of panic, even though some of his messages quoted the opinion of naval officers that the "Merrimack" would not venture outside the Chesapeake capes. Thus Stanton's efforts greatly increased the importance of the "Monitor's" achievements, and helped to establish her as an invincible engine of war.

In undertaking to create a navy. Confederate officers agreed that they required a number of ironclads to break the blockade proclaimed by the federal government on April 19, 1861. five days after the surrender of Ft. Sumter: The Union navy had abandoned the Norfolk, Va., navy yard on April 20, and burned a number of vessels on that occasion. including the steam frigate "Merrimack." This vessel was raised from the Elizabeth river and hauled into drydock on May 30, where inspection disclosed that she had suffered relatively little damage. except to her upper decks. Soon afterward the Confederates faced the fact that they lacked the facilities to build engines for the ironclads wanted, and a plan was made for converting the "Merrimack." On July 25, the Confederates were still engaged in repairing fire damage in the navy yard. but work on the ships began soon after that date.

The "Merrimack" had been built at the Boston navy yard, where she was first commissioned on Feb. 20, 1856, and named for the river which flows from central New Hampshire, through northern Massachusetts, into the Atlantic. Her length was 275 ft.; beam. 38½ ft.; draft. 24 ft.: displacement 4.436 tons when built. Authentic records of the conversion of the "Merrimack" were lost when the yard was burned again, and men's memories differed as to details. but she was cut down to the water line. and a casemate with rounded ends was constructed on her hull to house ten guns. The casemate was 17j ft. long. with sides sloping at an angle of 45 degrees extending about 2 ft. below the water line. The flat top of the casemate was covered with an iron grating to admit light and air. A cast-iron ram was fitted 2 ft. below the water line. projecting 24 in. from the bow. Sides of the casemate were built up of pine. 20 in. thick: covered with 4 in. of oak, and sheathed with two layers of 2-in. iron plates. A Brooke 7-in. rifle on a pivot was in each end, and there were two Brooke 32-pounder rifles, as well as six Dahlgren 9-in. smooth-bore guns in the broadsides.

John Ericsson designed. built and named an ironclad for the Union, the "Monitor," and abundant publicity attended her progress as well as the work of converting the "Merrimack." The "Monitor" displaced 987 tons; mounted two 11-in. shell guns in her revolving turret. Her length was 172 ft.; beam, 41½ ft.; draft, 10½ ft. She left New York harbour on March 6. commanded by Lieut. John L. Worden with Lieut. Samuel D. Greene as executive officer. accompanied by two steamers, under tow of a tug.

Renamed the "Virginia," the Confederate ironclad left the navy yard for a trial trip after noon on March 8 with two gunboats, under the command of Capt. Franklin Buchanan, whose executive officer was Lieut. Catesby ap R. Jones. The "Virginia" headed for Newport News, where the Union sailing frigate "Congress," and the newer sailing sloop "Cumberland" lay at anchor. After raking the "Cumberland," the "Virginia" rammed her. and was joined by three Confederate vessels from the James river. Buchanan attacked the "Congress" with his guns, killed her captain, set her on fire and sent his gunboats to receive her surrender,

while Union guns on shore at Newport News joined the combat and injured him among others. In trying to join in the battle, the Union steam frigate "Minnesota" ran aground about one mile away, but Buchanan's attempts to secure the surrender of the two sailing ships delayed him, and prevented him from attacking her because of darkness and the falling tide. The "Virginia" anchored off Sewell's Point; Buchanan and 20 other Confederate wounded or dead were sent to Norfolk. That night, the "Monitor" arrived at Hampton Roads and went alongside the "Minnesota."

Crowds of Union soldiers occupied every vantage point along the northern shores of Hampton Roads, on Sunday morning, March 9, 1862, to see the naval battle. Decks of the Federal ships were crowded, and it was known in the fleet that the "Monitor" had arrived. Norfolk and Portsmouth thought of the "Virginia" as their own ship. Huge crowds on shore, and all who could find standing room on floating craft turned out to see the blockading vessels destroyed. Soon after 8 A.M. the "Virginia" opened fire on the "Minnesota," and the "Monitor" appeared. They passed on opposite courses; turned, and passed again. Both crews lacked training; shooting was ineffective. The "Monitor" could fire only once in seven or eight minutes but she was faster and able to turn more quickly than her larger opponent. In two hours she had exhausted the ammunition in her turret and ran into shallow water to renew it. In the interlude, the "Virginia" pounded the "Minnesota" vigorously. When the "Monitor" intervened again, the "Virginia" grounded, and was slow in freeing herself. Jones then tried to ram his opponent, but the "Virginia" turned so slowly that she struck only a glancing blow, and did little damage because her ram had been broken off in the "Cumberland." Jones made the "Monitor's" pilothouse the target; a hit drove iron splinters into Worden's eyes. The "Monitor" sheered into shallow water while Greene mas called to the pilothouse to take over the command from Worden. Jones concluded she was disabled, and he turned again to the "Minnesota." His officers reported ammunition low, a leak in the bow, difficulty in keeping up steam and that it would be necessary to cross the Elizabeth river bar soon or to wait 24 hours. At about 12:30 P.M. the "Virginia" headed for the navy yard. The battle was over.

The "Virginia" was in dry dock until April 4. Efforts were made to complete her armour as planned, a new ram was installed and Commodore Josiah Tattnall took command on March 26. Delayed by engine repairs, the "Virginia" appeared in Hampton Roads on April 11, and offered battle. Neither the "Monitor" nor any other Union vessel interfered as the Southerners seized three army transports. The "Virginia" remained at Sewell's point until April 21; and returned May 8 on news that the "Monitor" with other Union ships was shelling the batteries at Sewell's Point; whereupon the Union vessels withdrew. After the Confederates evacuated Norfolk, Tattnall destroyed the "Virginia" ("Merrimack") May 11, 1862.

See also AMERICAN CIVIL WAR: *The Navies and the Blockade;* MONITOR, NAVAL. (J. B. HN.)

MONITORING RECEIVER is a receiver so arranged as to enable an operator to check the operation of a radio transmitting set.

MONIUSZKO, STANISLAW (1819–1872), Polish composer! wrote religious music, songs and choral works, and became known particularly for his operas. Born at Ubiel, in the province of Minsk, on May 5, 1819, he studied in Warsaw and Berlin. He lived in Wilno, Pol., before moving to Warsaw in 1858. From that year until his death on June 4, 1872, he was conductor of the opera there. His opera *Halka* (produced in four acts in Warsaw, 1858) proved a permanent contribution to the Polish repertoire.

MONK (MONCK), GEORGE, 1ST DUKE OF ALBEMARLE (1608–1670), the second son of Sir Thomas Monk, a Devonshire knight. was horn at Potheridge, near Torrington in Devonshire, on Dec. 6, 1608. He volunteered for service in the expedition to Cadiz. Sp., in 1625 and two years later joined the 1st duke of Buckingham (*q.v.*) in the Île de RC. Probably in 1629 he joined an English regiment in Dutch pay and fought in Holland for the next eight years or so. Back in England he was commissioned a lieutenant colonel in the army Charles I raised to subdue the Scots. and one account of the defeat at Newburn (1640) credits him with saving the royal artillery. In 1642 and 1643 he fought, usually successfully, against the rebels in Ireland. He joined the army sent from Ireland to fight for Charles I and shared in its defeat at Nantwich (Jan. 1644). He was captured there and confined in the Tower for two years. When released he served again in Ireland. mainly in Clster. Monk was obliged to arrange an armistice with the Irish catholics in 1649 and, soon afterward, to return to England. When Cromwell invaded Scotland in July 1650 he formed a regiment for Monk from two existing regiments. It became the Coldstream guards at the Restoration and is the sole link between the modern army and the New Model army.

At the battle of Dunbar (Sept. 3) he led the infantry which assailed the Scots' centre. After this victory he was employed in reducing various fortresses until Cromwell started on his pursuit of Charles II into England when Monk was left behind as commander in chief. After the storming of Dundee (Sept. 1, 1651) he met with little organized resistance and had subdued Scotland by Feb. 1652. His next appointment was surprising because, although without experience of naval warfare, he was joined to Robert Blake and Richard Deane as a general at sea. He took part in the major conflicts with the Dutch fleets in 1653, and was in sole command when the Dutch admiral Martin Tromp was defeated and slain at the end of July. Discipline, organization and tactics, especially fighting in line, were all improved and. while Monk's precise share in the improvements cannot be ascertained, he is certainly entitled to some of the credit.

From 1654 to 1660 he was again commander in chief in Scotland. At the outset he had to subdue a royalist insurrection. One of his colonels, Thomas Morgan. defeated Lord Middleton at Dalnaspidal. By ravaging their cornfields and destroying their homes he soon compelled the highland chiefs to submit. By his firm but just measures he reduced Scotland to a state more peaceful than it had perhaps ever known. He suppressed Robert Overton's plot, a design of dissatisfied officers to seize him and overthrow the protectorate. After Oliver Cromwell's death, Sept. 3, 1658, and Richard Cromwell's accession, he advised the latter to favour the moderates in both religious and political matters and to reduce the army by combining two regiments into one. and so get rid of aspiring politicians among the officers. This advice was not followed. Richard dissolved parliament (April 22, 1659) in order to please the officers in London. He did not appeal to Monk for aid. Therefore, Monk acquiesced in the fall of the protectorate and in the recall of the remnant of the Long parliament nicknamed the Rump. Whether, as his two chaplains, Thomas Gumble and John Price, aver, he was preparing to assist in Sir George Booth's rising when news of the defeat of the royalists and presbyterians reached him is uncertain because no signs of preparations for intervention can be detected.

He was not surprised at the news that John Lambert (*q.v.*) had ejected the Long parliament (Oct. 13, 1659). He at once announced his determination to uphold the parliamentary authority which employed him. He began a drastic purge of his army. From first to last he replaced about 140 officers and noncommissioned officers, whose politics or religion (in that day the one often determined the other) he distrusted, by officers on whose loyalty he could depend. He was most careful to explain to his army and to the people at large how parliamentary government, the law and individual liberty were all threatened by an ambitious clique of officers in London. To gain time he entered into negotiations with the opposing leaders, but they came to nothing. Soon the soldiers sent to oppose him in northern England, without pay and exposed to the intense hostility of the populace, decided they would not fight to satisfy their officers' ambition. When Monk crossed the Tweed at the beginning of 1660 and Lord Fairfax raised Yorkshire in their rear, they melted away and allowed Monk an unopposed March to London, which he reached on Feb. 3. There he found that the Rump. permitted to resume its sittings on Dec. 26. had not complied with the almost universal demand for a free parliament. Londoners were talking of refusing to pay taxes unless an election took place speedily. The Rump ordered Monk to coerce the city. and at first he obeyed. Then he suddenly

changed his attitude and sent parliament a letter requiring the prompt issue of writs for new elections. Finding the Rumpers obdurate. Monk withdrew the guards round the house of commons so that members excluded since Pride's Purge in 1648 could take their seats. They soon dissolved themselves and the new parliament—the Convention—recalled the king.

Meanwhile Monk had been in touch with Charles II and much of his advice was incorporated in the Declaration of Breda. He prevented the presbyterians from imposing conditions on the restored monarch. His greatest service. however. was to bring about the Restoration without bloodshed. He relied largely upon public opinion which overwhelmingly favoured the old constitution. He stooped to deception in order to beguile the army until it became too divided to offer resistance. He was generously rewarded. He was created knight of the Garter and duke of Albemarle and given a pension of £7,000 a year. He was made master of the horse, lord lieutenant of Ireland and captain general for life. Naturally, he played no very prominent part in politics, but in times of emergency his aid was the first to be sought. During the Dutch war (1665–67) he was usually either in charge at home when the lord high admiral, the duke of York, was at sea, or himself in command of the fleet. Though he was defeated in the four days' battle (June 1666) he was not responsible for the division of the fleet which left him heavily outnumbered. When the Dutch fleet appeared in the Thames, Monk was again sent for, but his orders were neglected and the Dutch burned or captured nine ships. He remained in London during the great plague and the fire. and his presence and advice were invaluable. He died Jan. 3, 1670.

Monk represents the best type of professional soldier. Though he served many masters he was faithful to them all while in their employment. He believed in the subordination of the army to the civilian authority which paid it. He was a stern disciplinarian, but was popular with his soldiers. who called him "Black George." Like the great Count von Moltke he might have been styled "the reticent." Like Cromwell he was a superb judge of men and rarely, if ever, erred when purging his army of possible opponents. Unlike Cromwell, he was a moderate in all things, especially religion, and preferred a presbyterianism "not rigid" to other ecclesiastical systems. When a prisoner in the Tower he wrote his *Observations upon Military & Political Affairs,* published posthumously in 1671.

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MONK, a member of a community of men living a life under vows of religious observance; the term is properly confined to a member of a Christian community, but is sometimes applied to members of Buddhist and Mohammedan religious brotherhoods. The Greek and Latin name was first used of the hermits, but was early widened to embrace the coenobites. *See* MONASTICISM.

MONKEY, a term applicable to all members of the order Primates (*q.v.*) except man, the lemurs and, strictly, the true or anthropoid apes.

MONKEYNUT, a rarely used name for the plants, nuts or other fruits of some quite unrelated species. In India and Ceylon the peanut *(Arachis hypogaea)* may be called monkeynut. The name also has been applied to a species of *Anacardium* and to *a* species of basswood, *Tilia glabra.* (V. R. B.)

MONKEY PUZZLE, common name of the Chile pine *(Araucaria araucana),* an evergreen timber tree of the Chilean Cordilleras, often 150 ft. tall. Rigid, overlapping, needle-pointed leaves, one to two inches long and half as wide, cover the stiff branches and act to thwart climbing monkeys. The oblong cones, five to seven inches long, fall apart at maturity; each scale bears one edible seed. It is cultivated widely in temperate zones. *See* ARAUCARIA.

See S. J Record and R. W. Hess, *Timbers of the New World* (1943). (I. L. W.)

MON-KHMER LANGUAGES: *see* AUSTROASIATIC LANGUAGES.

MONKHOUSE, WILLIAM COSMO (1840–1901), English poet and critic, was born in London on March 18, 1840. He was educated at St. Paul's school, and entered the civil service. In 1870–71 he went on a mission to South America and served on different departmental committees, notably that of 1894–96 on the Mercantile Marine fund. He died in London on July 20, 1901. His first book of poems, *A Dream of Idleness and Other Poems* (1865), is strongly coloured by his admiration for Wordsworth and Tennyson. His other poetical works are *Corn and Poppies* (1890), *The Christ on the Hill* (1898) and the posthumous *Pasiteles the Elder and other Poems.* His most important work was done as an art critic and historian. Much of his work on art was contributed to the *Dictionary of National Biography* and to periodicals. Separate works are: *The Italian Pre-Raphaelites* (1887), *The Earlier English Water-Colour Painters* (1890 and 1897), *In the National Gallery* (1895) and *British Contemporary Artists* (1899).

MONKSWELL, ROBERT PORRETT COLLIER, 1ST BARON (1817–1886), English judge, was born at Plymouth, on June 21, 1817, the son of a merchant. He was educated at Oxford, was called to the bar in 1843, and went the western circuit. He obtained a high reputation by his successful defense of Brazilian pirates in 1845; the conviction was quashed on appeal on a point of law which the judge had refused to reserve. He was elected member of parliament for Plymouth in the Liberal interest in 1852, and in 1859 was appointed counsel to the admiralty and judge advocate to the fleet. In this capacity he gave in 1862 an opinion in favour of detaining the Confederate rams which were being built in the Mersey, which would have saved his country much money and much credit if it had been acted upon. In 1863 he became solicitor general. in 1868 attorney general and in 1869 successfully passed a bankruptcy bill. In 1871 he was appointed by Gladstone one of four new judges upon the judicial committee of the privy council, although it was expressly provided by the act creating these offices that none of them should be filled by a law officer of the crown. This prohibition was evaded by making Collier a judge of common pleas, and transferring him after a few days to the privy council. He received a peerage in 1885 and died on Nov. 3, 1886.

MONMOUTH, JAMES SCOTT, DUKE OF (1649–1685), pretender to the English throne, was born at Rotterdam on April 9, 1649, the son of Lucy Walter, mistress of Charles II. Shortly before the death of his mother, which took place toward the close of 1658, he was entrusted to the care of William, Lord Crofts, by whose name he was for some time known, and under the direction of Thomas Ross was brought up in the Protestant religion. On the whole, however, his early education appears to have been neglected, which may in part account for the fatuity of his later political conduct. In the summer of 1662 he was brought to England and received by the king with the utmost favour, a marriage being almost immediately arranged between him and one of the wealthiest of Scottish heiresses, Anne Scott, countess of Buccleuch in her own right. With this marriage in view he abandoned the name of Crofts, was knighted as Sir James Scott, and on Feb. 14, 1663. was created duke of Monmouth. The marriage itself, which took place on April 20 of the same year, was marked by the grant of further honours, including the garter and the title of duke of Buccleuch in the Scottish peerage.

From an early stage the possibility was entertained that Monmouth might succeed Charles on the throne, and as it became increasingly apparent that Queen Catherine was unlikely to have children this possibility was taken more and more seriously. As he grew into manhood Monmouth developed into the very ideal of an English ruler. Extremely handsome, yet without the least suggestion of effeminacy in his appearance, he was an adept at all manly exercises, a good enough soldier to win praise from the great Marshal Turenne, generous, affable and capable of making himself at home in any company, male or female. The fact that he was deficient both in intelligence and in resolution was not immediately apparent, and did little to detract from his popularity. By contrast James. duke of York, the king's brother and heir presumptive, having gained a high reputation by his activity and public spirit at the beginning of the reign, was declining in general

esteem, mainly because of his inclination toward Roman Catholicism. which culminated in his failure to take the tests required by the Test act and his marriage to the Catholic Mary of Modena in 1673.

Thus an inevitable rivalry developed between the two dukes. in which York, being excluded from office by the Test act. was at a serious disadvantage compared with Monmouth, on whom the king, with injudicious partiality. conferred one important office after another. Captain of the king's own troop of guards in 1668, he was admitted to the English privy council on April 29. 1670, and to the Scottish privy council on May 18. 1674. During the second Dutch War of the reign he was given command of the British forces operating in conjunction with the French on the continent. On April 14. 1674. he took the duke of Buckingham's place as master of the horse, and on July 14 of the same year. on the king's recommendation. was elected chancellor of the University of Cambridge. In April 1678 he was appointed captain general of all the arnied forces in England. and on being given a similar appointment in Scotland gained a great reputation not so much by his defeat of the Covenanting army at Bothwell bridge on June 22. 1679, as by the clemency he showed to the rebels thereafter.

When it came to the point, however, and the frenzy roused by the revelations of Titus Oates (*q.v.*) made the succession to the throne an immediate and serious issue, the king refused to desert his brother. On March 3, 1679, he made a solemn declaration in council that he had never been married to Monmouth's mother, and although three successive parliaments endeavoured to deprive the duke of York of his right to the throne he firmly refused to accept their policy of exclusion. Unfortunately Monmouth by this time had fallen under the influence of the earl of Shaftesbury and other irreconcilable enemies of Pork. and at least partly in the belief that the interests of his countn and religion were vitally concerned refused to accept the king's decision. He was thereupon ordered abroad, and. returning without permission, was deprived of most of his offices. Refusing to leave the country again he embarked on a series of progresses in the southwest and iater in the northwest, in the course of which he assumed almost royal state and was everywhere hailed with enthusiasm as the Protestant duke. In the confused conspiracy vaguely called the Rye House plot he was deeply involved, though precisely how deeply it is impossible to say. For this he was pardoned; but on his failure to make a full and explicit confession he was forbidden the court, and early in 1684 took refuge in the Netherlands. Any prospect he had of restoration to favour was cut short by the death of Charles II on Feb. 6, 1685.

At this point Monmouth would gladly have abandoned his pretensions and resigned himself to a private life; but neither his pretended friends nor his very real enemies were at all inclined to leave him in peace, and he mas thus induced to embark on his disastrous expedition to England in the summer of 1685. Landing at Lyme Regis. Dorset. with 82 followers on June 11, he received considerable support from the populace of the surrounding district, and experienced little serious opposition from the militia hastily embodied to bar his progress. The gentry, however, held aloof. and it was partly in the mistaken hope of bringing them over to his side that on June 20. after his entry into Taunton, he abandoned his earlier undertaking to leave to a free parliament the decision of his title to the crown and had himself formally proclaimed king. Unfortunately for himself if not for his country. the moment he had chosen for his enterprise was the worst possible, when the duke of Pork. now James II, had had sufficient time to seat himself firmly on the throne but insufficient to antagonize any considerable section of his subjects. and responsible men were thus unwilling to throw in their lot with a movement which seemed to them both hopeless and unnecessary.

Moreover Monmouth was not the man for the task he had undertaken. A regular soldier by training, he showed little capacity for handling the untrained forces now under his command, and failed to grasp the need for pushing on at all costs. Too late in his advance on Bristol, where he found the forces of the regular army closing in upon him, he fell back on Bridgwater, and after much hesitation determined to stake everything on the hazardous expedient of a night attack on the royal army which he could see, carelessly encamped before him on the plain of Sedgemoor. There in the early hours of July 6 he just failed to bring off a complete surprise; but the flight of his small body of horse and the failure of his foot to press home their attack over the deep rhine or ditch which covered the royalist front left his men at the mercy of a combined onslaught from horse foot and guns, of which there could be only one outcome. Flying nith unwonted pusillanimity from the battlefield he was captured a few days later, and, having with even greater pusillanimity endeavoured to purchase his life from James by a slavish submission and an offer to turn Roman Catholic. met his end on the scaffold nith courage and dignity on July 1j. He was then only 36 years of age.

BIBLIOGRAPHY.—Monmouth mas not a ready writer, and his surviving lcttcrs and papers arc few, badly put together and worse spelled. The most reliable accounts of his career are still George Roberts. *The Life, Progresses and Rebellion of James, Duke of Monmouth,* 2 vol. (London, 1844), and the article, by A. W. Ward, in the *Dictionary of National Biography;* but there are also a number of more recent works, of which the most useful are Allan Fea, *King Monmouth* (London and New Work. 1902) and *The Loyal Wentworths* (London, 1928); Elizabeth D'Oyley, *James, Duke of Monmouth* (London, Toronto, 1938); and Lord George Scott, *Lucy Walter, Wife or Mistress* (London. New York, 1947). The crisis and final stage of Monmouth's life are exhaustively examined in William R. Emerson, *Monmouth's Rebellion* (New Haven, Oxford, 1951). (A. BG.)

MONMOUTH, ROBERT CAREY, 1ST EARL OF (*c.* 1560–1639). was the youngest son of Henry Carey, 1st Baron Hunsdon, chamberlain and first cousin of Queen Elizabeth. In 1587 he joined in the attempt to relieve Sluys. in 1588 volunteered against the Spanish Armada and in 1591 commanded a regiment in the earl of Essex's expedition to Normandy, and was knighted by Essex for having interceded with the queen to procure his recall. He was member of parliament for Morpeth (1586 and 1588); Callington (1593); Northumberland (1j97 and 1601); and Grampound (1620.) From 1593 to 1603 he was engaged in governing the border. In March 1603 he witnessed the queen's last illness and was widely blamed for the unseemly precipitancy with which he made sure of being the first to break the news to King James in Scotland. The appointments he had been promised by James were thus not bestowed, but his wife obtained control of Prince Charles and in 1605 he became his master of the household. in 1611 master of the robes, in 1617 chamberlain, and in 162j gentleman of the bedchamber. Created Baron Carey of Leppington in 1622, after Charles's accession, he was made earl of Monmouth in 1626. He died on April 12, 1639, at Moor Park. Hertfordshire.

See his *Memoirs,* first published by the earl of Cork and Orrery (London, 1759), 4th ed. annotated by Sir Walter Scott (London, 1808).

MONMOUTH (Welsh *Trefynny*), a municipal borough, in the Monmouth parliamentary division, and the county town of Monmouthshire, Eng., 21 mi. S. of Hereford and 36 mi. N.E. of Cardiff by road. Pop. (1951) 5.438 Area 11.1 sq.mi. It is at the confiuence of the Wye and the Monnow and is almost surrounded by hills. Monmouth (the name. *Monemude* in Domesday Book meant "mouth of the Monnow") was possibly a fort from Roman times. Situated between Severn and Wye its strategic importance was early recognized by the Saxons. while in later years it played a leading part in Welsh border warfare. At the time of the Domesday survey the castle was in the custody of William Fitz Osbern. earl of Hereford, by whom it had been built. Henry III granted it to his son Edmund Crouchback, through whose descendants both borough and castle passed into the duchy of Lancaster. Henry V was born there. Since the 18th century the dukes of Beaufort have been lords of the borough. Portions of the town malls remain. The old gateway (13th century) on the Monnow bridge is unique in the country. but there are only insignificant ruins of the castle. The principal buildings are St. Mary's church on an ancient site, the chapel of St. Thomas, a late Norman structure, and the grammar school (1614). In the Nelson museum are relics of the great admiral.

Monmouth n-as a borough by prescription as early as 1256, and was governed by a mayor in 1461, but was not incorporated until

1549. By the act of 1535–36 Monmouth, as county town, obtained representation in parliament. but is now in the Monmouth division.

There is an annual fair in May and weekly and fortnightly markets. Many of the inhabitants are employed in neighbouring industrial areas.

MONMOUTH COURT HOUSE. BATTLE OF. The battle of Monmouth Court House was 'fought (June 28, 1778) between the Americans under General Washington and the British commanded by Sir Henry Clinton. who having evacuated Philadelphia (June 18) was marching through New Jersey to Sandy Hook. Washington had decided that for his country's honour and his own reputation he must strike a vigorous blow at the retreating enemy even at the risk of bringing on a general engagement, and ordered Charles Lee with the advanced guard to attack the British rear (June 28), promising to support him with the main body of the army.

Lee had claimed this command, as the senior major general in the army, though it had been originally assigned to Lafayette, and Washington now added to it two brigades, bringing it up to a strength of about 5,000. But Lee had no intention of carrying out the spirit of his orders. A former officer of the British army, who had seen much service in the Seven Years' War, he believed the Continental troops to be no match for British regulars in the field and held it madness to risk a pitched battle before the arrival of French troops in America. He contemplated nothing more than a forced reconnaissance. Clinton after a 40 hours' halt at Monmouth Court House (now Freehold) made an early start (June 28).

The British baggage train of 1,500 wagons led the way under escort of Knyphausen's German division, and Cornwallis' British division formed the rear-guard.

When Lee approached Monmouth he found only a small covering force there. He was executing an elaborate manoeuvre to envelop it, when Cornwallis' division appeared. Clinton had ordered his lieutenant to turn back and strike hard at the attacking force, in order to prevent any attempt to harass his trains. Instead of fighting a delaying action with a force not much stronger than his own on ground well adapted for the purpose and gaining time for Washington to come up, Lee allowed his troops to retreat. He had ordered his right to fall back, but gave no orders to the rest, and they finding themselves in danger of being cut off, also retired. Lee made little effort to check the somewhat disorderly retreat and sent Washington no warning that he was retiring. When the commander in chief came up, he mas surprised and indignant, and hastened to form a line of battle with the divisions of Greene and Alexander (called by the Americans Lord Stirling) on the right and left, while part of Lee's force rallied under Wayne and checked the pursuit of the British cavalry. Cornwallis brought up his infantry and endeavoured to dislodge Washington but without success. The fiercest fighting was in front of the centre behind a hedge fence held by the heroic Wayne, who repulsed three fierce assaults of British grenadiers. Toward evening Cornwallis fell back. Washington sent forward three brigades to renew the battle, but darkness forestalled them. During the night Cornnallis withdrew, undetected by the American outposts, and overtook Knyphausen near Middletown, where the high ground secured them from further attack.

Washington finding the enemy gone attempted no pursuit and presently marched to the Hudson to join General Gates, while Clinton's army was conveyed by transports from Sandy Hook to New York. The two combatants resumed the positions, which they had held two years before.

Of the two armies Clinton's seems to have been a little the larger — about 17,000 to 14,000. But not much more than half of the British army was actually engaged. Washington returned 360 casualties and Clinton 358, but the Americans claimed to have buried 249 British dead on the battlefield.

Due to the intense heat nearly 100 men in the two armies died of sheer fatigue. A court-martial suspended Lee from any command in the American armies for 12 months. Subsequently he was dismissed from the American service on account of his attacks upon Washington.

In 1860 Lee's letter to General Howe, written when he was a prisoner in British hands, suggesting a plan of campaign for Howe's forces. came to light, and later writers have added to the charge of incompetence and insubordination against Lee that of deliberate treachery. The evidence seems in favour of acquitting Lee of any worse crime than disloyalty to his commander.

It was at the battle of Monmouth Court House that Mary Hays (later McCauley), wife of an American soldier in the artillery, received the nickname "Molly Pitcher" (*q.v.*) by carrying water to the troops, and won a place in American history by reportedly manning her husband's cannon when he fell unconscious from heat prostration.

See W. S Stryker, *The Battle of Monmouth* (Princeton, *1927*).

MONMOUTHSHIRE, a county of England on the Welsh border, bounded east by Gloucestershire, north and northeast by Herefordshire, north and northwest by Breconshire, west and southwest by Glamorgan and south by the estuary of the river Severn. Area 541.8 sq.mi. Pop. (1951) 425,115.

Physical Features. — The county falls into two natural regions —the Plain of Gwent which comprises the basin of the Usk (after that river emerges from the gap between the Brecknock Beacons, 2,906 ft., and the Black mountains, 2,632 ft.) and forms the northeastern and central portions of the county, and the coal field region which embraces the basins of the rivers Rhymney, Sirhowy and Ebbw that drain the southeastern slopes of the Brecknock Beacons. The river Monnow forms the northeastern boundary of the county, but its upper waters include a section of the Black mountains within the county boundary on the northern side. After the junction of the Monnow with the Wye at Monmouth, the Wye becomes the eastern boundary; the upper and middle river Rhymney form its western border with Glamorganshire.

The Monnow, and the Wye as far as Tintern. pass over Old Red Sandstone rocks (a great series of red marls, sandstone and concretionary limestones), which occupy the northeastern and central parts of the county, grits and conglomerates of the highest beds giving rise to bold escarpments and lofty plateaus (*e.g.*, the Sugar Loaf. 1.955 ft.; Skirrid Fawr, 1,596 ft.; and Blorenge, 1,834 ft.; which almost encircle the town of Abergavenny). West of the town of Usk, the Old Red Sandstone plain is interrupted by an extensive anticline of older Silurian strata (Wenlock shale and limestone and Ludlow beds), a small inlier of the same rocks appearing at Rhymney near Cardiff. The Rhymney (down to Caerphilly), and the Ebbm (with the Sirhowy and other tributaries), which joins the Usk below Newport, are parallel consequent streams draining the coal field, which there consists of a series of north-northwest to south-southeast valleys, separated by high ridges of Pennant grit, and related to lines of faulting that are much later than the foldings of the coal field. These valleys are deep and narrow, and often of U-shaped transverse profile, due to scouring by glaciers from the Brecon Beacons. The Carboniferous Limestone, Millstone Grit and Coal Measures dip westward and succeed each other from east to west. The Coal Measures abound in coal seams and ironstone and their valleys, densely populated with people formerly occupying higher pastoral districts now forsaken, give rise to acute social and economic problems Around the eastern edge of the coal field a narrow rim of Carboniferous Limestone occurs, and is crossed by a western tributary of the Usk at Pontypool.

Very striking land forms are seen in the valley of the Wye betneen Tintern and Chepstow, where Carboniferous Limestone again appears on the western rim of the outlying Forest of Dean coal field (Glos.). Rhaetic and Lias limestones and shales outcrop at Llanwern and Goldcliff, near Newport. Glacial gravel and boulder clay are found in the valleys. and a broad tract of alluvium borders the Bristol channel from Rhymney to Portskenett.

History. — Monmouthshire in early times was heavily forested and formed part of the difficult country of the lower Severn. There are evidences of the use of the route to the west (via the south Wales coastal plain) in the Bronze Age; finds of flat axes

and socketed celts being important in the southern section of the county. The westward route was used by the Romans. who built Caerwent (*Venta Silurum*) and Caerleon (*Isca Silurum*), the latter of which fulfilled a function similar to that performed by Chester in the north, guarding the coastal route into Wales. Other Roman stations were constructed in the county at Abergavenny (*Gobannium*). Usk (*Burrium*) and Monmouth (*Blestium*). Parallel with the construction of these main forts and towns, the Romans carried out an active program of building main roads connecting the fortresses and towns with one another and with other areas to the east and west of the county.

Monmouthshire, at the time of the Heptarchy (5th to 9th century). formed the Welsh kingdom of Gwent, and no permanent English settlement was effected in the district until about the middle of the 11th century. The incursions of the West Saxons began in the 7th century, and Brochmael and Fermael, kings of Gwent, acknowledged Alfred as their lord. In the 9th and 10th centuries the district was frequently harried by the Danes. who in 915, under Ohter and Hwald, sailed round Wessex and Cornwall to the Severn, plundered the banks of the Wye and took prisoner the bishop of Llandaff. In 926 Aethelstan met the kings of the North Britons at Hereford and fixed the Wye as the limit of their territory. In 976 the Danes destroyed Caerleon. at this time the chief town of the district. The early 11th century was taken up with interminable contests between the Welsh princes for the succession in south Wales, and the *Welsh Chronicle* relates that in 1047 the whole of south Wales lay waste, and in 1049, Griffith, the king of south Wales, assisted Irish pirates in plundering. In 1065 Harold conquered the district between the lower Wye and the Usk. After the Conquest, this district was bestowed on William Fitz-Osbern, earl of Hereford. who built Monmouth castle, and continued the line of defense against the Welsh frontier along the Wye, while a second line of fortifications along the Csk valley marked the continued advance of the Normans. who by 1085 had subjugated almost the whole of Gwent. The district still ranked as Welsh territory at the time of Domesday Book, but the town of Monmouth, the castle of Caerleon and the district of Xrchenfeld are assessed under Herefordshire, and the three hardwicks of Llanwern. Portskewett and Dinam under Gloucestershire. The Norman lords of the present county held their lands per *baroniam,* so that the king's writ did not run in them, and the lives and property of the poorer inhabitants were entirely at the mercy of these lords marcher.

The county still has the remains of a5 Norman castles. The province of Gwent was formerly divided into four cantrefs, each comprising several commotes. Under the act of 1536 for the abolition of the marches, these 24 lordships were united to form a shire with Monmouth as the shire town, and the sheriff's court was held alternately at Monmouth and Newport. The act of 1536 did not expressly separate the county from Wales, and it was only gradually that Monmouthshire came to be regarded as an English county, being included in the Oxford circuit for the first time in the reign of Charles II. In the 20th century, however. it was again linked with Wales for all central, local government and administrative purposes. Ecclesiastically Monmouthshire has been almost entirely in the diocese of Llandaff since its foundation in the 6th century. Monmouth was in the diocese of Hereford. and a few parishes formed part of the diocese of St. Davids until 1836, when the whole county was placed under the bishop of Llandaff. It is now in the diocese of Monmouth, formed in 1921.

Architecture. — Of Norman fortresses, the more interesting are: Caldicot, seat of the De Bohuns, with a round keep of the 13th century, gatehouse and other portions. still partly inhabited; Chepstow, one of the finest examples of Norman fortress extant, on a cliff above the Wye; Newport; Xbergavenny: the gateway and hall of Grosmont. once the residence of the dukes of Lancaster: and Usk castle. rebuilt by the Clares in the time of Edward IV. Raglan castle, begun in the reign of Henry V. is a very extensive ruin. still in good preservation. Charles I resided in it after the battle of Naseby, and in 1646 it was delivered up to the parliamentary forces after a stubborn resistance of ten weeks against Col. Anthony Morgan and Sir Thomas Fairfax.

At the Reformation Monmouth possessed 2 hospitals and 15 other religious houses; of these only Llanthony abbey and Tintern abbey (both Cistercian) are important. Llanthony abbey in the Black mountains was founded by Hugh de Lacy in c. 1108, and the church, dating from about 1200, is one of the earliest examples in England of the Pointed style. Tintern abbey (*q.v.*), founded by Walter FitzRichard of Clare in 1131, occupies a position of great beauty on the Wye, and is among the finest monastic ruins in England and Wales. Churches worthy of mention are Abergavenny, belonging to a Benedictine priory; Chepstow, partly Norman; St. Woolos' church, Newport, also Korman; the Norman chapel of St. Thomas, Monmouth; Christchurch, principally Norman; Mathern, Early English. with a tablet to Tewdrig, king of Gwent in the 6th century; and Usk, formerly attached to a Benedictine priory.

Agriculture.—Along the Severn shore the soil is deep and loamy and admirably suited for intensive agricultural production. The most fertile land in the county is that resting on the Red Sandstone. especially along the banks of the Usk, where wheat of fine quality is raised. In the mountainous regions more attention is paid to grazing than to the raising of crops. By tradition, Monmouthshire is a pastoral county, concentrating on the rearing and fattening of cattle and sheep. During and after World War I, however, this general picture was altered—for many areas were laid down to arable crops and many farmers became milk producers so that about two-thirds of the total areas of the county was under cultivation by 1939. The chief crops were oats and barley. There is a large extent of hill pasture, and a considerable acreage under orchards. The river fisheries of Monmouthshire have been famed from early times.

Mining and Industries. — It is known that the Romans from the end of the 1st century A.D. to the beginning of the 5th century worked iron and lead in the county and lead works were established at Cefn-Pwll du in the Rhymney valley. During the 16th and 17th centuries manufacturers were attracted by a plentiful supply of timber, and iron forges were established on the Wye and at Pontypool and a famous mire works was built at Tintern. One of the first immigrant iron masters was Capel Hanbury who founded his works at Pontypool in 1565. In 1740 Monmouthshire contained only tn-o furnaces making 900 tons of iron annually but from 17jo to 1760 onward a great change occurred in the iron industry by the discovery that pit coal could be used in place of charcoal for blasting iron ore. The ironworks were now moved nearer to the source of coal supply and the manufacturing of iron and tin plate rapidly flourished and became the staple industries of the county. Coal mining lapsed until the construction of the Blaenavon-Newport canal (1792–95). From 1800 to 1835 onward extensive colliery sinkings took place in the northern outcrop areas at Tredegar. Blaenavon, Nantyglo and Blaina, Ebbw Vale and Rhymney. The winning of coal brought a large migration of workers into the county from south Wales and the west of England necessitating the rapid expansion of the industrial towns of western Monmouthshire.

By the beginning of the 20th century the industrial pattern of the county was well established; namely. eastern Monmouthshire, agriculture and forestry, and western Monmouthshire, coal, iron, steel and tin plate manufacture. Immediately after World War I the coal mining and heavy industrial areas suffered severe depression and in the 1930s such places as Rlaenavon. Blaina. Ebbw Vale and Rhymney were virtually derelict and were well-known "distressed areas" being included in the south Wales "special area." As a result of government action in the periods 1937–39 and 1945–50 a considerable number of new industries of varied types have been provided in the county including the production of nylon yarn. soft toys, industrial rubber goods, children's clothing, structural steelwork. motor vehicle parts. agricultural implements, hot brass pressings, telephone components. metal pressings, aluminum ladders. clocks, electrical switchgear, explosives, aluminum, veneers and furniture. paints and varnishes, light engineering goods, etc. Coal mining, iron and steel production and tin plate manufacture, however, still remain the county's basic industries.

Communications.—The county is served by the Western re-

gion of British railways. Main lines run from Cardiff (Glarn.) eastward and northnard through Newport, Pontypool and Abergavenny to Hereford; southwest along the Severn estuary irom Gloucester to Chepstow, Newport (with branch to Caerphilly) and Cardiff: across the centre of the county irom Monmouth to Usk, Pontypool and on to Pontypridd (Glam.). The Crumlin canal from the Ebbw valley and the hlonmouthshire canal irom Pontypool converge upon Newport, which is the principal port in the county. The Brecon canal runs northward from Pontypool into the valley of the Usk. These canals are now disused. There were 1.rjo.21 mi. of roads under the jurisdiction of the county council in 1954 and 90.61 mi. of trunk roads. The National Trust owned 2,374 ac. and had protective control over a further 725 ac. in 1954.

Administration. — The area of the administrative county is 530.3 sq.mi. and the population at the 1951 census was 319,568. Wartime movements caused an increase of 7% between Sept. 1939 and Feb. **1941.** Municipal boroughs are Abergavenny (pop.. 1951, **8,848)** and Monmouth (5,438). Newport (105,547), outside the administrative county, is a county borough. There are **16** urban districts and 5 rural districts. Monmouthshire is in the Oxford circuit and Usk and Nenport are assize towns; it has one court oi quarter sessions and there are 11 petty sessional divisions. The boroughs of Monmouth and Newport have commissioners of the peace, but no separate court of quarter sessions. The parliamentary divisions are Abertillery, Bedwellty, Ebbw Vale, Monmouth and Pontypool, each returning one member; the parliamentary borough of Newport returns one member. By the act of 1536 two knights were to be returned for the shire and one burpcss for the borough of Monmouth, but the first returns for the county were made in 1547 and for the borough in 1553.

MONO or MONACHI, two Shoshonean-speaking Indian groups of central California. of the same dialectic division as the northern Paiute of Nevada and the Bannock of Idaho. The western Mono, in the pine belt of the Sierra Nevada, are acculturated to the nearby Yokuts: the eastern branch. of Mono and Owens valley across the crest, locally called Paiute, are more similar to their congeners of the Great Basin. There were an estimated 600 Mono in the state in 1960.

See Smithsonian Institution, Bull. 30, *Handbook* of *American Indians,* vol. i (1912).

MONOCHORD, an instrument having a single string. used by the ancient Greeks for tuning purposes and for measuring the scale arithmetically. A movable bridge was so contrived. as to slide along over the string and stop it at any point.

MONOCOTYLEDONS: *see* ANGIOSPERMS.

MONOD, ADOLPHE (1802–1856), French Protestant clergyman, was born on Jan. 21. 1802. in Copenhagen. Den.. and was educated at Paris and Geneva. He began his lifework in 1825 as founder and pastor of a Protestant church in Naples, from which he moved in 1827 to Lyons. There his evangelical preaching. and especially his sermon on the duties of communicants, led to his deposition. In 1836 he became professor in the Theological college of Montauban. removing in 1847 to Paris as preacher at the Oratoire. He died on April 6. 1856. Monod was undoubtedly the foremost Protestant preacher of 19th-century France.

His chief works are *Sermons* **(1844;** Enp. trans., 1849), *La Femme* (1848; Eng. trans., 1851) and S. **Paul** (1851; Eng. trans., 1853). Extracts from his correspondence appeared at Paris (1885–1902).

FRÉDÉRIC MONOD (1794–1863), his brother, was born at Monnaz, Switz.. on May 17, 1794, and died at Paris on Dec. 30, 1863. Ordained at Geneva in 1818. he spent most of his life in Paris, where with Count Gasparin he founded in 1849 the Union of the Evangelical Churches of France.

MONOGENISTS, the term applied to those anthropologists who claim that all mankind is descended from one original stock (*monos,* "single." and *genos,* "race"), and even from a single pair; while polygenists (*polus,* "many") contend for a multiple ancestry.

MONOGRAM, originally a cipher consisting of a single letter. now a design or mark consisting of two or more letters intertwined. The letters thus interlaced may be either all the letters of a name cr the initial letters of the Christian name and surname of a person for use upon note paper. seals or elsewhere. Many of the early Greek and Roman coins bear the monograms of rulers for whom, or the towns in which, they were struck. The late Latin and Greek words were first applied to the signatures, which took this form, of the emperors of the eastern empire. The signatures of the Frankish kings also were of a monogram.

The most famous of monograms is that known as the "Sacred Monogram," formed by the conjunction of the two initial letters of Χριστός, "Christ." The most usual form of this is the symbol ☧ and sometimes the α (alpha) and ω (omega) of the Apocalypse were placed on each side of it. The symbol was incorporated in the *Labarum* (*q.v.*) when the imperial standard was christianized. The interlaced I.H.S. (also called the "Sacred Monogram") apparently possesses no great antiquity: it is said to have been the creation of St. Bernard of Siena in the mid-I jth century.

Monograms or ciphers were often used by the early printers as devices and are of importance in fixing the identity of early printed books. Similar devices have been used by painters and engravers. The middle ages were, indeed, extremely prolific in the invention of ciphers alike for ecclesiastical. artistic and commercial use. As the merchant had as a rule neither right nor authority to employ heraldic emblems. he. therefore, fell back upon plain simple letters arranged very much in monogram form. These "merchants' marks" generally took the form of a monograin of the owner's initials together n-ith a private device. They nearly always contained a cross, either as a protection against storms or other catastrophes, or as a Christian rnark to distinguish their goods from Moslem traders in the east.

MONOLOGUE, a passage in a drama in which a personage speaks unconsciously aloud, either alone on the stage or with others keeping silent. The tragedies of the 17th and 18th centuries greatly affected the monologue, which has always, however, been liable to ridicule. There is something of a lyrical character about the monologue in verse: and many of the examples in the tragedies of Corneille are nothing more or less than odes or cantatas. The monologues of Shakespeare and Racine have a more dramatic character. The French critics record as striking examples that of Figaro in Beaumarchais's *Le Mariage de Figaro* and the 160 lines of Charles V in Victor Hugo's *Hernani.* In the Elizabethan drama, the popularity of Kyd's *Spanish Tragedy,* in which Hieronymo spouts interminably, set a fashion for ranting monologues, which occur frequently in Marlowe and others. After 1600 the practice was much reduced. but it returned in exaggerated form aiter the Reformation. to fall once more into deserved contempt. In the 19th century it was revived in lyric poetry by Robert Browning in such poems as *Andrea del Sarto,* and by Tennyson in *Ulysses* and *Rizpah.* In the 20th century it has been employed in plays such as Eugene O'Neill's *Strange Interlude,* and in poetry; T. S. Eliot used it with great subtlety in "Prufrock" and "Portrait of a Lady."

By means of the "interior monologue." which is an extension of the stage soliloquy; Marcel Proust and James Joyce revolutionized the novel. (G. W. A.; X.)

MONOMETALLISM: *see* BIMETALLISM; MONEY.

MONOMOTAPA. In old maps of southeast Africa, derived originally from Portuguese and from Dutch sources; an extensive region on the Çuama or Zambezi and to the south of it is styled *regnum monomotapae.* The precise character of the kingdom has been the subject of much discussion, and some modern historians relegate it to the realm of myth. But such scepticism is unjustifiable since all Portuguese writers from the beginning of the 16th century onward reiterated the assertion that there was a powerful rule known far and wide by that title.

The n-ord monomotapa is of Bantu origin and has been variously interpreted. Father J. Torrend. in *Comparative Grammar of the South African Bantu Languages* (p. 101), renders it "Lord of the water-elephants," and remarks that the hippopotamus is even in modern times a sacred animal among the Karanga. The earliest recorded bearer of the name is Mokomba Rlenamotapam, mentioned by Diogo de Alcaçova in 1506 as father of the Kwesarimgo Menamotapam who ruled at that date over Vealanga, a kingdom that included Sofala. His capital was called Zumubany. an obvious corruption of the term "Zimbabwe," the residence of any important chief. Portuguese chroniclers not only refer to the territory and the people of the monomotapa as "Mocaranga" (*i.e.,*

of the Karanga tribe), but explicitly assert that the "emperor" himself was a "Mocaranga." Consequently, he must have been a Negro, and the Dominican who records the baptism of Dom Filippe by a friar of the order in the middle of the 17th century actually states that this "powerful king" was a black man (corn as *carnes pretas*).

It is difficult to arrive at an estimate of the extent of territory over which this great Negro chief exercised direct or indirect control. The most extravagant theory is naturally that which was expressed by the Portuguese advocates in connection with the dispute as to the ownership of Delagoa bay. The crown of Portugal based its case against England on the cession of territory contained in a well-known treaty with the monomotapa (1629) and stated that this monarch's dominions then extended nearly to the Cape of Good Hope. A more moderate and usual view is given by Diogo de Couto, who in 1616 speaks of "a dominion over all Kaffraria from the Cabo das Correntes to the great river Zambezi." Several 17th-century writers extend the "empire" to the north of the Zambezi, Bocarro giving it in all "a circumference of more than three hundred leagues." It was "divided among petty kings and other lords with fewer vassals who are called inkosis or fumos." According to these authors, however, including Dos Santos, the paramountcy of the monomotapa was impaired in the 17th century by a series of rebellions. His zimbabwe, wherever it may have been in earlier days, was now fixed near the Portuguese fort of Masapa, only a short distance south of the Zambezi. A Portuguese garrison was maintained in it, and the king himself from 1607 onward was little more than a puppet, generally baptized with a Portuguese name.

MONONGAHELA, a river of southwestern Pennsylvania and northern West Virginia, and a major headwater of the Ohio river (*q.v.*), whose source is the confluence of the Allegheny and Monongahela rivers at Pittsburgh, Pa. The headwaters of the Monongahela are the Tygart and West Fork rivers, which join at Fairmont, W.Va. The river flows in a northerly direction in a very sinuous course. Its total length is 128 mi., and it drains about 7,390 sq.mi. The principal tributaries are the Cheat and Youghiogheny rivers. The most important cities along the course of the Monongahela are Fairmont and Morgantown, W.Va., and Brownsville. Charleroi, Monessen, Donora and McKeesport, Pa. In its upper reaches the river has a swift current and furnishes hydroelectric power to several cities. The entire river has been made navigable for 128 mi. from its mouth to Fairmont, W.Va. The Monongahela flows through some of the richest coal fields of the United States and is a major artery of transportation carrying such commodities as coal. coke, iron and steel. (E. W. Mi.)

MONONUCLEOSIS, INFECTIOUS: see INFECTIOUS MONONUCLEOSIS.

MONOPHYSITES, the name given to those who hold the doctrine that Christ had but one (*monos*) composite nature (*physis*) and especially to those who maintained this position in the great controversies of the 5th and 6th centuries. The synod of Chalcedon (*q.v.*) in 451, following the lines of Pope Leo I's famous letter, endeavoured to steer a middle course between the so-called Nestorian and Eutychian positions. But the followers of Cyril of Alexandria and those of Eutyches saw in the Chalcedon decree of two natures only another form of the "Nestorian" duality of persons in Christ, and they rose everywhere in opposition. For a century they were a menace not only to the peace of the church but to that of the empire.

Between the Council of Chalcedon and the death of Justinian the movement on the whole gained in strength, especially in Egypt, and caused civil disturbances in Jerusalem, Alexandria, Antioch, Constantinople and other centres in the east. Justinian himself in his later days adopted it; but his successor, Justin II, took no action either way for six or seven years and then instituted a quiet but thorough system of suppression, closing churches and imprisoning their bishops and priests.

There are two principal varieties of monophysitism: (1) Severus (bishop of Xntioch 513) and his followers objected to Chalcedon only because it was an innovation; they fully acknowledged the distinctness of the two natures in Christ, insisting only that they became indissolubly united so that there was only one energy of Christ's will. Severus laid great stress on the human infirmities of Christ as proving that His body was like man's, created and corruptible; and some of his followers extended the argument to Christ's human soul. which they said mas (like man's) limited in knowledge. (2) Julian, bishop of Halicarnassus, and his followers held that Christ's body was so inseparably united with the Logos as not to be consubstantial with humanity; its natural attributes were so heightened as to make it sinless and incorruptible. Some even held that from the moment the Logos assumed the body the latter was uncreated, the human being transmuted into the divine nature; and the adiaphorites went still further, denying like Stephen Barsudaili, an Edessan abbot, all distinction of essence not even between the manhood and the Godhead in Christ, but between the divine and the hunian. and asserting that "all creatures are of the same essence with the Creator." The disintegration caused by monophysitism largely facilitated the rapid and easy victory of Islam in Syria and Egypt. See MONOTHELITES.

MONOPLACOPHORA, a class of marine invertebrate animals belonging to the phylum Mollusca (*q.v.*) and characterized by having a single. cap-shaped shell and bilateral symmetry. They are represented in modern seas by two rare and small species (up to 1 j mm. in length) found in waters as deep as 19,200 ft. They are distributed in deep-sea trenches off the coasts of Central and South America. Monoplacophorans have an exceedingly peculiar geologic distribution: they are first known in Lower Cambrian deposits of Newfoundland (about 500,000,000 years old) and are completely unknown in the fossil record after the Lower Devonian (about 320,000,000 years old). One of the most exciting finds in the biological sciences occurred in 1952, during the Danish deep-sea expedition "Galathea," a research vessel, about 12 live monoplacophorans were dredged up from 11,400 ft. off the coast of Costa Rica.

Monoplacophorans are unusual and important because of the combination of primitive characters they possess. These characters provide one of the few known instances where a group of animals help bridge the morphologic gap between several animal phyla. In addition to the single, cap-shaped shell, they have paired organs which may be multiple (*e.g.*, several elements of gills and kidneys), reflecting at least partial segmentation (metamerism). Gill structures and the type of metamerism suggest a much closer affinity of the mollusks with the annelid worms than was previously known and also may provide a means of associating the mollusks with the arthropods.

Within the Mollusca. the Monoplacophora stand as a very primitive group. They are similar to the class Xmphineura (*q.v.*) which differ in having eight articulated plates (requiring a complex musculature) instead of the single, cap-shaped shell. Amphineura, however, do not show metamerism. Monoplacophorans, because of their single, partly coiled shells. were thought to be members of the class Gastropoda (*q.v.;* snails. whelks, etc.) until paleontologists showed them to possess bilateral symmetry. Gastropods generally lack one of a paired set of organs, thus are asymmetrical, and are not metamerized. The gastropods are fundamentally different from the Monoplacophora in being torted, *i.e.*, early in the growth of gastropods the gastrointestinal tract, along with other features, twists or torts into a figure eight so that the anus is brought near the mouth.

See J. Brookes Knight, "Primitive Fossil Gastropoda and Their Bearing on Gastropod Classification," *Smithsonian Miscellaneous* Collections, vol. 117, no. 13, publication 4092 (1952). (R. L. Bn.)

MONOPOLY. The term monopoly is applied to the advantage accruing to any undertaking or associated group of undertakings which has the power, however acquired, of fixing the price of its goods or services in the knowledge that those who need them cannot get them in adequate measure elsewhere. This article considers the subject in three sections: *Economic Theory*, History and Legal Aspects.

ECONOMIC THEORY

Pricing and Allocation of Resources.—The theory of monopoly price is most precise where the entire market for a com-

modity or service is occupied by a single firm which also controls all entry into its field. Such a firm will of necessity consider the effect of changes in its output on the resulting price and on its total receipts. Consequently, in deciding whether to utilize another unit of productive services purchased in a competitive market, it will compare the cost of such a unit with the amount the resulting product will add to its receipts, taking account of the fact that the additional output will lower the price of its total output. And if the firm is also the principal purchaser of the productive services, it will also take account of the effect its purchases have on the prices of these services. This behaviour is in marked contrast with that of competitive firms *(see* COMPETITION, ECONOMIC), which take the market price as given and adjust their output to the point where the cost of an additional unit is just equal to its price. This difference in behaviour results in a misallocation of productive resources mhen monopoly is prevalent. The output of a monopolized industry is smaller than it would be under competition; and the price of the commodity or service is higher. Whether misallocation of productive resources results also from the fact that monopolies are less efficient than competitive enterprises, or contribute to greater instability in the economy, is a matter of dispute.

The same type of analysis, with slight modification, is applicable to the industry in which there are a great number of firms that remain as independent entities, but combine for the purpose of making a collective decision with respect to the basic issue of price and output. The general direction of the result is the same as that indicated for the single firm: a smaller output and a higher price than result from competition. But since the participating firms are independent, they will endeavour to enlarge their scale of operations in order to increase their individual claims to the higher profits prevailing in the industry. Similarly, new firms will be tempted to enter the industry in order to get a share of the higher profits. and will have to be given a share in total output if the collective action is to be continued. In this way the amount of productive resources attached to the industry is greater, although the total output is smaller, than it would have been under competition. Ultimately the rate of return to productive resources will be reduced to the competitive level, but the productive resources attached to the industry are not utilized efficiently. One difference between the two types of monopoly is that in the single firm type the misallocation of resources is the result of having too small an amount in the industry, while in the association type it is the result of having too large an amount. Another difference is that in the single firm type the rate of profit is higher than it is under competition, while in the association type it is the same.

Formation and Maintenance. — Monopoly may be inevitable. It may be due to the fact that cost of production is smaller for a single firm than it would be for several smaller firms because of economies, of scale. Industries characterized by such cost conditions are usually designated as natural monopolies; *e.g.,* public utilities. Because competition is impossible, such industries are generally subjected to some form of state regulation over prices and the scale of operations. While generally associated with public utilities, economies of scale may also be a characteristic of other industries. Whether such cost conditions are prevalent in other industries cannot be readily determined. Conclusions must be based on such factors as the length of time during which a single relatively large firm continues to thrive, and the extent to which smaller firms survive. On the other hand, an industry characterized as a natural monopoly at one time need not always remain one. Railroads may still be subject to economies of scale, but the advent of alternative forms of transportation — trucks and airplanes — has probably eliminated the monopoly element from railroads.

All monopolies are temporary except those based on economies of scale or exclusive grants from the state. The prices and profits of monopolized industries will attract new firms whose entry will in time destroy the monopolies. The most general method of establishing such temporary monopolies is that of purchasing existing firms or merging with them into a single relatively large firm. Or a temporary monopoly may be established by creating a single association to replace the individual decisions of the independent firms over price and output with a collective decision. It is frequently suggested that temporary monopolies can also be established through coercive methods such as general or local price-cutting, exclusive dealing with or without rebates, tie-in sales or licensing under patents, price discrimination and price maintenance. *(See* PRICE MAINTENANCE.) But these policies can be utilized only mhen some monopoly power already exists. A competing firm has no advantage in price-cutting not available to other competing firms. A buyer with adequate alternative sources of supply will not accept imposed conditions of exclusive dealing or tie-in sales unless he is paid for such conditions by offsetting rebates. The payment of such rebates does not establish any advantages for the seller not available to other competing sellers. A producer will not enforce price maintenance at the distribution level except where peculiar conditions of marketing make this an advantageous procedure, unless the distributors already have sufficient power to exact such enforcement. A competitive seller will not continue to accept lower prices from some buyers when he can divert his output to other buyers.

If effective at all. coercive methods or predatory practices can be utilized only if some firm already has some monopoly power obtained in other ways. The alternative functions of such practices is said to be that of increasing the monopoly power obtained in other ways, or maintaining a given degree of power by discouraging potential competition. The effectiveness of such methods for this purpose is also subject to significant limitations. The cutting of prices on a local or general basis imposes the same costs per unit on the firm initiating such reductions in order to destroy a rival or a nencomer as it imposes on the rival or the newcomer. The evidence of price-cutting can usually be interpreted as the result of the expansion of rivals or the entry of new firms rather than as a practice to keep such rivals from expanding or to prevent new firms from entering the industry. Even a complete monopoly is not unlimited in its power. Once a monopoly has imposed a monopoly price it has exhausted its market power. Thus it cannot both charge a monopoly price and impose exclusive dealing on its purchasers. If it does the latter, it must make some concessions from the monopoly price. Such a practice. therefore, involves some cost, and unless the cost assumed is less than the cost imposed on rival firms, the method cannot be eifective as a device to increase or maintain a given degree of monopoly. There are special circumstances which may make the costs of exclusive dealing smaller for the firm nith some monopoly power than for the firms without such power. This would be the case where the firm with monopoly power has a greater variety of the product than all the other firms, and where such variety is economically important to the distributor. In the general case, as when the product is standardized. the costs are the same to both the firm with monopoly power and the other firms, and exclusive dealing is not an effective method of preventing other firms from expanding or entering. Beyond this, exclusive dealing or its equivalent — ownership of the channels of distribution — may impede the expansion of existing firms, or the entry of new ones, because it increases the capital required for entry or expansion. Increased capital requirements may impede expansion or entry either because of the difficulties of obtaining capital or because of the greater risks attached to entry and expansion on a large scale than on a small scale.

Tie-in sales, when the sale or licence of the monopoly product or machine is made conditional on the purchase of some complementary unpatented product. are commonly found in connection with patented machines or products. As in the case of exclusive dealing, setting a monopoly price exhausts market power. The monopolist cannot both set a monopoly price and impose other coercive conditions. Hence in the usual case he cannot increase his monopoly profit by attempting to monopolize another product. In many instances, it is difficult to make certain that the practice of tie-in sales is in fact coercive. It may result from the advantage of selling the two products in a single transaction and the disadvantage of offering them separately. In other cases the practice may be an indirect method of charging different prices for the monopoly product to different buyers. The sale of the unpatented

complementary product may be the most effective means of making such a differentiation in price. Thus a firm which has a patented machine could not ordinarily sell it at different prices. Resale would promptly establish a uniform price. And yet different prices might result in maximum profits. By setting appropriate prices for the machines and for the materials used in the machines, the firm may collect higher prices for the machines from those who use large quantities of the materials than from those who use small quantities of the materials. Price discrimination may indeed be a characteristic of monopoly whenever a given market can be separated into two or more parts; and the customers in each have different demand conditions. But such discrimination is a method of maximizing the profits from a monopoly and not one of increasing the degree of monopoly. In fact. insofar as price discrimination increases the profits of monopoly, it increases the incentive for expansion of other firms and entry of new ones. The interpretation of price discrimination as a method of extending monopoly is in part at least based on failure to distinguish between nominal prices and prices which reflect other conditions of selling. In part the interpretation is based on a failure to separate sporadic price discrimination. which may be a characteristic of competition. from systematic price discrimination! which is a characteristic of monopoly conditions.

Oligopoly and Monopolistic **Competition.**—Monopolies of the single firm type are quite rare except for natural monopolies and those based on exclusive grants from the state. The commoner phenomenon is that of markets in which a few firms account for the bulk of the industry output. These monopolies also may be based on economies of scale so that the cost of production of three or four firms is significantly less than that of many smaller firms. Or monopolies may arise from the purchase by three or four firms of many of the other firms in the industry, or the merger of competitive firms into three or four relatively large firms. The behaviour of such oligopoly industries, cannot be predicted with the same confidence that the behaviour of a single monopoly firm can be predicted. In general, if the firms can work out a satisfactory scheme for sharing in the advantages of monopoly, they can be expected to approximate the prices set by a single firm monopoly. The smaller the number of firms the more likely is such a result to follow. But the difficulties of arriving at a satisfactory division of the market may make the behaviour of an oligopoly industry approximate that of competition rather than that of monopoly. *(See* CARTEL; COMPETITION, ECONOMIC; MARKET: *Economic Theory.)*

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HISTORY

Ancient **Forms.**—Monopolies are probably as old as commercial civilization. Corners and combinations were prohibited by the most ancient lams of China. Babylonia and India, and these indirect signs are confirmed by the mention of specific monopolies in classical literature. Aristotle (384–322 B.C.) tells in the Politics that Thales hired all the olive presses in Miletus during the winter and was able to lease them profitably when a plentiful harvest came. Aristotle treats the maneuver as a commonplace: all Thales did, he says, was to create a monopoly, just as cities do in order to raise revenues. In Egypt, this method of public finance was carried to an extreme when the Ptolemies (323–30 B.C.) took over from the temples the control of all manufactures, and required merchants to sell materials at fixed prices to the royal monopolies, which enjoyed exclusive rights to the services of craftsmen and were the only sellers of papyrus, oil and cloth. In Rome such practices were less common, though the Flavian and Xntonine emperors in the 1st century A.D. established some monopolies of corn so that by manipulating its supply they could control their subjects, while Alexander Severus and Aurelian in the 3rd century A.D. created monopolies to rent them to private contractors. Complaints recorded by Pliny the Younger and a prohibition passed during the reign of Tiberius show that unauthorized monopolies often sprang up during the 1st century A.D.; an edict of Zeno, issued in 483 and perpetuated in the Code of Justinian. gives evidence that combinations had by then become frequent, especially among builders, who agreed that none would complete a house begun by another. By the 5th century A.D., all the fundamental varieties of monopoly mere known and its basic principle understood, although many forms and uses were devised later.

Medieval Monopolies.— An important innovation was made during the middle ages, when governments began to bring economic life under their domination and adapted to this end privileged institutions that had arisen for other purposes. They based their control over foodstuffs partly on powers that lords of manors traditionally exercised over markets, powers they successfully defended in royal courts as early as the 12th century and which precluded anyone from trading outside the official stalls and hours, or from holding any other market within a certain distance. As part of their effort to keep prices low and stable by law, governments reinforced these monopolies by imposing punishments sometimes as severe as death on those who evaded the markets and the fixed prices. A statute for the "assize of bread and ale," passed in 1266 by Henry III of England, provided that bakers or brewers who charged more than the law permitted would be fined, or "corrected" by pillory and timbrel, and like many similar laws of the next 500 years it prohibited interference with the established prices by forestallers, engrossers, regrators, and, in short, all speculators or wholesale traders. *(See* ENGROSSING.)

Other institutions were empowered by royal authority to establish control over manufactures and commerce. The most important were the guilds, which, originating as private associations of townsmen, grew by the 12th century to be organizations of particular crafts, armed by charter with considerable monopolistic powers. The guilds fixed conditions of membership, set limits to the number of employees as well as to the hours and conditions of work, and were able to uphold the joint monopoly of the handful of masters by the power of search and seizure. *(See* GUILDS.) During the 16th century, for instance, no Londoner could lawfully work in precious metal unless he belonged to the Goldsmiths company, which had power to assay and stamp all gold and silverware made nearby, to destroy any that fell below their standards and to punish the makers. Although the guilds often paid annual fees and made large occasional gifts to the crown, the income they gave the treasury was not considered a more important contribution to the public good than the order they imposed on trade. Foreign commerce was often regulated in the same manner by companies of merchants privileged to trade with certain parts of the world, and some of the great mercantile companies that grew up in the 17th century accepted in addition responsibility for supporting armed forces and their nations' ambassadors abroad. They were thus pressed into public service and, like the guilds, became in effect administrative agencies of the government.

Monopolies by Grant and Patent.— Special privileges were created also in order to encourage new trades, and were granted with special liberality to enterprises that needed large sums of capital. In 1538, Duke George of Saxony gave Michel Puffer, a merchant of Leipzig, a three-year monopoly to sell all the tin produced by several mines, in return for which Puffer provided capital for the working of the mines and paid a set price for the product. In 1549, Emperor Ferdinand I granted similar powers over Bohemian tin to a merchant of Augsburg, who mas required in turn to extend a large loan to the emperor and to pay royalties on his profits. But the monopoly was threatened by the competition of tin from Saxony, even though the emperor forbade its importation and ordered special vigilance against smuggling, and despite further concessions the monopolist sustained great losses. Industries depending on rare skills were encouraged by the same means. In 1467, a monopoly of papermaking mas granted by Berne; two years later a monopoly of printing was given by Venice; and in 1507, another Venetian was given a monopoly of mirror making. In England during the 16th century, patents were given to induce foreign craftsmen—Italian glassworkers, French iron founders, German armourers and Dutch drainage engineers—to settle there.

But such grants were not always disinterested. The privilege granted John Peeche in 1373 to be the sole retailer of sweet wine in London, despite the general rule that sweet wine should not be sold at retail, recompensed him for having made loans or gifts to John of Gaunt, the king's brother. To grant monopolies as rewards for faithful service or to sell them to the highest bidder remained an only occasional practice until Elizabeth I made it a frequent if not characteristic exercise of prerogative. Beginning in 1561, patents were regularly issued for the

sale of common commodities, so that by 1590 paper, glass, vinegar, salt, starch, oil and even playing cards were sold exclusively by patentees, and opponents oi the policy asked whether bread was not controlled in the same way. Parliament resented the powers oi patentees to search private houses and order arrests, regarded the whole system as an abuse of royal power, and attacked it with such energy that Elizabeth promised in 1601 to forego it. Although her successors during the rest of the century alternately issued and revoked similar patents, the Statute of Monopolies of 1624 established the broad principle that patents must be awarded by parliament for a limited term to inventors, the principle on which modern patent law is erected.

The Statute of Monopolies, however, was neither the climax of a long development of antimonopoly law nor the end oi the system of public control by private privilege. Legislation against monopolistic behaviour was common enough throughout Europe long before the 17th century, and indeed there have probably been antimonopoly laws ior almost as long as there have been private monopolies. Capitularies of Charlemagne prohibited combinations irom raising the price of iood; a municipal law of Viterbo, Italy, adopted in 1251, penalized merchants who associated to buy or sell fish; and Wenceslaus II of Bohemia toward the beginning of the 14th century condemned combinations to raise the price of ore. Similar rules were contained in the municipal statutes of Florence, Nürnberg and Cologne during the 14th and 1 jth centuries and in ordinances oi French kings, as well as in the acts of England. But these lams were less broad than they seem at first sight; almost invariably they mere directed against unauthorized efforts to raise the price of ioods and basic raw materials such as wool, ore and hides; they did not question the validity of established and authorized monopolies. The city councilors who prohibited combinations of food sellers were often themselves representatives of guilds, and kings who vigorously enforced laws against engrossers were often simultaneously setting up patent monopolies. Even as late as the 17th century, the Statute of Monopolies itself, while strictly limiting the issue of new patents, expressly exempted all prescriptive and statutory privileges of guilds, companies and municipal corporations. Many statutory monopolies were never abolished, but decayed as the governments, more or less dedicated to free trade or democracy. withdrew their support. Unauthorized monopolies continued in many places to be prohibited by law, but aiter the 18th century they became more liable to be prosecuted for interfering with competition than with government control of the economy.

Industrial **Monopolies.**—After the early 19th century, the most noticeable feature in the history of monopoly mas the apparent increase in the number of private monopolies, often national and sometimes international in scope, and the efforts of promoters to organize them in legally and economically stable forms. As increasing ease oi transportation extended the area of markets, the scale of monopolies grew accordingly, and with it the difficulty of organizing combinations, since as the number of associated firms grew greater it became simpler for any one of them to undercut prices secretly or to exceed its quota. As a result of this, many U.S. combinations during the second half of the 19th century collapsed. Also, it was usually impossible to enforce agreements among members, since the courts continued to uphold the common law rules against contracts and combinations in restraint of trade. Moreover, because U.S. corporations generally lacked power to own stock in other corporations, it was difficult to devise any lawful arrangement to give a monopolistic combination legal permanence. But in 1882 the Standard Oil company combination reorganized as a trust; the stockholders of each corporation participating in the combination turned over their shares to a small group of managers, who became the trustees of the former owners and by holding all the stock mere able to operate the separate legal entities as a single economic unit. The scheme seemed to answer the purpose so well that it mas widely copied, and by 1890 a number of important national monopolies had organized as trusts, particularly in the oil, sugar and distilling industries. The device mas soon attacked, however. on the principle that by joining trusts the corporations had exceeded their powers; and it was readily abandoned after 1890 when a number of states altered their lams so as to allow one corporation to own another, as a result of which the more tightly knit monopolies organized as holding companies or simply as consolidated corporations.

The apparently sudden growth of great industrial combinations that took place in the U.S. and gave rise there to the antitrust laws was paralleled in England, where no legal obstacles were interposed until aiter World War II, and in Germany, where government neither prohibited nor ignored the cartels but established public agencies to regulate them. *(See* CARTEL.) In these countries during the 20th century, as elsewhere in the past, monopolies and large firms that were assumed to be monopolistic were always being formed and always fading or vanishing. In the latter 1950s the impression was very widespread that monopolies controlled a much larger fraction of economic life than they had in the past, even though investigators did not agree that close statistical study substantiated this conclusion. The longer history of monopolies, based, as it must be, on less precise and complete evidence, makes it clear that hosts of private monopolies existed even though they were prohibited, but that none of them survived very long unless it was protected by the positive intervention of the state.

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LEGAL ASPECTS

The Common Law Background. — The intellectual tradition favouring competition as the method of organizing production and distribution is of recent origin compared with the English common law regarding restraints of trade. It is not surprising, then, that over most of its history the common law as to restraints was not concerned with the preservation of competitive conditions. Similarly, the English statutes against forestalling, regrating and engrossing may not have been lams against cornering the market, as they are usually regarded, but rather laws designed to prevent competition from interfering with established channels of distribution. The case of John Dyer, decided in 1414, said that a covenant not to practice a trade in a given town ior a hali pear was void as against the policy of the lam. Modern readers infer that the law favoured competition; actually the rule was geared to the guild economy of the 15th century. If a man could not ply his trade in his home town, guild restrictions might prevent him from earning his living elsewhere. In 1711 *Mitchel* v. *Reynolds* further refined the law, stating that such restraints mere void unless limited as to time and place, based on good consideration and ancillary to a valid main contract, such as the sale of a business. For a time in the 19th century, nonancillary restraints were struck down because their sole purpose was to stifle competition, but soon even such restraints were upheld as reasonable. In 1894 Lord Macnaghten in *Nordenfelt* v. *Maxim Nordenfelt Guns & Ammunition Co.* laid down the rule that a valid restraint need only be reasonable with reference both to the interests oi the parties concerned and to the interests of the public. The two standards are, of course, incompatible as applied to cartel arrangements, and in opinions such as that in *Adelaide Steamship Co.*, English courts equated the interest of society with that of the cartel members. The English common law has resumed its original attitude oi indifference, even hostility, toward competition.

U.S. common law resembled the English: the state had no right of action against agreements embodying unreasonable restraints, but they were unenforceable. Some U.S. courts, however, defined the reasonableness oi a restraint according to its nature rather than, in the English iashion, according to the "reasonableness" of the price agreed upon or the effect upon the parties. Under this divergent view, competitors' price fixing agreements, for example, are incapable of justification. Some courts also judged a restraint by its magnitude, upholding price agreements when the fraction of all competitors involved was so small that no effect upon prices seemed likely. This was the state of the common law when the Sherman Antitrust act was passed in the U.S. in 1890.

United States. — Section 1 of the Sherman act forbids "Every contract, combination . . . or conspiracy, in restraint" of trade; section 2 prohibits monopolization, and attempts, combinations or conspiracies to monopolize. Both civil and criminal sanctions are provided. The act was little used in its early years and there mas widespread uncertainty as to what activities were prohibited. In terms, the statute struck down all restraints, whether reasonable or not at common law; but it was obvious that such an interpretation would be stultiiying, since some restraints, such as those inherent even in ordinary contracts, may often be socially desirable. The *Standard Oil* and *American Tobacco* cases decided by the supreme court in 1911 announced the "rule of reason" as the canon of construction: the act reaches only unreasonable restraints. Because the common law had often defined "reasonableness" according to the interest oi the cartel or the "fairness" of a fixed price, it was at first feared that the court, although ordering the dissolution of the oil and tobacco combinations, had emasculated the act. Later decisions demonstrated, however, that "reasonableness" mas defined, as under one strain of the U.S. common law, by the character and magnitude of the restraint and its effect on the public. The *Socony-Vacuum* opinion (1940) partially removed the issue of magnitude (the market power of the participants in a restraint), stating that the nature of price fixing agreements, at least, renders them illegal per se. Market division by competitors is also a per se offense. Organized bcycotts may fall within that category, but other restraints, *e.g.*, requirements contracts, clearly do not but must be analyzed in terms of impact upon competition.

The Sherman act has had greater difficulty with the problem of monopoly. Partly because the statute prohibits monopolizing rather than monopoly, and perhaps partly from iear that monopoly may be the natural tendency of competition, the courts have vacillated between the views that monopoly power is illegal in itself and that such power is outlawed only when abusively exercised or obtained. The abuse (predatory practice) theory was adopted in the 1911 *Oil* and *Tobacco* cases and reaffirmed in the 1920 *United States Steel* opinion. The power interpretation gained ascendancy in the 1945 *Aluminum Contpany* decision which stated that 90% control of a market mas illegal, 30% mas not and 64% was doubtful. Neither the power or abuse theory has gained dominance and judicial wavering between the two seems likely to continue.

The Clayton Antitrust and the Federal Trade Commission acts were passed in 1914 to strengthen supposed weaknesses oi the Sherman act. These laws are based on the theory that monopolies and restraints must be arrested in their incipiency. The Clayton act outlaws specific be-

haviour when its effect "may be to substantially lessen competition or tend to create a monopoly." This standard has been interpreted to require a reasonable probability oi an anticompetitive effect. Practices covered include mergers, exclusive dealing, price discrimination and tie-in sales. The 1950 amendment strengthened the merger provisions. An acquisition by one corporation of the stock or assets of another is made illegal where the effect in any line of commerce in any section of the country may be substantially to lessen competition or to create a monopoly. Controlling considerations include the percentage of market control created, the strength of remaining competition and the ease oi entry of new competitors into the market. Although litigation has not yet given firm content to the new law, its more stringent provisions clearly displace the Sherman act's tests as to acquisitions of competitors, leaving to section 2 of that act only the problems of attempted and actual monopolizations through predatory practices or normal growth.

The Clayton act permits persons injured by violations of any of the antitrust laws to recover triple their actual damages. Private litigation under this provision is heavy and increasing.

The Federal Trade Commission act established a commission empowered, among other things, to investigate and to issue cease and desist orders against violations of the Clayton act and "uniair methods of competition." The latter term is undefined but includes at the least behaviour violative of any antitrust law.

The Robinson-Patman act of 1936, an amendment to the Clayton act's price discrimination provision, is at once the most complex and poorly drawn oi the antitrust statutes. Although sponsored by a wholesale grocers' association as a device for softening the competition offered by chain stores, the act applies to all interstate trade. In general, it prohibits discrimination in prices which may tend to lessen competition, but permits differentials justified by cost savings to the seller or by the meeting oi a competitor's price. Robinson-Patman carries iurther the theory oi the Clayton and FTC acts, the prohibition oi specific behaviour oi a single person or firm as harmiul to competition. To a large extent, the spirit and effect of these statutes is opposed to that oi the Sherman act as originally interpreted. The Sherman act's concern in the early cases was with the maintenance of a competitive market structure. To this end it struck down collusive arrangements between competitors and monopolies gained by combination, but was not particularly concerned with the business behaviour of individual firms except as it indicated an intent to monopolize.

The difficulty with banning predatory practices is that it is often impossible to distinguish them from competitive hehaviour. The distinction tends to be drawn according to the effect upon competitors, thus shifting attention irom the effect upon the market. Because small effects upon competitors are easily seen and are usually present, these statutes have received rigid interpretation, resulting in almost per se illegality for many oi the practices covered. In this way, the antitrust laws tend to become somewhat less rules ior the preservation of a iree market and somewhat more like tort rules, designed to prevent that injury to competitors which it is the nature of competition to inflict.

The Miller-Tydings legislation (1937) provides antitrust immunity for resale price maintenance agreements authorized by state statute. The McGuire amendment (1952) permitted the operation in interstate commerce of state laws making such contracts binding even upon resellers not parties to them. Although labeled "Fair Trade" acts, these laws serve primarily to legalize dealer cartel arrangements. In some instances, manufacturers favour them as the only feasible means of paying dealers ior extra service and sales effort. Because evasion of the state laws is easy, and because a number of them have been declared invalid under state constitutions, "fair trade" is declining in importance.

Canada. — In 1889 Canada added to its criminal code provisions outlawing agreements to enhance prices unreasonably, to lessen competition unduly, and so forth. The amendment of 1935 prohibits rebate or discount discriminations between purchasers buying under similar conditions, and also makes illegal price discrimination by area and predatory price-cutting. In contrast to U.S. experience, the price discrimination statute has been little used.

The Combines Investigation act of 1910, revised in 1923, 1937 and 1952, supplements the criminal code. Besides covering many of the practices covered by the code, it makes resale price maintenance illegal, and also bans mergers, trusts and monopolies likely to operate to the detriment of the public. This act provides for a director of investigation and research who makes a preliminary investigation of suspected antitrust violations. His findings are put before the Restrictive Trade Practices commission. The commission conducts hearings, at which evidence is taken and the parties heard, and then reports to the minister of justice who decides whether prosecution shall be undertaken. The substantial publicity given the commission's reports is viewed as an additional deterrent to law violation. If prosecution is successiul, fines or imprisonment up to two years are in the discretion of the court. In addition, the court may enter a restraining order in the nature of injunction against further offenses and to dissolve illegal mergers, trusts or monopolies.

Under Canadian law, which interdicts the undue prevention or lessening oi competition, public detriment is conclusively presumed to arise from a price-fixing combination if the participants have substantial control of the market. It is no defense that the price arrived at is "fair" or "reasonable." This principle was settled by the supreme court of Canada in the *Howard Snzith Paper Mills* decision. Combinations not so clearly anticompetitive as those engaged in price fixing may be susceptible oi justification even where market control exists.

Great Britain. — British antitrust legislation consists of the Monopolies and Restrictive Practices act (1948) and the Restrictive Trade Practices act (1956). The 1948 act, which defines no substantive offienses, is administered by the Monopolies and Restrictive Practices commission under the direction of the board of trade. The commission investigates and reports to the board, mhich then presents the report to parliament. A parliamentary order, or a ministerial order subject to parliament's approval, may then require the termination, in the particular case, oi the practices adversely reported on. The act describes general situations in exporting, supply and processing against which the commission may move; generally, it requires that one-third of a "particular type of business" be "dominated" by one or more firms. The 1948 act, therefore, is applicable to practices of single firms as well as to collusive agreements. Once a restrictive practice or agreement is iound, the commission must decide whether it conflicts with the "public interest." The act permits the commission to consider any factors it deems relevant in determining the "public interest," but specifies that among such factors are efficiency, technological progress, the correct volume of output at proper prices and the best allocation of factors of production. The 1948 act thus does not necessarily envision a free market but may approve monopolies and collusive arrangements whose performance is thought proper by the commission, the board or parliament.

The 1956 act bans collective enforcement of resale price maintenance but permits individual enforcement against all resellers, whether or not parties to the original contract, if they have notice of it. The 1956 act also creates a registrar, a restrictive practices court (composed of five judges and ten laymen) and a category of "registrable" agreements between two or more persons or firms which are presumed to be against the public interest unless a defense specified by the act is proved. Registrable agreements include those relating to prices, terms of sale, output, product description, manufacturing processes, persons with whom business may be done and areas where goods may be supplied, acquired or processed. Agreements relating to services and ordinary buyer-seller contracts, as well as labour union restrictions, are not covered. The statutory defenses are that the restriction is reasonably necessary for public safety — to counteract a third party's restrictive practice, to ensure fair negotiation with predominant buyers or sellers, or to the maintenance of an approved restriction; and that removal of the restriction mould deny the public substantial benefits (such as organized research), would cause permanent local unemployment or would cause a substantial reduction in export earnings. These defenses are not absolute but must be balanced against any detriment likely to flow from a restriction.

Parties to registrable agreements may be required to disclose their contents to the registrar who in turn will submit them to the restrictive practices court for determination of their conformity to the "public interest" standard. Restrictions held contrary to the public interest are void. The court may order the parties to refrain irom giving effect to such restrictions or making other agreements oi similar effect.

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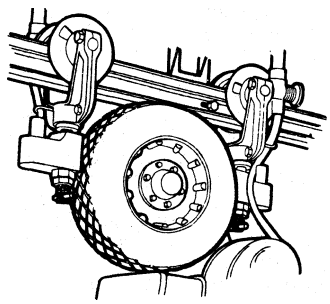
MONORAILS. A type of material-handling equipment which employs free- or power-driven trolleys traveling on overhead tracks or rails is known as a monorail. (See also MECHANICAL HANDLING.) Monorails differ from trolley conveyors in that the load carriers are independent and are not connected together by chain or cable. The free monorail carrier is pushed or pulled along its track by an operator walking along the floor, whereas power-driven monorail carriers have independent electric motors to provide locomotion. Loads are moved intermittently over a fixed path and in an elevated position. The overhead trackage may consist of a pipe, flat bar or structural rail, attached to the overhead structure of the building, or to special structural supports, by hanger rods, structural angles, side-strain brackets, and clamps.

Pipe or tubing tracks have been widely used in the garment industry. The pipe or tubing can he bent during installation to form curves, and the sections are welded together to form a complete system. Either hooks, wire hangers, or small-wheeled trolleys may be employed to guide on the pipe rails.

Flat-bar rails are used largely in the meat industry. The track consists of straight and curved sections of steel flats which are butt-welded during installation. Special mounting hangers support the bar rail from one side, and the load is supported on hangers

which extend from the trolley wheels on the other side of the rail. Single pulley-type trolley wheels are employed to ride on the top edge of the bar rails.

Structural rail systems are by far the most common and are used in all types of industry. The tracks must be sufficiently strong to withstand heavy loads and they must be designed to provide flat and wear-resistant surfaces to support the trolley wheels. The rail sections may be modified I- or T-beams, or they may consist of specially constructed steel truss assemblies, slotted rectangular tubing, or twin-track sections bolted back to back. In most of these rail systems, the trolley wheels are employed in pairs riding on each flange of the beam. These pairs of wheels are mounted into yokes which in turn support the load directly beneath the centreline of the rail. An individual load carrier may be supported on two, four! or eight trolley wheels. Where slotted rectangular tubing track is employed, the smaller trolley wheels ride inside the tubing on the bottom flanges and the load is supported on hangers which extend through the slot in the bottom of the rails. For all monorail systems, the track is installed parallel to the floor at one selected elevation. Elevating sections may be employed to raise or lower one section of the rail to other elevations or to tracks at other levels. Such elevating sections employ manual, electric, or pneumatic hoists. Coupled with a powerized carrier, a completely automatic carrier system can be designed to provide a repeating cycle of lifting, carrying, and lowering operations.



RUBBER-WHEEL MONORAIL

As with a model railroad, switches and cross tracks can be provided to connect intersecting track sections. Turntables may also be provided to rotate the carrier and its load for spraying, cleaning, or inspection operations. As has been indicated, the individual carriers may be powerized with an electric motor drive. which is supplied current from an electric feed rail that runs parallel to the trolley-support rail. Rubber-tired traction wheels bear on the monorail track to provide locomotion. The powerized carrier is usually operated from the floor, although in some installations the operator rides overhead with the carriers in a cab supported on the monorail.

The use of the monorail principle of a single overhead track for passengcr-carrying trains is exemplified by the Wuppertal (Ger.) Schwebebahn ("suspension railway"), conceived by Eugen Langen and put into operation in 1901. In 1956 a 970-ft. pilot line was opened in Houston. Tex., to show the possibilities of such a system for urban transportation. The term "monorail" is also sometimes confusingly applied to track systems like conventional ones except that only one rail is used. Such a system was the Ballybunion railway in Ireland (1882–94); another such, the "Alweg," was demonstrated near Cologne. Ger., in 1952.

Attachments.--Many types of load supports may be used with the trolley carriers, including hooks, grabs, slings, clamps, buckets, hoppers, baskets, racks. magnets and others. In addition. a hoisting mechanism may be employed to raise and lower the load.

See D Oliphant Haynes, Materials Handling Equipment (Philadelphia and London, 1957). (H. H. YG.)

MONOTHELITES, in church history, the name given to those who, in the 7th century, while otherwise orthodox, maintained that Christ had only one will. Their theory was an attempt to effect some kind of solution of the vital unity of Christ's person on the basis of the now firmly established doctrine of the two natures. The controversy had its origin in the efforts of the emperor Heraclius to win back for the church and the empire the excommunicated and persecuted Monophysites or Eutychians of Egypt and Syria. In Egypt especially the monophysite movement had assumed a nationalistic. patriotic character.

It was in Armenia, while on his expedition against Persia, in 622 that, in an interview nith Paul, the head of the Severian Monophysites (*q.v.*) there, Heraclius first broached the doctrine that the divine and human natures in Christ, while quite distinct in his one person. had but one activity and operation. Sergius, patriarch of Constantinople, was a strong upholder of the doctrine of one divine-human energy, and was the emperor's adviser on the whole question. The emperor's action led to such intense and widely spread controversy that his successor Constans II issued an edict forbidding all discussion of the questions of the duality or singleness of either the energy or the will of Christ. The scheme of doctrine of the first four general councils, with all its vagueness as to these points. was to be maintained; so far as controversy had gone, the disputants on either side were to be held free from censure; but to resume it would involve penal consequences. This decree secured silence, notwithstanding the protest of the western church at the Lateran Council of 649; but with the accession of Constantine Pogonatus in 668 the controversy once more revived, and the new emperor resolved to summon a general council. It met at Constantinople in 680, having been preceded in 679 by a brilliant synod under Pope Agatho at Rome, where it had been agreed to depart in nothing from the decrees of the Lateran synod. The will, Agatho said. is a property of the nature, so that as there are two natures there are two wills; but the human will determines itself ever conformably to the divine and almighty will.

MONOTREMATA, the lowest existing order of mammals, including the duck-billed platypus of Australia and the echidnas or spiny anteaters of Australia and New Guinea. Unlike all other existing mammals, these animals lay eggs; their right and left oviducts remain separate, not uniting to form a median uterus, and the ducts, leading respectively from the ovaries or testes, from the bladder and from the digestive tract, all open into a single cloaca or common outiet (whence the name Monotremata).

The platypus (*q.v.*) is adapted for semiaquatic life, having an otterlike form, with webbed feet; it is covered with smooth sleek fur and has a long beaverlike tail. It eats small crustaceans, worms and insect larvae, obtaining them by nuzzling in the mud with its ducklike bill. It has true molar teeth when young, but later these are replaced by hornyplates. The echidna (*q.v.*) lives in dry country, is covered with quills and coarse hair and has a short tail and long pointed toothless bill with an extensile tongue for feeding upon ants. It is more compactly built than the platypus and has immense strength for digging. The New Guinea echidna (Zaglossus) is larger, and has a very long bill and short spines almost covered by long underfur.

In 1792 the "spiny anteater" of New South Wales, Australia, was described and figured by G. Shaw, as Myrmecophaga aculeata, the impression of the author being that it was related to the South American anteater. In 1799 Shaw published the first description and figures of the duckbill, naming it the "Platypus *anatinus,*" and noting the beaverlike tail and body, the serrated ducklike bill, the small eyes, the ear holes behind the eyes, the webbed and clawed feet and other details. He came to the conclusion that it must be a resident in watery situations; that it has the habits of digging or burrowing in the banks of rivers, or underground; and that its food consists of aquatic plants and animals.

In 1800 Johann F. Blumenbach received a stuffed specimen collected by Sir Joseph Banks, which he described under the name "Ornithorhynchus *paradoxus,*" referring it to the Edentata (*q.v.*). The generic name Platypus of Shaw had already been invented by another author for a genus of beetles, so that the correct scientific name of the typical species is Ornithorhynchus anatinus; but the name platypus is now the common one for the animal.

In 1802 E. Home published a description of the anatomy of two spirit specimens of the platypus, in which he noted that "the structure of the female organs is unlike anything hitherto met with in quadrupeds. . . ." He was led to examine the corresponding parts in birds and reptiles and found most resemblance to the organs of ovoviviparous lizards. Later in the same year Home examined the anatomy of the spiny anteater. He at once recognized its affinity to the platypus and included it in the same genus as *"Ornithorhynchus hystrix."* Home also concluded that Ornzthorhynchus represented a new tribe of quadrupeds, "so that it may be considered as an intermediate link between the classes Mammalia, Aves and Amphibia. . . . Between it and the bird,

no link of importance seems to be wanting." Thus arose the misleading and still widely prevalent notion that the platypus is a link between mammals and birds, whereas its true position is more that of a link between mammals and reptiles.

In 1803 Etienne Geoffroy, the colleague of Cuvier, established a new order, Monotremata, characterized by: "Digits clawed, no true teeth; a common cloaca opening to the exterior by a single orifice." In 1809 Lamarck added a class, Prototheria, for the platypus and echidna, deciding that they were not mammals. for they had no mammary glands and were probably oviparous; they were not birds, for their lungs differed, and they had no wings; and they were not reptiles, for they possessed a four-chambered heart. Then followed a long argument whether the monotremes were to be classed as mammals. Finally in 1834 Henri de Blainville arranged the mammals under three subclasses: (1) Ornithodelphia (birdlike uteri): including the monotremes; (2) Didelphia (double uteri): including the marsupials; (3) Monodelphia (single uteri): including the placental mammals. In 1884 W. H. Caldwell obtained evidence enabling him to cabie to the British Association meeting at Montreal, "Monotremes oviparous, ovum meroblastic." In 1891 Richard Semon secured monotreme material in Queensland, including new-laid eggs and a series of embryos of the echidna. He deduced that the egg of echidna, unlike the eggs of reptiles or birds, grows within its shell by receiving nutriment through the shell from the uterine tissues of the mother. Later H. Burrell, working under Launcelot Harrison, gave accurate descriptions of the underground tunnels dug by the platypus, and of the carefully constructed nests of leaves and grass in which their eggs are laid.

According to J. T. Wilson and J. P. Hill, the ovum of the platypus at the time of fertilization is about .1 in. in diameter; after fertilization it becomes surrounded by an exceedingly thin layer of albumen, and outside this by a thin translucent horny shell. It grows to a length of .6 in. to .7 in. before oviposition. The eggs, which resemble those of certain lizards, are usuallv laid in pairs which stick together. Burrell infers that when the eggs-are laid the animal is sittingcurled up and receives them in its forepaws, by which they are placed between the curled-in tail and the abdomen, where they are brooded. For some time after the young are hatched no milk is secreted; the young when born have a very short bill with "lips." There are no teats but the young lick and suck the milk from the surface of the mammary field. In the platypus there is no pouch but in the echidna a "brood pouch" is developed.

While the platypus and the echidna differ widely in habits, external appearance and in skeletal and anatomical characters connected with the difference in "habitus," they have many important features in common. For instance, both possess a peculiar poison-secreting apparatus, in some ways analogous with those of poisonous snakes. The fang, represented by a large horny spur attached to each ankle of the male, is better developed in the platypus than in the echidna. The sharp tip of the spur is perforated by a canal leading to a duct running up the leg to a large gland beneath the skin on the upper surface of the femur. The albuminous secretion is poisonous but not fatal to other mammals. The spurs may be used in fighting between the males during the breeding season.

The existing monotremes are definitely excluded from ancestry to the marsupials or placental mammals by the possession of such curious specializations as the poison gland and tarsal spur. In the other direction there is no known group of extinct Mesozoic mammals from which we may confidently derive the monotremes. Notwithstanding the widespread impression that the monotremes have been derived from the extinct Multituberculata, palaeontological evidence weighs heavily against this view.

The anatomy of the monotremes reveals many important features of the brain and skeleton in common with the marsupials, to which group indeed they appear to be more nearlv related than to the olacental mammals. (W. K. G.)

MONOTYPES, in art, are unique impressions on paper. (For a discussion of the typesetting machine called Monotype, see PRINTING TYPE: Hot-Metal Machine Composition.) A monotype is printed from a drawing which has been painted on a hard surface (glass, metal, wood, etc.) in printers' ink or thinned oil paint. While the pigment is still wet the impression is taken by passing it through a press or by rubbing, as in the printing of a woodcut. The monotype produces an effect unlike any other printmaking process: on the paper it has no raised quality like the line engraving (see ENGRAVING. LINE) or acid-bitten etching (*q.v.*); although flat, like a lithograph (*q.v.*), it has much more of the spontaneity and directness of a water colour or wash drawing. Sometimes additional impressions are made from the same plate, but these, of course, are much duller and fainter.

The earliest appearance of the monotype as a printmaking medium is in the work of Benedetto Castiglione (1616–70) who produced about 20 prints of this kind. The process seems forgotten in the 18th century until William Blake (1757–1827) made use of it for several subjects. During the latter half of the 19th century the monotype enjoyed increasing popularity and was practised by artists as varied in their expression as Whistler, Gauguin, Toulouse-Lautrec, Carrière, Renoir, Forain, Steinlen, Pissarro and Ensor. Its greatest exponent was Edgar Degas (1834–1917) who made original and compelling use of the medium. His monotypes present many new aspects of this great artist's flair for experimentation and his ability to extend tradition into new forms. The experimental possibilities and freedom of the monotype medium have made it very popular. (H. Es.)

MONREALE (monte-reale, from a palace built by Roger I), a town in Sicily, province of Palermo, 5 mi. inland from the city, on the slope of Monte Caputo, overlooking the valley La Conca d'oro (the "golden shell"), famed for its orange, olive and almond trees. Pop. (1951) 17,140.

A large Benedictine monastery. the church of which was the seat of the metropolitan archbishop of Sicily, was the greatest of all monuments of the Normans in northern Sicily. Begun in 1174 by William II, in 1182 the church was dedicated to the Assumption of the Virgin Mary and made a metropolitan cathedral. The archiepiscopal palace and monastic buildings on the south were surrounded by a massive precinct wall, crowned at intervals by 12 towers. Little now remains except ruins of some of the towers, a great part of the monks' dormitory and frater and the splendid cloister, completed about 1200.

The plan of the church is Lombardo-Norman. The basilican nave is wide, with narrow aisles. Monolithic columns of grey oriental granite (except one of cipollino), with Corinthian capitals, support eight pointed arches on each side much stilted. There is a high clerestory with wide two-light windows, with simple tracery like those in the nave aisles and throughout the church. The other half, both wider and higher than the nave, is divided into a central space with two aisles, each of the divisions ending at the east with an apse. The roofs throughout are of open rich coloured woodwork very low in pitch. At the west end of the nave are two projecting towers, with a narthex entrance between them. A large open atrium, which once existed at the west, has been replaced by a Renaissance portico. The exterior of the aisle walls and three eastern apses is decorated with intersecting pointed arches and other ornaments inlaid in marble. The outsides of the principal doorways and their pointed arches are magnificently carved and inlaid.

The enormous extent (70,400 sq.ft.) and glittering splendour of the glass mosaics covering the interior are remarkable. With the exception of a high dado made of marble slabs with bands of mosaic between them, the whole interior surface of the walls is covered with minute mosaic pictures in brilliant colours on a gold ground. The mosaics are arranged in tiers (in parts of the choir as many as five), divided by horizontal and vertical bands.

In the central apse at Monreale, behind the high altar, is a fine marble throne for the archbishop. On the north side, in front of the high altar, is a throne for the king. The tomb of William I, the founder's father, and the founder William II's tomb, erected in 1575, were both shattered by fire in 1811. On the north of the choir are the tombs of Margaret, wife of William I, and her two sons Roger and Henry, together with an urn containing the viscera of St. Louis of France. The pavement of the triple choir is a very magnificent specimen of marble and porphyry mosaic in opus Alexandrinum.

Two bronze doors, north and west of the church, are divided into square panels with subjects and single figures, chiefly from Bible history, cast in relief. (J. H. MI.; T. A.; X.)

MONROE, HARRIET (1860–1936), **U.S.** poet and editor, founder and for many years editor of Poetry magazine was born in Chicago, Ill., Dec. 23, 1860. Educated at the Visitation convent in Georgetown, she was early ambitious to become a dramatist and a poet. Fame arrived when she was commissioned to write the

ode for the dedication of the World's Columbian exposition. Though none of her plays was performed professionally, *Valeria* was published in **1892** (*Valeria and Other Poems*) and a collection of short verse plays in 1903 (*The Passing Show.*) Meanwhile Miss Monroe served as art or drama critic on various newspapers. Elated by Chicago's artistic renascence, she resolved that poetry, the one neglected art, should have a journal of its own. After guarantors had been found, she solicited work from more than **50** poets. Their response was enthusiastic. *Poetry:* a *Magazine of Verse* (first issue, Oct 1912) soon became the leading journal of its kind. A list of its contributors, beginning with the earliest—Pound. Yeats, Frost, Eliot, Stevens, Lindsay, Masters and Sandburg—became an index to contemporary poetry. Miss Monroe was an ideal editor. Though her own verse was rhapsodic and her editorials romantic and reformist, her contributors rightly trusted her open-mindedness. Her later publications include two volumes of verse, *You and I* (1914) and *The Difference* (1924). A collection of essays. *Poets and Their Art* (1926), contains some of her editorials. In 1917 she co-edited the influential *The New Poetry, an Anthology of Twentieth-Century Verse in English* (revised 1923 and 1932). Miss Monroe died on Sept. **26, 1936.**

Indispensable to a knowledge of Miss Monroe's career is her posthumously published autobiography, *A Poet's Life, Seventy Years in a Changing World* (1938). Her books and correspondence files are in The University of Chicago library. . .

MONROE, JAMES (1758–1831), fifth president of the United States, was born on Monroe's creek, in Westmoreland county, Virginia, on April **28,** 1758. His father, Spence Monroe, was of Scottish, and his mother, Elizabeth Jones, of Welsh descent. At the age of **16** he entered the College of William and Mary, Williamsburg, Va., but in **1776** he left college to take part in the Revolutionary War. He enlisted in the Third Virginia regiment, in which he became a lieutenant, and subsequently took part in the battles of Harlem Heights, White Plains, Trenton (where he was wounded), Brandywine, Germantown and Monmouth. In 1780 he began the study of law under Thomas Jefferson, then governor of Virginia, and between the two there developed an intimacy and a sympathy that had a powerful influence upon Monroe's later career.

In 1782 he was elected to the Virginia house of delegates, and though only **24** years of age he was chosen a member of the governor's council. He served in the Congress of the Confederation from 1783 to **1786** and was there conspicuous for his vigorous insistence upon the right of the United States to the navigation of the Mississippi river, and for his attempt, in 1785, to secure for the weak Congress the power to regulate commerce, in order to remove one of the great defects in the existing central government. On retiring from Congress he began the practice of law at Fredericksburg, Va., was chosen a member of the Virginia house of delegates in 1787, and in **1788** was a member of the State convention which ratified for Virginia the Federal constitution. In 1790 he was elected to the United States senate and although in this body he vigorously opposed Washington's administration, Washington in 1794 nominated him as minister to France. It was the hope of the administration that Monroe's well-known French sympathies would secure for him a favourable reception, and that his appointment would also conciliate the friends of France in the United States. His warm reception in France and his enthusiastic Republicanism, however, displeased the Federalists at home; he did nothing, moreover, to reconcile the French people to the Jay treaty (*q.v.*), which they regarded as a violation of the French treaty of alliance of 1778 and as a possible *casus belli.* The administration therefore decided that he was unable to represent his government properly and late in **1796** recalled him.

Monroe returned to America in the spring of 1797, and in the following December published a defence of his course in a pamphlet of 500 pages entitled *A View of the Conduct of the Executive in the Foreign Affairs of the United States.* Washington seems never to have forgiven Monroe for this, though Monroe's opinion of Washington and Jay underwent a change in his later years In **1799** Monroe was chosen governor of Virginia and was twice re-elected, serving until 1802. At this time there was much uneasiness in the United States as a result of Spain's restoration of Louisiana to France by the secret treaty of San Ildefonso, in Oct. 1800; and the subsequent withdrawal of the "right of deposit" at New Orleans by the Spanish intendant greatly increased this feeling and led to much talk of war. Resolved upon peaceful measures, President Jefferson in Jan. **1803,** appointed Monroe envoy extraordinary and minister plenipotentiary to France to aid Robert R. Livingston, the resident minister, in obtaining by purchase the territory at the mouth of the Mississippi, including the island of New Orleans and at the same time authorized him to co-operate with Charles Pinckney, the minister at Madrid, in securing from Spain the cession of East and West Florida On April **18,** Monroe was further commissioned as the regular minister to Great Britain He joined Livingston in Paris on April **12,** after the negotiations were well under way; and the two ministers, on finding Napoleon willing to dispose of the entire province of Louisiana, decided to exceed their instructions and effect its purchase Accordingly, on April **30,** they signed a treaty and two conventions, whereby France sold Louisiana to the United States (*see* LOUISIANA PURCHASE). In July **1803** Monroe left Paris and entered upon his duties in London; and in the autumn of **1804** he proceeded to Madrid to assist Pinckney in his efforts to secure the definition of the Louisiana boundaries and the acquisition of the Floridas. After negotiating until May **1805,** without success, Monroe returned to London and resumed his negotiations concerning the impressment of American seamen and the seizure of American vessels. As the British ministry was reluctant to discuss these vexed questions, little progress was made, and in May **1806** Jefferson ordered William Pinkney of Maryland to assist Monroe The British government appointed Lords Auckland and Holland as negotiators, and the result of the deliberations was the treaty of Dec. **31, 1806,** which contained no provision against impressments and provided no indemnity for the seizure of goods and vessels. In passing over these matters Monroe and Pinkney had disregarded their instructions, and Jefferson was so displeased with the treaty that he returned it to England for revision Just as the negotiations were reopened, however, the questions were further complicated and their settlement delayed by the attack of the British ship "Leopard" upon the American frigate "Chesapeake." Monroe returned to the United States in Dec. **1807,** and was elected to the Virginia house of delegates in the spring of 1810 In the following winter he was again chosen governor, serving from Jan. to Nov. 1811, and resigning to become secretary of state under Madison, a position which he held until March 3, 1817. The direction of foreign affairs in the troubled period immediately preceding and during the second war with Great Britain thus devolved upon him On Sept. 27, 1814, after the capture of Washington by the British, he was appointed secretary of war, and discharged the duties of this office, in addition to those of the state department, until March 1815.

In **1816** Monroe was chosen president of the United States; he received **183** electoral votes, and Rufus King, his Federalist opponent, 34. In **1820** he was re-elected, receiving all the electoral votes but one, which William Plumer (1759–1850) of New Hampshire cast for John Quincy Adams, in order, it is said, that no one might share with Washington the honour of a unanimous election. The chief events of his administration, which has been called the "era of good feeling," were the Seminole War (1817–**18**); the acquisition of the Floridas from Spain (1819–21); the "Missouri Compromise" (1820), by which the first conflict over slavery under the constitution was peacefully adjusted; the veto of the Cumberland Road bill **(1822)** on constitutional grounds; and—most intimately connected with Monroe's name—the enunciation in the presidential message of Dec. 2, **1823,** of what has since been known as the Monroe Doctrine (*q.v.*), which has profoundly influenced the foreign policy of the United States.

On the expiration of his second term Monroe retired to his home at Oak Hill, Loudoun county, Virginia. In **1826** he became a regent of the University of Virginia, and in **1829** was a member of the convention called to amend the state constitution. Having neglected his private affairs and incurred large expenditures during his missions to Europe, he experienced considerable pecuniary

embarrassment in his later years, and was compelled to ask congress to reimburse him for his expenses in the public service. Congress finally (in 1826) authorized the payment of $30.000 to him, and after his death appropriated a small amount for the purchase of his papers from his heirs. He died in New York city on July 4, 1831. while visiting his daughter. In 1858, the centennial year of his birth, his remains were reinterred with impressive ceremonies at Richmond, Virginia. Jefferson. Madison. John Quincy Adams, Calhoun and Benton all speak loudly in Monroe's praise; but he suffers by comparison with the greater statesmen of his time. Monroe was married in 1786 to Elizabeth Kortmright (1768–1830) of New York, and was survived by two daughters.

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MONROE, the largest and most important city in northeastern Louisiana, U.S., is on the Ouachita river and is the seat of Ouachita parish. Pop. (1960) 52.219; standard metropolitan statistical area (Ouachita parish), 101,663.

Monroe was founded in 1785 when a group of French pioneers from south Louisiana, under the leadership of Don Juan Filhiol, established a trading post on a land grant obtained from King Charles X of Spain. Until a fort was constructed and named in honour of Don Esteban Miró. Spanish governor general at New Orleans. the settlement was simply referred to as the "Post." Fort Miró mas renamed Monroe in 1819 to honour the arrival of the first steamboat: which had been named for Pres. James Monroe. The town was incorporated in 1820. It was shelled during the American Civil War.

Monroe, along with its smaller twin city across the Ouachita, M'est Monroe, is a manufacturing city and also the cultural and commercial centre for the surrounding rural parishes. The predominant manufactured items in Monroe are paper and paper products, supplemented by lumber, furniture: clothing and cottonseed products. The nearby Monroe gas field, over 400 sq.mi. in area with more than 2,000 producing wells, supports chemical and carbon black industries. Although the city has experienced steady growth; it is surrounded by rural parishes with declining populations as agriculture slowly shifts from cotton and corn to forestry and beef cattle. Northeast Louisiana State college (1931) serves the whole northeastern corner of the state. (P. K. C.)

MONROE, a city of southeastern Michigan. U.S.. on the Raisin river 2 mi. inland from Lake Erie, 39 mi. S.W. of Detroit and 20 mi. E. of Toledo; the seat of Monroe county and Michigan's only port on Lake Erie. Monroe's diversified industries include the manufacture of paper, automotive parts, metal products and office supplies. Because of its extensive nurseries, Monroe is often called the "Floral City." The choice of Monroe as the site for the Enrico Fermi Atomic Power plant in 1956 further enhanced the city's industrial position. The city is the home of St. Mary's Academy (Roman Catholic) for girls.

Monroe's formal beginnings can be traced to 1784 when a small community, largely French-Canadian, on the Raisin river was known as Frenchtown. There. on Jan. 23, 1813, Gen. James Winchester's troops were massacred by Indians allied with England. In 1817 Frenchtown was renamed Monroe in honour of Pres. James Monroe. It was incorporated as a city in 1837.

For comparative population figures see table in MICHIGAN: *Population.* (SI. G.)

MONROE DOCTRINE, THE, enunciated by Pres. James hlonroe of the United States on Dec. 2, 1823. had its roots in the general principle that Europe and the Americas constitute two separate and distinct spheres of political activity and, politically speaking, should have as little to do with each other as possible. This principle had been given precise form in the farewell address of Pres. George Washington, on Sept. 19. 1796, and had been reiterated in the first inaugural address of Pres. Thomas Jefferson. It had become widely, if not universally, accepted at the time that James Monroe became president of the Cnited States, and from it there flowed quite naturally his famous message of Dec. 2, 1823.

Origin. — The message itself had a dual origin. It was in part due to the pretensions of the Russian government with regard to the northwest coast of North America. In 1821. the tsar had issued a ukase by which foreign vessels were forbidden to come within 100 mi. of the shore of the territories claimed by Russia (the modern Alaska) on the American continent. This ukase was, from the first, contested by the G.S. secretary of state. John Quincy Adams, and in the course of the diplomatic negotiations that followed. Adams laid down the general principle that European states could claim no right to establish colonies in the new world. Adams' principle was taken over by Monroe in the president's annual message of 1823 to the U.S. congress. It was declared therein that "the American continents, by the free and independent condition which they have assumed and maintain, are henceforth not to be considered as subject for future colonization by any European power." The president and the secretary of state had based this declaration on the thesis that every part of the American continents had been already occupied. In view of the fact that there were stili many areas entirely unsettled. and others in dispute, it is doubtful whether this viewpoint accorded with the actual situation in 1823.

The second, and in the long run the more important, part of the declaration was directed against the assumed danger that the continental European powers mould intervene in Central and South America to restore to Spain its revolted colonies, most of which had won their independence by this time, and a number of which had been recognized by the United States. The fear of such reconquest derived in part from the fact that, acting at the mandate of the Holy Alliance (*q.v.*); *i.e.*, Russia, Austria, Prussia and France. the last-named government had put down a revolutionary movement in Spain. In Aug. 1823 George Canning, the British foreign secretary, had approached the U.S. envoy, Richard Rush, had intimated to him that there was some danger of intervention in Central and South America, and had proposed a joint declaration on the colonial question. Rush's dispatches, transmitted to Washington. aroused the apprehensions of the U.S. cabinet, as did also the language of the Russian tsar. Long discussions took place in advance of the president's message. It was finally decided not to act with Great Britain, but independently. And so, in the message of Dec. 2, 1823. Monroe declared that "we could not view any interposition for the purpose of oppressing" the former colonies, or "controlling in any other manner their destiny by any European power in any other light than as the manifestation of an unfriendly disposition toward the United States."

Significance. — It is now known that the danger of European intervention was virtually nonexistent. But Monroe's message was. in the face of the situation as he saw it, a bold act; it was a striking example of open diplomacy, more dramatic and less dangerous than direct representations to the European powers could have been; it took courage also, to act alone instead of waiting on the action of Britain. Its effects, horn-ever, were for a long time overvalued and misunderstood.

In Central and South America it was! on the whole, well received: but the new republics in most cases looked for protection more to Great Britain than to the United States; on the European continent it was received with irritation and silent contempt; in London it was applauded by the opposition, but regarded with some dislike by Canning as an effort to compete with England for the favour of the new republics. Furthermore, it was not followed by closer relations with Central and South America. When, after 1823, on four separate occasions Central and South American powers sought to secure from the United States fuller commitments looking to the carrying out of the policy enunciated in the message of 1823, such commitments were refused. In the debates in congress on the so-called Panama congress of 1826 projected by Simón Bolivar with a view to closer co-operation between the states of North and South America, opinion in the United States was seen to be distinctly hostile to any political understanding with the states to the south.

For some time, indeed, Monroe's message commanded little attention. The British occupation of the Falkland Islands, the French blockades of Mexico and Argentina in 1838, the encroachments of Great Britain in Central America, produced no great excitement in the United States. It was Pres. James K. Polk who drew renewed popular attention to the principles of 1823, and set them on the way to becoming doctrine in the literal sense of the word Polk was aroused by the intrigues of the French and the British in Texas, and wished to controvert the principle laid down by François Guizot, the French premier and foreign minister, that the idea of the balance of power applied to the new world, and specifically to the question of annexing Texas to the United States. He also uished to use Monroe's declaration to bring the British to yield on the Oregon question. and he probably feared British activities in California. With these matters in mind. in his message of Dec. 2, 1845, he re-stated the principles of 1823, and gave them special weight in regard to North America. In 1848 he again had recourse to those principles when he declared that the United States could not acquiesce in the establishment of a British or French protectorate over the province of Yucatan, then in revolt against Mexico, and even suggested that it might be the duty of the United States to assume such a protectorate rather than permit such action by a European power.

Mid-19th Century Applications. — But Polk's message. like Monroe's, produced little effect abroad. and like Monroe's. it received at the time no congressional sanction. It was in the 1850s that the famous message of 1823 was actually translated into doctrine, chiefly as the result of disputes with Great Britain over Central America. At first largely relied on by the Democrats and subjected to some partisan criticism, it was in due course adopted also by the Whigs. It was first cited as doctrine in a dispatch of 1854. Though its validity was by no means recognized by any other government, it had by 1860 become fairly well known in Europe.

Sharp challenges to the doctrine took place in the period of the American Civil War. Spain occupied the Dominican Republic. its former colony; and France, intervening in Mexico, set up there a monarchy under the Austrian archduke Maximilian. In the first of these two instances William H. Seward, the U.S. secretary of state. made formal protest, citing the famous American doctrine by name. He received a sharp rebuff from Madrid. Taught by this experience. he proceeded more cautiously in dealing with the French. alluding in general terms to the U.S. position. keeping the record straight but waiting until the end of the Civil War before becoming emphatic in opposition to the policy of Napoleon III. His increasingly strong diplomatic representations were admirably timed to take account of French difficulties in Mexico. and they played a part in producing the eventual French withdrawal, along with the gallant opposition of the Mexicans. French fiscal difficulties and popular opposition in France itself.

Later Applications. — By 1870 the popularity of the doctrine was unquestioned. Moreover, in the next 40 years. it was more and more liberally interpreted. The first extension of its original terms was in what is usually known as the no-transfer principle. On many occasions prior to the 1870s, the United States had declared its opposition to the transfer of new-world territories from one power to another, and there had been repeated pronouncements to this effect in connection with the island of Cuba. But the link between this principle and the Monroe Doctrine was first established by Pres. Ulysses S. Grant in 1870, and reiterated in a long and able memorandum of the secretary of state. Hamilton Fish, on July 17 of the same year. In the course of the next 20 years the opposition of the United States to the cession of American territory to a European state was made clear on at least eight occasions.

A second development with regard to the doctrine came in connection with the development of an interocean canal. In the period before the Civil War the United States had entered into a compact with Great Britain for the joint control of such a waterway. But when the question of transisthmian communication became a matter of immediate interest, with Ferdinand de Lesseps' famous project to build a canal across the Isthmus of Panamá, there was a widespread reaction among U.S. politicians. Pres. Rutherford B. Hayes, it is true, merely declared that no European power could intervene for the protection of the projected line of communication "without adopting measures on this continent which the United States mould deem wholly inadmissible." He did not mention the Monroe Doctrine by name. But there were a number of persons who were more definite; in 1881, Secretary James G. Blaine, in a circular note of June 23. declared in discussing the isthmian question that "it is the long-settled conviction of this government that any extension to our shores of the political system by which the great powers have controlled and determined events in Europe would be attended with danger to the peace and welfare of this nation." The same view was expressed by Blaine's successor, Secretary Frederick T. Frelinghuysen, and by Pres. Theodore Roosevelt after the turn of the century.

A third extension of the Monroe Doctrine was made by Pres. Grover Cleveland in 1895. For many years there had been a dispute between Great Britain and Venezuela with regard to the boundary between the latter country and the British colony of British Guiana. Despite frequent appeals on the part of the Latin-American republic to the United States in the name of the doctrine, the U.S. government for some time remained quiescent. But in 1895 Secretary Richard Olney took up the cudgels for the regime at Caracas. In a remarkable dispatch of July 20, 1895, he demanded that the British arbitrate the issue. When this demand was repelled by the British. the president transmitted to congress on Dec. 17 an aggressive message in which 'he declared that the boundary dispute would be examined by an impartial tribunal, and that when its report was made. it would be "the duty of the Cnited States to resist by every means in its power, as a wilful aggression upon its rights and interests, the appropriation by Great Britain of any lands or the exercise of governmental jurisdiction over any territory which after investigation we have determined of right belongs to Venezuela." After a brief period of excitement. the British yielded to U.S. pressure. and the dispute was arbitrated (on terms, however. that ensured British possession of a large part of the contested territory). While the position of the Cnited States met with much criticism abroad. and was not even generally accepted in Central and South America, it undoubtedly directed world attention to the doctrine on a scale hitherto unknown.

A fourth extension of the doctrine came with the beginning of the 20th century. During the 77 years since its enunciation, the doctrine had never been construed to prevent coercive action against an American state by a European state if the objective was merely punitive, and did not involve either domination or any cession of territory. But with the rise of U.S. power, and with the increasing importance of the U.S. position in the Caribbean, popular sensitiveness with regard to the action of old-world governments began to develop on an increasing scale. This was well illustrated by the blockade of Venezuela at the end of 1902. The then ruler of that republic was an unsavory dictator. Cipriano Castro. He had committed various offenses against both Germany and Great Britain, and these two powers determined to take joint action against him. They notified the United States of their purpose, and at the time of such notification the U.S. administration made no protest of any kind. But when, in Dec. 1902, a naval blockade was instituted against Venezuela, indignation in the United States was widespread. The irritation was particularly strong against Germany, which was suspected of having various designs for establishing itself in the new world. The blockade was terminated in Feb. 1903, and the questions in dispute were arbitrated. It has frequently been stated that this settlement came about as a result of pressure from the United States. and Pres. Theodore Roosevelt later claimed that he directed an ultimatum to the government of the Rcich. While this claim was still widely believed in the second half of the 20th century, it is important to note that there exists not the slightest confirmation of any such episode in the archives of the United States, Great Britain or Germany.

Roosevelt Corollary. — The Venezuela episode of 1902–03 had

important consequences. It led to the first formal recognition of the Monroe Doctrine by another state, Great Britain. It also raised the question of what should be done to forestall punitive action by European states against the republics of the new world. President Roosevelt's answer to this problem was the so-called Roosevelt corollary to the doctrine, adopted by him, in part at least, at the suggestion of Great Britain. This corollary was first stated by him in May 1904, and reiterated in his message of Dec. 6. "In the Western Hemisphere," the president stated, "the adherence of the United States to the Monroe Doctrine may force the United States, however reluctantly, in flagrant cases of such wrongdoing or impotence, to the exercise of an international police power." While his position was much criticized abroad, it was followed out in practice in the years that followed. The United States government in 1905 established customs control over the Dominican Republic, by agreement with that state; Secretary Philander C. Knox, in the administration of Pres. William H. Taft, sought to develop similar understandings with Honduras and Nicaragua, and in the latter case followed up a treaty with the landing of marines; the administration of Pres. Woodrow Wilson actually intervened forcibly in both Haiti and the Dominican Republic in the name of the principles of 1823. Wilson's secretary of state, Robert Lansing, developed the Roosevelt corollary to the fullest extent, declaring that the United States government should "aid the people of those republics (*i.e.*, the Caribbean republics) in establishing and maintaining honest and responsible governments to such extent as may be necessary in each particular case" and "should declare that it will not tolerate control over or interference with the political and financial affairs of these republics by any European power or its nationals, or permit the occupation, even temporarily,,by any European power, of any territory of such republics." This statement was not made public, but the administration acted on it in repelling German and French schemes for customs control in Haiti.

A final extension of the doctrine, in the period before World War I, has sometimes been seen in the resolution of Sen. Henry Cabot Lodge of Aug. 2, 1912, which declared that "when any harbor or other place in the American continents is so situated that the occupation thereof for naval or military purposes might threaten the communications or the safety of the United States, the Government of the United States could not see without grave concern the actual or potential possession of such harbor or other place by any Government, not American, as to give that Government practical power of control for naval or military purposes." Senator Lodge himself, however, did not connect this resolution with the principles of 1823, and the rumours of purchase of land in the Magdalena bay region of Mexico by Japanese interests, rumours on which the resolution was based, appear to have been unfounded.

Post-World War I Period. — The Monroe Doctrine, with its various extensions. unquestionably had become a central tenet of U.S. foreign policy by the period of World War I The importance which U.S. opinion attached to it nas well demonstrated in the debates over the League ot Nations covenant in 1919 and 1920. In proposing the establishing of a League of Nations which should maintain peace by collective action against an aggressor, President Wilson had at first argued that this was merely an extension of the principles of 1823 The covenant as drafted stated. honever, that "nothing in this Covenant shall be deemed to affect the validity of international engagements such as treaties of arbitration or regional understandings like the Monroe Doctrine, for securing the maintenance of peace." This phraseology was regarded as unsatisfactory by President Wilson's opponents at home, who declared that the doctrine was not a regional understanding bur a unilateral declaration of U.S. policy. The Lodge reservation to the treaty, adopted by the senate, declared that the doctrine was "to be interpreted by the United States alone and is hereby declared to be nholly outside the jurisdiction of said League of Nations and entirely unailected by any provision contained in the said treaty of peace with Germany." In the same way, when the question of U.S. adherence to the protocol creating the World Court was up for discussion and again, nhen the Kellogg-Briand pact for the outlawry of war was before the senate. it was necessary to propitiate the friends of the doctrine, in the first instance by a reservation, in the second by a gloss on the treaty.

But if the Monroe Doctrine seemed securely established in the minds of U.S. citizens by the 1920s, it was nonetheless true that it was already undergoing an important and lasting transformation, a transformation that operated to diminish its significance. It is not necessary to consider at length a view widely disseminated at the time of World War II that the doctrine owed its force, riot to the power of the United States, but to the British navy. Such a view was, in reality, little more than a rationalization to justify closer U.S. association with Britain itself. It is nearer to truth to say that throughout the latter part of the 19th and earlier part of the 20th century, the imperial nations of Europe were sufficiently occupied in Africa and the middle and far east to reduce to a minimum their ambitions with regard to the American continents. It is also relevant that many of the Central and South American states had now attained a consistency and solidity that made the possibility of intervention in their affairs remote. While just before the outbreak of World War I, there were proposals for the control of customs in the Dominican Republic and in Haiti, while the German naval office, contrary to the views of the German foreign office, flirted with the idea of naval bases in the new world in the first decade of the 20th century, the danger of interference on an important scale never existed after the French invasion of Mexico in the 1860s.

But what is more significant is that there developed within Central and South America a growing resentment against the doctrine as an offensive expression of U.S. hegemony in the new world. Many expressions of this resentment can be found in Central and South American literature in the period between 1902 and 1915, in the work of the eminent Nicaraguan Rubén Darío, in the writings of the Uruguayan José Rodó, in *Latin America* of the Peruvian Garcia Calderón, and in the widely read volume of Manuel Ugarte, *The Future of Latin America.* The tone of Central and South American publicists in many instances reflected the same temper. And in the United States itself such works as that of Hiram Bingham, *The Monroe Doctrine, an Obsolete Shibboleth* (1913), gave wider circulation to the critical view of many of the statesmen to the south. In 1920, the little state of El Salvador called for a definition of the doctrine in the midst of "anarchy of opinions"; the Mexican government declared that it would not recognize the principles of 1823. These attacks had an important influence on U.S. policy. In 1923 Secretary Charles Evans Hughes, in two very able speeches, attempted to answer the critics. He denied that the doctrine conveyed any implication of overlordship or superintendence, and he sought to dissociate U.S. interventions in the Caribbean from the principles of 1823, declaring that these interventions stood upon different grounds. But the critics were not silenced; in the Pan-American conference of 1923 the policies of the United States were severely criticized; and at the next conference at Havana, in 1928, a proposal was brought forward declaring that all intervention in the domestic or external affairs of one state by another was illegal. The proposal was opposed by Hughes, the leader of the United States delegation, but it had important effects. When the senate ratified the Kellogg-Briand pact in 1929, it adopted a gloss which, while maintaining the validity of the doctrine, dissociated the principles of 1823 from the Roosevelt corollary; and in 1930 the U.S. state department published a memorandum prepared in 1928 by Undersecretary J. Reuben Clark, which explicitly declared that the corollary was not "justified." New steps were to be taken in due course along the same line. At the conference of Montevideo in 1933 the United States set its signature to a protocol which followed the lines of the proposal made at Havana; at the same time, however, it reserved its rights under international law. At Buenos Aires in 1936 it went still further; again it subscribed to the nonintervention doctrine, and this time there was no reservation whatsoever. Both the protocol of 1933 and the protocol of 1936 were ratified unanimously by the senate of the United States.

Inter-American Consultation. — Thus disappeared the interpretation of the doctrine most offensive to the Central and South Americans; and perhaps it is fair to say that no great and powerful

nation had ever put its name to so remarkable a self-denying ordinance as did the United States at this time. But a still more remarkable development was ahead; for with the rise of Hitler's Germany, the U.S. government moved toward a series of understandings with the states of the new world that gave a new international sanction to the principles of 1823. The first step in this direction was taken at the conference of Buenos Aires and consisted of an agreement that "in the event of an international war outside America, the New World republics would consult together as to the necessary measures to be taken." At Lima in 1938 machinery to facilitate such consultation was set up. At Havana in 1940, after the fall of France, resolutions were adopted declaring that an attack against any American state was an attack against all, and a procedure was also outlined for the possible occupation and administration of French or Dutch colonies in the new world which might otherwise fall a victim to the Nazis. In 1942 the nations of the new world agreed to break off relations with the Axis powers, and in most cases this agreement was promptly honoured. In 1945 and again in 1547, at the conferences of Chapultepec and Rio de Janeiro, the principle of collective action against aggression was again accepted. These steps did not internationalize the doctrine; the United States retained the right to take action on its own initiative if it deemed such action necessary, but they gave the principles of the doctrine international validity. During this period, moreover, the doctrine was extended to Canada and Greenland.

Post-World War II Period. — In a sense, however, there were fundamental developments in the World War II and postwar periods that altered the place of Monroe's great pronouncement in the scheme of things. U.S. citizens discovered that constant reference to that pronouncement was likely to rasp the susceptibilities of their Central and South American friends; and, as a consequence, there was a striking decline in the number of such references. In the second place, the danger of a direct physical attack upon the nations of the new world diminished, and the strategic significance of the nations declined with the growth of long-range nuclear weapons. The danger seemed rather to lie in the possible subversion of American governments by Communism.

The United States was bound by the protocols of Montevideo and Buenos Aires to abstain from direct intervention to overthrow a communist or protocommunist regime, and by the declaration of Bogotá (1948) international intervention was also banned. In an effort to deal with this problem, the U.S. government urged the passage of resolutions at Pan-American conferences, notably at Bogotá in 1948 and at Caracas in 1954. underlining the danger. At Caracas it was declared that "the domination or control of the political institutions of any American state by the international Communist movement, extending to this hemisphere the political system of an extracontinental power, would constitute a threat to the sovereignty and political independence of the American states. endangering the peace of America, and would call for a meeting of consultation to consider the adoption of appropriate action in accordance with existing treaties." In the same year, when it appeared that Guatemala was falling under communist control. and nhen that state was receiving massive shipments of arms from behind the "iron curtain," a meeting of the American states was summoned. But before any action could be determined upon. the victory of a revolutionary movement against the protocommunist regime removed the question from the area of international discussion.

Much more serious were the events that occurred in Cuba toward the end of the decade. (See also CUBA: History.) The regime of President Batista was overthrown, and a new government constituted under the insurgent leader. Fidel Castro. Castro soon showed himself to be. if not a Communist, under the influence of Communists. He governed without elections; he confiscated U.S. properties on an increasing scale; he whipped up public feeling against the United States as an "imperialist" nation. How stood it with the Monroe Doctrine in these circumstances? Broadly speaking. the Eisenhower administration did not invoke it, but preferred to act through the Organization of 'American States in rousing opposition to the Castro regime, and its success in this purpose was. at any rate up to the end of 1960. not marked. Yet it was widely recognized that unilateral action would be unwise, and that the invocation of the name of Monroe would do little to bring the states of Latin America to the side of the United States. The principle that European domination should be excluded from the hemisphere was as sound as ever, and President Kennedy declared his adherence to it. But to all intents and purposes there was substituted for the historic doctrine a new approach to the problem of European intermeddling in Latin America. How this new approach would operate in practice it was difficult to say; but it was safe to predict that the dictum of Monroe would be less confidently and less frequently cited in the second half of the 20th century than in the years that had passed.

Influence on Public Opinion. — In the history of the development of the Monroe Doctrine, one other fact should be stressed. The doctrine is an illustration of the tendency. in a democratic diplomacy, such as that of the United States, to lay down broad principles of action that can be easily understood by the mass of the people. These principles come to have great influence and undeniable force. They operate to provide strong public support for decisions in detail. While they are subject to modification and divergent interpretations, and while their significance alters at different epochs, they play a useful and significant role in the diplomacy of a democratic state. See PAX-AMERICAN CONFERENCES; AMERICAN STATES. ORGANIZATION OF; DRAGO DOCTRINE; TRUMAN DOCTRINE; EISENHOWER DOCTRINE; see also references under "Monroe Doctrine, The" in the Index volume.

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MONROVIA, the capital city of the republic of Liberia, on the bulge of west Africa. Named for Pres. James Monroe, the city was founded (1822) as a haven for ex-slaves from the Cnited States. A large proportion of the population of 41.829 (1956) is descended from these people. Site of the city is Cape Montserrado on the south side of Mesurado creek. one of the distributaries of the St. Paul river. The only modernized sections mere the main avenue. lined with government offices and the mansions of leading families. and the diplomatic quarter.

Industry is negligible. Liberia college and the Methodist College of West Africa are located at Monrovia. Across Mesurado creek on Bushrod Island is a modern harbour, opened as a free port in 1938. Exports include iron ore. palm oil. gold. rubber and iorest products. A modern airport is at Roberts field. 30 mi. S.E.

(J. W. RH.)

MONROVIA, a residential city of California, U.S., 18 mi. E. of Los Angeles (*q.v.*) in the foothills of the Sierra Madre mountains at the eastern end of the San Gabriel valley. Its townsite was once part of Ranchos Santa Anita and Azusa de Duarte. Incorporated in 1887, Monrovia was developed by Los Angeles realtors and speculators William N. Monroe and Edward P. Spence among others, who planned to make their boom town a tropical paradise with palm and pepper trees lining the streets, and groves of citrus trees surrounding the site. After the wild speculation of the 1880s Monrovia settled down to be a rural farm town of citrus growers and retired people from the eastern U.S. While the rural atmosphere of earlier decades remained the city had a considerable increase in population after 1940, and in the 1960s had more than 50 light industries. Monrovia has a council-manager form of government, in effect since 1549. For comparative population figures see table in CALIFORNIA: Population.

(J. A. Sz.)

MONS, the capital of Hainaut province, Belgium. Pop. (1555

est.) 25,567. The town originated probably in the Roman citadel Château-César. About 804 Charlemagne recognized it as the capital of Hainaut. At first the counts occupied the castle of Hornu, leaving Mons to the abbey and the church of St. Waudru. Regnier V moved to Mons at the beginning of the 11th century, and his only child, a daughter, Richilde, married Baldwin VI of Flanders. The two countdoms were again divided between Richilde's sons. At the beginning of the 14th century Mons uas converted into a trading town by establishment of a cloth market. At the same time the count transferred his principal fortress from Valenciennes to Mons. When the Hainaut title became merged in the duchy of Burgundy, Mons was a stronghold near the French frontier. Its capture, defense and surrender by Louis of Nassau in 1572 and its many sieges in the 17th and 18th centuries attest its troubled history. Mons was converted into an open town in 1862.

The cathedral of St. Waudru, named after the first countess, was built 1450–1600 and contains some good glass as well as a few pictures by Van Thudden. The *hôtel de ville* is about the same age as the cathedral. having been commenced in 1443 and finiehed in 1467. The tower was added in 1718. There is also a fine belfry with a peal of bells. Mons is a flourishing town with a good trade in cloth, lace, sugar refinery, etc.; but its chief importance is derived from its proximity to the Borinage (place of boring) district containing mines of the finest coal in Belgium. The military engineering college for the Belgian army was established there, and not far from Mons are the battlefields of Malplaquet (1709) and Jemappes (1792).

Battle of Mons, 1914.—This. the first battle of the British expeditionary force in World War I, took place on Aug. 23, 1914, and next day the heavily outnumbered British army began the historic retreat which. marked by the battle of Le Cateau (*q.v.*) ended on the Marne (*q.v.*), where the Franco-British counteroffensive turned the invasion.

See FRONTIER, BATTLES OF THE.

MONSIEUR, the general title of address in France used vocatively in speaking formally to any male person, like the English "sir" or prefixed to the name like the English "Mr." (Fr., formed from *mon,* "my," and *sieur,* "lord"). It is, however, in France also prefixed to nobiliary. official and other titles; *e.g., Monsieur le président, Monsieur le duc d'E.,* etc. It is abbreviated M.. not Mons.

As a specific title "monsieur" *(tout court)* was used from the time of Louis XIV, of the eldest brother of the king, as "monseigneur" mas of the dauphin; as a general title of address it was given to the princely members of a royal house.

MONSIGNOR, a title of honour granted by the pope to bishops and to high dignitaries and officials of the papal household (Italian. *monsignore,* "my lord"). It is abbreviated Msgr.

MONSON, SIR WILLIAM (1568–1643), English naval officer best knonn for his *Naval Tracfs,* was the son of Sir John Monson of Lincolnshire. He entered Balliol college, Oxford. in 1581, but four years later ran away to sea; however. he took his degree in 1594. In the Armada campaign he served as volunteer in the "Charles" pinnace and afterward accompanied the earl of Cumberland on three voyages to the West Indies. In 1596 he was flag captain to the earl of Essex at the capture of Cadiz, and in 1602 was vice-admiral of the last fleet to be sent against Spain, when the great carrack "St. Valentine" was taken. From 1604 to 1616 he was Admiral of the Narrow Seas, being chiefly engaged against pirates. He was dismissed partly for accepting bribes from Spain and partly on account of his supposed connection with the murder of Sir Thomas Overbury. Monson's last service at sea was in command of the ship-money fleet of 1635. During his retirement he composed his *Naval Tracts,* which were first printed in abbreviated form in 1682, then in full in 1704, a definitive edition in five volumes being edited by M. Oppenheim for the Navy Records society in 1902–14. It is to these writings that Monson owes his fame, since. besides being the first account by a naval officer of a war in which he himself served, they provide a valuable commentary on the Elizabethan war with Spain and conditions at sea during that period. Monson died at Kinnersley, Surrey, in Feb. 1643. (C. C. L.)

MONSOON, originally the name given by the Arabs to those seasonal winds of the Arabian sea which blow for approximately six months from the northeast and six months from the southwest. The name (Arabic *Mausim* or *Mawsim,* "season") is applied to all wind systems on a continental scale that seasonally reverse their direction. Southeast Asia, from the Arabian sea to China, is the most prominent instance; other examples are the Gulf coast of the United States and northern Australia.

The primary cause of the monsoon lies in the difference of the annual temperature trends over land and sea. Changes are large over land, small over the oceans. The monsoon blows from cold toward warm regions: from sea toward land in summer, from land toward sea in winter. Further, atmospheric pressure is high in the cold and low in the warm regions, permitting the air movement to take place. Beyond these facts, a complete explanation of the monsoon has not been offered.

At the poleward limit of the monsoon the winds shift sharply. In India, for instance, the monsoon blows from the southwest in July–August, and north of India winds are from the east. Over northern Australia the monsoon comes from northwest in January–February, and at the southern limit winds again become easterly. Along the line where monsoon winds and easterlies meet, much convergence of mass and ascent occurs; because of the condensation of water vapour during ascent the monsoon is one of the most important rain-producing currents of the globe. Unfortunately, its intensity and duration are not uniform from year to year, for unknown reasons. A heavy season with floods may be followed by several seasons with below average rainfall, failure of crops and famine. (H. RL.)

MONSTER. Among the newborn young and embryos of man and most species of animals are found occasional individuals who are malformed in whole or in part. The most grossly abnormal of these have been referred to from ancient times as monsters, probably because the birth of one was thought to signify something monstrous or portentous; while the less severe are known as abnormalities or anomalies. No sharp line separates these grades of malformation, all being due to various kinds and degrees of modification of the normal course of development of the embryo. The study of these deviations forms the subject of teratology, a branch of morphology or embryology.

A knowledge of the kinds of abnormalities which occur and of the causes which call them forth may, like the more deliberate experiments of the laboratory, lead to a better understanding of normal development.

According to form, two major classes of monsters may be recognized, those which represent defective or excessive growth in a single body and those which involve partial or complete doubling of the body or one of its axes.

SINGLE MONSTERS

Giants and dwarfs are often classed as monsters, probably because of the prominent places they occupy in mythology. Since in man they generally result from abnormal growth they can not usually be recognized as abnormal at birth. An exception is the disproportionate dwarfism known as *achondroplasia* or *chondrodystrophia* in which the limbs and especially the legs are short, thick and bent, with head and trunk disproportionately large. This is a congenital abnormality in man, in cattle, particularly in the Dexter-Kerry breed in which the monstrous "bulldog calves" with chondrodystrophic dwarfism are often aborted before term, in domestic fowl and other animals. In bulldogs, a similar abnormality has become a breed character. In all of these cases the abnormal characters are inherited together. Cases in which this type of dwarfism in a human family behaves as a simple hereditary character have been reported. In other cases it may be due to other causes. Rudolf Virchow long ago noted the familial association of the chondrodystrophic type of monster with another type in which the limbs except for digits are nearly absent *(phocomelus).* It has since been shown by Landauer that in the fowl phocomelus and chondrodystrophia result from the same hereditary factor, the former representing the homozygote, the latter the heterozygote.

Gigantism usually expresses itself during early growth. In man

it often arises from endocrine unbalance. It may declare itself at birth in greater size. and sometimes in lower animals and plants, is due to the doubling of the normal chromosome number. (See HEREDITY: Chromosome Theory of Heredity.)

Repetition or Deficiency of single parts such as fingers or toes (polydactyly, hypodactyly) are frequent anomalies in man and other mammals. Absence or abnormality of whole limbs is less common and includes besides club-foot, the so-called congenital amputations, once thought to be due to strangulation of a limb by a fold of embryonic membrane (amnion). It is probable that endogenous abnormalities of the bone are more frequent causes of such "amputations" than are strangulations. Cases are recorded of human identical twins in which both members have the same type of limb abnormality, suggesting an hereditary predisposition to this type of malformation. In other cases injury and malposition are probably responsible.

In addition to monsters with rudimentary limbs (phocomelus), others are known with incomplete or underdeveloped extremities (hemimelus, *micromelus, ectromelus*).

A rare type of monster but one which has always attracted especial interest has the lower extremities more or less united, as in mammals of the order Sirenia such as the dugong or manatee and in the mythical figures of sirens or mermaids. Such sirenoid monsters may have a single foot (uromelus) or limbs fused throughout their length with no separate feet (*sirenomelus* or symelus).

Defective Closure of Bnes of junction in the embryo produces monstrosities, such as harelip and cleft palate, in which the ventral laminae of the palate have failed to fuse. A frequent abnormality in human infants is spina bifida in which the spine fails to close over, and a gap is left in the vertebral column. Both conditions are inherited albeit somewhat irregularly in man.

A related abnormality is hydrocephalus in which the embryonic spaces of the brain persist and are filled with fluid resulting in a greatly distended brain and head. An hereditary form is known in the mouse. Occasional monsters are found in which a part of the brain protrudes through the cranium as an encephalocoele; an extreme along this line is reached in *pseudencephaly* in which the whole brain is everted and rests upon the top of the cranium like a wig.

Hermaphrodites, as individuals containing both functional testes and ovaries, probably do not occur in higher mammals and man in which the sex is determined in the fertilized egg and is fundamentally sharply distinct at birth. *Intersexual* offspring occur in which the sexual organs undergo some development in the direction of those of the opposite sex. Minor anomalies of the genitalia, such as hypospadias, are relatively frequent.

A remarkable feature of monsters in vertebrates including man is the association of multiple abnormalities in complex syndromes. Thus in man harelip, spina bifida, hydrocephalus and *polydactyly* may be found in the same monster; while in *acro*cephalosyndactyly we find an egg- or dome-shaped skull, partial or complete fusion of digits in both hands and feet and, often in addition, harelip, contractures, spina bifida and mental abnormality. Several authors have suggested that such multiple abnormalities trace to a common source in a retardation in early development which in the above cases is probably due to a defective gene.

The Origin of Single Monsters.—Much light has been gained from a study of those abnormalities which occur in graded series. Thus S. Wright and K. Wagner showed that an extensive series of monsters found in one inbred family of guinea pigs could be arranged in a series in which those with least defect are normal except for a single median lower incisor, while with increasing grade of defect the lower jaw is reduced and lost (agnathia), the ears approach each other on the ventral side and fuse (otocephaly) leaving a single ear aperture in the throat; then the mouth and upper teeth are reduced, the nostrils formed into a proboscis, the eyes are reduced (*microphthalmia*) and fused in the centre of the forehead (cyclopia) and finally all head structures are lost except a small median ear (acraniate monster). The primary factor in these cases is an abnormal heredity acting together with a chance assortment of minor environmental factors to produce varying degrees of inhibition at different times in early development when the antecedents of the head are being formed. Otocephaly, cyclopia and related defects have been produced in experimental animals (fish and amphibian embryos) by chemical treatments which have inhibiting effects to which the head region is especially sensitive. Monsters falling in similar series are found in man and other vertebrates. They probably arise as a result of interaction between a specific heredity and abnormalities in the environment of the embryo sometimes due to disease or injury.

DOUBLE MONSTERS

Individuals partially or wholly double, but joined together, are represented by the rare occurrence in man of Siamese twins, which also reveal the mode of origin of this type of monster. Siamese twins, so-called from a famous pair exhibited for many years in the 19th century, are identical twins joined by a bridge of tissue through which the circulatory systems of the twins communicate. They probably arise by the nearly complete separation of a single fertilized egg into two parts. The experimental production of such double monsters in newts was accomplished by Hans Spemann by constricting the egg in the two cell stage with a hairloop. Human identical twins arise by the complete separation of the two halves of one embryo at a very early stage and thus represent an extreme of the same process which results in double monsters.

In man partially double symmetrical monsters are found varying from those with a single head but with neck, trunk and limbs doubled, through those with two heads and a single trunk, to others with head, shoulders and arms doubled but with one trunk and one pair of legs. Such double monsters probably arise following the less complete separation of the halves of the early embryo or partial separation at later stages. **A** rare type is one in which there is a Janus head, two faces on a single head and body. Janus monsters have been produced experimentally by a variety of treatments of amphibian embryos in early stages. **A** group of cases in which the hinder end of the body was doubled from the sacrum back has been found in one strain of mice and appears to be due to abnormal heredity. Doubling of whole limbs in amphibia has been produced experimentally by injuring the limb rudiment at an early sensitive stage.

Unequal Double Monsters consist of two parts of which one is usually well formed while the other is small, vestigial or abnormal, occurring as a parasite upon the more normal partner. Thus a young man of Genoa, Lazarus Colloredo, born in 1716, who was figured as a child by Fortunias Licetus and later by Caspar Thomeson Bartholinus, bore at the lower end of his breast bone a living child as parasite. In other cases the parasite is attached in the head region or to the trunk. The parasite often shows the same types of monstrosities which in single monsters have been attributed to delayed development. Rarely the parasite is included within the abdominal cavity of the larger partner as **a** foetus in foetu.

The Origin of Double Monsters has been traced to a variety of causes including disease of mother or embryo, faulty placentation in man and other mammals, and other factors which reduce the oxygen supply or nutrition of the embryo. The most thoroughgoing application of the latter idea has been made by Charles R. Stockard who produced double monsters of many types as well as single monsters by subjecting eggs and early embryos of fish to a variety of stimuli (low temperature, poisons, etc.). He concluded that, "the primary action of all the treatments is to inhibit the rate of development, and the type of deformity that results depends simply upon the developmental moment at which the interruption occurs." Wright and Wagner showed in addition that some of the factors determining the inhibition are internal, that is, part of the heredity of the embryo. In general for double as for single monsters, it is probably true to conclude that most of them are due to modifications of normal development during critical periods of embryonic life.

Monsters have been regarded by primitive peoples as of supernatural origin. Human monsters have been attributed to intercourse between women and the devil or between men and animals. Many mythical beings. such as races of dwarfs and giants, cyclops with a single eye, sirens. mermaids, races of men with a single median leg. were probably suggested by actual observations of human monsters.

The scientific study of monsters began with William Harvey (1651) who attributed them to deviations from the normal course of embryonic development. The present system of classification of monsters was introduced by I. Geoffroy Saint Hilaire whose great work on anomalies (Paris, 1832–37) remains a valuable source of information.

BIBLIOGRAPHY.—The most complete modern account of all classes of monsters is to be found in E. Schwalbe's *Die Morphologie der Missbildungen des Menschen und der Tiere* (1906–37). Recent descriptions and interpretations of the mode of origin of monsters are given by C. R. Stockard, "Developmental rate and structural expression: An experimental study of twins, double monsters and single deformities . . . etc.," in *Amer. J. Anat.*, vol. 28 (1921); by S. Wright and K. Wagner, "Types of subnormal development of the head . . . and their bearing on the classification and interpretation of vertebrate monsters," in *Amer. J. Anat.*, vol. 54 (1934) and by L. C. Dunn, "Heredity and development of early abnormalities in vertebrates," *The Harvey Lectures* (1939–40). (L. C. D.)

MONSTRANCE, a vessel used in the Roman Catholic Church for the exposition of the Host at Benediction (*q.v.*) and also when carried in processions. The earlier monstrances followed the usual shape of reliquaries, viz., a cylindrical crystal case mounted in metal frames, elaborately ornamented and jeweled. In the 16th century the present shape was adopted, viz., a crystal or glass circular disk, more suited to the shape of the sacred wafer.

MONSTRELET, ENGUERRAND DE (*c.* 1400–1453), French chronicler, belonged to a noble family of Picardy. He was for some time bailiff of the cathedral chapter and then provost of Cambrai. He died on July 20, 1453. Monstrelet was present, not at the capture of Joan of Arc, but at her subsequent interview with Philip the Good, duke of Burgundy. Continuing the work of Froissart, he wrote a *Chronique,* which extends to two books and covers the period between 1400 and 1444, when, according to another chronicler, Matthieu d'Escouchy, he ceased to write. A clumsy sequel, extending to 1516, was formed out of various chronicles and tacked on to his work.

Monstrelet's own writings, dealing with the latter part of the Hundred Years' War, are valuable because they contain a large number of documents which are certainly, and reported speeches which are probably, authentic.

Among many editions of the *Chronique* may be mentioned the one edited for the *Société de l'histoire de France* by M. Douët d'Arcq (1857–62). *See* A. Molinier, *Les Sources de l'histoire de France,* tomes iv. and v. (1904).

MONTAGNA, BARTOLOMMEO (c. 1450–1523), Italian painter, the most eminent master of the school of Vicenza, was born in Brescia about 1450. G. Vasari classes him among the pupils of Andrea Mantegna, but. although there can be little doubt of the influence of the great Paduan master on his style, he more probably studied at Venice (where he was living in 1469) under the influence of Alvise Vivarini and Giovanni Bellini. His first datable work, oi 1487, shows the influence of Vivarini. He interpreted his favourite subject, "The Virgin and Child," either alone or attended by saints, with a solemn, quiet grandeur. Montagna' is first heard of at Vicenza in 1474; he also worked at Praglia near Padua and at Verona (1504–07), where he painted a fresco in the oratory of S. Biagio in the church of SS. Nazaro and Celso, as well as an altarpiece for the church of S. Sebastiano now in the Venice academy.

His most important work is probably the great altarpiece for S. Michele at Vicenza dated 1499, now in the Brera gallery, Milan. Here the stateliness of the composition, staged under a lofty vault, the nobility of the enthroned Madonna, the dignity of the attendant saints and the charm of the angels making music at the foot of the throne are profoundly impressive. It would be impossible here to enumerate the many works of Montagna in Vicenza and in many public and private collections. One of his last pictures is the altarpiece, dated 1522, in the cathedral at Cologna Veneta. He died at Vicenza on Oct. 11, 1523. Bartolommeo founded a school of painting at Vicenza, which influenced Giovanni Speranza and partly also Giovanni Bonconsiglio and Francesco da Ponte, the father of Jacopo.

His son, BENEDETTO MONTAGNA (1481–1558), imitated the style of his father in his paintings. He was a distinguished engraver.

See T. Borenius, *The Painters of Vicenza* (1909). (P. J. MY.)

MONTAGNAIS AND NASCAPEE. North of the St. Lawrence. the Montagnais and Nascapee Indians resemble the southern Algonkin (*q.v.*) though their culture is affected by their unfavourable habitat.

No crops are raised; they are hunters of caribou rather than fishers, chiefs have little authority, and no trace can be found of any political unit above the simple band. The canoe and wigwam of birch-bark are typical elements of culture, and the painted skin clothing of the Nascapee is distinctive. Life is unusually hard, material culture scanty, and women occupy an inferior place in the social scale.

MONTAGNANA, a town of Veneto, Italy, province of Padova, 30 mi. S. of Vicenza. Pop. (1951) 5,237. It is entirely surrounded by medieval walls (1242–60) which are among the most perfect in Italy. The cathedral and S. Francesco are Romanesque-Gothic churches.

MONTAGU (*Family*). Dru of Montaigu or Montagud, the ancestor of the Montagus, earls of Salisbury, came to England with Robert, count of Mortain, half-brother of William the Conqueror. He is found in Domesday among the chief tenants of the count in Somerset, holding the manor of Shepton. This holding is represented in the return of 1166 by the ten knights' fee upon which his descendant, another Dru, is assessed. William Montagu of Shepton was among the knights summoned by Henry III to the Gascon War and to the Welsh border in 1257. His son Simon, the first of the family to make a figure in history, followed Edward I in 1277 and in 1282 against Llywelyn ap Gruffydd. In 1298 he was summoned as a baron; and in 1301, as Simon lord of Montagu, sealed the famous letter of the barons to the pope with his seal of the arms of Montagu, the counterseal showing a griffon.

His son William (d. 1319), a favourite of Edward II, and seneschal of Aquitaine and Gascony. was succeeded by his eldest son, another William, who in 1330 secretly led the young king's partisans into Nottingham castle, and carried off the earl of March.

In 1337 Montagu was created earl of Salisbury, and on the death of Thomas of Brotherton in 1338 was made marshal of England. His king employed him in missions to France, Scotland, Germany and Castile. and some time between 1340 and 1342 he led an expedition of his own against the Isle of Man, winning from the Scots the little kingdom to which he had inherited a claim through his grandfather Simon who had been granted the island by a certain Auffray or "Aufrica," who styled herself "Aufreca of Counnoght, heir of the land of Man." The first earl was succeeded in 1344 by William, his son and heir, who was one of the knights founders of the Order of the Garter, fought at Crécy, and commanded the rearward battle at Poitiers. According to Froissart he attended the young Richard in Smithfield when the king faced the mob after the death of Wat Tyler. His only son was killed in 1383 at a tournament, and in 1393 the earl sold the lordship and crown of Man to William Scrope of Bolton. He was succeeded by his nephew John, the third earl (c. 1350–1400), son of Sir John Montagu by Margaret, the heir of the barons of Monthermer. The new earl was notorious as a Lollard, and was accused, after Henry IV's accession, of a share in Gloucester's death. He joined Kent, Huntingdon and Rutland in their plot against Henry, and was beheaded with the earl of Kent by the Cirencester mob.

His son Thomas (1388–1428) was summoned as an earl in 1409, his father's dignities being restored to him in 1421, by which time his services at Harfleur and Agincourt had earned him French lordships, the lieutenant generalship of Normandy and the earldom of Perche. He was killed at the famous siege of Orleans. His only daughter, Alice, married Richard Neville, a younger son of the first earl of Westmorland, who was allowed the earldom

of Salisbury in right of his marriage. The famous "Richard-Make-a-King," earl of Warwick and Salisbury, was the grandson of the last of the Montagu earls.

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MONTAGU, EDWIN SAMUEL (1879–1924), British politician, played an important part in introducing the Government of India act in 1919, a measure which marked a decisive stage in India's constitutional development. The second son of the 1st Lord Swaythling (*q.v.*), he was born in London on Feb. *6, 1879.* and educated at Clifton college, at the City of London school and at Trinity college, Cambridge.

He entered parliament as a Liberal in 1906 and became secretary to H. H. Asquith. As parliamentary secretary to the India office, 1910–14, under Lord Morley and Lord Crewe, he had the task of explaining their constitutional reforms to the house of commons. He visited India in 1912.

During the first years of World War I, Montagu held a number of minor posts, entering the cabinet in 1915 as chancellor of the duchy of Lancaster. As financial secretary to the treasury, he helped to popularize the first war loans and to set up voluntary war-saving organizations. Although he resigned with other supporters of Asquith when Lloyd George took office in *1916,* in *1917* he became secretary of state for India and began work on a declaration of British policy toward India, made in August, and then on measures to provide the "progressive realization of responsible self-government" which it promised.

As head of a delegation to the Indian provinces in the winter of 1917–18, he collaborated with Lord Chelmsford, the viceroy, in the preparation of the hlontagu-Chelmsford report. Its main recommendations were embodied in the Government of India act. 1919, by which, for the first time, control over some aspects of provincial government passed to Indian ministers responsible to an Indian electorate *(see* INDIA: *History).* Montagu's personal diary of the tour, edited by his wife, was published in 1930, and throws a revealing light on the personalities behind the report.

Overzealous pressing of the Indian objections to Lloyd George's Turkish policy. which offended opinion among Moslems in India! led to friction between Montagu and the government, culminating in March *1922* when he authorized publication of India's protest against the proposed treaty of Sèvres (*q.v.*) without consulting the cabinet. Lloyd George demanded his resignation and his political career ended when he lost his seat at the general election that year. He went into the City, and died in London on Nov. 15, 1924.

MONTAGU, ELIZABETH ROBINSON (1720–1800), English leader of intellectual society and first of the "bluestockings," was born at York, Oct. *2, 1720.* In 1742 she married Edward Montagu, grandson of the first earl of Sandwich. She made his Mayfair house the social centre of intellectual society in London, Lord Lyttleton. Horace Walpole, Dr. Johnson and Sir Joshua Reynolds. who painted her portrait, being among her regular visitors. The term "bluestocking" was applied for the first time to her assemblies.

In 1760 she contributed to Lyttleton's *Dialogues of the Dead* and in *1769* published an *Essay on the Writings and Genius of Shakespeare.* Her husband, who died in 1775, left her a considerable fortune and large estates, including Sandleford Priory, which she enlarged. In 1781 she built Montagu house, now 22 Portman square. London, where she died, Aug. 25, 1800.

See E. J. Climenson (ed.), *Elizabeth Montagu, the Queen of the Blue Stockings: Her Correspondence From 1720 to 1761,* 2 vol (1906); *Mrs. Montagu, Queen of the Blues,* a continuation of Climenson's book ed. bv R. Blunt, 2 vol. (1923); J. Busse, *Mrs. Montagu, Queen of the Blues* (1928).

MONTAGU, LADY MARY WORTLEY (1689–1762), English letter writer, eldest daughter of Evelyn Pierrepont, afterward duke of Kingston, was baptized at Covent Garden on May *26, 1689.* Her mother. who died while her daughter was still a child, was a daughter of William Feilding, earl of Denbigh. Her father was proud of her beauty and wit, and when she was eight years old she is said to have been the toast of the Kit-Kat club. He took small pains with the education of his children, but Lady Mary was encouraged in her self-imposed studies by her uncle, William Feilding, and by Bishop Burnet. She formed a close friendship, and carried on an animated correspondence with Mary Astell, who was a champion of woman's rights, and with Anne Il'ortley Llontagu, granddaughter of the first earl of Sandwich. The letters on Anne's side, however, were often copied from drafts written by her brother, Edward Wortley Montagu, and after Anne's death in *1709* the correspondence between him and Lady Mary was prosecuted without an intermediary. Lady Mary's father, now marquess of Dorchester, declined. however, to accept Montagu as a son-in-law because he refused to entail his estate on a possible heir. Negotiations were broken off, and when the marquess insisted on another marriage for his daughter the pair eloped *(1712).*

The early years of Lady Mary U'0rtley Montagu's married life were spent in rigid economy and retirement in the country. Her husband was M.P. for Westminster in 1715, and shortly afterward was made a commissioner of the treasury. When Lady Mary joined him in London her wit and beauty soon made her a prominent figure at court.

Early in 1716 Montagu was appointed ambassador at Constantinople. Lady Llary accompanied him to Vienna, and thence to Adrianople and Constantinople. He was recalled in 1717, but they remained at Constantinople until *1718.* The story of this voyage and of her observations of eastern life is told in a series of lively letters full of graphic description. From Turkey she brought back the practice of inoculation for smallpox. She had her own children inoculated, and encountered a vast amount of prejudice in bringing the matter forward.

Before starting for the east she had made the acquaintance of Alexander Pope, and during her absence he addressed to her a series of extravagant letters, which appear to have been chiefly exercises in the art of writing gallant epistles. Very few letters passed after Lady Mary's return, and various reasons have been suggested for the subsequent estrangement and violent quarrel and the *Verses addressed to an Imitator of Horace.* Lady Mary aluays professed complete innocence. The reason was possibly that Pope had made love to her and been received with laughter.

In any case, Pope attacked her again and again with the grossest insults, and her chief ally, Lord Hervey, as well. In return she is credited with a hand in *A Pop upon Pope.* She had a romantic correspondence with a Frenchman named Rémond, who addressed to her a series of excessively gallant letters before ever seeing her. She invested money for him in South Sea stock at his desire, and, as was expressly stated, at his own risk. The value fell to half the price, and he tried to extort the original sum as a debt by a threat of exposing the correspondence to her husband. This disposes of the second half of Pope's line "Who starves a sister, or forswears a debt" *(Epilogue to the Satires,* i. 113), and the first charge is quite devoid of foundation.

In 1739 she went abroad, and although she continued to write to her husband in terms of affection and respect they never met again. At Florence in 1740 she visited Horace Walpole. uho cherished a great spite against her, and exaggerated her eccentricities into a revolting slovenliness. (See *Letters,* ed. Cunningham, i. 59.)

Lady Mary lived at Avignon, at Brescia. and at Lovere, on the Lago d'Iseo. She was disfigured by a painful skin disease, and her sufferings were so acute that she hints at the possibility of madness. She was struck with a terrible "fit of sickness" while visiting the countess Palazzo and her son, and perhaps her mental condition made restraint necessary. As Lady Mary was then in her sixty-third year, the scandalous interpretation put on the matter by Horace Walpole may safely be discarded. Her husband spent his last years in hoarding money, and at his death in 1761 is said to have been a millionaire. His extreme parsimony

is satirized in Pope's *Imitations of Horace* (2nd satire of the 2nd book) in the portrait of Avidieu and his wife. Her daughter Mary, countess of Bute, whose husband was now prime minister, begged her to return to England. She came to London, and died in the year of her return, on Aug. 21, 1762. The general opinion of her was that as a letter-writer she was second only to Mme. de Sévigné. However that may be, there could hardly be two people more unlike. Lady Mary's letters are vivid, downright and scandalous; their interest lies not so much in the works as in the scenes and incidents of her wandering life.

Her son, EDWARD WORTLEY MONTAGU (1713–1776), author and traveller, inherited something of his mother's gift and more than her eccentricity. He was born in May 1713, twice ran away from Winchester School, and the second time made his way as far as Oporto. He was then sent to travel with a tutor in the West Indies, and afterwards with a keeper to Holland. He made, however, a serious study of Arabic at Leyden (1741), and returned twenty years later to prosecute his studies. His father made him a meagre allowance, and he was heavily encumbered with debt. He was M.P. for Huntingdon in 1747, and was one of the secretaries at the conference of Aix-la-Chapelle. In 1751 he was involvea in a disreputable gaming quarrel in Paris, and was imprisoned for eleven days in the Châtelet. He continued to sit in parliament, and wrote *Reflections on the Rise and Fall of the Antient Republics* . . . (1759). His father left him an annuity of £1,000, the bulk of the property going to Lady Bute. He set out for extended travel in the East, lived at Venice and died at Padua on April 29, 1776.

Lady Mary's "Town Eclogues" were published in a pirated edition as *Court Poems* in 1716. Of her famous *Letters* from the East she made a copy shortly after her return to England. She gave the MS. to Benjamin Sowden, a clergyman of Rotterdam, in 1761. After Lady Mary's death this was recovered by the earl of Bute, but meanwhile an unauthenticated edition, supposed to have been prepared by John Cleland, appeared (1763), and an additional volume, probably spurious, was printed in 1767. The rest of the correspondence printed by Lord Wharncliffe in the ,edition of her letters is edited from originals in the Wortley collection. This edition (1837) contained "Introductory Anecdotes" by Lady Bute's daughter, Lady Louisa Stuart. A more critical edition of the text, with the "Anecdotes," and a "Memoir" by W. Moy Thomas, appeared in 1861. A selection of the letters arranged to give a continuous account of her life, by Mr. A. R. Ropes, was published in 1892; and another by R. Brimley Johnson in "Everyman's Library" in 1906. *See* also George Paston, *Lady Mary Wortley Montagu and her Times* (1907), which contains some hitherto unpublished letters. Lady Mary's journal was preserved by her daughter, Lady Bute, till shortly before her death, when she burnt it. There is a full and amusing account of Edward Wortley Montagu in Nichols's *Anecdotes of Literature*, iv. 625–656; L. Melville, *Lady Mary Wortley Montagu* (1925); Iris Barry, *Portrait* of *Lady Mary Wortley Montagu* (1928).

MONTAGU, RALPH, 1ST DUKE OF (1638–1709), English diplomatist, was the second son of Edward. 2nd Baron Montagu of Boughton (1616–84), whose peerage was one of several granted in the 17th century to different members of the Montagu family (*q.v.*). He was born in London and baptized on Dec. 24, 1638. Appointed in 1665 master of the horse to Queen Catherine, wife of Charles II, he soon acquired a reputation for gallantry at the court.

As ambassador to France (1666, 1669, 1676 and 1677–78) Montagu took an active part in the king's negotiations with Louis XIV. He was a privy councillor, 1672–79, and again in 1689, and sat in the house of commons for Northampton in 1678 and 1679–81 and for Huntingdon in 1679. He supported the movement for excluding the duke of York from the succession and for recognizing the duke of Monmouth as heir. His elder brother having predeceased his father, Ralph became Baron Montagu of Boughton on the death of the latter in 1684. Notwithstanding his former intrigues he gained the favour of James II. but this did not deter him from welcoming William of Orange, who created him Viscount Monthermer and earl of Montagu in 1689. His position was further strengthened in 1705 by the marriage of his son to Mary, daughter of the great duke of Marlborough. In the same year he was raised to the dukedom as duke of Montagu and marquess of Monthermer. He died in London on March 9, 1709. His London residence, Montagu House, Bloomsbury, was bought by the government in 1753 to hold the national collection of antiquities, and on its site was built the British Museum.

At the death of his son John in 1749, the title became extinct.

(R. B. WM.)

MONTAGU (or MOUNTAGUE), **RICHARD** (1577–1641), English divine, was born at Dorney, Buckinghamshire, and educated at Eton and King's college. Cambridge. He was appointed to the deanery of Hereford in 1616, but exchanged it next year for a canonry of Windsor, which he held with the rectory of Petworth, Sussex. He was also chaplain to James I. Like Archbishop William Laud, he disliked the extremes of Calvinism and Romanism. About 1619 he came into collision with some Roman Catholics in his parish, and Matthew Kellison (1560?–1642) attacked him in a pamphlet entitled *The Gagg of the Reformed Gospell* (Douai, 1623). Montagu replied with *A Gagg for the New Gospell? No. A New Gagg for an Old Goose* (1624). The publication of the *Immediate Addresse unto God alone* (1624) incensed the Puritans, who appealed to the house of commons, but Montagu was protected by the king. After the appearance of his famous *Appello Caesarem* (1625), in which be vindicated himself from the divergent charges of Arianism and popery. his case frequently came before parliament and conferences of bishops, but his influence at court and with Laud saved him. He was consecrated bishop of Chichester in 1628. and became bishop of Norwich in 1638. He died on April 13, 1641.

MONTAIGNE, MICHEL DE (1533–1592), French essayist, was born, as he himself tells us, between eleven o'clock and noon on Feb. 28, 1533. The patronymic of the Montaigne family, who derived their title from the château at which the essayist was born and which had been bought by his grandfather, was Eyquem. Montaigne is not far from Bordeaux, with which the Eyquem family had for some time been connected. Pierre Eyquem, Montaigne's father, had been engaged in commerce (a herring-merchant Scaliger calls him, and his grandfather Ramon had certainly followed that tradej, had filled many municipal offices in Bordeaux, and had served under Francis I. in Italy as a soldier. He married Antoinette de Louppes (Lopez), descended from a family of Spanish Jews. The essayist was the third son. By the death of his elder brothers, however, he became head of the family. He had also six younger brothers and sisters. Montaigne was put out to nurse with a peasant woman, and had his sponsors from the same class. He was taught Latin orally by servants who could speak no French, and many curious fancies were tried on him, as, for instance, that of waking him every morning by soft music.

At six years old Montaigne was sent to the collège de Guienne at Bordeaux, then at the height of its reputation. At thirteen Montaigne began to study law, probably at Toulouse. In 1548 he was at Bordeaux during one of the frequent riots caused by the gabelle, or salt-tax. Six years afterwards he was made a counsellor in the Bordeaux parlement. In 1558 he was present at the siege of Thionville, in 1559 and 1561 at Paris, and in 1562 at the siege of Rouen. He was also much about the court, and he admits that in his youth he led a life of pleasure, if not exactly of excess.

In 1565 Montaigne married Françoise de la Chassaigne, whose father was, like himself, a member of the Bordeaux parlement. Three years later his father died, and he succeeded to the family possessions. Finally, in 1571, he retired to Montaigne, having given up his magistracy the year before. His health, never strong, had been further weakened by hard living. He resolved, accordingly, to retire to a life of study and contemplation, though he indulged in no asceticism except careful diet. He lived on excellent terms with his wife, and bestowed some pains on the education of the only child (a daughter Léonore) who survived infancy.

THE ESSAYS

In his father's lifetime, and at his request, he had translated the *Theologia naturalis* of Raymund de Sabunde, a Spanish schoolman (published 1569). On first coming to live at Montaigne he edited the works of his deceased friend Etienne de la Boétie. But the years of his studious retirement were spent on a work

of infinitely greater importance. Garrulous after a fashion as Montaigne is, he gives us no clear idea of any original or definite impulse leading him to write the famous *Essays*. It is very probable that if they were at first intended to have any special form at all it was that of a table-book or journal. The earlier essays, those of the first two books, differ from the later in one most striking point, in that of length. Speaking generally, the essays of the third book average fully four times the length of those of the other two. This of itself would suggest a difference in the system of composition. These first two books appeared in 1580, when their author was 47 years old.

They contain, as at present published, no fewer than ninety-three essays, besides an exceedingly long apology for the already mentioned Raymund Sabunde, in which some have seen the kernel of Montaigne's philosophy. The book begins with a short *avis* (address to the reader), opening with the well-known words, "*C'est icy un livre de bon foy, lecteur,*" and sketching in a few lively sentences the character of meditative egotism which is kept up throughout. His sole object, he says, is to leave for his friends and relations a mental portrait of himself, defects and all; he cares neither for utility nor for fame. The essays then begin, without any attempt to explain or classify their subjects. Their titles are of the most diverse character. Sometimes they are proverbial sayings or moral adages, such as "Par divers moyens on arrive à pareille fin," "Qu'il ne faut juger de notre heur qu'après la mort," "Le profit de l'on est le dommage de l'aultre." Sometimes they are headed like the chapters of a treatise on ethics: "De la tristesse," "De l'oisiveté," "De la peur," "De l'amitié." Sometimes a fact of some sort which has awaked a train of associations in the mind of the writer serves as a title, such as "On est puni de s'opiniastrer à une place sans raison," "De la bataille de Dreux," etc. Occasionally the titles seem to be deliberately fantastic, as "Des puces," "De l'usage de se vestir." Sometimes, though not very often, the sections are in no proper sense essays, but merely commonplace book entries of singular facts or quotations, with hardly any comment.

In 1571 he had received the order of Saint-Michel; in 1574 was with the army of the duke de Montpensier; two years later was made gentleman-in-ordinary to Henry III., and next year again to Henry of Navarre. He visited Paris occasionally, and travelled for health or pleasure to Cauterets, Eaux Chaudes and elsewhere. But his health grew worse and worse, and he was tormented by stone and gravel. He accordingly resolved to journey to the baths of Lucca. Late in the 18th century a journal found in the château of Montaigne, giving an account of this journey, was published in 1774; part of it is written in Italian and part dictated in French, the latter being for the most part the work of a secretary or servant. The ms. disappeared early, and the work is almost destitute of literary interest. At Rome he received news of his election as mayor of Bordeaux with a peremptory royal endorsement enjoining residence, and after some time journeyed homewards.

The memory of his father, however, and the commands of the king induced Montaigne to accept the mayoralty; and he seems to have discharged it neither better nor worse than an average magistrate. He was re-elected at the close of his term. His second term of office terminated in 1585; and in 1588 after a visit of some length to Paris, the third book of the *Essays* was published, together with the former ones considerably revised. The new essays, as has been remarked, differ strikingly from the older ones in respect of length; and the whimsical unexpectedness of the titles reappears in but two of them: "Des Coches" and "Des Boiteux." They are, however, identical with the earlier ones in spirit, and make with them a harmonious whole—a book which has hardly been second in influence to any of the modern world.

HIS POSITION IN LITERATURE

This influence is almost equally remarkable in point of matter and in point of form. Montaigne is one of the few great writers who have invented a literary kind. The essay as he gave it had no forerunner in modern literature and no direct ancestor in the literature of classical times. In matter of style and language Montaigne's position is equally important, but the ways which led him to it are more clearly traceable. His favourite author was beyond all doubt Plutarch, and his own explicit confession makes it undeniable that Plutarch's translator, Jacques Amyot, was his master in point of vocabulary and (so far as he took any lessons in it) of style. Montaigne, however, followed with the perfect independence that characterized him. He was a contemporary of Ronsard, and his first essays were published when the innovations of the Pléiade had fully established themselves. He adopted them to a great extent, but with much discrimination, and he used his own judgment in latinizing when he pleased. In the same way he retained archaic and provincial words with a good deal of freedom, but by no means to excess.

Perhaps the only actual parallel to Montaigne in literature is Lamb. There are differences between them, arising naturally enough from differences of temperament and experience; but both agree in their attitude—an attitude which is sceptical without being negative and humorous without being satiric. There is hardly any writer in whom the human comedy is treated with such completeness as it is in Montaigne. There is discernible in his essays no attempt to map out a complete plan; and then to fill up its outlines. But in the desultory and haphazard fashion which distinguishes him there are few parts of life on which he does not touch, if only to show the eternal contrast and antithesis which dominate it. The exceptions are chiefly to be found in the higher and more poetical strains of feeling to which the humorist temperament lends itself with reluctance and distrust, though it by no means excludes them. The positiveness of the French disposition is already noticeable in Rabelais; it becomes more noticeable in Montaigne. He is always charming, but rarely inspiring.

Montaigne did not very long survive the completion of his book. On his way to Paris for the purpose of getting it printed he stayed for some time at Blois, where he met De Thou. In Paris itself he was for a short time committed to the Bastille by the Leaguers, as a kind of hostage, it is said, for a member of their party who had been arrested at Rouen by Henry of Navarre. But he was well known to and favoured by both Catherine de' Medici and the Guises, and was very soon released. In Paris, too, at this time he made a whimsical but pleasant friendship with Marie de Jars de Gournay (1565–1645), one of the most learned ladies of the 16th and 17th centuries, who became his "fille d'alliance" (adopted daughter), a title which she bore for the rest of her long life. When Henry of Navarre came to the throne of France, he wished Montaigne, whom he had visited in 1584 and 1587, to come to court, but this was refused. It would seem that he returned from Paris to his old life of study and meditation and working up his *Essays*. No new ones were found after his death, but many alterations and insertions. He was attacked with quinsy, which brought about paralysis of the tongue, and he died on Sept. 13, 1592. He was buried, though not till some months after his death, in a church in Bordeaux, which after some vicissitudes became the chapel of the collège.

When Mlle. de Gournay heard of the death of Montaigne she undertook with her mother a visit of ceremony and condolence to the widow, which had important results for literature. Mme. de Montaigne gave her a copy of the edition of 1588 annotated copiously; at the same time, apparently, she bestowed another copy, also annotated by the author, on the convent of the Feuillants in Bordeaux, to which the church in which his remains lay was attached. Mlle. de Gournay thereupon set to work to produce a new and final edition with a zeal and energy which would have done credit to any editor of any date. She herself worked with her own copy, inserting the additions, marking the alterations and translating all the quotations. But when she had got this to press she sent the proofs to Bordeaux, where a poet of some note, Pierre de Brach, revised them with the other annotated copy. The edition thus produced in 1595 has with justice passed as the standard, even in preference to those which appeared in the author's lifetime.

Unluckily, Mlle. de Gournay's original does not appear to exist and her text was said, until the appearance of MM. Courbet and Royer's edition, to have been somewhat wantonly corrupted, especially in the important point of spelling. The Feuillants copy is in existence, being the only manuscript, or partly manuscript, authority for the text. This manuscript was edited in 1803 by Naigeon, the disciple of Diderot; but, according to later inquiries, considerable liberties were taken with it. The first edition of 1580, with the various readings of two others which appeared during the author's

lifetime, was reprinted by MM. Dezeimeris and Burckhausen in 1870. That of Le Clerc (3 vols., 1826–28) and in a more compact form that of Louandre (4 vols., 1854) have been most useful; but that of MM. Courbet and Roper (1872–1900) is at present the standard; a more recent edition is by P. Villey (1922). The *Journal,* long neglected and still (*vide supra*) doubtful, was re-edited by Professor A. d'Ancona (Citta di Castello, 1895) and translated into English by W. G. Waters (1903). The *Oeuvres complètes* were edited by A. Armaingaud in 1924. Modern books of importance are P. Bonneion's *Montaigne, l'homme et l'oeuvre* (1893) and P. Stapfer's *Montaigne* (1895) in the *Grands écrivains,* the latter a book of remarkable excellence. Edmé Champion's *Introduction aux essais* may also be noticed, and Professor Dowden's *Montaigne* (1905), which has an excellent bibliography. The somewhat earlier *Montaigne* of M. E. Lowndes (Cambridge, 1898) is noteworthy in especial for its attention to his life and character.

In England Montaigne was early popular. It was long supposed that the autograph of Shakespeare in a copy of Florio's translation showed his study of the *Essays.* The autograph has been disputed, but divers passages, and especially one in *The Tempest,* show that at first or second hand the poet was acquainted with the essayist. The book best worth consulting on this head is J. Feis's *Shakespeare and Montaigne* (1884). Towards the latter end oi the 17th century, Cotton, the friend of Izaak Walton, executed a complete translation, which, though not extraordinarily faithful, possesses a good deal of roueh vigour. It has been frequently reprinted with additions and alterations; W. C. Hazlitt's edition (1892) was reprinted in 1923. Reprints of Florio are also numerous. One in the "Tudor Translations" (1893) has an introduction by G. Saintsbury; another translation of the essays is by E. J. Trechmann (2 vols., 1927). .4n English biography of Montaigne by Bayle St. John appeared in 1858, and Walter Pater's unfinished *Gaslon de Latour* borrows irom Montaigne and his story. The most notemorthv critical handling of the subject in English is unquestionably Emerson's in *Representative Men* *See* also E. Sichel, *Michel de Montaigne* (1911); *D* Frame, *Montaigne in France* (1940).

MONTALE, EUGENIO (1896–), Italian poet, a leader of the "Hermetic" movement in Italian poetry *(see* ITALIAN LITERATURE), was born at Genoa. Oct. 12, 1896 He fought in World War I, but was never a nationalist. and opposed Fascism from its beginning. He was director of the Gabinetto Vieusseux. a literary society and library in Florence. from 1929 to 1938, and later became literary editor of the Milan daily *Corriere della sera.*

Montale's first book of poems, *Ossi di seppia* (1925), expressed the bitter pessimism of the postwar period. In form it reacted against the D'Annunzian and futurist poetry of the preceding decade. and sought to express by means of symbols the poet's inner self. The rocky landscape of Liguria. the sea and a tragic vision of the world as a dry. barren. hostile wilderness (not unlike T. S. Eliot's *Waste Land)* inspired Montale's best poems. In *Le occasioni* (1939) and *La bufera* (19j6) he was inspired mainly by his memories and his efforts to recapture the atmosphere of the past are singularly moving.

Twenty of Montale's poems are translated in *The Penguin Book of Italian Verse,* edited by *G.* Kay (1958).

See R. Lunardi, *E. Montale* e *la nuova poesia* (1948). (F. DI.)

MONTALEMBERT, CHARLES FORBES RENÉ DE (1810–1870), French publicist, historian and academician (1851), was born on April 15, 1810. Nontalembert's father. Marc René. emigrated, fought under Condé and subsequently served in the English army; he married Elise Rosée Forbes, and his eldest son. Charles, was born in London. At the Restoration of 1814 Marc René returned to France, was raised to the peerage in 1819 and became ambassador to Sweden (where Charles completed his education) in 1826. He died in 1831. a year after the overthrow of the legitimate monarchy. Charles de Montalembert was a liberal. in the English sense, but was unable to support the government of Louis Philippe on religious grounds. He wished to see the church free from the control of the state, and passionately attacked the monopoly of public instruction by which the monarchy fortified its position. Montalembert was formally charged with unlicensed teaching. He claimed the right of trial by his peers, and made a notable defense (1831). On the other hand, he thought that the church should not obstinately oppose new ideas. He collaborated with his friends. F. de Lamennais and Jean Lacordaire, in the newspaper *L'Avenir.* The Ultramontane party was roused by their boldness, and Montalembert and his two friends left for Rome. This famous pilgrimage proved useless to mitigate the measures which the Roman curia took against *L'Avenir.* Its doctrines were condemned in two encyclicals (*Mirari vos,* 1832, and *Singulari vobis,* 1834), and Montalembert submitted. After the revolution of 1848 he sat in the chamber of deputies till 1857. He was recognized as one of the most formidable opponents of the empire. Meanwhile his liberal ideas had made him enemies among the Ultramontanes, notably Louis Veuillot, editor of *L'Univers.* Montalembert answered his attacks by reviving the *Correspondant* (1855), in which he opposed both the fanatical party of Pius IX and the *Syllabus,* and the more or less freethinking liberals of the *Revue des deux mondes.* After the promulgation by the Vatican council of the dogma of papal infallibility he would not allow himself to be seduced from obedience to the pope; he now severed his connection with Père Hyacinthe (Loison) as he had with Lamennais, and made the submission expected of him to the council. He died on March 13, 1870.

Montalembert's first historical work, *La Vie de Ste. Elisabeth de Hongrie* (1836), is not so much a history as a religious manifesto. His studies of monachism in the west bore fruit in his *Moines d'occident* (first 5 vol., 1860–67) unfinished at the time of the author's death, but completed later from some long fragments found among his papers (vol. vi and vii. 1877).

See Margaret Oliphant, *Memoir of Count de Montalembert* (1872); *P.* de Lallemand, *Montalembert et ses amis* (1927).

MONTALEMBERT, MARC RENÉ, MARQUIS DE (1714–1800), French military engineer and writer who developed a new system of field fortification. was born at Angoulême on July 16, 1714, and entered the French army in 1732. He fought in the War of the Polish Succession on the Rhine (1733–34), and in the War of the Austrian Succession made the campaigns of 1742 in Bohemia and Italy. In the years preceding the Seven Years' War, Montalembert devoted his energies to the science of fortification, to which Vauban's *Traité de l'attaque* attracted him, and founded the arsenal at Ruelle, near his birthplace. On the outbreak of war he became French commissioner with the allied army of Sweden, with the rank of brigadier general. He constructed the field fortifications of Anklam and Stralsund. In 1761 he was promoted *maréchal de camp,* and began the works on which his fame rests. Montalembert's fortress has been aptly described by an English author as an "immense battery." The intricacies of trace by which Vauban and Louis de Cormontaigne sought to minimize the power of the attack were abandoned in favour of a simple tenaille plan giving the defenders an overwhelming fire power.

The "polygonal" method of fortification was the direct outcome of Montalembert's systems. In his own country the caste spirit of the engineer corps was roused to defend Vauban, and though Montalembert was allowed to construct some successful works at Aix and Oléron, he was forbidden to publish his method. and given but little opportunity for actual building. After 15 years of secrecy he published in Paris (1776–78) the first edition of *La Fortification perpendiculaire.* At the time of the Revolution he emigrated for a time. After his return Lazare Carnot often called him into consultation on military affairs. and in 1792 promoted him general of division. He died in Paris on March 29. 1800.

MONTANA, popularly known as the "Treasure state" because of its rich mineral resources, is located in the Rocky mountain region of the United States, athwart the continental divide. It is bounded on the north by Canada, on the east by North Dakota and South Dakota, on the south by Wyoming and Idaho and on the west by Idaho. In area it ranks 4th among the states of the union (after Alaska, Texas and California) having 145,736 sq.mi. of land area and 1,402 sq.mi. of water. a total area of 147,138 sq.mi. It averages 535 mi. in length and 275 mi. in width. Its population in 1960 was 674,767, giving it 41st rank among the states.

Montana became a territory on May 26, 1864, and was admitted to the union as the 41st state on Nov. 8, 1889. Its name, proposed by James M. Ashley, sponsor of the bill for its territorial organization, is derived from the Spanish *montaña,* meaning "mountainous region." The state capital, Helena, traces its origin to a mining camp of the 1860s known as Last Chance Gulch. The official state bird is the western meadowlark; the state flower, bitterroot; state tree, Ponderosa or western yellow pine. The state motto, *Oro* y *Plata* ("Gold and Silver"), appears on both the state flag and state seal.

PHYSICAL GEOGRAPHY

Physical Features. — Montana lies between 44° 23' and 49° N. latitude. and 104° 2′ and 116° 3' W. longitude. The eastern three-fifths of the state is in the Great Plains and is characterized by vast stretches of range land and dry-farming areas sharply cut by many small streams leading to the larger rivers. Near the centre of the state distinctive isolated mountains, known as mountains of the plains, rise abruptly. These mountains cause sufficient precipitation to promote the growth of grass and trees and provide irrigation water for adjacent communities. The alternating ranges and valleys of the Rocky mountains occupy the western two-fifths of the state. The continental divide follows the boundary line between Montana and Idaho west and northwest of Yellowstone National park (*q.v.*) to Ravalli county; it turns eastward through Deer Lodge and Silver Bow counties, then northward to Lewis and Clark county, and from there extends north-northwest to Glacier National park and Canada.

The area west of the continental divide is made up of fertile valleys of rare beauty. The Bitterroot valley merges into the broad Missoula valley, and to the north Flathead lake and its adjacent timber and ranch lands are bounded on the east by the majestic Mission range. To the east of the Bitterroot valley the high mountain valleys of Flint creek and Deer Lodge lie at the headwaters of the Clark Fork of the Columbia river. The Clark Fork rises near Butte and is joined by the Little and Big Blackfoot rivers from the east, the Bitterroot from the south and the Flathead from the north. The Rootenai river has carved a beautiful valley in the extreme northwest corner of the state. Here, near Troy, is the lowest point in the state. 1.800 ft. above sea level.

Crossing the continental divide just south of the Canadian border is Glacier National park. It was created in 1910 and contains 915.000 ac. of towering mountains and long, narrow mountain lakes. The Glacier watershed drains into the Pacific, the Atlantic and Hudson Bay. Nearly all of Yellowstone National park lies in Wyoming, but the park has three entrances from Montana Just north of Yellowstone park lie the Absaroka and Snowy ranges, and to the east the Beartooth range contains Granite peak (12.799 ft.), the highest point in the state. The Great Plains slope from about 4.000 ft. above the sea at the foothills of the mountains to 2,000 ft. in northeastern Montana. As noted above, several isolated mountain groups such as the Highwoods, Bear Paws, Little Rockies and Sweet Grass hills modify the character of the plains in mid Montana.

Montana has an exceptionally good river system. The two main rivers east of the continental divide are the Missouri and the Yellowstone. The Missouri is formed by a union at Three Forks of the Jefferson, Madison and Gallatin. Farther north the Missouri is joined by the Smith river from the south, and from the west by the Sun, the Teton and the hlarias. After making a big bend to the east it is joined from the south by the Judith and the Musselshell rivers. and on the north by the Milk and Poplar.

The Yellowstone river rises in Yellowstone park and has only one minor tributary from the north, the Shields river. From the several mountain groups to the south, however, it is joined by the Clark's Fork, Big Horn. Rosebud, Tongue and Powder rivers. The Yellomstone joins the Missouri just across the state's eastern border.

The average altitude of Montana is 3,400 ft., with more than half the state lying under 3,000 ft. This low average, much lower than that of any other Rocky mountain state, to some extent offsets its northern position and tempers its climate. Montana's mountains contain a number of low passes that provide favourable routes for railroads and highways. The largest of the state's many natural lakes is Flathead lake in the northwestern section. There are in addition numerous man-made water storage reservoirs that have been developed as recreation areas

Climate. — —Montana has a varied and generally favourable climate. The average mean temperature for the state is 42.6" F. It ranges from 46° in the lower Yellowstone valley to 35° in the higher mountain valleys, but extremely low temperatures are occasionally recorded in the minter. The mean precipitation is 15.48 inches. Nearly half the rainfall comes during the growing season from May to August. Northern Montana lies in the chinook belt where frequent warm winter winds remove the snow cover. The growing season varies from 87 frost-free days at Philipsburg to 141 at Roundup. Ninety frost-free days are considered necessary for most of Montana's crops.

Vegetation. — Plant life in Montana has developed around three distinctive natural groupings according to geographic location: subalpine or high mountains. montane and plains.

The Great Plains are covered for the most part with forage grasses of the bunch types, particularly blue grama and wheat grasses. These mature quickly and by mid-July are highly nutritious and take on a dry, brown appearance. Generous patches of sagebrush, cedar and low pine trees characterize the broken terrain of eastern Montana, with willows and cottonwood on the bottom lands. The mountains of western Montana are densely covered with forests below the timber line. Important commercial trees include Ponderosa or western yellow pine, Douglas fir, western larch and Engelmann spruce.

Animal Life. — The American buffalo, or bison, which formerly ranged the plains in great herds. was almost exterminated by early hunters and settlers. but protective measures in the 20th century rescued the buffalo from extinction. Three herds are maintained, one at the National Bison range near Moiese, another on the Crow Indian reservation and a third in adjacent Yellowstone park. Favourite game animals in Montana include deer, elk, moose and antelope. Controlled herds of antelope increased greatly during the 1950s. Fur-bearing animals found in Montana include beaver, mink, muskrat and weasel. Geese, ducks, pheasants and grouse are numerous. Most popular among the 60 species of fish are the cutthroat trout, rainbow trout, grayling trout and sockeye salmon. Lakes, rivers and mountain streams are restocked regularly by state and federal fish hatcheries.

HISTORY AND GOVERNMENT

Early Exploration and Settlement. — -Eastern Montana was probably reached in 1742 by French traders from Canada, the Verendrye brothers, François, titled the Chevalier, and Louis Joseph. Fur traders reached the area occasionally during the next 50 years but the first major expedition of record is that of Lewis and Clark, who reached the state in April 1805. This expedition opened the way for traders and settlers. Manuel Lisa appears to have built the first trading post in Montana at the mouth of the Big Horn river in 1807. In the same year, John Colter, while securing Indian trade, discovered the future Yellowstone park area. Lisa's Missouri Fur company operated on the Yellowstone for 20 years. David Thompson of the Canadian North West company explored and mapped the Columbia basin and established the second trading post in Montana in 1808 by sending Finan McDonald to trade near the present town of Jennings. McDonald built Salish House near the present Thompson falls on Clark Fork river in the northwestern part of the state. From 1820 to 1840 the Hudson's Bay company sent annual brigades up the Columbia and its branches, and many of its best traders were in the Montana area.

The American Fur company dominated the fur business east of the mountains, largely through its important posts, Ft. Union, which was established in 1829 by Kenneth McKenzie near the junction of the Missouri and Yellowstone rivers, and Ft. Benton, which was built by Alexander Culbertson in 1846 at the head of navigation on the Missouri river.

Indian affairs on the west slope were aided substantially by the work of the Belgian Jesuit missionary, Pierre Jean DeSmet, who established St. Mary's mission in the Bitterroot valley in 1841. He was joined in 1845 by Father Anthony Ravalli, an Italian Jesuit. The mission of St. Ignatius in the Flathead area in the northwestern section of the state was established in 1854.

Gold discoveries brought the first population boom to Montana. The first discovery of gold is credited to François Finlay in 1852 in the lower Deer Lodge valley, but it aroused no great interest. Six years later James and Granville Stuart publicized their discoveries on Gold creek in the same area. Following 1860, when the Mullan road leading from Ft. Benton to Ft. Walla Walla

was built past the small settlement, prospectors fanned out to discover some of the richest placer deposits in the world. Discoveries were made at Bannack in 1862; Alder Gulch, where one of the greatest gold discoveries was made in 1863. soon grew into Virginia City; Last Chance Gulch became Helena, the future capital city. in July 1864; and the Confederate Gulch discovery was made in December of the same year, taking the name of Diamond City. These boom mining camps created markets for the farms that appeared in the valleys of the Bitterroot, Deer Lodge, Madison and Gallatin rivers.

Territorial Status. — The growth of population in the territory led to a demand for independent political status. The region had been under various administrations during the preceding half century. The area east of the mountains had been included in the Louisiana Purchase of 1803 and its subsequent government. The western section had been a part of the Oregon country following the treaty with Great Britain establishing the boundary at the 49th parallel in 1846. The Territory of Idaho, created in 1863, included the Montana area but access to the capital at Lewiston was difficult. The rise of a large band of thieving road agents caused the organization of the Vigilantes of Montana, an extragovernmental law enforcement agency. To provide more adequate government services for the area the Territory of Montana was created May 26, 1864, with Sidney Edgerton as the first governor. The first territorial legislature met at Bannack but the following year the capital was moved to Virginia City, and in 1875 to Helena.

There was continued development of mining. which went from placer gold to quartz gold veins, to silver (in the 1870s) and then to copper (in the 1880s). Combined with mining was a thriving agriculture and a growing range cattle industry, all of which led to a movement for the building of railroads. The growth of the territory also created urgent pressures to obtain possession of the lands held by the Indians and rights of travel over such natural highways as the Bozeman road and the Northern Overland road to Minnesota.

The most dramatic episode in the movement to deal with the Indian problem took place in June, 1876, on the Little Big Horn when Col. George A. Custer and over 200 men were annihilated by the Sioux and Cheyennes. The spectacular march through Montana in 1877 of the Nez Percés in protest to reservation conditions in Idaho further emphasized the Indian problem. A series of new forts and new treaties led the Indians to withdraw reluctantly to reduced reservations and white men expanded into their lands.

The stockmen profited most from the withdrawal of the Indians. The beginning of cattle raising in Montana may be traced to the year 1833 when a few milk cattle had been driven down the Big Horn to Ft. Union. Both cattle and sheep were brought into the western valleys by the missionaries in the 1850s and by stockmen in the early 1860s. The first drive of cattle from Texas to the Montana ranges was made in 1866 by Nelson Story of Bozeman. Eight years later a herd of Montana cattle was driven to Ogden, Utah. and from there shipped east on the Union Pacific railway. After the Indians were quieted in 1877 most of the herds were driven to Cheyenne, Wyo., for shipment. The completion of the Northern Pacific railway through the state in the early 1880s further stimulated the cattle industry but the drought and severe winter of 1886–87 killed thousands of cattle and caused withdrawal of much of the foreign capital intent on huge profits.

Sheep raising, which developed in Montana along with the cattle industry, was not as dependent upon transportation. Large quantities of wool were shipped by flatboat down the Missouri and Mississippi rivers to New Orleans and thence by steamer to Boston. Sheep increased in number from about 4,000 in 1870 to 250,000 by 1880 and to more than 6,000,000 in 1900, when the wool clip of Montana exceeded that of any other state.

Statehood. — As the territory grew in population during the 1880s it took steps to acquire statehood, beginning in 1884 with a constitutional convention which congress ignored. In 1889 a convention drafted a state constitution which was approved by popular vote and by congress. After 25 years as a territory, Montana was admitted to the union on Nov. 8, 1889, as the 41st state. The capital was at Helena and the first governor was Joseph K. Toole. (See *Government* below.)

The decade 1895–1905 was also characterized by the bitter "war of the copper kings." William A. Clark, Marcus Daly and F. Augustus Heinze. Their feud affected such diverse problems as methods of mining, manipulation of copper prices on international exchanges, control of the courts, the organization of labour, the location of the state capital and whether Clark should be U.S. senator.

During the first quarter of the 20th century Montana gained nevi industries with the discovery of natural gas and oil. Petroleum refineries mere built in 16 Montana communities during the 1920s. including Great Falls. Billings, Shelby and Sunburst, and pipelines to distribute the products of Montana wells spread throughout the state. In 1951 wells in the Williston basin began to pump oil in quantities far surpassing the output of earlier wells.

One of the most notable figures in Montana's political history during the first three decades of the 20th century mas Thomas J. Walsh (*q.v.*). First elected to the U.S. senate from Montana in 1912, he nas re-elected in 1918 and 1924. He won aide recognition as a skilled and energetic senate investigator. Another Montanan prominent in politics was Burton K. Wheeler, who was elected to the U.S. senate from Montana in 1923 and served continuously until 1947. He was the Progressive party's candidate for vice-president in the election of 1924.

Montana mas hard hit during the 1930s by the nationwide depression and by severe droughts. Rfines closed and lumbering operations came to a virtual standstill. Farmers not only reaped poor harvests but also received low prices for their products. The federal government initiated large projects for irrigation, soil conservation, rural electrification and control of insects such as the grasshopper. One of the most important projects of this era mas construction of Fort Peck dam on the Missouri river; it was completed in 1940 and was the largest earth filled dam in the world. Meanwhile, in 1935, the state capital. Helena. was hit by an earthquake that caused property damage amounting to several million dollars.

During the 1940s more abundant rainfall brought a revival of Montana's agriculture while the wartime demand for copper, lead, zinc and other minerals stimulated the mining industry. An important air force base was constructed near Great Falls during World War II and continued in service in the postnar years. Construction of additional dams for flood control, irrigation and production of electric power continued through the 1950s. Hungry Horse dam on the Flathead river was completed in 1952 and made possible increased industrial expansion in the northwestern part of the state. An even larger hydroelectric project. Noxon Rapids dam on the Clark Fork river, was completed in 1960.

Government. — The state is governed under a constitution adopted in 1889. To amend this constitution an affirmative vote of two-thirds of the members of each house of the legislature is required, followed by an affirmative vote of a majority of the electors voting thereon at the next general election; or, as an alternative method, by a like vote of each house of the legislature and of the electorate, a convention may be called to revise or amend it. A revision or amendment in this manner requires the ratification of the electorate not less than two months nor more than six months after the adjournment of the convention.

The officers of the executive department are the governor, lieutenant governor, secretary of state, attorney general, treasurer, auditor and superintendent of public instruction, each of whom is elected for a term of four years. The governor. with the advice and consent of the senate, appoints various administrative officers such as the state engineer, state forester. the commissioner of agriculture, and numerous boards including the State Board of Equalization and the State High ay commission. He may veto any bill passed by the assembly, or in the case of a bill making appropriations of money he may veto any item of it, and no bill or item of an appropriation which he vetoes within five days (Sunday excepted) after it has been presented to him can become a law or a part of a lam unless passed over his veto in each house by a tno-thirds vote of the members present.

The legislature consists of a senate and a house of representa-

tives. meeting regularly on the first Monday of January in odd-numbered years only. Senators are elected, one from each county, for a term of four years; representatives are elected, one or more from each county according to population, for a term of two years. The senators in 1960 numbered 56. and the representatives 94. The action of the legislature is much restricted by the constitution. a long list of cases being named in mhich that body is prohibited from passing any local or special laws.

The administration of justice is entrusted to a supreme court, 18 district courts and at least two justices' courts in each organized township, besides police and municipal courts. The supreme court is composed of a chief justice and four associate justices elected for a term of six years. It holds four sessions a year at Helena and has limited original and plenary appellate jurisdiction. For most district courts there is only one judge, but for the more populous districts there are two judges; they are all elected for four years.

In addition to two U.S. senators. Montana has t o representatives in the house of representatives, elected from two separate districts. The state thus has 4 votes in the electoral college. Montana adopted the initiative and referendum in 1906 and extended the right to vote to women in 1914. Two years later Montana elected Jeannette Rankin to the U.S. house of representatives. the first woman to be elected to that body. Voters in Montana must be 21 years of age and citizens of the United States; they must have resided in the state for one year and in the county for 30 days preceding an election.

ECONOMIC AND SOCIAL CONDITIONS

Population. — The population of Montana in its first census in 1870 was 20,595; by 1890 it was 142,924. In 1940 it was 559,456 and an increase in the following two decades made the 1960 population 674,767. The population per square mile in 1960 was 4.6, as compared with 49.6 for the U.S. as a whole. In 1950 the population of Montana was 89.5% native white; 7.3% foreign-born white; and 3.2% nonwhite, including 16,606 Indians and 1,232 Negroes. Of the total number of employed males, 29.9% were engaged in agriculture, 25.7% in transportation and trade, 10% in manufacturing, 8.5% in construction and 5.4% in mining.

*Montana: Places of 5,000 or More Population (1960 Census)**

Place	Population				
	1960	1950	1940	1920	1900
Total state	674,767	591,024	559,456	548,889	243,329
Anaconda	12,054	11,254	11,004	11,668	9,453
Billings	52,851	31,834	23,261	15,100	3,221
Bozeman	13,361	11,325	8,665	6,183	3,419
Butte	27,877	33,251	37,081	41,611	30,470
Glasgow	6,398	3,821	3,799	2,059	—
Glendive	7,058	5,254	4,524	3,816	—
Great Falls	55,357	39,214	29,928	24,121	14,930
Havre	10,740	8,086	6,427	5,429	1,033
Helena	20,227	17,581	15,056	12,037	10,770
Kalispell	10,151	9,737	8,245	5,147	2,526
Lewistown	7,408	6,573	5,874	6,120	1,096
Livingston	8,229	7,683	6,642	6,311	2,778
Miles City	9,665	9,243	7,313	7,937	1,938
Missoula	27,090	22,485	18,449	12,668	4,366

*Populations are reported as constituted at date of each census.
Note: Dash indicates place did not exist during reported census, or data not available.

Finance. — The largest item in the state's bonded indebtedness in the years folloning World War II was the veterans bonus, which mas being rapidly retired by a two cents per package tax on cigarettes. Among the major tax sources, property taxes yielded the largest single sum. In 1955 the gasoline tax was raised to seven cents per gallon; 75% of this amount was allocated to highways. The state university system was permitted in 1948 to levy six mills on property valuations. As early as 1923 the Montana legislature passed a low but effective inheritance tax. The following year a controversy of long standing was settled when a metal mines tax nas passed graduated from 0.25% to 1% of the gross product. Since the repeal of national prohibition in 1933 a state monopoly on liquor sales has been another important source of revenue.

Education. — Under the state's consolidation program the number of school districts nas reduced from more than 1,500 at the end of World War II to fewer than 1,000 by 1960. Total annual expenditures amounted to about $64,000,000. The districts bore somewhat more than 75% of the total cost of the schools, the state bore about 20% and the federal government about 5%. The school lands totaled over 5,000.000 ac., income from which amounted to $4,387,548. The state also had a permanent school fund of over $30.000.000. The rapid increase in enrollments is indicated by comparing the 1945–46 enrollment of 67.565 elementary pupils and 25.362 high school pupils with the 1957–58 enrollment of 102,467 elementary pupils and 34,365 high school students.

The University of Montana, chartered in 1893, operates under the direction of a state board of education–ex officio regents, and consists of six institutions: Montana State university at Missoula; Montana State college at Bozeman; Montana School of Mines at Butte; Western Montana College of Education at Dillon; Eastern Montana College of Education at Billings; and Northern Montana college at Havre. Three private colleges consist of Carroll college of Helena. founded in 1909, and the College of Great Falls, established in 1932, both Roman Catholic. and Rocky Mountain college of Billings supported by three denominations — Congregational, Methodist and Presbyterian. It has continued since 1947 the work of the Protestant college movement which began as the College of Montana in 1883.

Agriculture and Livestock. — Over the years, agriculture has been Montana's main economic activity. It began in the western mountain valleys close to the markets in the mining camps. The colonization activities of the railroads led to enthusiasm for dryland farming in the 1890s. By the middle of the 20th century dry lands produced 92% of the state's wheat, 75% of its barley and 65% of its oats.

Irrigation began in the western valleys in the 1860s. With federal assistance the state had, nearly a century later, a total of 1,890 671 ac. of irrigated cropland, representing 17.6% of the state's total harvested cropland. Montana thus ranked fifth in the nation in irrigated lands

By the middle of the 20th century Montana's agricultural income exceeded $365,000.000 annually, of mhich crops represented 57% and livestock 43%. The total acreage of farm land rose from approximately 13,500,000 ac. in 1910 to 35,000.000 ac. after World War I and to more than 60,000,000 ac. at mid-20th century. During the same span of time the number of farms decreased from approximately 57,000 to about 33,000. Farm size meanwhile increased from approximately 600 ac. to more than 1,800 ac., reflecting large gains in livestock raising and farm mechanization. Of farm operators the great majority were full or part owners; only 14.5% were tenants.

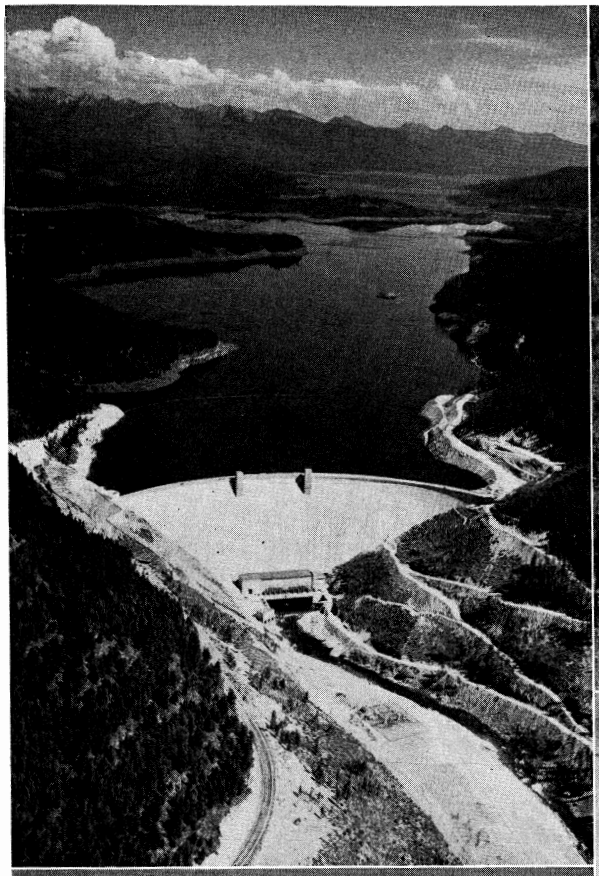
Wheat is Montana's most valuable agricultural crop, normally amounting to 87,000,000 bu. annually and making Montana the third largest wheat-producing state in the nation (following North Dakota and Kansas). Hay is the next most important crop. Barley showed striking increase from 4,582,000 bu. in 1939 to 41,370,-000 bu in the late 1950s to take third place in crop value. Sugar beets, corn, oats and potatoes, in this order, are also important.

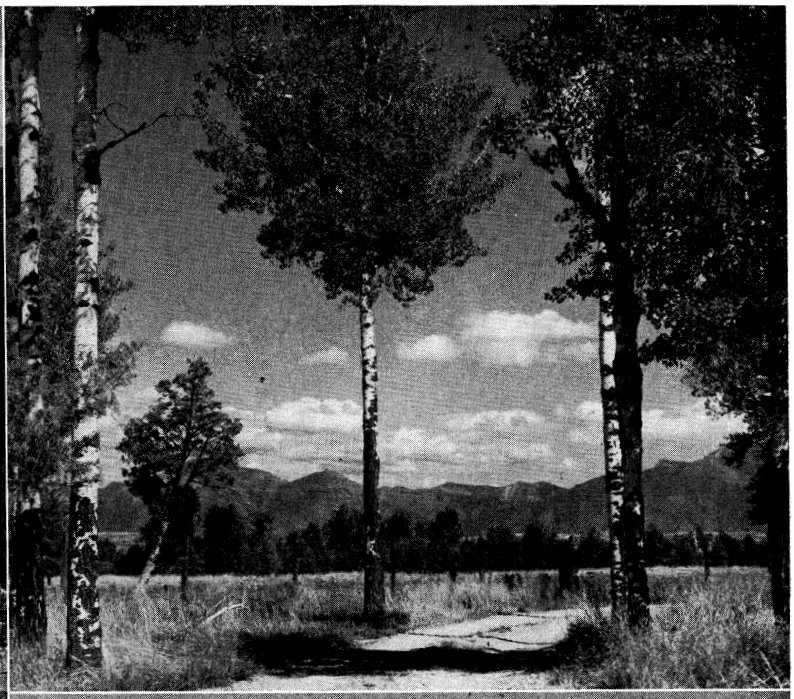
Beef is Montana's second most valuable agricultural product. Annual sales amount to more than 800,000,000 lbs. valued at over $100,000,000. Sheep and lamb production, wool, dairy products, poultry and swine are also important.

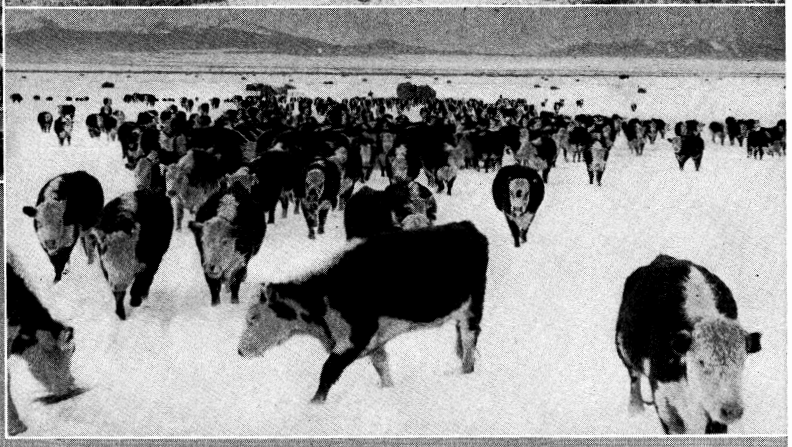
Mining. — Next in importance to agriculture and livestock is the mining industry. By the late 1950s mining, metal processing and petroleum refining employed 18,200 workers or 11% of all nonagricultural workers in Montana. The value of the state's mineral production exceeded $200,000,000 annually and included 78% of the nation's chromite concentrates, 37% of its manganese ore, 17% of its silver, 14% of its zinc, 8% of its copper and 5% of its lead.

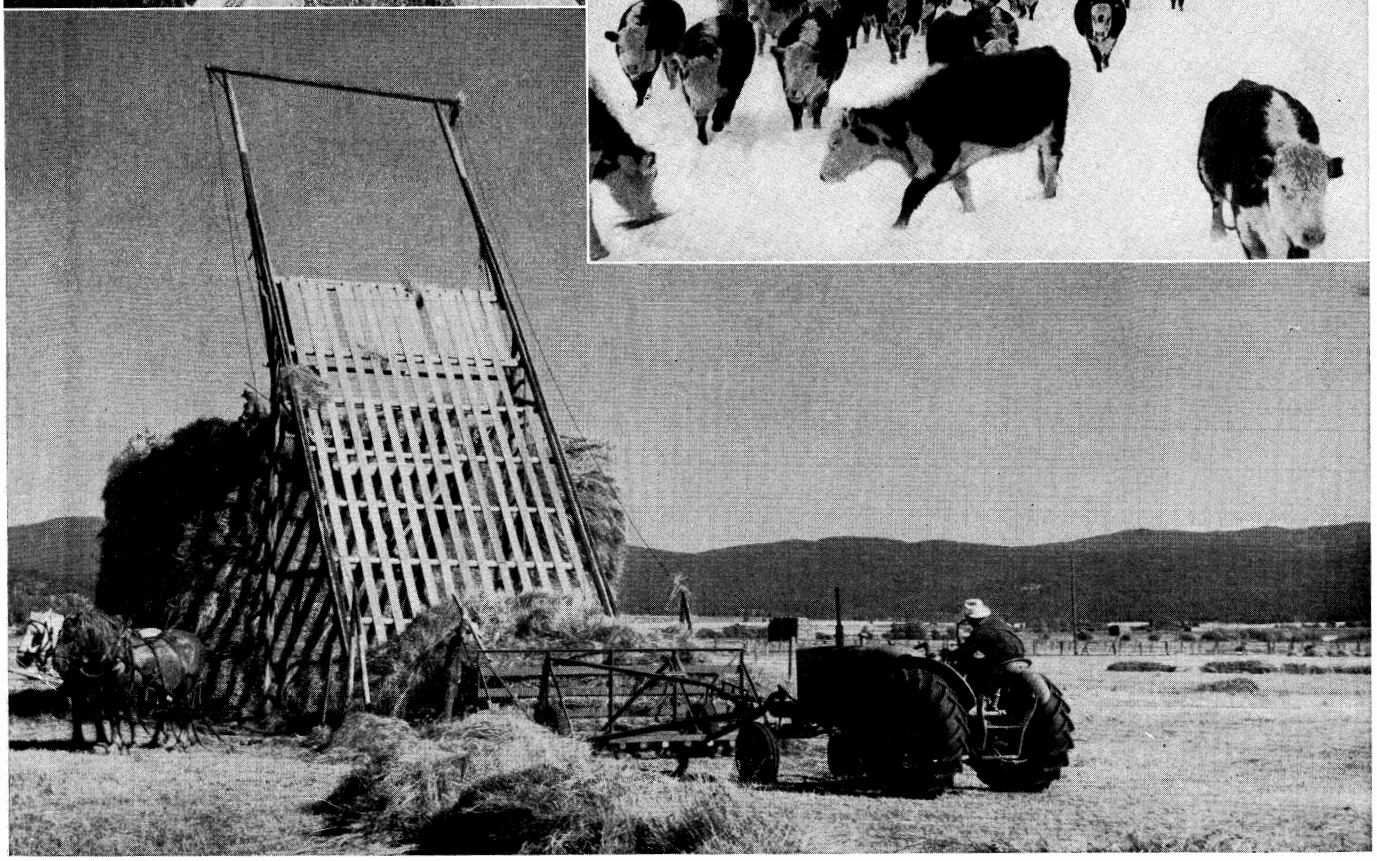
Copper is Montana's leading metal, representing about 40% of the value of the state's total metal production. Annual production exceeds 96,000 tons. From the early 1880s to mid-20th century, the small Butte district produced 18% of the nation's copper output.

Montana also ranks high in the production of silver, producing in the late 1950s approximately 6,500,000 fine ounces per year, valued at nearly $6,000,000. In 1916 an electrolytic process was









BY COURTESY OF (TOP LEFT, TOP RIGHT, BOTTOM) MONTANA HIGHWAY COMMISSION; PHOTOGRAPH, (CENTRE RIGHT) ERNST PETERSON

SCENES IN MONTANA

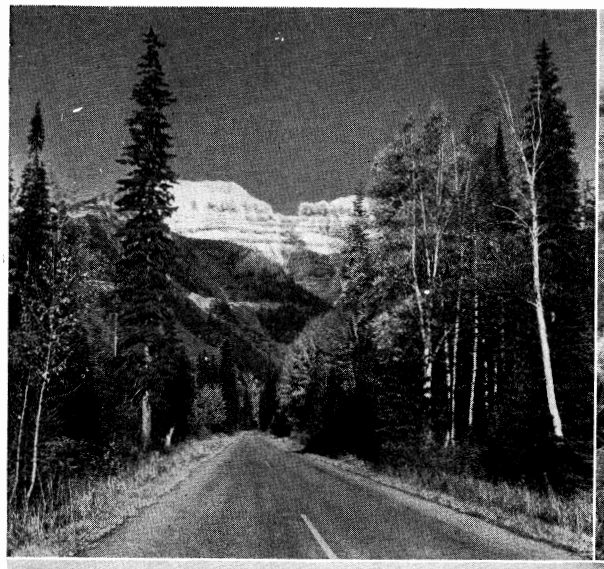
Top left: Hungry Horse dam, 564 ft. high, across the South fork of the Flathead river. A highway crosses the top of the dam

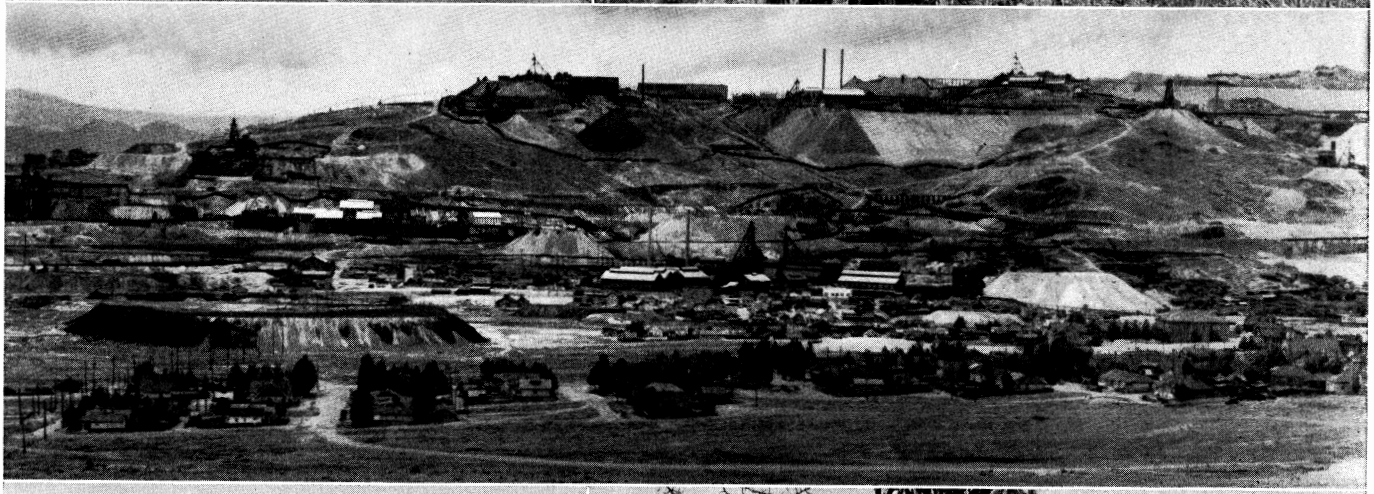
Top right: White birches lining a back country road with mountains in the background

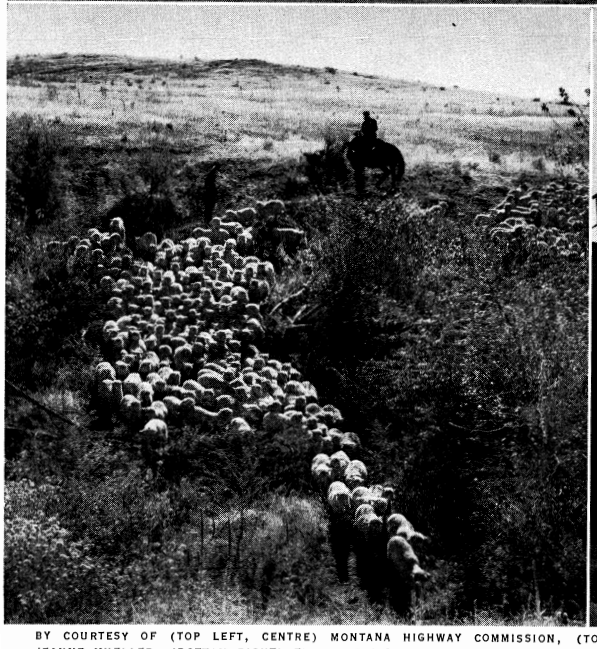
Centre right: Hereford cattle wintering at Big Hole valley in southwestern Montana

Bottom: Ranchers making hay in late summer for winter feed

MONTANA







BY COURTESY OF (TOP LEFT, CENTRE) MONTANA HIGHWAY COMMISSION, (TOP RIGHT) INTERNATIONAL HARVESTER CO. FROM "HARVESTER WORLD"; PHOTOGRAPHS, (BOTTOM LEFT) JEANNE MUELLER, (BOTTOM RIGHT) ERNST PETERSON

VIEWS OF MONTANA

Top left: The Garden Wall, a terraced rock formation towering above the lesser peaks at Logan pass on the continental divide near the Canadian border

Top right: Members of the Hutterite sect harvesting one of Montana's extensive wheat fields

Centre: Copper mines near Butte which account for about 50% of the state's total metal output

Bottom left: Herding sheep in the Bitterroot valley. Sheep raising is carried on extensively in the western part of the state

Bottom *right:* Virginia City, old territorial capital of the gold rush days, was restored to preserve most of the buildings in their original state

devised whereby zinc ores. formerly an impediment in refining copper, could be reduced profitably. As a result, by the 1950s zinc was second only to copper in value. The Anaconda company (formerly Anaconda Copper Mining company) operates plants at Anaconda and Great Falls, with a subsidiary lead and zinc plant at East Helena. This company also opened an aluminum plant in Columbia Falls in 1955.

Production of gold. once the most valuable of Montana's metals. amounted in the late 1950s to only about 33,000 fine ounces valued at about $1,000,000. Among other mineral resources is a body of high-grade manganese ore found just west of the Butte copper district. Large phosphate deposits are used for the manufacturing of fertilizers by the Anaconda company, and the Victor Chemical company plant near Butte manufactures elemental phosphorus.

Coal is found throughout the state. The resources are estimated by the U.S. geological survey to contain 389.114.000.000 tons or 11% of the nation's total reserves. Of the total deposits, 315,000,000.000 tons are lignite.

Natural gas was discovered near Glendive in 1913 and petroleum was discovered in commercial quantities at Elk basin in 1915. The leading oil fields for many years were Elk basin. Kevin-Sunburst and Cut Bank. In 1951 the Williston Basin fields were developed in eastern Montana. with natural gas as an important associated product. Other significant mineral products include chromite ore, vermiculite. cement, gypsum and sapphires.

Lumbering. — In 1949 the first field-based estimate of the timber stand in Montana placed its total at 55.960.000.000 bd.ft. of which more than 98% was softwood. Of this stand. 65% was in federal forests; 5% was in state forests; and 30% was in privately owned forests. Forest lands equal one-fourth of Montana's area for a total of 22,400,000 ac. Commercial forests total 15.800.000 ac. Annual production of lumber by mid-20th century was 800,000,000 bd.ft. valued at $69.000.000. The most important commercial trees are western yellow pine. Douglas fir, larch and western white pine. Pulpwood, fuelwood, poles, posts, mine timbers and Christmas trees are additional products of importance. Montana has 11 national forests—Beaverhead, Bitterroot, Custer, Deer Lodge. Flathead, Gallatin. Helena. Kaniksu, Kootenai, Lewis and Clark. and Lolo. Of Montana's eight state forests the largest is Stillwater state forest near the town of Stillwater.

Manufactures.—By the second half of the 20th century, the state had more than 800 manufacturing establishments. Value added to the product by manufacturing exceeded $140,000,000, representing a substantial gain over earlier years. The total number of employees in manufacturing exceeded 21,000 with a total annual wage of $76,000,000. Lumber and timber products, primary metals and food products were the three highest areas of manufacturing employment. Increases in electrical power from huge hydroelectric projects assisted the growth of manufactures. Power production in 1957 amounted to 943,752 kilowatts in 22 private plants and four large government plants—Canyon Ferry, Fort Peck, Hungry Horse and Marias river-Shelby.

Transportation.—Montana is served by three transcontinental railways: the Great Northern traversing the northern portion of the state; the Chicago, Milwaukee, St. Paul and Pacific in central Montana; and the Northern Pacific traversing the southern portion. At Butte. the Oregon Short Line from Utah connects with all three, and at Billings the Burlington makes a connection from Wyoming. Six major highways cross the state. By mid-20th century the state had a total of almost 25,000 mi. of surfaced roads. Its annual highway expenditures amounted to about $25,000,000. Three major airlines serve Montana. The Montana aeronautics commission, established in 1946, coordinates the state's 95 airports and sets standards for pilots.

Tourist 'Grade. — The tourist trade ranks close behind agriculture and mining as a source of revenue. Montana's game and natural wonders attracted visitors of international note as early as 1850. In 1890 the tourist trade produced $250.000 revenue.. Dude ranches attracted visitors as early as 1920. By 1935 an income of over $25,000,000 was obtained from 1,295,000 tourists. By 1960 the number of tourists exceeded 3,500,000, with proportional increase in expenditures. The state's chief attractions include Glacier National park and Yellowstone National park.

See also Index references under "Rlontana" in the Index volume.

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(T. J. W.; E. E. B.; M. G. Bu.)

MONTANELLI, GIUSEPPE (1813–1862), Italian statesman and author, was born at Fucecchio in Tuscany, and in 1840 was appointed law professor at Pisa. In 1847 he founded a newspaper called *L'Italia,* the program of which was "Reform and Nationality." In 1848 he formed a ministry at Leopold's invitation, and on Jan. 10, 1849, induced the grand duke to establish a national constituent assembly. But Leopold, alarmed. fled from Florence, and Montanelli, Guerrazzi and Mazzini were elected "triumvirs" of Tuscany. Like Mazzini, Montanelli advocated the union of Tuscany with Rome. But after the restoration of the grand duke. Montanelli, who was in Paris, was tried and condemned by default; he remained some years in France, where he became a partisan of Napoleon III. On the formation of the kingdom of Italy he returned to Tuscany and was elected member of parliament; he died in 1862. His most important literary work is his *Memorie sull' Italia e specialmente sulla Toscana dal 1814 al 1850,* in 2 vols. (Turin, 1853).

MONTAÑÉS, JUAN MARTÍNEZ (1568–1649), who has been called the greatest Spanish sculptor, was born at Alcalá la Real. in Jaén province on March 16, 1568. He studied at Granada (*c.* 1579–82) under Pablo de Rojas and about 1587 went to Seville. There he was admitted as a master in 1588 and stayed until his death on June 18.1649. Like his contemporary. Gregorio Hernandez at Valladolid, Montañés accomplished the transition from mannerism to an increasingly realistic baroque. He achieved admirable aristocratic dignity, idealized to some degree, and the spiritual life expressed by his statues was understood by persons in all walks of life. Called "god of wood carving," he specialized in wooden altars and altar figures, covered with polished gold and colour. They can be seen in Seville at the museum and several churches, and at Lima: Peru. His statues of Christ on the cross. looking at the beholder, of the child Christ and of the Immaculate Conception (all at Seville cathedral) set a style. The church in Santiponce near Seville contains his finest altar (1610–13), while his largest one is at San Miguel in Jerez (1617–45). As sculptor of images and as an architect of altarpieces, his influence was paramount not only on the sculptors and altar makers of Spain and Latin America! but also on the Spanish painters of his century.

See J. H. Diaz, *Juan Martínez Montañés* (1949); George Kubler and Martin Soria, *The Art and Architecture of Spain and Portugal aad Their American Dominions 1500–1800* (1959).

(M. S. S.)

MONTANISM, also known as the Cataphrygian heresy and the "New Prophecy" was a movement founded by the prophet Montanus which arose in the Christian church in Asia Minor in the and century. Primitive Montanism grew up especially in central Fhrygia: western Montanism flourished principally in Carthage

under the leadership of Tertullian.

The Montanist writings have perished except for the brief oracles or sayings preserved by ecclesiastical writers. The chief sources are the *Ecclesiastical History* of Eusebius, who cites or records the views of the martyrs of Lyons, the bishops of Asia and the anti-hlontanist writers of the late 2nd century; the writings of Tertullian and Epiphanius; and inscriptions, particularly those of central Phrygia. There. in the latter half of the 2nd century, hlontanus, a recent convert. appeared at Ardabau, a little village on the border of Mysia. According to one tradition, which may be a later invention, he had been a priest of Cybele. At all events his movement was to spread far and wide in Phrygia, the home of the ecstatic cult of Cybele. In the year when Gratus was proconsul of Asia, Montanus fell into a trance and began to "prophesy under the influence of the Spirit." Which year Gratus was proconsul is not known; Eusebius gives the year 172 while Epiphanius in one place assigns 156 for the rise of the new prophecy. and the matter has been disputed. The earlier date fits better with the known development of the movement and is generally regarded as the more probable.

Montanus was soon joined by two women, Prisca or Priscilla and Maximilla, who likewise began to "prophesy in the power of the Paraclete." The movement spread throughout Asia Minor and reached as far as Thrace, but it was in Phrygia that the new prophecy found its chief strength. Inscriptions from Asia hlinor have shown that many ton-ns went over almost completely to Montanism but that after the first enthusiasm had waned the followers of Montanus were found mainly in the rural districts, where the movement lasted for several centuries.

The essential principle of hlontanism was that the Paraclete. the spirit of truth, whom Jesus had promised in the Gospel of St. John. was manifesting himself to the world through Montanus and the prophets and prophetesses associated with him. This did not seem at first to deny the doctrines of the church or to attack the authority of the bishops. Prophecy from the earliest days had been held in honour and the church acknowledged the charismatic gift of such prophets as Quadratus and Ammia of Philadelphia. But it soon became clear that this prophecy mas really new. True prophets did not, as Ltontanus did, deliberately induce a kind of ecstatic madness and a state of passivity and then maintain that the words they spoke were the voice of the Spirit. In one of his oracles hlontanus thus described the divine activity: "Behold man is as a lyre and I hover over him as a plectrum. Man sleeps and I wake; behold it is the Lord who takes away the hearts of men and gives them other hearts."

'This novelty in the form of the prophecy. as well as the moral life of the prophets. provoked the earliest attacks of the Christian bishops and apologists. It also became clear that the claim of Wlontanus to have the final revelation of the Holy Spirit implied that something could be added to the teaching of Christ and the Apostles and that now the church had to accept a fuller revelation.

Another prominent element in the new prophecy was the expectation of the second coming of Christ. which was believed to be imminent. Such a notion was not confined to hlontanists, but with them it took a special form, giving their activities the character of a popular revival. They believed the heavenly Jerusalem was shortly to descend on the earth in a plain between the two villages of Pepuza and Tymion in Phrygia. The prophets and many enthusiastic followers went there; many Christian communities were almost abandoned.

The leaders thought of the movement as the last period of revelation. which would be followed by the descent of the new Jerusalem. As Maximilla said: "After me there shall be no other prophetess, but the end." To this exaltation was joined a legalistic moral rigorism. Certain fasts were prescribed and the time of fasting lengthened; it was forbidden to flee from martyrdom,. second marriages were prohibited and marriage itself was at least discouraged.

It was now obvious that the Montanist doctrine was in fact an attack on the Catholic faith; even though some Christian teachers seem to have advocated treating it leniently. the bishops of Asia Minor gathered in synods and finally excommunicated the followers of Montanus, probably about the year 177, under the leadership of Apollinaris, bishop of Hierapolis in Phrygia.

Montanism now became a sect with its seat of government at Pepuza. It maintained the ordinary Christian ministry but imposed on it higher orders of patriarchs and associates who were probably the successors of the prophets. In Phrygia it seems to have had many adherents down to the end of the 4th century and enough vitality to call for refutations by Origen and Clement of Alexandria. Its destruction as a sect was tragic. for, when they were proscribed by a decree of Justinian. the Phrygian Montanists shut themselves in their churches and burned them down.

The earliest record of any knowledge of Montanism in the west is from A.D. 177, when the martyrs of Lyons wrote to Pope Eleutherius and to the brethren in Asia and Phrygia expressing their opinion of the movement. It is not known what these opinions were. Probably they joined Asian and Phrygian Christians in asking Eleutherius to condemn Montanism. Twenty-five years later there was a group of Montanists at Rome; their leader, Proclus, engaged in a dispute with the Roman presbyter Gaius. It was at Carthage in Africa, however, that the sect gained a real foothold. There it won its most illustrious convert in Tertullian (*q.v.*), who began his progress toward Montanism *c.* 206 and finally broke with the church in 212–213.

In the writings of Tertullian the direction of the movement was changed. Though he accepted the new prophecy and the claims of individual inspiration by the Paraclete, he inconsistently maintained that the Apostles had received the fullness of the Spirit and that the bishops were the successors of the Apostles. On him the ecstatic element characteristic of the eastern prophecy had little influence, and. though he expected the immediate coming of the new Jerusalem, he never said that it would descend on Pepuza.

Tertullian's genius was mainly directed to supporting the moral rigorism of the movement against what he considered the laxity of the Catholic bishops. He condemned all Christians who associated with pagans in military affairs, schools, business or public administration; he forbade flight from persecution, second marriage and the forgiveness of sins such as adultery, and fornication; the soldier could not accept rewards from the emperor, the virgin must wear a veil of a certain length, the recently established fasts were to be observed. It was not his rigorism, however, which excluded Tertullian from the Christian communion. He waged a vigorous battle in defense of tradition and the Catholic rule of faith and then broke with the church because he accepted the new prophecy and its claim to private inspiration. Later Montanists were sometimes called Tertullianists in the west, but they were not especially influential there.

The history of Montanism is thus relatively clear. Not so clear is the nature of its effect on the Catholic Christianity of the late 2nd century. Some liberal Protestant scholars have argued that as the church was becoming more at home in the world and was developing a philosophical theology, a more elaborate penitential and sacramental system and a more tightly knit ministry, the Llontanists arose and protested in the name of primitive enthusiasm. The Catholic Church was then created. There is little evidence, however, to support the notions either that Christianity underwent a revolution in the course of the 2nd century or that the Montanists were trying to recover a primitive ideal. From the documents it is clear that the influence of the bishops, and especially that of the bishop of Rome, was strengthened in the course of the church's struggle with charismatic anarchy; it is by no means clear that this influence then came into existence.

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MONTAUBAN, a town of southwestern France, capital of Tarn-et-Garonne, is 31 mi. N. of Toulouse by rail. Pop. (1954) 38,321. The town stands on the right bank of the Tarn at its confluence with the Tescou. A remarkable early 14th-century bridge of brick connects the town with the suburb of Villebourbon. The former *hôtel de ville,* 17th century with some older portions, on the site of a castle of the counts of Toulouse and once the residence of the bishops of Montauban, stands at the east end of the bridge. It contains a valuable library, and a museum including most of the work of the painter J. A. D. Ingres, who was horn there. A square. the Place Nationale (17th century), is entered at each corner by gateways giving access to an open space surrounded by houses carried on double rows of arcades. The cathedral possesses the "Vow of Louis XIII," one of the masterpieces of Ingres. and the church of St. Jacques (13th to 15th centuries) has a handsome octagonal tower. Montauban is the seat of a bishop. a prefect and a court of assize. The commercial importance of Montauban is a result of its trade in agricultural produce. especially early vegetables, and poultry. Industries include nursery gardening, food processing, hatmaking and the manufacture of textiles and furniture. The town lies at the intersection of the Paris-Toulouse and Bordeaux-Sète railway lines. and is connected with the Garonne river by the Canal of Montech.

With the exception of Mont-de-Marsan, Montauban is the oldest of the fortified towns, or bastides, of southern France. Its foundation dates from 1143 when Alphonse Jourdain, count of Toulouse, granted it a liberal charter. The inhabitants were drawn chiefly from Montauriol, a village which had grown up around the neighbouring monastery of St. Théodard. In the 13th century the town suffered much from the ravages of the Inquisition, but by 1317 it had recovered sufficiently to be chosen by John XXII as the head of a diocese of which the basilica of St. Théodard became the cathedral. By the treaty of Brétigny (1360) it was ceded to the English; but in 1369 they were expelled by the inhabitants. In 1560 the bishops and magistrates embraced Protestantism, expelled the monks, and demolished the cathedral. About ten years later it became one of the Huguenot strongholds, and formed a small independent republic. It was the headquarters of the Huguenot rebellion of 1621, and was vainly besieged by Louis XIII for 86 days; nor did it submit until after the fall of La Rochelle in 1629. when its fortifications were destroyed by Richelieu. In the same year the plague killed more than 6,000 of its inhabitants. The Protestants again suffered persecution after the repeal of the Edict of Nantes.

MONTAUSIER, CHARLES DE SAINTE-MAURE, DUC DE (1610–1690), French soldier, was born on Oct. 6, 1610, being the second son of Léon de Sainte-Maure, baron de Montausier. His parents were Huguenots, and he was educated at the Protestant college of Sedan under Pierre du Moulin. He served brilliantly at the siege of Casale in 1630. Having served under Bernard of Saxe-Weimar in Germany in 1634 he returned to the French service in 1636, and fought. in the Rhenish campaigns of the following years. He was taken prisoner at Rantzau in Nov. 1643. and only ransomed after ten months' captivity. On his return to France he became a lieutenant general. Montausier is famous for his courtship of Julie Lucine d'Angennes, daughter of Madame de Rambouillet, famous in the annals of French literature because of the *Guirlande de Julie,* a garland of verse consisting of madrigals by Montausier, Jean Chapelain. Guillaume Colletet, Claude de Malleville, Georges de Scudéry, Pierre Corneille (if M. Uzanne is correct in the attribution of the poems signed M.C.), Philippe Hubert, Simon Arnauld de Pomponne,[1] Jean Desmarests de Saint Sorlin, Antoine Gombaud *(le nain de la Princesse Julie)* and others. It was copied by the famous calligraphist N. Jarry in a magnificent manuscript, on each page of which was painted a flower, and was presented to Julie on her fete day in 1641.

Montausier had bought the governorship of Saintonge and Angoumois, and became a Roman Catholic before his marriage. The Parisian public regarded him as the original of Alceste in the *Misanthrope.* Montausier received from Louis XIV the order of the Saint Esprit, the government of Normandy, a dukedom, and in 1668 the officeof governor of the dauphin, Louis. He initiated the series of classics *Ad usum Delphini,* directed by the learned Huet. for the use of his pupil. He died on Nov. 17, 1690.

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MONTBÉLIARD, a town of eastern France, capital of an *arrondissement* in the *département* of Doubs, 49 mi. S.E. of Besançon on the P.L.M. line between that town and Belfort. Pop. (1954) 15,783. Montbéliard stands at the confluence of the Luzine and the Xllaine. Forts on outlying hills connect it with Belfort on the one side and (through Blamont and the Lomont fortifications) with Besançon on the other. The castle of the counts of Montbéliard was rebuilt in 1751, but the Tour Bossue and the Tour Neuve, dating from 1425 and 1594, are preserved. Most of the inhabitants are Protestant, and the church of St. Martin, built early in the 17th century, now serves as a Protestant place of worship. The old market hall and some old houses of the 16th century also remain. Montbéliard is the seat of a subprefect and has a board of trade arbitrators. a chamber of arts and manufactures and a museum of natural history.

After 1870 a considerable impetus was given to its prosperity by Alsatian immigrants. Its industries include watch- and clockmaking and dependent trades, cotton spinning and weaving, the manufacture of hosiery, textile machinery, furniture, spare parts for motor cars, tools, nails and wire and brewing. There is commerce in wine, cheese, wood and MontbCliard cattle.

After belonging to the Burgundians and Franks, MontbCliard (*Mons Peligardi*) was, by the treaty of Verdun (843), added to Lorraine. In the 11th century it became the capital of a countship, which formed part of the second kingdom of Burgundy and latterly of the German empire. Its German name is Mömpelgard. In 1397 it passed by marriage to the house of Wiirttemberg, to whom it belonged till 1793. It resisted the attacks of Charles the Bold (1473), and Henry I of Lorraine (1587 and 1588), duke of Guise, but was taken in 1676 by Marshal Luxemburg, who razed its fortifications. The tolerance of the princes of Württemberg attracted to the town at the end of the 16th century a colony of Anabaptists from Frisia. In 1793 the inhabitants voluntarily submitted to annexation by France. In 1871 the battle of the Lisaine between the French and Germans was fought in the neighbourhood and partly within the walls.

MONT BLANC (Ital. MONTE BIANCO), mountain massif and peak in the western Alps, southwest of the Rhône at Martigny. Though shared by France, Italy and Switzerland, over half the massif, including the summit, is French territory; it is there that Europe reaches its highest point, 15,771 it. above sea level. It is this mountain that first attracted the attention of scientists, and its first ascent; on Aug. 8, 1786, was one of the most important events in the history of mountaineering (*q.v.*).

Structure and Relief. — The Mont Blanc massif is a remnant of the southern Hercynian mountains. In origin a batholith intruded during the Permian period, the crystalline massif was peneplained in the same period. Later covered by the sea, it was uplifted and broken into wedge-shaped slices. These are separated by mylonites, zones of crushed rocks. Both the varying resistance of the different rocks and the altitude are responsible for the present relief. The post-Permian rocks form the floor of the Chamonix valley, dark-coloured schists form the flanks of the massif and probably also the summit under its ice capping. All the major rocky peaks consist of granite, whereas the mylonites have been eroded to form cols and depressions occupied by the glaciers.

Mont Blanc is literally overflowing with ice which covers more than 38.6 sq.mi. From the central ice dome, ice streams stretch

[1](1618-1699), a son of hrnauld d'Andelly and minister of foreign affairs in succession to Lionne.

down to altitudes below 4,900 ft. The largest, the Mer de Glace (*q.v.*), 9 mi. in length and the second longest in the Alps, ended in 1930 at 4,100 it. This and others (des Bossons, d'Argentière) present the strange spectacle of ice within the zone of cultivation. The size of the glaciers has varied greatly. At the beginning of the 17th century they advanced to the bottom of the Chamonix valley. destroying or burying cultivated land and dwellings. After a retreat lasting until the second half of the 18th century came a new advance of the giaciers, reaching its climax about 1820. In 183j began another retreat. which, interrupted by minor advances in 1878–90 and 1908–20, later became particularly pronounced.

Mountaineering and **Tourism.**—When the first travelers came to Chamonix (*q.v.*) from the late 17th century onward. it was not to attempt an ascent but to behold the glaciers and delight in the sublime emotions they aroused. Among the first of the early visitors to relate their experiences in a published report were R. Pococke and W. Windham who had come in 1741. It was the scientists who drew attention to the fact that Mont Blanc is the highest mountain in Europe—P. Martel in 1742, J. A. Deluc in 1770 and later H. B. de Saussure—and this stirred people to climb. The summit was conquered in 1786 by Michel Gabriel Paccard. a doctor in Chamonix. together with Jacques Balmat as his porter. Paccard's achievement was overshadowed by De Saussure's ascent the year after. Worse still. through M. T. Bouritt, who out of jealousy published a biased account of the first ascent, the myth was started that all credit for the climb was due to Balmat. In addition to the mountaineers the number of visitors to Chamonix increased steadily, but until about 1870 when a proper road was opened it remained a very exclusive resort. Among the British. generally the largest group, there were in 1788 Prince Edward and Pitt the Younger, and later Byron, Ruskin, Shelley (whom Mont Blanc inspired to write a poem) and Wordsworth. Famous visitors of other nationalities were: Goethe (1779), J. P. C. Florian. T. Fontane. L. V. Delille. A. Chénier, L. de Chênedollé, Mme. de Staël, Carl Ritter. Chateaubriand. Victor Hugo, Lamartine. Alexandre Dumas. George Sand. J. Michelet, T. Gautier; in 1810 Empress Josephine was hoisted to Montenvers by 68 guides and porters. The Mont Blanc region now forms the largest tourist centre of the Alps and not surprisingly the traditional pastoral economy of the region has become completely overshadowed.

Work on the road tunnel was first suggested by the French engineer G. de Lépiney in 18jo and started in Oct. 1958. The tunnel runs for 7 mi. irom Barats. 4 mi. from Chamonix, to the Italian village of Entrèves. The road width is 23 it. with additional sidewalks, and lay-bys (sidings) every 330 yd.

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MONTCALM, LOUIS JOSEPH DE MONTCALM-GOZON, MARQUIS DE (1712–1759), French general chiefly noted for his service in Canada during the Seven Years War. He was born at Candiac near Nîmes, Feb. 28, 1712. His family dated back to the 12th century and many of his ancestors served in the king's armies with distinction. In the 16th century sorne members of the family were converted to Calvinism and were active on the Huguenot side in the religious wars. Montcalm's mother, however, was a devout Catholic and caused his father to adopt her faith. Commissioned an ensign in the Hainaut regiment at the age of 12, he became an active soldier at 15. His first war experience was in 1733 against the Austrians in the War of the Polish Succession.

In 1735 he succeeded to his father's titles and property and the following year married Angélique Louise Talon du Boulay. They had 10 children. He was wounded in 1742 at the defense of Prague during the War of the Austrian Succession and became colonel of the regiment of Auxerrois the following year. In 1746 he distinguished himself at the battle of Piacenza where his regiment was decimated-and he was taken prisoner after receiving five sabre wounds. He was later exchanged. promoted to brigadier and at the end of the war was in command of a cavalry regiment. The following few years he spent with his family at Candiac; then, in Jan. 1756, he was appointed to command the French regular troops in North America with the rank of major general. On May 13 he arrived at Quebec.

Montcalm's commission gave him no authority over the colonial regular troops or the militia, only over the regular troops sent from France. and he was subject to the superior authority of the governor-general of the colony, the Canadian-born Marquis de Vaudreuil. The temperaments of the two commanders n-ere incompatible and their relations rapidly deteriorated. The planning of military strategy eventually was handicapped by their jealousy. suspicion and mutual recriminations. For the first three years, however, Montcalm was successful against the British forces. In the summer of 1756 Oswego was captured, restoring control of Lake Ontario to the French. This campaign was planned by Vaudreuil and effected largely by the Canadian forces, but Montcalm was in tactical command. The next year he captured Ft. William Henry, at the head of Lake George. with its 2.000-man garrison. This victory was marred by the slaughter of many of the prisoners by the Indian allies of the French. Although Montcalm deplored this event and risked his life to curb it. he had failed to take the precautions that would have prevented it.

Montcalm's greatest victory occurred in July 1758, when. with about 3.800 men, he held Ticonderoga against 15.000 British troops under Gen. James Abercrombie, inflicting nearly 2.000 casualties on the British and suffering only 372 in his own ranks. This success was due more to Abercrombie's stupidity than to Montcalm's tactical skill and Vaudreuil was very critical of Montcalm for not exploiting the victory. This merely served to worsen relations between the two men until they n-ere almost as much concerned with their personal feud as with fighting the enemy. Unfortunately, Montcalm was never able to rise above this squabbling. In consequence of his victory at Ticonderoga, however, he was promoted to the rank of lieutenant general and Vaudreuil was ordered by the king to defer to Montcalm in a11 military matters.

In 1759 the British sent an army. numbering only about 8.500 men hut of excellent quality, under the command of Maj. Gen. James Wolfe (*q.v.*) and convoyed by a large fleet under Vice Adm. Charles Saunders, against Quebec. Montcalm had about 15,000 men. of varying quality, with which to defend the citadel. Taking full advantage of his entrenched position, he wisely refused to be drawn into open battle. For more than two months Wolfe was baffled. but finally effected a landing close above Quebec and by dint of taking grave risks got his army onto the Plains of Abraham. Montcalm was forced to give battle. He did so precipitately. was mortally wounded and his army defeated. He died the next day, Sept. 14, and was buried in the Ursuline chapel.

Montcalm was a gallant, brave and attractive figure. A devoted husband and father, he possessed great charm and was popular with his immediate subordinates; but his impetuous temper and nervous impatience tended to undermine his judgment. Although an accomplished soldier. he was not a really great general. He capitalized successfully on his enemies' mistakes for a time, in the face of grave odds, but committed some serious tactical errors, and the last such proved fatal to himself and to New France.

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MONTCEAU-LES-MINES, a town.of east-central France, in the *département* of Saône-et-Loire, is about 22 km. (14 mi.) S.S.W. of Le Creusot on the Besançon-Clermont line of the national railways. Pop. (193'4) 9,650. Area 5.2 sq.mi. It is the centre of the Blanzy coal basin, in the valley of the Bourbince, paralleled by the Canal du Centre, linking the Saône and Loire rivers.

The principal industry is coal mining. There are iron and

copper foundries. and factories for shoes and stockings (7,000,000 nylon pairs a year), textile machinery, electrical appliances. sanitary equipment and plastic and rubber goods. (R. PI.)

MONT CENIS, a mountain (10.892 ft.) and pass (6,860 ft.) in Savoie *département*, France, which forms the limit between the Cottian and Graian Alps. A carriage road (1803–10) was built across it by Napoleon, while a light railway was opened alongside the road in 1868. but was destroyed in 1871. The tunnel (called Tunnel de Fréjus, highest point 4,245 ft.) is really 17 mi, west of the pass, below the Col de Fréjus. From Chambéry the line runs up the Isère valley, but soon bears through that of the Arc or the Maurienne past St. Jean de Maurienne to hfodane (61 mi. from Chambéry). The tunnel (8 mi. long) leads to Bardonnèche, below which, at Oulx (18 mi. from Modane) the line joins the road from the Mont Genèvre. Thence the valley of the Dora Riparia is followed to Turin (64½ mi. from Modane). The motor road mounts the Arc valley for 16 mi. from Modane to Lanslebourg, whence it is 8 mi. to the hospice. The descent lies through the Cenis valley to Susa (37 mi. from Modane) where the road joins the railway. To the southwest of the Mont Cenis is the Little Mont Cenis (7.159 ft.) which leads from the summit plateau (in Italy) of the main pass to the Étache valley (in France) and so to Bramans in the Arc valley (7 mi. above Modane). This pass was crossed in 1869 by the Vaudois, and is believed by some to have been Hannibal's pass.

MONTCHRETIEN, ANTOINE DE (1575 or 1576–1621), French dramatist and economist, son of an apothecary at Falaise named hlauchrestien, was born about 1576. In one of his numerous duels he killed his opponent, and took refuge in England. Through the influence of James I, to whom he dedicated his tragedy, *L'Ecossaise,* he was allowed to return to France. and established himself at Auxonne-sur-Loire, where he set up a steel foundry. In 1621 he joined the Huguenot side in the civil wars. He raised troops in Maine and Lower Normandy, but was killed in a skirmish near Tourailles on Oct. 8, 1621. In 1615 he published a valuable *Traité de l'économie politique,* based chiefly on the works of Jean Bodin. His dramas are *Sophonisbe* (1596), rewritten as *La Cartaginoise; L'Ecossaise, Les Lacènes, David, Aman* (in 1601); *Hector* (1601).

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See K. Willner, *Montchrestiens tragodien und die Stoische Lebensweisheit* (1932).

MONTCLAIR, a town of Essex county, N.J., U.S., is located on the east slope of Watchung mountain, whose heights command a fine view of New York city and its harbour. Founded in 1666 as part of Newark, Montclair was detached in 1812 as a part of Bloomfield and was incorporated as a township in 1868 when West Bloomfield, Speertown and Cranetown merged. It is 6 mi. N.W. of Newark and 12 mi. W. of New York, and since 1900 has been a developing suburban community of outstanding homes, schools, private schools, churches and hospitals. It is also noted for its excellent library and art museum. The city is the home of Montclair State college, established in 1908, and was the residence of George Inness, late 19th-century landscape painter. Principal manufactures include metalware, paints. chemicals and printers' supplies. A feature of historic interest is the smallest park in the world, consisting of a boulder bearing a plaque commemorating George Washington's visit to the area during the American Revolution.

For comparative population figures *see* table in NEW JERSEY: *Population.* (D. N. A.; M. P. M.)

MONT-DE-MARSAN, a town of southwestern France and capital of the *département* of Landes, lies at the confluence of the Midou and the Douze, 92 mi. S. of Bordeaux. Pop. (1954) 13.103, Mont-de-Marsan, the first of the bastides *(see* BASTIDE) of the middle ages. was founded by Pierre, vicomte de Marsan, as the capital of his territory in 1141. In the 13th century it passed to the viscounts of Béarn and was later involved in civil and religious wars. After being taken by the Calvinists it was besieged by General de Montluc in 1569 and surrendered in 1580 to the Catholic Sire de Poyanne of Baylens. On the accession of Henri de Béarn (Henry IV) in 1585, it was united to the crown of France. Most of the buildings are in the older quarter, on the peninsula between the two rivers forming the Midouze. A 14th-century keep, later used for military purposes, was built by Gaston Fébus. There are also remains of ramparts, fortifications and a postern dating from the 12th century.

The town is the seat of a prefect, court of assizes and of a tribunal of first instance. It is a supply centre for the north and east of the Landes and for the neighbouring district of Gers. There are several foundries and it has a small trade in timber, resinous products and other goods. An important food-preserving factory exports goose and duck *"foies gras des Landes"* to nearly all parts of the world. (J. CA.)

MONTDORY, (GUILLAUME DESGILBERTS) (1594–1651). French actor and manager, whose presentations of the works of Corneille were especially notable. was born on March 13, 1594. at Thiers in the Auvergne. He began his theatrical career in 1612 in a troupe led by Valleran le Conte, a company specializing in the tragicomedies of Alexandre Hardy. A member of the company of the Prince of Orange in 1622, Montdory gained a foothold in Paris in 1629 when he, with his associate Charles Le Noir, established a playhouse in one of the indoor tennis courts of the capital. Immediate success came with the performance of Pierre Corneille's first play *Mélite.* After opening the Marais theatre, another converted tennis court, in 1634. Montdory. who had produced all the earlier plays of Corneille, in 1636 staged *Le Cid* and played the part of Rodrigue in Corneille's masterpiece. In contrast with his predecessors Montdory never acted in farce. Among the principal tragic parts which he created mere Masinisse in Jean de Mairet's *La Sophonisbe*, Brutus in Georges de Scudéry's *La Mort de César*, and Jason in Corneille's *Médée.* As an actor he was a great conveyer of passions employing very little stylization. While playing Hérode in *Marianne* by Tristan l'Hermite. he suffered a stroke which paralyzed him. He died in Dec. 1651. (A. M. N.)

MONTE, PHILIPPE DE (1521–1603), an outstanding composer of the Netherlands school, was born in Malines in 1521. After an early period spent in Naples, he visited England in 1554–55 with the choir of Philip II of Spain, befriending the 13-year-old William Byrd. He then returned to Italy. In 1568 he became court musical director to the Habsburg emperors and held this position until his death in Prague, July 4, 1603. Though prolific, he was never perfunctory; a fluent but not experimental technician, he excelled in subtle contrasts of register and voice-grouping. His 38 masses and 319 motets stand comparison with Palestrina. He was also one of the last Netherlandish masters of the Italian madrigal, publishing more than 1,200 in 42 books.

See his *Opera Omnia* (1927–39); G. van Doorslaer, La *vie et les oeuzres de Philippe de Monte* (1921). (B. L. TR.)

MONTEAGLE, WILLIAM PARKER, 4TH BARON, and 11TH BARON MORLEY (1575–1622). was the eldest son of Edward Parker, 10th Baron Morley (d. 1618), and of Elizabeth, daughter and heiress of William Stanley, 3rd Baron Monteagle (d. 1581). He received knighthood when with Essex in Ireland in 1599, and in 1601 with Catesby and others: took part in the latter's rebellion in London, when he was punished by imprisonment and a fine of £8,000. In 1602 he supported the mission to Spain inviting Philip III to invade England. However, he acquiesced in James I's accession and assisted the earl of Southampton in securing the tower for the king. He mas taken into favour and received a summons to attend the parliament of Nov. 5, 1605, as Lord Monteagle. On Oct. 26, 1605, he received the celebrated letter giving warning of the gunpowder plot, probably written by Francis Tresham, Lady hlonteagle's brother. After having it read aloud by Ward, a gentleman in his service and an intimate friend of Winter, one of the chief conspirators, he took it to Whitehall and showed it to Lord Salisbury and other ministers. On Nov. 4, he accompanied Lord Suffolk, the lord chamberlain, to the vault under the parliament house, where Guy Fawkes was found. Monteagle received £700 a year for his services in averting the disaster. In 1609 he was chosen a member of the council of the Virginia Company and subscribed to its funds. The same year "disorders

in his house" are reported, probably referring to his harbouring of Roman Catholic students from St. Omer. In 1618, on the death of his father, he was summoned to parliament as Baron Morley and Monteagle. He died on July 1, 1622, at Great Hallingbury, Essex.

MONTEBELLO, a residential and industrial city of California, U.S., 9 mi. E. of Los Angeles (*q.v.*) on the slopes of the La Merced hills. Incorporated in 1916 with Monterey Park, and formerly known as Newmark, Montebello became a separate city in 1920. Oil was discovered in 1916 on property owned by Walter P. Temple, an early settler of the area. Until World War II, Montebello was a farming region, with walnut orchards, strawberry patches, citrus groves and stock trees and shrubs for commercial nurseries. After 1943 the city became an industrial centre for automobile assembly, rubber materials, television sets and warehousing. At the eastern boundary of the city is the Whittier Narrows dam, a flood control project which is also used as a recreational park. The city has a council-manager form of government, in effect since 1957.

For comparative population figures *see* table in CALIFORNIA: *Population.* (J. A. Sz.)

MONTE CARLO, one of the four towns in the principality of Monaco (*q.v.*), is situated on the Riviera (*q.v.*) 18 km. (11 mi.) E.N.E. of Nice, France. Pop. (1961) 9,516. It stands on an escarpment (Spélugues rocks) northeast of the port (La Condamine). One of Europe's most luxurious resorts: its social life centres around the Place du Casino with its picturesque gardens overlooked by the International Sporting club (1932) and the Théâtre de la Lumière. The casino, built in 1861 and later enlarged, is administered by a concessionaire (La Société Anonyme des Bains de Mer et du Cercle des Etrangers) whose annual grant to the principality constitutes about 5% of the state budget. Within the casino is the opera, built by Charles Garnier, and the Foyer de la Dance where most of Sergei Diaghilev's Russian ballets were first performed.

Among the festive and sporting events is the Monte Carlo car rally, so called because first organized there, and the Monaco Grand Prix motor race which takes place through the streets of Monte Carlo.

MONTE CASSINO, an isolated hill overhanging the town of Cassino (*see* CASSINO), region of Lazio, Italy. St. Benedict migrated there from Subiaco in A.D. 529, and established the monastery that became the metropolis of western monachism. It was sacked by the Lombards (580–590), rebuilt in 720, destroyed by the Saracens in 884 and restored 70 years later. It was most influential under Desiderius (who became Pope Victor III in 1087) and Oderisius (1059–1105). The abbot became overlord of an extensive territory and bishop of several dioceses. At the dissolution of monasteries in 1866 Monte Cassino became a national monument and the monks were recognized as custodians. During World War II the abbey was entirely demolished, though most of its treasures, however, were saved. The abbey was later completely rebuilt.

MONTECATINI TERME, a mineral spa of Tuscany, Italy, in Val di Nievole, province of Pistoia, is 11¼ km. (7 mi.) S.W. of the town of Pistoia and 105 ft. above sea level. Pop. (1951) 10,950.

Known since the 14th century for its health waters, Montecatini acquired importance when Leopold, grand duke of Tuscany, built the first thermae. Unified under government sponsorship, its hydrothermal wealth has made it Italy's foremost thermal station. There are 250 hotels and the saline waters, used by about 100,000 visitors annually, are also exported. Good communications include railway and bus services and Florence and Pisa airports.

MONTÉCLAIR, MICHEL PIGNOLET DE (1667–1737). French composer of operatic and instrumental works. Born at Andelot, Haute-Marne, where he was baptized on Dec. 4, 1667, he became a chorister at Langres and later entered noble service. Settling in Paris in 1700, he played the double bass at the Opéra from 1707 until 1737. His first *opkra-ballet, Les Fêtes de l'Été,* was produced in 1716 and his most famous work, the *tragédie-lyrique, Jephté,* in 1732. Banned because of its biblical subject by the archbishop of Paris, it has a grandeur associated with Lully and had great influence on Rameau. Montéclair's *Cantates Françaises et Italiennes* (1709–17) show the duality of style in his approach to composition, and his three theoretical and pedagogic treatises are valuable on ornamentation and contemporary practices in performance. He died at St. Denis, near Paris, Sept. 27, 1737. (B. P.)

MONTE CORVINO, GIOVANNI DI (1247–1328), Franciscan missionary, traveler and statesman, founder of the earliest Roman Catholic missions in India and China, and first Roman Catholic archbishop of Peking. In 1272 he mas commissioned by the emperor Michael Palaeologus to Pope Gregory X to negotiate for the reunion of Greek and Latin churches. Around 1280 he began his missionary work in Armenia and Persia. In 1289 he was sent as papal legate to the Great Khan, the Ilkhan of Persia, and other leading personages of the Mongol world, as well as to the "emperor of Ethiopia" or Abyssinian negus. Arriving at Tabriz, then the chief city of Mongol Persia, and indeed of all western Asia, Monte Corvino moved down to India to the Madras region, from nhich he wrote home, in Dec. 1292 or 1293, the earliest noteworthy western account of the Coromandel coast. In 1294 he appears in Khanbaliq (Peking). His letters of Jan. 8, 1305, and Feb. 13, 1306, describe the progress of the Roman mission in the far east, in spite of Nestorian opposition; alluding to the Roman Catholic community he had founded in India, and to an appeal he had received to preach in "Ethopia" and dealing with overland and oversea routes to "Cathay," from the Black sea and the Persian gulf respectively. In 1303 he received his first colleague, the Franciscan Arnold of Cologne; in 1307 Pope Clement V created him archbishop of Peking and patriarch of the entire orient, and dispatched seven bishops to consecrate and assist him; only three of these survived the hardships of the two-year journey to China. Three more suffragans were sent out in 1312, of whom one at least reached east Asia. A Franciscan tradition maintains that in 1311 Monte Corvino baptized the Great Khan (*i.e.*, Khaishan Kuluk, third of the Yuen dynasty; 1307–11) and his mother. This has been disputed, but he unquestionably won remarkable successes in north and east China. Besides three mission stations in Khanbaliq, he established one near the present Amoy harbour, opposite Formosa.

At Monte Corvino's death in 1328 heathen vied with Christian in honouring him. He was apparently the only effective European bishop in the Peking of the middle ages.

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MONTECRISTI, a province in the extreme northwestern part of the Dominican Republic. Pop. (1960) 59,240. Area 768 sq.mi. It occupies the western part of the fertile Cibao region and is drained by the Rio Yaque del Norte, which is used extensively for irrigation. The province, established in 1879, is the nation's leading rice producer and has significant tobacco and banana production.

The port of Pepillo Salcedo mas built in 1945 to export bananas from Libertador and Montecristi. The capital, San Fernando de Montecristi (pop. [1960] 5,912) was founded in 1506, destroyed in 1606 for trading illegally with pirates, and reconstructed in 1756. (D. R. D.)

MONTECRISTO (anc. OGLASA), an island of Italy, belonging to the province of Livorno, 25 mi. S. of Elba (highest point 2,116 ft. above sea level; area about 4 sq.mi.). It contains the ruins of a Camaldulensian monastery, abandoned in 1553. The island was the private property of the king of Italy. The fame of the island is attributed to *Le Comte de Monte-Cristo,* by the elder Dumas (*q.v.*).

MONTECUCCULI, RAIMONDO, COUNT OF (1609?–1680), prince of the Holy Roman Empire and Neapolitan duke of

Melfi, Austrian general, born Feb. 2, 1608 or 1609, at the castle of Montecucculo in Modena. At the age of sixteen Montecucculi began as a private soldier under his uncle, Count Ernest Montecucculi, a distinguished Austrian general (d. 1633), but seeing continuous service in Germany and the Low Countries, he rose by 1634 to a colonelcy. In 1639 he was taken prisoner at Melnik and detained for two and a half years in Stettin and Weimar. In captivity he studied military science, geometry, history and architecture and planned his great work on war. On his release he distinguished himself again in Silesia, and in Lombardy (1643). On his return to Germany he was promoted lieutenant-field-marshal and obtained a seat in the council of war. In 1645–46 he served in Hungary, on the Danube and Neckar, and in Silesia and Bohemia. The victory of Triebel in Silesia won him the rank of general of cavalry, and at Zusmarshausen in 1648 his rearguard fighting rescued the imperialists from annihilation. For some years after the peace of Westphalia Montecucculi was chiefly concerned with the business of the council of war, though he went to Flanders and England as the representative of the emperor, and to Sweden as the envoy of the pope, and at Modena his lance was victorious in a great tourney. In 1657, soon after his marriage with Countess Margarethe Dietrichstein, he saw further active service. He became field-marshal in the imperial army, and with the Great Elector of Brandenburg completely defeated Rakoczy and his allies (peace of Oliva, 1660). From 1661 to 1664 Montecucculi defended Austria against the Turks, whom he defeated so completely at St. Gotthard Abbey, on the Raab, that they made a truce for twenty years (Aug. 1, 1664). He was given the Golden Fleece, and became president of the council of war and director of artillery. He also devoted much time to the compilation of his various works on military history and science. When the war broke out against France, he received command of the imperial forces. In 1673 he completely out-manoeuvred his great rival Turenne on the Neckar and the Rhine. He retired from the army when, in 1674, the Great Elector was appointed to command in chief, but the brilliant successes of Turenne in the winter of 1674 and 1675 brought him back. After Turenne's death Montecucculi invaded Alsace, where he engaged in a war of manoeuvre with the great Condé. The siege of Philipsburg was Montecucculi's last achievement in war. The rest of his life was spent in military administration and literary and scientific work at Vienna. In 1679 the emperor made him a prince of the empire, and shortly afterwards he received the dukedom of Melfi from the king of Naples. Montecucculi died at Linz on Oct. 16, 1680, as the result of an accident. He shared with Turenne and Condé the first place amongst European soldiers of his time. His *Memorie della guerra* profoundly influenced the age which followed his own.

AUTHORITIES.—The *Memorie della guerra,* etc., was published at Venice in 1703 and at Cologne in the following year. A Latin edition appeared in 1718, a French version in 1712, and the German *Kriegsnachrichten des Fürsten Raymundi Montecuccoli* in 1736. Many memoirs on military history, tactics, fortification, etc., written in Italian, Latin and German, remain still unedited in the archives of Vienna. The collected *Opere di Raimondo Montecuccoli* were published at Milan (1807), Turin (1821) and Venice (1840), and include political essays and poetry.

See Campori, *Raimondo Montecuccoli* (Florence, 1876); Spenholtz, *Aureum vellus seu catena,* etc. (Vienna, 1668); Paradisi, *Elogio storico del conte Raimondo Montecucculi* (Modena, 1776); Pezzl, *Lebensbeschreibung Montecucculis* (Vienna, 1792); Hormayr, *Oesterreichischer Plutarch,* XIII. (Vienna, 1808); Wurzbach, *Btographisches Lexikon des Kaiserthums,* etc., pt. 19 (Vienna, 1868); *Die Hofkriegsraths, präsidenten* (Vienna, 1874); Weingartner, *Heldenbuch* (Teschen. 1882); Grossmann, *Archiv fur ost. Geschichte* (Vienna, 1878); *Allgemeine deutsche Biographie,* vol. xxii. (Leipzig, 1885). Important controversial works are those of Turpin and Warnery, two distinguished soldiers of the 18th century *(Commentaires sur les mémoires,* etc. [Paris], 1769, and *Commentaires sur les comm. . . . du comte Turpin,* Breslau, 1777). A critical estimate of Montecucculi's works will be found in Jähns *Gesch. der Kriegswissenschaften,* ii. 1162–78 (Leipzig, 1890).

MONTEFIASCONE, a town and episcopal see, province of Wterbo, Italy, built on a hill (2,077 ft.) on the S.E. side of the Lake of Bolsena, 70 mi. N.W. of Rome by rail. Pop. (1951), 3.892. The cathedral (1519) is one of the earliest structures by Sammicheli. In it the Old Pretender was married to Clementine Sobieski (1719); San Flaviano (built in 1032, repaired and enlarged in the Gothic style late in the 14th century), is a curious double church.

MONTEFIORE, JOSHUA (1762–1843), English soldier and author, was born in London, Aug. 10, 1762. He was educated at Oxford university, where he studied for the bar and in 1784 began to practise as a lawyer. In 1791 he became a member of a society established by naval officers and London businessmen, which planned to colonize an island off the coast of west Africa, and when the expedition set out the following year Montefiore was in charge of military arrangements. The colonization venture was a failure, largely because of difficulties with the natives which might have been avoided had the members of the expedition heeded Montefiore's advice to purchase the island before occupying it. His *An Authentic Account of the Late Expedition on the Coast of Africa, with a Description of the Present Settlement of Sierra Leone and the Adjacent Country* (1794) contains the story of the group's adventures. On his return to England he was offered a knighthood but refused. He turned instead to military service, becoming the first Jew to hold a commission in the English army. In 1812 he resigned his commission and settled in the United States, where he remained until his death, which took place in St. Albans, Vt., June 26, 1843. Montefiore was well-known both in his own day and for many years after for his writings, which were chiefly concerned with commercial and legal subjects. He was the author of a *Commercial Dictionary* (London, 1803) which went into a second edition in the United States and was considered a standard reference work.

MONTEFIORE, SIR MOSES HAIM (1784–1885), Jewish philanthropist who performed exceptional services to the Jewish people, was born at Leghorn, It., on Oct. 24, 1784. A member of a merchant family settled in Italy since the 17th century, he emigrated to England and practised as a broker on the London stock exchange, rapidly becoming a rich man. Through marriage Montefiore established a close personal and business connection with the Rothschilds. Retiring in 1824 with a large fortune, he devoted himself thereafter to the cause of Jewish emancipation and betterment. From 1827 he was one of the United Deputies of British Jews, in whose struggle to obtain full civil and political rights he always remained active. In 1837 Montefiore was knighted while serving as sheriff of the City of London, and in 1846 he was made a baronet by Sir Robert Peel.

After 1839 Montefiore's efforts on behalf of his co-religionists were mainly concentrated in eastern Europe, the middle east and north Africa, the regions of most intense persecution. During his first pilgrimage to Jerusalem in 1827, Montefiore established his friendship with Mohammed Ali, which was of great benefit to Egyptian and Syrian Jews, notably in 1840. In 1839 he tried, without success, to promote a scheme for Jewish colonization in Syria; but in the following year triumphantly persuaded the sultan to extend to Jews throughout the Ottoman empire the maximum privileges enjoyed by aliens. In 1863 this concession was reaffirmed, at his request, by the new sultan, Abdul Aziz. Montefiore vigilantly defended these gains, particularly in Syria, always his central interest in the middle east, as late as 1866. In 1864, with British naval escort, he effectively countered an outbreak of anti-Semitism in Morocco. His efforts were everywhere supported by lavish personal generosity.

In Europe Montefiore was equally persistent, though less successful. However, in 1847 he secured valuable assistance from Louis Philippe of France in meeting further difficulties in Syria. His relations with the tsars were excellent, and produced one major concession, despite later setbacks. In 1846 Montefiore managed to obtain Nicholas' withdrawal of the ukase of 1844, which had ordered all Jews to retire from the western frontier areas of Russia. His high standing in St. Petersburg was illustrated by the respect paid him on his last visit in 1872; but neither on this occasion nor during his mission to Rumania in 1867 were any new gains recorded. Montefiore made a final pilgrimage to the Holy Land in 1875, and retreated thereafter to his house East Cliff Lodge, near Ramsgate, where he maintained a centre of religious observance and theological research. He died there, a centenarian, on July 28, 1885.

Montefiore was a pious Jew, rigidly orthodox, who displayed great skill as a diplomat, adept at gaining access to the appropriate sovereigns, and failing only with Pope Pius IX over the Mortara case in 1859. Important to the English community and its advancement, Montefiore became a figure of European reputation.

(A. F. T.)

MONTÉGUT, JEAN BAPTISTE JOSEPH ÉMILE (1825–1895), French critic. was born at Limoges on June 14, 1825, and died in Paris on Dec. 11. 1895. He began to write for the *Revue des deux mondes* in 1847, contributing between 1851 and 1857 a series of articles on the English and American novel, and in 1857 he became chief literary critic of the review. Émile Montégut translated the *Oeuvres complètes* (10 vol., 1868–73) of Shakespeare. Among his numerous critical works is *Ecrivains modernes d'Angleterre* (3rd series, 1885–92).

MONTÉLIMAR, a town of southeastern France in the *département* of Drôme, near the Rhône, 93 mi. S. of Lyons on the railway to Marseilles. Pop. (1954) 10,567. Montélimar was called by the Romans *Acunum*. At a later period it belonged to the family of Adhémar and received the name Monteil d'Adhémar, whence the present name. Toward the middle of the 14th century it was sold by them partly to the dauphins of Viennois and partly to the pope, and in the next century it came into the possession of the crown. During the religious wars it valiantly resisted Gaspard de Coligny in 1570, but was taken by the Huguenots in 1587. The ancient castle is now used as a prison. Remains of the ramparts and four old gates, dating from the 14th, 1jth and 16th centuries, are also preserved.

The industries of Montélimar include tanning and the making of tiles, bricks, hats, lime, farming implements, preserved foods, nougat and wines.

MONTELIUS, OSKAR (1843–1921), Swedish archaeologist. was born in Stockholm on Sept. 9, 1843. He studied at the University of Stockholm, and took the degree of Ph.D. in 1869. In 1888 he was appointed a professor in the Museum of National Antiquities. Stockholm, and in 1913 became state archaeologist. As an archaeologist his aim was to utilize and develop the typological method explained by him in his book *Die Typologische Methode* (1903). He died at Stockholm on Nov. j. 1921. His works include: *The Civilisation of Sweden in Heathen Times* (1888); *Les temps préhistoriques en Suède et dans les autres pays Scandinaves* (1895); *Kulturgeschichte Schwedens* (1906); and *La civilisation primitive en Italie depuis l'introduction des mktaux* (3 vol., 1895–1910).

See *Oscar Montelius, in Memoriam* (Stockholm, 1922).

MONTEMAYOR or **MONTEMOR, JORGE** (1520?–1561), Spanish novelist and poet. of Portuguese descent, was born at Montemôr o Velho (near Coimbra). whence he derived his name, the Spanish form of which is Montemayor. His reputation is based on a prose pastoral romance. the *Diana* (1559?). It is important as the first pastoral novel published in Spain; as the starting point of a universal literary fashion; and as the indirect source, through the translation included in Googe's *Eglogs, epytaphes and sonnets* (1563), of an episode in the *Two Gentlemen of Verona*. Montemayor's mastery of Spanish is amazing, and that he pleased his own generation is proved by the 17 editions and two continuations of the *Diana* published in the 16th century, by parodies, imitations and renderings in French and English.

See G. Schonherr, *Jorge de Montmayor, sein Leben und sein Schaferroman* (Halle, 1886); H. A. Rennert, *The Spanish Pastoral Romances* (Philadelphia, 1912).

MONTENEGRO (*Crna Gora*), an independent country of southeast Europe until 1918. when it united with Serbia and the south Slav territories of Austria-Hungary to join the kingdom of the Serbs, Croats and Slovenes, later Yugoslavia (*q.v.*). In 1945, as Crna Gora, the Serbo-Croat form of its name, it became one of the constituent republics of Yugoslavia. It is bounded northwest by Croatia and Bosnia-Hercegovina, northeast by Serbia and Kosovo-Sfetohija. southeast by Albania and Lake Scutari and southwest by the Adriatic.

Montenegro takes its name—a Venetian variant of the Italian *Monte Nero*—from the "Black blountain." Mt. Lovcen (Lovchen) (5,738 it.), which formed its geographical and historical centre as an independent state. A natural fortress, the mountain was a refuge for the Serb nobles after Serbia's defeat at the battle of Kosovo in 1389 (*see* SERBIA). Montenegro was in fact the only one of the Balkan states not subjugated by the Turks. partly because of the inaccessible nature of the territory. and partly because of the courage of its inhahitants, nhich became legendary

The core of the country, the old Montenegro, forms the western half of the republic. nhich is divided by the Zeta valley It is arid and rocky, with small cultivable areas; *e.g.*, round Cetinje, the former capital.

The eastern half of the area includes part of the Dinaric Alps and rises to 8,274 ft. (Mt. Durmitor).

Area and Population. — In 1945, after the incorporation into the republic of the town and fjord of Kotor, Montenegro had an area of 5.333 sq.mi. This was roughly equivalent to its area before the accessions which followed the Balkan war of 1912. In 1961 its population was given as 471.433; the estimate for 1912 was about 250.000. For approximately the same area the Yugoslav census of 1931 gave a population of 223.949, nearly all Orthodox Serbs. but including 11,868 Roman Catholics and 26.351 Moslems. presumably Albanians. The capital, which was moved from Cetinje to Titograd (formerly Podgorica) in 1945, had a population of 29,100 in 1961.

HISTORY

Mediaeval Period. — Montenegro became an independent state after the death of the Serbian tsar Stephen Dusan (1355) and the break-up of the Serb empire. It was roughly equivalent to the district of Zeta or Duklja which had become incorporated into the Serb empire under Stephen Nemanja in the late 12th century. The Balsa family ruled the district around Lake Scutari and the Zeta valley from about 1356 until 1421. To the Balsa succeeded the Crnojevic dynasty. As the Turks overran Albania and Hercegovina. Ivo the Black Crnojevic was forced to move his capital to the remote mountain village of Cetinje in 1484. There he founded a monastery and a bishopric; and in 1493 the first printing press in the Balkans was set up at Obod and produced some of the earliest Slav books.

The Vladikas: 1516–1851. — The last Crnojevic resigned and retired to Venice in 1516. Thereafter till 1697 the mountaineers were ruled by bishops (*vladikas*) elected by popular assemblies. In 169; the succession was restricted to the Petrovic family and, because Orthodox bishops are celibates, it passed from uncle to nephew. For more than two centuries the Montenegrins maintained the struggle against Turks and Albanians, which for them was almost the whole duty of man. (Hence the Montenegrin's reputation for dignity. bellicosity and aversion to work. which last is a standing Yugoslav joke.) In 1711 Yladika Danilo I (the first hereditary *vladika*) started the tradition of alliance with Russia, receiving an envoy and a subsidy from Peter the Great and himself visiting St. Petersburg. True to that tradition, Peter I, "the Great Vladika" (reigned 1782–1830), joined the Russo-Turkish war of 1787 and co-operated with the British and Russians against Napoleon in Dalmatia, for a few months holding the coveted port of Kotor, which, however, Russia made him hand over to Austria in 1814. Peter I succeeded in doubling the area of his authority in the mountains, as well as introducing a rough code of law and the rudiments of administration. His nephew Peter II (reigned 1830–51) was not only remarkable as warrior and statesman, but is recognized as the greatest of Serb poets (for his two epics "The Mountain Garland" and "Light of the Microcosm"). He established a senate in 1831, was interested in education, and showed his belief in national unity by cordial relations with Alexander of Serbia and Colonel Jelacic. *Ban* of Croatia. He was buried on the summit of Mount Lovchen.

Peter's nephew, Danilo II (reigned 1851–60), refusing episcopal status. converted Montenegro into a secular principality and vindicated its claim to independence by successful resistance to the Turks.

Nicholas I.—On Danilo's assassination, he was succeeded by his

nephew. Nicholas, who reigned for 58 years (1860–1918). Nicholas led his warriors to success in support of the Hercegovinan insurgents in 1876–77 and occupied Kiksic and a stretch of the coast. The settlement at the Congress of Berlin (1878) doubled the size of Montenegro and recognized its independence. but. due to Albanian resistance the southern frontier was not agreed till 1880. It eventually acquired all the plain of Podgorica and 25 mi. of coast with the little ports of Bar and Ulcinj (Dulcigno). But, as Austria-Hungary now administered Hercegovina. occupied the Sanjak of Novi Pazar, protected the Catholic tribes of north Albania and exercised maritime control of the Montenegrin coast, the little principality was surrounded by the power of its great neighbour. With the growth of nationalism, the Habsburg control became as insufferable to Montenegrin as to Serbian enthusiasts.

Hor+-ever, for 30 years Montenegro experienced unusual peace. only relieved by occasional scuffles with the Albanian tribes along the frontier. Prince Nicholas ruled autocratically. He had some roads made. issued a code of laws, created a minute standing army and began a system of education. His numerous daughters established dynastic connections. One married Prince Peter Karagjorgjevic. who in 1903 became king of Serbia. Two married Russian grand dukes. But the great match was that of the Princess Elena, who married Prince Victor Emmanuel and became queen of Italy in 1900. Nicholas crowned this European recognition of his position by proclaiming himself king in 1910.

Nicholas maintained his authority by tradition, by his prestige as a war lord, a poet and a diplomat, and by the judicious distribution of parts of the large subsidies that he received from several foreign powers. But the spread of education, the return from the United States of some of the emigrants, the existence of parliamentary institutions in Serbia and the contrast between Montenegro's poverty and its ruler's wealth combined to produce dissatisfaction. In 1905 Nicholas proclaimed a parliamentary constitution. The resulting instability and violence were unedifying, and Nicholas soon paid little attention to the niceties of his constitutional law. A feature of his later years was the growing movement for Serb unity and Nicholas' challenge to the Serbian dynasty for its leadership.

In 190; the Serbian government was accused of complicity in a plot against Nicholas and for a time diplomatic relations were severed. But the Balkan War of 1912 saw the two Serb states co-operating against Turkey. Kicholas picturesquely firing the first gun of the mar. His troops occupied much Turkish territory, but were held up by the defense of Scutari. With Serbian aid, he at last captured it in April 1913; though warned by the powers that he would not be allowed to keep it. For three weeks he defied an international naval demonstration; but then surrendered Scutari; which the powers occupied on behalf of the future Albania. The result of the war was greatly to extend Montenegro to the north and east and to give it a common frontier with Serbia. The question of Serb unity became more urgent. and in 1914 official discussions began for an economic and political union, though with the retention of the two dynasties.

Montenegro supported Serbia, as a matter of course, in World War I. But. when the Austro-Hungarian army invaded Montenegro in the winter of 191j-16, Nicholas tried to negotiate for terms. Failing to obtain his desires. he fled with most of his family to Italy: though his second son. Prince Mirko, went to Vienna (where he later fell ill and died in an Austrian sanatorium) and was credited with projects for a vassal Yugoslav state within the Habsburg monarchy, but under the Petrovic dynasty. In western Europe thereafter two voices claimed to speak for Montenegro—Nicholas! who moved his court to Neuilly and demanded his own restoration as a condition of increased Serb unity: and the Montenegrin committee at Geneva. under Radovic, a politician whom for a time Nicholas accepted as his premier. The committee. in defiance of the king. accepted the Declaration of Corfu (July 20, 191;), which only alluded to Montenegro as destined to form part of an indivisible Yugoslav kingdom.

Between World Wars I and 11.—When the Austro-Hungarian forces were withdrawn from Montenegro early in Nov. 1918. their place was taken by Serbian troops and *četnici* (chetniks, irregular bands). Under this new control a "national assembly" convened at Podgorica and on Nov. 26 "unanimously" resolved that King Nicholas was dethroned and Montenegro was absorbed into Serbia. A Montenegrin rising followed. with demands for an Allied occupation and free elections. The movement was suppressed and in April 1919 a Serbian civil governor took over authority.

King Nicholas' government protested to the Allied supreme council against the proceedings at Podgorica and was assured that the Montenegrin people would be afforded "an opportunity to pronounce freely on the political form of their future government." No such opportunity was afforded. Allied investigations on the spot led to the conclusion that nearly all Montenegrins desired inclusion in the new Yugoslavia. though also desiring administrative autonomy within it. The governments of Great Britain and France accordingly took the elections for the Yugoslav constituent assembly in Nov. 1920 as the free pronouncement of the Montenegrin people, and on July 13,1922, accepted the incorporation of Montenegro into Yugoslavia.

In the politics of Yugoslavia the Montenegrins, though resenting administration by any non-Montenegrins. were ultra-Serb. It was a Montenegrin who wrecked the early hopes of Serbo-Croat unity and good will by shooting several Croat deputies in parliament in 1928. But the preoccupations of most Montenegrins were economic rather than political. They were miserably poor. Emigration to the United States and subsidies from foreign states had ceased. They complained that they were forgotten by Belgrade; though the Serbian statesmen replied with justification that the Yugoslav government spent far more on Montenegro than they received from it. The country's position was a little alleviated by King Alexander's reforms. when Cetinje became the administrative centre of the *banovina* of the Zeta, which included southeastern Hercegovina and southern Dalmatia. But the Zeta was much the most thinly populated of the nine *banovine* and had to be supported out of the taxation of the richer north.

It was normal for the local crops (chiefly maize) to be supplemented by 50,000 tons of grain and 2,000 tons of sugar annually. Some employment was given by the construction of two short lines of narrow-gauge railway. one from Podgorica to Lake Scutari and the other linking Niksic with the Bosnian railway. Two ambitious schemes were constantly discussed. but not put into effect—the draining of Lake Scutari. which would have needed Albanian co-operation, and a railway from Serbia through Montenegro to the coast. These might have greatly encouraged the exploitation of Montenegro's small resources—tobacco-growing, bauxite and manganese in the south, and stock-breeding, the forests and possible mining in the north.

After 1941.—In April 1941 Italian troops occupied parts of Montenegro. At Cetinje, in July, the Italians staged a quite unrepresentative "national assembly." which declared Montenegro independent! elected an executive body and requested the king of Italy to nominate a king. Victor Emmanuel does not appear to have acted on this request. During July a rebellion broke out and Montenegro was the scene of seldom interrupted fighting until late in 1944. In the winter of 1941–42 Serbian *četnici*, more or less under the command of the Serbian general Draza Mihajlovic, and Tito's Communist partisans retreated from the Germans into Montenegro and there came to blows with each other. A series of confused three-cornered struggles, between loyalists, partisans and the Italians, followed. The Italians soon retired to the coast and left the Yugoslavs to fight it out. Late in 1943 a German occupation of the south succeeded the Italian. But by the end of 1944 the Communists, with British arms and equipment, controlled most of Montenegro.

Communism of a special sort, for there was virtually no industry or urban proletariat in Montenegro, had been prevalent since 1918. It had the prestige of representing Russia, the country's traditional ally, and of expressing the poorer peasants' hatred of a bourgeois ruling class. Montenegrin Communists had formed some of the toughest elements in Tito's partisans and provided many of his most vigorous officers and leaders. It is not surprising that by the federal constitution of the new Yugoslavia (1946) Montenegro, despite its diminutive size (approximately its pre-

1913 area) and extreme poverty, was made one of the six nominally autonomous, federated units. Its position in Yugoslavia was much the same as before 1939. The administrative centre was moved from Cetinje to Titograd (the former Podgorica), which was rebuilt after 1945, provided with large official buildings and linked with Niksic and the Bosnian railway system by a narrow-gauge line. But Montenegro remained a "passive area" which had to receive economic aid from the other provinces. (See also SERBIA; YUGOSLAVIA.)

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MONTEPULCIANO, town and episcopal see, province of Siena, Toscana, Italy, 44 mi. S.E. of it by rail. Pop. (1957 est.) 17.019 (commune). The town, 6 mi. W. of the station, crowns the summit of a hill (1.984 ft.), and is surrounded by medieval walls. Protected by Siena till 1202, it declared for Florence and thenceforward passed from one power to the other, until it finally became Florentine (1559).

Most of the buildings belong to the Renaissance, except the castle and the 14th-century Palazzo Pubblico. There are fine private houses by Antonio da Sangallo the elder (1455?–1534), Baldassare Peruzzi (1481–1536) and Vignola (1507–1573). The beautiful church of S. Biagio — Sangallo's masterpiece — was built in 1518–45.

The cathedral built by Bartolommeo Ammanati (1570) contains a large altarpiece by Taddeo di Bartolo of Siena, and the fragments of the tomb of Bartolommeo Aragazzi, secretary of Pope Martin V erected by Michelozzo (1427–36). Montepulciano is famous for its wine, and was the birthplace of Politian (*q.v.*) and of Cardinal Bellarmine (1542–1621).

See F. Bargagli-Petrucci, *Montepulciano, Chiusi &c.* (Bergamo, 1907)

MONTEREAU, a town of northern France, in the *département* of Seine-et-Marne at the confluence of the Yonne nith the Seine, 21 mi. S E. of Melun by rail. Pop. (1954) 9,470. The 13th century church has a facade of the Renaissance period. The industries include the manufacture of porcelain, fireproof and decorative bricks, boots and shoes and agricultural machines and colours and varnish and trade is in grain, cattle and agricultural produce Among the institutions are a tribunal of commerce and a chamber of arts and manufactures. Montereau in the beginning of the 15th century nas of some importance. There on the bridge over the Yonne Jean Sans-Peur. duke of Burgundy. was assassinated in the presence of the dauphin, afternard Charles VII, in 1419. In 1438 the tonn was captured by Charles VII and during the wars of religion it nas several times taken and retaken. In 1814 Napoleon gained a victory at Montereau over the Würtemberg troops under Schwarzenberg.

MONTEREY, a city of Monterey county, Calif., U.S., 124 mi S. by E of San Francisco, situated on a peninsula fronting the bay of the same name. Monterey is one of the oldest sites of Spanish civilization in California; to tour the city is to walk in the path of history of the Pacific coast. The area was sighted by Juan Rodriguez Cabrillo in 1342 and in 1602 was explored by Sebastián Vizcaíno, who named it in honour of the count of Monte Rey, the governor of New Spain. Thereafter, Spain was oblivious of the area until in 1770 an expedition headed by Gaspar de Portola, governor of Alta California, and Father Junipero Serra (q v), a Franciscan monk, arrived to establish a presidio and a chapel. It was on the Monterey peninsula that Father Serra's great career was brought to fruition. Close by the presidio for protection, yet far enough removed for agricultural pursuits. Father Serra established the Carmel mission, after which many others were patterned. It was the missions under Father Serra which helped to strengthen Spain's control of Alta California. maintained until 1822. Under Mexico, Monterey remained the capital of the Pacific empire, an area including what is now California, New Mexico, Nevada, Arizona, Utah and parts of Colorado, Wyoming and New Mexico. Such an extensive and undefended domain was coveted, not the least by the United States, to which it was contiguous. With the defeat of Mexico by the United States in 1816, the American flag was unfurled in front of the customhouse at Monterey, and four years later California was admitted to the union. *(See* also CALIFORNIA: *History.)*

The hlonterey area is one of residences rather than of industries. and attracts many tourists, especially those interested in history. There is, however, a diversity of attractions, particularly the colourful wharves which were used commercially when the sardines were running but which are now used for restaurants, theatres and shops; plazas with flowers in blossom the year around; and a schedule of festivals reminiscent of the Spanish and Mexican eras. The Monterey peninsula has long been knonn as a retreat for artists, and the results of their skills may be seen in international galleries. The peninsula is also famous for its annual Bach festival.

Monterey is the hub of an extensive military establishment, to which its economy is closely related. The presidio of hlonterey, the oldest remaining military establishment west of the Rocky mountains, is the home of the U.S. army language school. A few miles eastward is Fort Ord. an important training and replacement centre for the U.S. army on the west coast. The U.S. naval postgraduate school is within the city limits.

Monterey Peninsula college. a public junior college. was opened in 1947. Monterey has a council-manager form of government, in effect since 1925. For comparative population figures see table in CALIFORNIA: *Population.* (B. L. B.)

MONTEREY PARK, a city of California. U.S.. formerly knonn as Ramona Acres, 5 mi E. of Los Angeles at the southeastern end of the San Gabriel valley, in the hlonterey hills. A residential city of medium priced homes, Monterey Park was developed in the 1880s by Harris Newmark, I. W. Hellman and Richard Garvey. It was incorporated in 1916 Monterey Park has a public library and a community hospital Recreational facilities are provided in Barnes Memorial park, La Loma park and Richard Garvey Ranch park. There are two institutions of higher learning near the city: Los Angeles State College of Applied Arts and Sciences. established in 1947, and East Los Angeles City college. a junior college opened in 1945. Monterey Park has a council-manager form of government. in effect since 1948. For comparative population figures *see* table in CALIFORNIA: *Population.* (J. A. Sz.)

MONTERO RIOS, EUGENIO (1832–1914), Spanish politician, was born at Santiago de Compostela on Nov. 13. 1832. Intended for the church, he abandoned his ecclesiastical career for the law, becoming professor of canon law at Madrid in 1864. Having already founded *La Opinión Pública* for the diffusion of radical ideas, he entered politics as a progressive. As minister of justice in Juan Prim's cabinet (1870), he promoted a number of judicial measures. including civil marriage and the reform of the criminal law. Although a devout Catholic, he advocated religious freedom and the separation of church and state. He faithfully served King Xmadeo and drew up his act of abdication. He next emerged in 1884 as a leader of the Fusionist-Constitutionalist party. Having been minister of national economy (1885–86), minister of justice again (1892–93) and twice president of the senate (1894–95 and 1898). he led the Spanish delegation that negotiated the treaty of Paris at the close of the Spanish-American War of 1898, contriving to settle advantageously the question of Cuba's colonial debt. In his last years he was opposed to Catalan separatism. He was president of the senate again from 1902 to 1903.

Succeeding Sagasta as leader of the Liberal party, Montero Ríos was prime minister for five months in 1905. After another period as president of the senate (1910–13), he died in Madrid on May 12. 1914.

MONTERREY, third largest city of Mexico and capital of the state of Nuevo León. Pop. (1960) 600,609. On main highways, rail and air lines between Laredo, Tex. (150 mi. N.), and Rlexico City (600 mi. S.). Monterrey also has good connections to coal and mineral areas to the north and west. to the grazing and

agricultural areas north and east, and to its port. Tampico, on the Gulf of Mexico, though its own site lacks significant natural resources. Ranking first in metallic industries and second in manufacturing, Monterrey is the dominant city of the large zone lying between the United States border and the densely settled Central Mexican highlands. At an altitude of 1 765 ft.. partly surrounded by mountains. Monterrey is on the flood plain of the eastward-flowing Santa Catarina river. On a semiarid piedmont north and east of the city there is considerable irrigated agriculture. Local rivers provide hydroelectric power, but for both irrigation and electricity Monterrey is the chief Mexican beneficiary of the great Falcón dam. jointly constructed by the United States and Mexico on the lower Rio Grande river for mutual benefit. Monterrey has a generally healthful climate, cool and wet in winter, hot and dry in summer.

It is a modern city, despite its early founding in 1579 Floods, hostile Indians. distance from Mexico City, lack of metals and poor communications kept it small and unimportant until the late 19th century; it has few notable colonial monuments. Its population in 177j was 2j8. Rail connection with Laredo (1882) opened the entrance to large-scale smelting and heavy industrial enterprises originally financed by Americans. In 1880 its population mas 29,000; by 1930 it was 132,571, which more than doubled by 1950. Monterrey has all the conveniences of a modern metropolis, in an area where native populations exerted negligible cultural influence. It is often called "The Pittsburgh of Mexico." Its city water has a lower bacteria count than that of many U.S cities.

Favourable state legislation, especially in 1888, plus active and efficient local governments fostered its development into one of the most energetic and up-to-date industrial complexes in the hemisphere. In addition to its heavy industries, fabricating plants and ore processing units, Monterrey counts literally hundreds of light manufacturers which produce beer, cigarettes, pottery, glass, textiles, cement, processed foods, plastics and other products. In addition to electric power, these industries also employ natural gas for fuel, piped through a 129-mi. line opened in 1947 that delivers 60.000.000 cu.ft. daily.

The Technological Institute of Monterrey (modeled on the Massachusetts Institute of Technology), which was founded by local industrialists in 1942, provides excellent training and research facilities. (J. A. Cw.)

MONTE SAN GIULIANO (now ERICE), town and episcopal see, Sicily, province of Trapani, 2 mi. E.S.E. of it. on the summit of an isolated bare hill, which rises 2,465 ft. above the sea. Pop. (1951) 1,539. The town occupies the site of the ancient Eryx. a city of the Elymi. (*See* SICILY.) It was famous for the temple of Venus Erycina on the summit of the mountain. The tomn was seized by Pyrrhus in 278 B.C., and by Hamilcar Barcas in 243–241, and was ceded to Rome at the end of the First Punic War.

In Roman times the temple possessed territory of its own, and a considerable number of female slaves. Eryx was the residence of the quaestor of the western half of the island, and Verres spent some time here. Considerable portions of the city wall (a Roman reconstruction), are preserved on the northwest (on the east and south are precipitous cliffs). The medieval castle, with three lofty towers guarding the entrance, occupies the southeastern extremity of the town. The cathedral (1314) has a fine porch and Gothic facade.

See J. Kromayer, *Antike Schlachtfelder* iii, 1 (1912), who maintains that the present tomn occupies only the acropolis, and that the city, which was occupied by Hamilcar, lay farther to the northwest.

MONTE SANT' ANGELO, a town of Puglia, Italy, province of Foggia, 10 mi. N. of Manfredonia by road. 2,765 ft. above sea level, on the southern slopes of Monte Gargano. Pop. (1951), 21,279. It has a ruined Norman castle and a famous sanctuary of S. Michele, founded in 491 over a cave in which the archangel is said to have appeared to S. Laurentius, archbishop of Sipontum; the bronze doors, made in Constantinople, bear the date 1076. The octagonal campanile dates from 1273. The portal of S. Maria Maggiore is noteworthy. The Tomba di Rotari is a domed building of the Norman period.

See S. Beltramelli, *Il Gargano* (1907), well illustrated.

MONTESPAN, FRANÇOISE-ATHÉNAÏS DE PARDAILLAN, MARQUISE DE (1641–1707), mistress of Louis XIV, was born at the château of Tonnay-Charente the daughter of Gabriel de Rochechouart. duc de Montmart. In 1661 she became maid of honour to Queen Maria Theresa, and two years later she married L. H. de Pardaillan de Gondrin, marquis de Montespan, by whom she had two children. A beautiful and brilliant woman, she became mistress of Louis XIV in 1667. The first of the seven children Mme de Montespan bore to the king was born in March 1669, and was entrusted to Mme. Scarron, the future Mme. de Maintenon. who acted as companion to Mme. de Montespan while the king was away at the wars. The eldest, Louis Auguste, became duc de Maine; the second, Louis César, comte de Vexin; and the third. Louise Françoise, demoiselle de Nantes (afterward duchesse de Bourbon). These children were all legitimatized in 1673. When Louis's affection showed signs of cooling, Mme. de Montespan resorted to magic. The frequent occurrence of her maid's name in the evidence before the *chambre ardente* threw suspicion on her connection with La Voisin, but the affair was hushed up. (*See* LA VOISIN, C., fcr an account of the poisoning affair.)

In 1691, Mme. de Montespan retired to the Convent of St. Joseph with a pension of half a million francs, and honours for the members of her family. She nas a generous patron of letters. and befriended Corneille, Racine and La Fontaine. She died at Bourbon l'Archambault on May 27, 1707.

See P. Clément, *Madame de Montespan et Louis XIV* (1869); monographs by Arsène Houssaye (1865) and by H. Williams (1903); also J. Lair, *Louise de la Vallière* (Eng. trans., 1908); F. Funck-Brentano, *Le Drame des Poisons* (1899); A. Durand, "Un épisode du grand règne," in *Rev. des questions hist.* (1868); the contemporary memoirs of Mme. de Sévigné, of Saint-Simon, of Bussy-Rabutin and others; also the proceedings of the *chambre ardente* preserved in the *Archives de la Bastille* (Arsenal library) and the notes of La Reynie preserved in the Bibliothèque Nationale. She figures in V. Sardou's *L'Affaire des poisons* (1907) and several other plays.

MONTESQUIEU, CHARLES LOUIS DE SECONDAT, BARON DE LA BRÈDE ET DE (1689–1755), French man of letters and philosopher, whose treatise *De l'Esprit des lois* was a major contribution to political theory.

Early Life and Work.—He nas born in the chbteau La Brède, near Bordeaux. on Jan. 18. 1689. His parents were Jacques de Secondat a soldier of modest aristocratic origin whose family had been enobled in the 16th century, and Marie-Françoise de Pesnel, a pious lady of partial English extraction, who brought to her husband a great increase in wealth in the valuable mine-producing property of La Brède. When she died in 1696 the barony of La Brkde passed to Charles Louis, who was her eldest child. then aged seven. Educated first at home and in the village. Charles Louis was sent in 1700 to the Collkge de Juilly, in the diocese of Meaux. This school. then much patronized by the prominent families of Bordeaux, belonged to the priests of the Oratory, who imparted to their pupils a sound education on enlightened and modern lines.

Charles Louis left Juilly in 1705, continued his studies at the faculty of law at Bordeaux university, graduated and was admitted advocate in 1708. and soon after appears to have moved to Paris in order to obtain practical experience of law. He was called back to Bordeaux by the death of his father in 1713. Two years later he married Jeanne de Lartigue, a nealthy Protestant who brought him a donry of 100 000 livres and in due course presented him with two daughters (from one of whom. nho retained her name by marrying her cousin, the present family is descended) and a son, Jean-Baptiste. Charles Louis. though he admired and took advantage of his wife's business skill, does not appear to have been either faithful or devoted to her. In 1716 an uncle, Jean-Baptiste, baron de Montesquieu, died and left to his nephew his estates (notably the barony of Montesquieu, near Agen) and the office of deputy president or *président à mortier* in the *parlement* of Bordeaux The young Montesquieu's position nas now socially and financially secure, and he settled down to exercise his judicial function (engaging to this end in the minute study of Roman law), to

administer his property and to advance his knowledge of the sciences, especially of geology, biology and physics, in the newly formed academy of Bordeaux.

In 1721 he surprised all but a very few close friends by publishing his *Lettres persanes*, in which he gives a brilliant satirical portrait of French and particularly Parisian civilization, supposedly seen through .the eyes of two Persian travelers, Usbek and Rica. 'This exceedingly successful work mocks the reign of Louis XIV, pokes fun at all social classes, discusses, in its allegorical story of the Troglodytes, the theories of Hobbes relating to the state of nature, makes an original if naive contribution to the new science of demography, continually compares Islam and Christianity, reflects the controversy about the papal bull *Unigenitus*, satirizes Roman Catholic doctrine, and is infused throughout with a new spirit oi vigorous, disrespectful, gay and iconoclastic criticism. The work's anonymity was very soon penetrated and Montesquieu became famous.

He now sought to reinforce his literary achievement with social success. Already acquainted through friends made at Juilly with several intellectual figures in Paris society, among them Nicholas Frkret and Bernard de Fontenelle, he went to Paris in 1722 and was assisted to enter court circles by the duke of Berwick, whom he had known as military governor at Bordeaux. He became a prominent member of the salon of Mme. de Lambert and appears to have visited the club of the Entresol, which was frequented by the marquis d'Argenson, Andrew Michael Ramsay and Bolingbroke. He retained his interest in the academy of Bordeaux, reading to it in 1725 some fragments of a *Traitt général des devoirs*, which was an earnest of future activity and his first attempt at a full-scale serious work. At the same time he indulged the lighter side of his character by publishing, for his friends at court: *Le Temple de Gnide* (1724), a mild essay in eroticism. His interest in the *parlement* of Bordeaux had dwindled, and in 1726 he sold his legal office. This move served both to re-establish his fortunes, depleted by life in the capital, and to assist him, by lending colour to his claim to be resident in Paris, in his attempt to enter the Académie Française. **A** vacancy there arose in Oct. 1727. Montesquieu had powerful supporters, but success seemed likely to elude him because of Cardinal Fleury's objection to certain passages in the *Lettres persanes*. He succeeded, however, in appeasing Fleury and was elected, taking his seat on Jan. 24, 1728.

He then sought to complete his education by foreign travel, and in April 1728 set off, without his wife and in the company of Lord Waldegrave, for Vienna. Tarrying there to meet Prince Eugene and to make an expedition to the mines of Hungary, he soon went to Venice, where Antonio Conti acted as his cicerone and where he met the exiled and impoverished John Lam. He visited most of the large cities of Italy and met most of the savants of the day. He refers in his journals to the works of both Pietro Giannone and G. B. Vico. From Italy he moved through Germany to Holland and thence (at the end of Oct. 1729), in the company of Lord Chesterfield, to England, where he remained until the spring of 1731. His account of his visit to England was destroyed by his grandson, but it is known that he had a wide circle of acquaintance, especially among the Tories and the dissident Whigs. He was presented at court; he attended parliamentary debates; he bought extensively for his library; he read the journals of the day, notably *The Craftsman;* and he became a freemason. His stay in England was intellectually one of the most fertile periods of his life.

On his return to France, Montesquieu hastened to La Brbde and remained there for two years in order to devote himself to literary activities. Apart from a tiny treatise on *La Monarchie universelle*, printed in 1734 but at once withdrawn (so that only his own copy is extant), he was occupied with an essay on the English constitution (not published until 1748, when it became part of his major work) and with his *Considérations sur les causes de la grandeur des Romains et de leur décadence* (1734). The merit of this book, which was ill received by the learned, does not iie in its handling of evidence, which shows a surprising disregard for archaeology, or in its documentation. which, though extensive, is arbitrary and uncritical. In these respects Montesquieu was behind his times. But his comments on the history of Rome are penetrating and vigorous and his approach to the study of historical causation is particularly interesting. In the distinction which, under the influence of Malebranche and of Italian writers, he draws between cause and occasion, he finds a formula for the reconciliation of free will and historical determinism. He shows a unifying grasp of the varied aspects of civilization which few before him could rival. The hatred of despotism which characterized the *Lettres persanes* is here flanked by a devotion to liberty as the major political good. This is a mature and well-written book.

De **l'Esprit** des **lois.**—Montesquieu had for some time been meditating the project of a major work on law and politics. After the publication of the *Considérations* he rested for a short time and then, undismayed by failing eyesight, applied himself to this new and immense task. He undertook an extensive program of reading in law, history, economics, geography and political theory, filling with his notes a large number of volumes of which one only survives, entitled *Geographica, tome II*. He employed a succession of secretaries, sometimes as many as six simultaneously, using them as readers and as amanuenses, but not as prkcis-writers. By 1740 the main lines of his work were established and a great part of it was written. By 1743 the text mas virtually complete, and he began the first of two thorough and detailed revisions n-hich occupied him until Dec. 1746. Now the actual preparation for the press was set in hand. A Geneva publisher. J. Barrillot, was selected. further corrections were made, several new chapters were written and in Nov. 1748 the work appeared under the title *De l'Esprit des lois, ou du rapport que les lois doivent avoir avec la constitution de chaque gouvernement, les moeurs, le climat, la religion, le commerce, etc.* It consisted of two quarto volumes, comprising 31 books in 1,086 pages.

Few indeed of the most intimate of Montesquieu's associates had known the nature of his occupation. Fewer still had seen the text. The public: not expecting a political treatise comparable with Aristotle's *Politics*, was taken by surprise. The work was at once very successful. None of the multiplicity of subjects touched by Montesquieu remained unadorned. His treatment of three was particularly memorable. The first of these is his classification of governments. Abandoning the classical division into monarchy, aristocracy and democracy, Montesquieu produces his own analysis and assigns to each form of government an animating *principle:* the republic, based on virtue; monarchy, based on honour; despotism, based on fear. His definitions show that this classification rests, not on the location of political power, but on the government's manner of conducting policy; it involves a historical and not simply a descriptive approach.

'The second of his most noted arguments, the theory of the separation of powers: is treated differently. Dividing political authority into the legislative, executive and judicial powers, he asserts that in the state which most effectively promotes liberty these three powers must be confided to diiferent individuals or bodies acting independently. His exemplar of such a state is England, which he sees from the point of view of the Tory opposition to Walpole, as expressed in Bolingbroke's polemical writings. The chapter (book xi, chapter 6), the most famous of the entire book, in which he expresses this doctrine, had lain in his drawers, save for revision or correction, since it was penned in 1734. It at once became perhaps the most important piece of political writing of the 18th century. Though its accuracy has in more recent times been disputed, in its own century it was admired and held authoritative, even in England; it inspired the Declaration of the Rights of Man and the constitution of the United States.

The third of Montesquieu's most celebrated doctrines is that of the political influence of climate. Basing his generalizations somewhat nai'vely on experiments conducted at Bordeaux, he stresses the effect of climate, primarily thinking of heat and cold, on the physical frame of the individual and, as a consequence, on the intellectual outlook of society. This influence, he claims, is not, save in primitive societies, insuperable. It is the legislator's duty to counteract it. Montesquieu takes care (as his critics have not always realized) to insist that climate is but one of many factors in an assembly of secondary causes which he calls the *general spirit*. The other factors (laws, religion and maxims of government being

the most important) are of a nonphysical nature, and their influence compared with that of climate grows as civilization advances.

Society for Montesquieu must be considered as a whole. Religion itself is a social phenomenon whether considered as a cause or as an effect, and the utility or harmfulness of any faith can be discussed in complete independence of the truth of its doctrines. Here and elsewhere, undogmatic observation is Montesquieu's preferred method. Sometimes the reader is beguiled by this into the belief that Montesquieu maintains that whatever exists, though it may indeed stand in need of improvement, cannot be wholly bad. It is then that a bold parenthesis or a rapid summing-up reminds one that for Montesquieu certain things are evil from their nature: despotism, slavery, intolerance. Though he never attempts an enumeration of the rights of man, and would probably have disapproved of such an attempt, he has a firm belief in human dignity.

In the final books of *L'Esprit des lois,* added at the last moment and imperfectly assimilated to the rest, he addresses himself to the history of law, seeking to explain the division of France into the two zones of written and of customary law, and makes his contribution to the much discussed controversy about the origins of the French aristocracy. Here he displays not only prudence and common sense, but also a real talent, not previously revealed in his life, for the handling of texts and the interpreting of philological evidence.

Last Years.—Very soon after the publication of *L'Esprit des lois* a campaign was begun against Montesquieu, and a variety of denunciatory articles and pamphlets appeared. Attacks made in the Sorbonne and in the general assembly of the French clergy were deflected, but in Rome, in spite of the intervention of the French ambassador, Montesquieu's enemies were successful, and the work was placed on the Index in 1751. This was but a momentary setback. Montesquieu had already (1750) published his *Défense de l'Esprit des lois,* the most brilliantly written of all his works, and his fame in France was assured.

Renown lay lightly on his shoulders. His affability and modesty are commented on by all who met him. He was a faithful friend, kind and helpful to young and unestablished men of letters, witty though absent-minded in society. The editors of the *Encyclopédie* wished to have his collaboration. When approached by D'Alembert, he declined to treat a political subject and proposed an article on taste. The resultant *Essai sur le gout* was his last work.

After a short illness he died at Paris on Feb. 10, 1755, leaving many literary projects unfinished.

The best edition of his *Oeuvres complktes* is by André Masson, in three volumes (1950–55). The Bibliothbque de la Pléiade has a useful edition by R. Caillois, in two volumes (1949–51), and the Association Guillaume Budé has a critical edition of *L'Esprit des lois* edited by J. Brethe de La Gressaye, in three volumes (1950–58).

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MONTESSORI, MARIA (1870–1952), Italian educator, originator of the method of education called the Montessori system (*q.v.*), was born at Chiaravalle near Ancona on Aug. 31, 1870. She graduated in medicine from the University of Rome in 1894, the first woman in Italy to do so. Her methods were originally devised for educating defective children, and when they proved extraordinarily successful she came to the conclusion that similar techniques might be applied to normal children of a lower age. She extended her methods to a large number of young children in certain private and public infant schools in Rome. Maria Montessori encountered opposition from advocates of orthodox methods in education, who regarded her system, which encouraged freedom of movement in the children, as destructive of discipline. But she was warmly supported by certain enthusiastic reformers. From 1900 to 1907 Maria Montessori lectured on pedagogical anthropology at the University of Rome and in 1922 was appointed government inspector of schools in Italy. Her ideas on education are set forth in *The Montessori Method* (1912) and *Education for a New World* (1946). She spent her later years in supervising training courses in Spain, India, England and the Netherlands. She died at Noordwijk, Neth., on May 6, 1952.

MONTESSORI SYSTEM. The Montessori method is a system of education originated by Maria Montessori, an Italian doctor of the University of Rome. Her first book, *The Montessori Method,* was published in 1912. It described experiments made with little children (ages 3 to 6) in the slum quarters of Rome, in *Casa dei Bambini* ("children's houses") or rooms set apart in the courtyards of large tenement buildings as part of a reformed dwelling scheme inaugurated by E. Talamo. Maria Montessori began her studies of educational problems with defective children. Working on lines first laid down by the French physician, É. Séguin, she achieved startling results; idiot children under her tutelage passing the state examination in reading and writing for normal children. She then turned her attention to the education of normal children, since it seemed to her that if backward children by educational means could be led to overtake normal children, it should be possible to produce still more startling results with the normal child. A year in the *Casa dei Bambini* justified her hopes. These schools became world-famous, and were visited from all parts.

Before starting work with normal children Maria Montessori had examined the educational systems of Europe, and to her it seemed astonishing to find everywhere the children reduced to immobility in the classrooms "like rows," as she said, "of butterflies transfixed with a pin." Such children, she declared, were not "disciplined but annihilated." In her schools the contrary practice was established. Freedom of movement was the rule, provided it did not transgress the borders of good manners, social order and harmony. She proved that on these lines an astonishingly perfect discipline can be built up, even with quite tiny children. The children worked happily together, moving independently to and fro, as in a well-ordered community of adults. Such "free discipline," as it was to be called, began to be everywhere adopted in schools.

But another, and, if anything, more profound aspect of her work lies in the "educational apparatus" or "didactic material" specially provided. Building on the work of Séguin, Maria Montessori discovered that it is possible to devise objects of a very simple and yet exact type which provoked in the young child a profound reaction of interest and attention, such as she, in common with previous psychologists, had never believed possible. At first, she tells us, she could hardly believe her eyes. Little children of between three and four would repeat an exercise with an air of concentration and indifference to surrounding distractions, that we have been hitherto accustomed to associate only with men of genius. Such a period of "work" might continue from a quarter of an hour to an hour, and then the child would seek other work, upon which he would concentrate in a similar way. Moreover, the child did not seem tired: as after an enforced effort, but rather refreshed and tranquilized. Indeed, disorderly children—those of a type likely at any moment to lapse into some form of indiscipline—invariably acquired inward stability once they had entered upon this form of spontaneous work. The teacher in the second and subsequent years of the class's formation had very little to do in the direction of maintaining order.

This set her the more free for a delicate and exacting portion of her work, the teaching of the children by giving them little, mainly individual, lessons at appropriate moments, and in introducing them to new portions of the material as required.

Wherever movements are involved, the teacher shows in the first instance the precise and best way of performing the movement. This prevents the formation of an imperfect habit and has universal importance, as all teachers of music or games are aware. Thus children, at an early age, can scrub a table and consider it part of the fun not to spill a drop of water; they can wash up after meals: wring out and iron their little dusters, etc. Little waiters carry round the dishes at meals, and it is not an uncommon sight to see a child of three in sole charge of the soup tureen. Students in the Children's Houses learned to write, read, count and work simple sums before the age of six.

After the publication of her first book, Maria Montessori worked

on material for older children, and perfected means by which they could individually study grammar, geometry, arithmetical operations with large numbers, fractions and so on. Music and art work were also fully developed. An account of this was given in her book *The Advanced Montessori Method* (1917), dealing with the ages six to ten. Maria Montessori, who was a Roman Catholic, also evolved methods of religious instruction for use in connection with her system.

See also KINDERGARTEN. (C. A. C.)

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MONTEVERDI (MONTEVERDE), **CLAUDIO** (1567–1643), Italian composer, was born at Cremona in May 1567. His attention was early directed to the infant art of instrumental music, and the duke of Mantua gave him his first appointment as viola player, under Ingegneri. a good polyphonic church composer (his *Responsoria* were long ascribed to Palestrina), from whom he learned composition. In i602 Monteverdi succeeded Ingegneri as maestro di cappella to the duke; and in 1608 he made a decisive impression with his first opera, *Arianna,* in which was revealed the emotional and dramatic value of a new treatment of discords, which, in his unaccompanied madrigals. had merely seemed to indicate the downfall of pure polyphony. This work at once elevated the lyric drama, feebly essayed by Peri's *Euridice* in 1600, to a level of art which musicians were henceforth compelled to take seriously. Still more successful was *Orfeo,* composed in 1607. In *Il Combattimento di Tancredi e Clorinda,* the description of a duel was accompanied by quickly repeated chords on the strings (not. as is usually alleged, a tremolo) which so scandalized the players that all Monteverdi's tact and determination was needed to induce them to play it. He had already written *pizzicato* passages (with the direction "here you put down the bow and pull the string with the finger"). The Amati family of violin makers at Cremona had begun their work in the nick of time for Monteverdi's purposes; for it is doubtful whether even his resourcefulness could have so effectively revolutionized music if the feeble flat-backed viols had been his only instruments with string and bow. In 1613 Monteverdi became maestro di cappella at St. Mark's, Venice, where he composed much sacred music, now lost. In 1632 he became a priest. He produced four more operas before his death, on Nov. 29, 1643.

Monteverdi's conspicuous position in musical history gives rise to many misunderstandings as to his artistic merits. In the history of the fine arts it is much easier to write vividly about tendencies than about results. Mature works of art are things in themselves, and demand to be so understood without regard to what comes after them. Resisting interpretation in other terms than their own, they are not easy to describe. But tendencies are always interesting. Accordingly the student finds that the historian whom Palestrina and Bach paralyse into hagiology writes as if Monteverdi were the Wagner of a 17th century more glorious than the 19th. And this is difficult to reconcile with the fact that if all the music of the 17th century were destroyed, not a single concert-goer would miss it. A glance at the score of one of Monteverdi's operas, or at the quotations given in musical histories, produces a disillusion unnecessarily great; we seem to be plunged into a more archaic period than that of the earliest efforts at polyphony. A modem stage performance restores the illusion. But an illusion it remains; for Monteverdi lived in the hey-day of baroque stage-production, and on anything like a faithful reproduction of his stage, it matters little whether we hear his finest rhet'oric, or poor Peri's efforts, or the experimental psalmody of modern amateurs who know nothing about music.

hieanwhile good service has been done in the rehabilitation of Monteverdi as an artist, by Malipiero's complete score of all his extant madrigals. In his preface, Malipiero holds up, as a warning to modern critics, the censure of Artusi, and points out that Artusi recanted afterwards. The warning is misplaced. Monteverdi was no Keats, neither was Artusi a *Quarterly* reviewer. Artusi saw, and said, that the treatment of discords in Monteverdi's madrigals was subversive of pure polyphony. This was true, and Monteverdi's reply was that the rules of Zacconi's *Practica* di *Musica,* which were in conflict with the details *(alcune minime particelli)* of modern music, did not concern him, since he was not writing by accident, but was establishing a *Seconda Pratica* which, at the instigation of Artusi's attack (*Degli Imperfezioni,* etc.) he would call *La Perfettione della Musica Moderna.* In these six books of extant madrigals, it is fascinating to trace the conflicting elements: the decadence of an old style; the too facile exploitation of new formulas; and, now and again, the achievement of something powerful and mature, which, if introduced into a madrigal concert, would make it impossible to continue the programme with orthodox madrigals.

(D. F. T.)

MONTEVIDEO, the southernmost. smallest and most important department in Uruguay, has about 45,000 inhabitants (1954 est.) not including the city of Montevideo (*q.v.*) (pop., 1954 est., 810,000). The city's growth has increasingly urbanized and industrialized the outlying department. Nevertheless. truck gardens, vineyards, dairy and poultry farms. orchards and commercial flower gardens send products to the capital.

Country homes for capital residents, common in the early 20th century, are gradually disappearing as land values in the department rise and new resorts emerge on the Atlantic. The department's territorial extension, including the capital, is 208 sq.mi.

(M. I. V.)

MONTEVIDEO, capital of Uruguay and one of South America's great cities, is on the northern shore of the Rio de la Plata estuary, 120 mi. E.S.E. of Buenos Aires. Airplane travelers land at Carrasco airport, but the best first sight of Montevideo still is from the sea, heading into the harbour, with the Cerro and its light. a famous landmark. looming up to the left. Formerly ships had to be unloaded in the harbour by lighters, but beginning in 1901 the port, a government-operated enterprise, was modernized; it can dock the largest ships, unload them and move cargo to the multistory Customs house. The harbour district opens out into the Old City. the Ciudad Vieja, which once was colonial Montevideo. The buildings there. for the most part. are old and the streets are narrow. but the Old City is still the financial and business heart of Uruguay. The stock exchange, the central Bank of the Republic, head offices of private banks, foreign bank branches, shipping firms. export-import houses and lawyers locate there. The Old City culminates in the Plaza de la Constitución, with the cathedral on one side and the *cabildo,* the colonial municipal building and for many years the home of the Uruguayan legislature, on the other. Sarandi street, a narrow shopping centre, connects the Plaza de la Constitución with the more recent Plaza de la Independencia, Montevideo's major square. The traditional gesture for distinguished foreign visitors is to place a wreath of flowers at the foot of the mounted statue of the hero of national independence. José Gervasio Artigas, in the centre of the plaza. Government house is on the right of the statue; the modernistic Victoria Plaza hotel on the left. Facing the statue is the Palacio Salvo. the city's first skyscraper. Leading off the Plaza de la Independencia is the Xvenida 18 de Julio, the Fifth avenue of Montevideo. Buses, Montevideo's basic public transportation, taxis and private cars, directed by one of South America's few traffic light systems. crowd the avenue. with its shops, theatres. *cafe's* and business houses. Part way up 18 de Julio. Agraciada street, cut diagonally through city blocks, connects with the marble legislative palace, the most lavish public building in Uruguay. Agraciada is Montevideo's modernistic showplace. Avenida 18 de Julio continues to its end, the obelisk at the entrance of Batlle y Ordóñez park, location of the football stadium.

There are many other parks in the city, as well as a line of beaches extending out to the Atlantic. Of the beach suburbs. Pocitos, with its modernistic apartment buildings, is especially

noteworthy.

The climate of Montevideo, somewhat blustery in winter, is moderate, with the mean annual temperature around 62° F. Rainfall is adequate, around 44 in. a year. Montevideo is one of the few South American capitals where tap water, brought from the Santa Lucia river, is totally safe, but the city's rapid growth has outstripped expansion of the water pipe system.

Perhaps nowhere else in the world does a city predominate in a nation's political, industrial, commercial and cultural life to the extent that Montevideo does in Uruguay. The port of Montevideo handles the vast bulk of Uruguay's foreign trade. Most of the country's manufacturing industry is there too. The most striking proof of Montevideo's predominance is its population size in relation to the rest of the country. The total population of Uruguay was estimated at 2,800,924 in 1954. Of these, 810,000 live in the capital city, and 853,649, nearly one-third the total national population. live in the capital department, blontevideo. One result of Montevideo's size is that Uruguay has a metropolis with cultural and economic opportunities far exceeding those a country with such a small population otherwise could afford.

Commerce and Industry. — Four rail lines converge on Montevideo, bringing the products of the interior for use, processing and export. About 90% of Uruguay's exports are from its ranches, with wool increasingly dominating the economy. Numerous establishments in the capital process wool, and refrigerated packing plants in the Cerro district are equipped to prepare meats. In addition to export-oriented processing industries, Montevideo possesses the largest portion of Uruguay's internally oriented consumers' goods industries. Textile, shoe, soap, match and clothing factories are scattered throughout the city. Wines and dairy products, mostly for local consumption, are produced in Montevideo.

Uruguay's well-known state enterprises, the ANCAP (Administración Nacional de Combustibles, Alcohol y Portland) oil refineries and cement works, the railway shops and the electric power system are concentrated there. Public employees are a large segment of Montevideo's consumers. Much of the city's economy revolves around providing varied services for its large population, which is notably spread out territorially.

History.—Montevideo was founded in 1726 by Bruno Mauricio de Zabala, governor of Buenos Aires, to counteract the Portuguese advance into the area from Brazil. The first families came from the Canary Islands, lured by offers of cattle, sheep and respectability in the form of the title hidalgo. During its early years, Montevideo was mostly a Spanish garrison town. Trade expanded toward the end of the colonial period and Montevideo's merchants played an important part in securing Uruguayan independence. From 1807 to 1830 Montevideo was alternately occupied by British, Spanish, Argentine, Portuguese and Brazilian forces, and its trade and population suffered. Independence, which came in 1830, did not bring stability. Uruguay was the scene of complicated interaction of local, Argentine and Brazilian influences which culminated in the nine-year great siege of Montevideo by a combined Argentine-Uruguayan army from 1843 to 1851. Montevideo defenders were assisted by French and English forces which blockaded Buenos Aires. The result, surprisingly, was that Montevideo flourished during the siege and became the major port of the Rio de la Plata. The city's population in 1843 was estimated at 31,197, of whom 15,252 were noncitizen Europeans. The end of the great siege in 1851 and the restoration of normal trade patterns disrupted Montevideo's economy. The gradual development of the Uruguayan interior, spurred by railroad building outward from Montevideo, starting in the 1870s, and the installation of modern public utilities in the city, starting about the same time, gave Montevideo new life. A speculative building boom opened new suburbs. The collapse of the boom in the 1890s thoroughly slowed the city's growth, but in the 20th century its development has been rapid, as the following population figures for the department of Montevideo indicate: 1860, 58,000; 1908, 300,000; 1941 (est.) 750,000; 1954 (est.) 853,649.

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MONTEZ, LOLA (stage name of MARIE DOLORES ELIZA ROSANNA GILBERT) (1818–1861), adventuress and "Spanish" dancer. achieved international notoriety through her association with King Ludwig I of Bavaria.

Daughter of a British army officer, she was born in Limerick, Ire.: lived briefly in India! and was educated in England. At 19 she eloped with Capt. Thomas James; this marriage was dissol ed in 1842. After superficial study of dancing, she made a disastrous debut in London, in 1843 Nevertheless, her striking beauty brought her engagements in Germany, Poland and Russia. In 1844 she appeared unsuccessfully at the Paris Opéra. Late in 1846, she danced in Munich. King Ludwig became deeply infatuated, and under her influence inaugurated liberal and anti-Jesuit governmental policies. She was named countess of Lansfeld. In 1848, however, the animosity of the Bavarian people forced her to flee.

From 1851 to 1853, she danced and acted in America. After appearances in Australia, she lectured in America on fashion, gallantry, beautiful women and similar subjects. Lola Montez' second marriage (1849). to Lieut. George Heald, ended with his death. Her third, to Patrick Purdy Hall of San Francisco, terminated in divorce. She died in New York on Jan. 17, 1861.

See Isaac Goldberg, *Queen of Hearts* (1936). (LS. ME.)

MONTEZUMA II (MOCTEZUMA II) (1466–1520), the last Aztec emperor of Mexico, succeeded his uncle Ahuizotl in 1502. Montezuma's great competence as a military leader and the fact that he was a priest in the temple of the war god Huitzilopochtli ensured his election over that of his brothers. In accordance with tradition, his coronation was accompanied by mass human sacrifices and festivities. His rule tended to be despotic and oppressive and was occupied with many expeditions of conquest for territory and sacrificial victims, the suppression of insurrections and the erection of temples. The empire was enlarged by armies dispatched to Honduras and Nicaragua. Montezuma's reign was also accompanied by omens unfavourable to Aztec rule, notably that of the return of Quetzalcóatl, a tribal god or hero! white in colour and bearded, whose return was believed to be imminent. As Cortés and his men were regarded as fulfilling this tradition, Montezuma did not deal with them aggressively. He was made a prisoner of Cortés in Mexico City and an uprising against the Spaniards ensued under the leadership of Cuitlahautzin, Montezuma's brother. In an effort to divert the attack, Cortés induced Montezuma to address his people from the Spaniard's stronghold. The angry mob responded by showering him with stones and arrows. Afontezuma succumbed, either from wounds inflicted by the mob or at the hands of the Spaniards. (J. L. TR.)

MONTFAUCON, BERNARD DE (1655–1741), French scholar and critic, was born at the Château of Soulage, in France, on Jan. 13, 1655. He entered the army in 1672 and served for two years under Turenne. In 1675 he became a monk, and lived at various abbeys, going to Italy in 1698, and finally retiring to St.-Germain-des-Pres, where he produced most of his works, and died on Dec. 21, 1741. His editions of the Fathers include *Athanasii opera omnia* (1690), still the best edition: *Collectio nova patrum* (1706); *Joannis Chrysostomi opera omnia* (1718–38). In addition, he wrote *Diarium italicurn* (1702), an account of the libraries of Italy; and *L'Antiquité expliquée et représentée en figures* (1719), which laid the foundation of archaeology. The last two were translated into English. His *Palaeographia graeca* (1708) illustrated the whole history of Greek writing.

MONTFERRAT, COUNT OF, a title derived from a territory south of the Po and east of Turin, and held by a family who were in the 12th century one of the most considerable in Lombardy. In 1147 a count of Montferrat took part in the second crusade. In 1176 William Longsword, eldest of the five sons of Count William III., came to the kingdom of Jerusalem, on the invitation of Baldwin IV. and the baronage, and married the heiress of the kingdom, Sibylla. He died within a few months; but his wife bore a posthumous son, who became Baldwin V. Count William III., himself (uncle to Philip of France and

brother-in-law to Conrad III.) afterwards came to the Holy Land to watch over the interests of his grandson; and he was taken prisoner by Saladin at Hittin in 1187. Shortly after the battle of Hittin Count William's second son, Conrad, appeared. Conrad, following the family tradition, and invited by the emperor Isaac Angelus, had gone to serve at the court of Constantinople. He soon became important; married Isaac's sister, and defeated and killed a usurper; but he was repaid by ingratitude and suspicion, and fled to Palestine in 1187. Putting into Tyre he saved the city from the Mohammedan conquest which followed Saladin's victory at Hittin. He established himself firmly in Tyre (refusing admission to Guy, the king of Jerusalem); and from it he both sent appeals for aid to Europe and despatched reinforcements to the crusaders, who, from 1188 onwards, were engaged in the siege of Acre. His elder brother had been the husband of the heiress Sibylla, who had carried the crown to Guy de Lusignan by her second marriage, and on her death Conrad married her younger sister, Isabella, now the heiress of the kingdom, and claimed the crown (1190). The struggle between Conrad and Guy, supported by Philip Augustus and Richard I. respectively, paralysed the energies of the Christians in 1191. After the departure of Philip, Conrad fomented the opposition of the French to Richard, and even intrigued with Saladin against him. But Richard was finally forced to recognize him as king (April 1192). In the very hour of success, however, Conrad was struck down by the emissaries of the Old Man of the Mountain (the chief of the Assassins).

Another son of Count William III., Boniface of Montferrat, the younger brother of Conrad, was chosen leader of the fourth crusade in 1201, on the death of Theobald of Champagne. In the winter of 1201–02 he visited Philip of Swabia; and there he arranged the diversion of the fourth crusade to Constantinopie (see CRUSADES). Yet in the course of the crusade he stowed himself not unsubmissive to Innocent III., who was entirely opposed to such a diversion. After the capture of Zara, however, he joined the crusaders, and played a great part in all the events which followed till the capture of Constantinople by the Latins in 1204. But Baldwin of Flanders was elected emperor over his head; and his irritation was not wholly allayed by the grant of Macedonia, the north of Thessaly, and Crete (which he afterwards sold to Venice). In 1207 he was killed in battle with the Bulgarians. He left a son Demetrius, who assumed the title of king of Thessalonica, which the father had never borne (cf. Luchaire, *Innocent III.:* La question *d'Orient,* p. 190). In 1222 Demetrius lost his kingdom to Theodore Angelus, and the house of Montferrat its connection with the East.

MONTFORT, the name of a famous French family long seated at Montfort-l'Amaury, near Paris. Of them SIMON IV. DE MONTFORT (c. 1160–1218), a son of Simon III. (d. 1181), took part in the crusade against the Albigenses. Twice he went to Palestine as a crusader, and in 1209, answering the call of Pope Innocent III., he joined the host which marched against the enemies of the Church in Languedoc. He became vicomte of Béziers and of Carcassonne, and was soon the leader of the crusaders. He took place after place, defeated Raymond VI., count of Toulouse, at Castelnaudary, and about a year later (September 1213) gained a victory over Raymond's ally, Peter II., king of Aragon, under the walls of Muret. Simon then turned his attention to administering Languedoc. The pope, somewhat reluctantly, confirmed him in the possession of the greater part of the lands of the count of Toulouse; and after two more years of warfare Simon mas killed while besieging the city of Toulouse on June 2j, 1218. For his youngest son, the earl of Leicester, see MONTFORT, SIMON DE.

Simon IV's eldest son, AMAURY DE MONTFORT (1192–1241), was unable to hold his own, although Philip Augustus sent some troops to his assistance in 1222. He abandoned his interests in the south of France in favour of the new king Louis VIII and, in 1239, went on crusade to the Holy Land, dying soon afterwards at Otranto. In 1230 he had been made constable of France. For John of Montfort, duke of Brittany, see BRITTANY.

MONTFORT, SAINT LOUIS MARIE GRIGNION DE (1673–1716), French priest, founder of two religious congregations and apostle of devotion to the Blessed Virgin Mary, was born the son of Jean Baptiste Grignion at Montfort-sur-Meu, Brittany, Jan. 31, 1673. After eight years as a student at the Jesuit college at Rennes, and two years of clerical studies, he entered the Seminary of St. Sulpice, Paris, where he was ordained a priest in 1700. He went to Nantes as a rural preacher, and then to Poitiers, where he reorganized a hospital for the poor and began the Congregation of the Daughters of Wisdom. Named (1706) apostolic missionary for France by Pope Clement XI, he spent the rest of his life zealously preaching parish missions in western France. In 1705 he founded the Company of Mary (Montfort Fathers), a missionary congregation, to continue his work.

Montfort died at the age of 43 at St. Laurent-sur-Sèvre, on April 28, 1716, and was canonized July 20, 1947. His feast day is April 28.

Although primarily a parish missioner, Montfort is best known as the author of True Devotion to *the* Blessed Virgin, whose doctrine is that true devotion to Mary is the best means to the love and possession of Wisdom Incarnate, Christ crucified, the supreme goal of life. The teaching of this book is fully understood only in the context of another of his books, The Love of Eternal Wisdom, the synthesis of his whole spirituality.

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MONTFORT, SIMON DE, EARL OF LEICESTER (c. 1200–1265), English statesman and soldier, was born in France, the fourth and youngest son of Simon IV. de Montfort (see above), the leader of the Albigensian crusade. Simon IV., whose mother was an heiress of the Beaumont family, claimed in her right, and received from King John, the earldom of Leicester (1207), only to lose it again through espousing the French side in the wars between that sovereign and Philip Augustus.

The young Simon, of whose youth nothing is recorded, came to England in 1230 and attached himself to Henry III., obtaining with the consent of his sole surviving brother Amaury a re-grant of the family earldom. Simon was for a time unpopular and closely attached to the royal party. He gave, however, an early proof of religious fervour, and of an unbending harshness, by the expulsion of the Jews from his borough of Leicester. In 1238 he married the king's sister Eleanor, the widow of the younger William Marshal. The match was resented by her brother Richard of Cornwall and the baronage on the ground that Eleanor had taken vows of chastity. With some difficulty Earl Richard was pacified; and Montfort obtained the pope's confirmation of the marriage by a personal visit to Rome. In 1239, however, the influence of detractors and a quarrel over some obscure financial transactions in which he appears to have used Henry's name without a formal warrant led to a breach between himself and the king. The earl and his wife went to France; and, though a nominal reconciliation with the king was effected, both departed on crusade with Richard of Cornwall in 1240. Returning in 1241, Simon took part in Henry's disastrous French expedition of 1242, and was readmitted to full favour.

He stood forward in parliament as a mediator between the court party and the opposition, and was keenly interested in Grosseteste's proposals for ecclesiastical reformation. In 1248 he again took the cross, with the idea of following Louis IX. to Egypt, but at the requests of the king and council, he gave up this project to act as governor in the disaffected duchy of Gascony. Bitter complaints were excited by his rigorous suppression of the excesses of the seigneurs and of contending factions in the great communes. Henry yielded to the outcry and instituted a formal inquiry into the earl's administration. hiontfort was formally acquitted on the charges of oppression, but his accounts were disputed by the king, and he retired in disgust to France (1252).

The nobles of France offered him the regency of the kingdom, vacant by the death of the Queen-mother Blanche of Castile, but he preferred to make his peace with Henry (1253), in obedience to the exhortations of the dying Grosseteste. He helped the king in dealing with the disaffection of Gascony; but their reconcilia-

tion was a hollow one, and in the parliament of 1254 the earl led the opposition in resisting a demand for a subsidy. In 1256–57, when the discontent of all classes was coming to a head, Montfort nominally adhered to the royal cause. He undertook, with Peter of Savoy, the queen's uncle, the task of extricating the king from the pledges which he had given to the pope with reference to the crown of Sicily; and Henry's writs of this date mention the earl in friendly terms. But at the "Mad Parliament" of Oxford (1258) Montfort with the earl of Gloucester headed the opposition. It is said that he was reluctant to approve the oligarchical constitution created by the Provisions of Oxford, but his name appears in the list of the Fifteen who were to constitute the supreme board of control over the administration. There is better ground for believing that he disliked the narrow class-spirit in which the barons used their victory; and that he would gladly have made a compromise with the moderate royalists. But the king's success in dividing the barons and in fostering a reaction rendered such projects hopeless. In 1261 Henry revoked his assent to the Provisions, and Montfort left the country in despair.

He returned in 1263, at the invitation of the barons, who were now convinced of the king's hostility to all reform; and raised a rebellion with the avowed object of restoring the form of government which the Provisions had ordained. For a few weeks it seemed as though the royalists were at his mercy; but he made the mistake of accepting Henry's offer to abide by the arbitration of Louis IX. of France. At Amiens, in Jan. 1264, the French king decided that the Provisions were unlawful and invalid. Montfort at once resumed the mar, and thus exposed himself to accusations of perjury, from which he can only be defended on the hypothesis that he had been led to hope for a genuine compromise. Though merely supported by the towns and a few of the younger barons, he triumphed by superior generalship at Lewes (May 14, 1264), where the king, the Lord Edward, and Richard of Cornwall fell into his hands. Montfort used his victory to set up the government by which his reputation as a statesman stands or falls. The weak point in his scheme was the establishment of a triumvirate (consisting of himself, the young earl of Gloucester and the bishop of Chichester) in which his colleagues were obviously figureheads. This flaw, however, is mitigated by a scheme, which he simultaneously promulgated for establishing a thorough parliamentary control over the executive, not excepting the triumvirs. The parliament which he summoned in 1265 was, it is true, a packed assembly; but it can hardly be supposed that the representation which he granted to the towns (*see* PARLIAMENT and REPRESENTATION) was intended to be a temporary expedient.

The reaction against his government was baronial rather than popular; and the Welsh Marchers particularly resented Montfort's alliance with Llewellyn of North Wales. Little consideration for English interests is shown in the treaty of Pipton which sealed that alliance (June 22, 1265). It was by the forces of the Marchers and the strategy of Edward that Montfort was defeated at Evesham (Aug. 4). For years after his death he was revered by the commons as a martyr, and the government had no little difficulty in reducing the remnants of his baronial supporters. He was undoubtedly harsh, masterful, and ambitious; but no mere adventurer could have won the friendship of such men as Adam Marsh and Grosseteste; their verdict of approval may be the more unhesitatingly admitted since it is not untempered with criticism.

The original authorities are those for the reign of Henry III. The best biographies are those by R. Pauli (trans. C. M. Goodwin, 1876); G W. Prothero (1877); C. Bémont (1884). *See* also the letters of Adam de Marsh in J. S. Brewer's *Monumenta franciscana*, vol. i. (Rolls series, 1858); H. R Luard, *Epistolae Roberti Grosseteste* (Rolls aeries, 1861); F. S. Stevenson, *Grosseteste* (1899); W. H. Blaauw, *The Barons' War* (1871); *T*. S. Bateman, *Simon de Montfort* (1923); E F. Jacob, *Studies in the Period of Baronial Reform and Rebellion 1258–67* (1925). (H. W. C. D.; X.)

MONTGOMERIE, ALEXANDER (*c.* 1545–*c.* 1611), Scottish poet, one of the last of the "makaris" (poets writing in Scots) of the 16th century, was the son of John Montgomerie, laird of Hessilheid in Ayrshire. He enjoyed the favour ot James VI, and nas awarded a pension of 500 marks in 1583 but a lengthy and unprofitable lawsuit arose over payment. Montgomerie's pro-Catholic political intrigues brought about his disgrace when he was implicated in the Ladyland plot of 1597. He was abroad from 1586 to 1591. perhaps on the king s service, and suffered imprisonment, for which he blamed the king in some bitter verses.

Montgomerie s contemporary reputation mas high. and during the 17th and 18th centuries his best-known poem, *The Cherrie and the Slae*, was reprinted many times. This poem, first printed in 1597 and later enlarged, is an allegory in the medieval manner, fresh in its descriptions but conventional in its May morning setting and in such figures as Danger, Dreid, Reason, Curage and Dispaire whose intricate and tedious debate fills the larger part. The poet's dilemma is whether to struggle toward the noble cherry tree on the crag or to be content with the sloe bush at his feet. The poem was printed by Allan Ramsay in *The Ever Green* (1724), and its long stanza was revived by Robert Burns in "The Jolly Beggars." Montgomerie's other poems include the scurrilously inventive "Flyting betwixt Montgomerie and Polwart" (1621); some versions of the Psalms; and a large number of sonnets, lyrics and songs, the best of which reveal a fluent and radiant talent for love poetry. Montgomerie's poems were edited by J. Cranstoun for the Scottish Text society (1887), with a supplementary volume edited by G. Stevenson (1910); *The Cherrze and the Slae* was edited by H. H. Wood (1937).

See C. XI. Maclean, *Alexander Scott, Montgomerie, and Drunznzond of Hawthornden as Lyric Poets* (1915). (E. G M.)

MONTGOMERY, JAMES (1771–1854), British poet and journalist, son of a Moravian minister, was born on Nov. 4, 1771, at Irvine in Ayrshire, Scotland. Part of his boyhood was spent in Ireland, but he received his education in Uorkshire, at the Moravian school of Fulneck near Leeds. He edited the *Sheffield Iris* for more than 30 years. As a journalist he advocated parliamentary reform, and was twice imprisoned (in 1795 and 1796). His *Wanderer of Switzerland* (1806), describing the French occupation, attracted the attention of Lord Byron, who declared, in a footnote to *English Bards and Scotch Reviewers,* that the book was worth a thousand "Lyrical Ballads." Montgomery wrote several volumes of verse, humanitarian and religious in sentiment. In *Pelican Island,* his last and best work as a poet, he evidently took Shelley as his model. His reputation now rests chiefly on his hymns. He died at Sheffield on April 30, 1854.

MONTGOMERY, RICHARD (1738–1775), British and American army officer,was born in County Dublin, Ire, on Dec. 2, 1738. Educated at Trinity college. he entered the British army in 1756 and took part in the Seven Years' War. He returned to England and became well acquainted with members of the parliament interested in development of American colonies. In 1772 he left the army, settled in New York and married a daughter of Robert R. Livingston, a justice of the New York supreme court. In 1775 he served as a delegate to the provincial congress and became a brigadier general in the continental army. When sent to invade Canada he was hampered by harsh weather and undisciplined troops but managed to capture Montreal and meet Benedict Arnold's contingent. They pushed on to Quebec barely 800 strong, but in the assault on Dec. 31, 1775, Montgomery mas killed. His body was interred by the Quebec garrison, but was removed in 1818 to St. Paul's church. New York city, where congress had provided a memorial. (H. H. P.)

MONTGOMERY, ROBERT (1807–1855), English poet, natural son of Robert Gomery, was born at Bath in 1807. He was educated at a private school in Bath, and founded an unsuccessful weekly paper in that city. In 1828 he published *The Omnipresence of the Deity,* which hit popular religious sentiment so exactly that it ran through eight editions in as many months. In 1830 followed *The Puffiad* (a satire), and *Satan.* His name was immortalized by Macaulay's famous onslaught in the *Edinburgh Review* for April 1830. This exposure did not, however, diminish the sale of his poems. *The Omnipresence of the Deity* reached its 28th edition in 1858. In 1830 Montgomery entered Lincoln college, Oxford; he took orders in 1835, and held various preferments. He died at Brighton in 1855.

MONTGOMERY, a tonn. with tehsil (administrative sub-

division), and a district in the Multan division of West Pakistan. Pop. (1951): town 50,158; tehsil 603,732. In 1865 the village Sahiwal was chosen as the headquarters of the district and renamed Montgomery. The town. 95 mi. S.W. of Lahore, is well built to a plan. It is an important cotton market, and is the seat of two colleges connected with Punjab university.

MONTGOMERY DISTRICT lies in the Bari Doab, or tract between the Sutlej and Ravi rivers, extending also northwestward across the latter. Area, 4,208 sq.mi.; pop. (1951) 1,816,120. The principal crops are wheat, cotton, pulses and oilseeds. The leading manufactures are of cotton and of lacquered woodwork, and there are factories for ginning and pressing cotton. Okara (35,350) has a cotton spinning and weaving factory.

From time immemorial the Bari Doab formed the home of a wild race of pastoral tribes. The important archaeological site of Harappa in this district indicates a very early connection between the northwestern part of the subcontinent and Sumerian culture. Ruins at Kamalia, Akbar, Satghara and Bavanni mark the sites of forgotten towns. The district came under British rule in 1849. There was a rising of the clans during the Mutiny of 1857.

MONTGOMERY, the capital of Alabama and seat of Montgomery county. located on a sharp bend on the Alabama river at the head of navigation of that stream, is one of the older and more historic cities of the deep south. The city has an average temperature in January of 48.9" F. and in July of 81.7°; the annual mean temperature being 65.6°. The annual rainfall is 5.73 in. Pop. (1960) city 131,393; standard metropolitan statistical area (Montgomery county) 169,210. For comparative population figures *see* table in ALABAMA: *Population.*

History.—Montgomery's early history is a story of Indians, Spaniards and Frenchmen, squatters and traders, speculators and settlers. In its earliest history the site of Montgomery was inhabited by the mound builders. Later, Indians migrated to the region and established their towns of Towassi and Econchati on the same ground. In 1540 De Soto and his entourage camped on the site. The Frenchman Jean Baptiste le Moyne, Sieur de Bienville, headed an expedition up the Alabama river and in 1715 built Ft. Toulouse a short distance above the present site of Montgomery. During the American Revolution the site was headquarters for the British sympathizers in the area.

The territorial government of Alabama was established in 1817 and the land in the new territory was sold in August at the Milledgeville, Ga., federal land office. John Scott and Andrew Dexter bought the land on which the present city of Montgomery is located. Shortly after the land sale three towns, New Philadelphia, East Alabama and Alabama were established on the site. In Dec. 1819, the legislature of Alabama chartered these three consolidated towns as Montgomery. The name was chosen in honour of Brig. Gen. Richard Montgomery, who was killed at Quebec in 1775.

The new town became the home of Georgians, Carolinians and Virginians who joined the westward movement. It was chartered as a city in 1837; in the 1840s it became one of the most important inland towns in the region. It was an important political centre for its immediate vicinity as well as the state as a whole and became the state capital in 1847. During the next few years it became the centre of southern political opinion in the secession movement and eventually became the first capital of the Confederacy in 1861. It was captured by federal troops in 1865.

Montgomery's recovery from the American Civil War was slow. Because of its central geographic location in the state and its being the state capital it benefited from the expansion of railroads in the 1880s. In the 20th century industrialization and population increased steadily.

The city has many points of historic and artistic significance. Among these are the present state Capitol, which was the first capitol of the Confederacy. It stands on a hill at the head of the main business street and is one of the finest examples of Georgian architecture in the U.S. It was there that Alabama voted to secede from the union on Jan. 11, 1861, and the Confederate States of America was organized there on Feb. 4, 1861—hence the popular designation of Montgomery as the "Cradle of the Confederacy." Other important buildings are the first White House of the Confederacy. where Jefferson Davis resided and which contains a collection of his personal belongings; the state's department of archives and history, which contains one of the largest collections of historical materials on the south and also extensive museum collections; the Museum of Fine Arts, which contains several historic collections; and the Alabama State coliseum, which contains one of the largest indoor arenas in the U.S.

Commerce and Industry. — Montgomery is an important centre and market for cotton, livestock, yellow pine and hardwood; it has many jobbing and wholesale businesses and is one of the principal cities in the nation for the manufacture of commercial fertilizer. It is the largest cattle market in the southeast, marketing approximately $30,000,000 worth of cattle annually. There are three large stockyards with full facilities for handling sales to the several local packing plants and to those in distant cities. Surrounding the city are rich farmlands and cattle ranches.

Montgomery is the site of Maxwell and Gunter air force bases. Maxwell is headquarters of the Air University system, consisting of the Air War college, Air Command and Staff college, Research Studies institute and the Air University library. Gunter is the location of the U.S. air force Extension Course institute and a branch of the School of Aviation Medicine. The personnel of these bases add much to the civic, commercial and cultural life of Montgomery. In addition to these air force bases, Montgomery has a fine municipal airport, Dannelly field.

Education, Communication and **Recreation.**—Montgomery has several private schools as well as an extensive public-school system. Facilities for higher education include Huntingdon college. a Methodist college established in 18.54; Alabama State college, moved to Montgomery from Marion in 1887; and a centre of the University of Alabama.

There are two daily papers and one weekly; the *Advertiser,* a morning paper. has been published continuously since 1828. The city has a number of parks. covering approximately 500 ac. The Blue and Gray football game, in which a picked team from the north meets a similar team from the south, has been played annually at Cramton bowl in Montgomery since 1939. on the last Saturday in December. The receipts go to charity.

Montgomery Bus Boycott. — Led by the Rev. Martin Luther King, who was a minister in Montgomery. Negroes organized a peaceful boycott of the public buses in Dec. 1955 as a protest against segregation. The boycott ended a year later when bus segregation mas prohibited by court order. (G. T. C.)

MONTGOMERY (Welsh, TREFALDWYN), a municipal borough in the Montgomery parliamentary division and titular county town of Montgomeryshire, Wales; the seat of country administration is Welshpool. Pop. (1951) 904. Area 5.3 sq.mi. Montgomery is a quiet market town, with a cattle market and industries associated with agriculture, built at the meeting place of two valley ways (via Minsterley and via Bishop's Castle) from England. It was a walled town and the original bank and ditch still remain. It lies within a mile of the English border, marked there by Offa's dike; under a steep wooded cliff which dominates the lowland area where the Camlad river, flowing from England, joins the Severn. There is above the town a camp occupied since Neolithic times, and to the northwest a Roman camp. Above the town rises the Castle hill with the ruins of a castle, built about 1072 by the Norman Roger de Montgomery, from whose ancestral home the fortress took its name; the present castle was built (1223) by Henry III.

The Welsh name (Baldwyn's Town) comes from that of the builder of the second castle on the site, Baldwyn de Boller, who held it for Henry I. The first charter was granted in 1227. The crown gave it, in the 15th century, to the Herberts, one of whom in 1644 surrendered it to the Parliamentarians, who dismantled it. The beautiful old parish church, originally a chapel for the nearby abbey of Chirbury. is dedicated to St. Nicholas; it contains the Elizabethan canopied tomb of Richard Herbert of Montgomery castle.

MONTGOMERY OF ALAMEIN, BERNARD LAW MONTGOMERY, 1ST VISCOUNT (1887–), British field

marshal, one of the outstanding military leaders of World War II, was born in London on Nov. 17, 1887; he was the son of Bishop H. H. Montgomery, of north Irish stock, and was educated at St. Paul's school and at Sandhurst Royal Military academy. Having served with distinction in World War I, he was recognized as a first-rate trainer of troops, with his forcible insistence on physical fitness, youth and efficiency in leaders. In World War II he commanded a division in France and held the southeastern command in England before succeeding to the command of the British 8th army in Egypt (Xug. 1942). There he restored the troops' shaken confidence and, combining drive with caution, inaugurated an unbroken series of successes in Africa and Europe by defeating Rommel at El Xlamein (Oct.–Nov. 1942), pursuing the Germans to their surrender at Tunis, and then invading Sicily and Italy. Under the supreme command of Gen. Dwight D. Eisenhower, Montgomery commanded the Allied armies which broke into Normandy in June 1944, and led the 21st army group (British and Canadian) through northern France and across the Rhine to receive the German surrender on Lüneburg heath on May 4, 1945.

After commanding the British Army of the Rhine, Montgomery served as chief of the imperial general staff (1946–48), chairman of the Western Europe Commanders'-in-Chief committee (1948–51), and deputy supreme Allied commander in Europe (1951–58) in NATO. Convinced that it is important for a commander's personality to impress itself on his troops and fellow countrymen if their confidence is to be won, Montgomery made himself one of the best-known figures of the day. His periodical pronouncements on strategy and military organization aroused widespread interest, as did the publication of his *Memoirs* in 1958. (J. R. M. B.)

MONTGOMERYSHIRE (Welsh *Sir Drefaldwyn*), a county of Wales. bounded north by Denbigh, northeast and east by Shropshire, south by Radnor and Cardigan. west and northwest by Merioneth. Its length from southeast to northwest is about 30 mi., and from northeast to southwest about 35 mi. Area 797 sq.mi. Pop. (1951) 45,990.

It occupies, in general. the valleys of the upper Severn and its tributaries. collected from the plateau under the Berwyn mountains on the northwest by the Severn river. which flows to the north-northeast; while the valley of the Dyfi (Doveyj opens onto Cardigan bay in the west. The dissected plateau of the northwest has heights varying from 1.500 ft. toward the Berwyns (which rise to 2,713 ft.) to 500 ft. in the east. In the southwest the county meets Cardigan on the Plynlimon moors (more than 2,000 ft.), while Rhyd Hywel and the Kerry hills (1,600 ft.) form the boundary on the south. On the Shropshire border most of the conspicuous Breidden hills (1,202 ft.) are included, and also Corndon hill (1,684 ft.). which forms a part of the group of hill ridges of ancient rock including Stiperstones and Long Mynd in Shropshire. In the Breiddens and in Corndon are large laccoliths of dolerite, quarried for road metal. On the edge of Clun forest the Old Red Sandstone crosses the Montgomeryshire border. For the rest the rocks are almost exclusively Ordovician and Silurian, with numerous metalliferous veins (lead, silver and zinc) which have been worked from time to time. The Silurian rocks are mainly Wenlock beds with a fringe of Llandovery rocks, and they lie in the form of a complex syncline down the centre of the county from Lake Vyrnwy to Llanidloes and Newtown. Glacial deposits cover a large proportion of the county. For the most part the shales and grits of the hilly regions are grass grown, but frequently boggy in the flatter moorland areas. The low entrances from England. the Severn and Rea valleys, are floored with alluvium and. though fertile. are liable to floods.

The moorland plateau of northern Montgomeryshire, from the Berwyn range to the Severn valley. is seamed by the deep tributary valleys of Tanat, Vyrnwy, Banwy and Rhiw. The upper Wye valley is included in this corner of the county. (X.)

History. — The earliest known living site in the central marches of Wales is a Neolithic open settlement on Ffridd Faldwyn, above the town of Montgomery. covered by a later hill fort of the Early Iron Age. Traffic in axes of stone and flint passing this may followed valley routes between north and south Wales, whereas many of the round barrows of the ensuing Bronze Age are on high ground and are related to moorland ridgeways, notably that along the Kerry hills which formed part of a west-east trade route from Cardigan bay to the lower Severn valley by way of the south Shropshire hills. The upper Severn valley was always an important line of diffusion. Distribution of stone and bronze implements also indicates ways following natural passes, such as the Carno-Dyfi route in the west of the county. the Bwlch-y-Fedwen in the northwest and the Tanat valley in the northeast. Otherwise the hill country of central Montgomeryshire suggests little evidence of occupation until the Early Iron Age. when the eastern part of the county was thick with hilltop camps. including a number of major hill forts, with penetration westward from the Severn basin. The builders of these strongholds may have been the introducers of Brythonic speech. The wedge of invasion thus indicated formed the basis for the geographical distinction of the future Powys and the shire of Montgomery. (L. F. Cy.)

The Roman occupation of Wales was primarily a military one, although this does not preclude peaceful relations with the native inhabitants. In Montgomerj-shire the principal Roman forts are the Forden Gaer (*Lavobrinta* ?) and Caersws (*Mediomanum* ?), both in the Severn valley, with smaller forts at Llanfair Caereinion on the road from Caersws to Chester, at Carno and probably at Cae Gaer near the source of the Wye and the Plynlimon lead mines, as well as at Pennal, just over the Merioneth border in the Dyfi estuary and on the road from Carmarthen to Caernarvon.

The dark ages were eventually lightened by the spread of Christianity through the efforts of the Celtic saints. St. Garmon, St. Tysylio and St. Beuno who are particularly associated with this area. The Anglo-Saxon invasion reached the borders of Wales about A.D. 600 and the supremacy of Mercia under its rulers Penda and Offa has left its mark in the immense mid 8th-century earthwork of Offa's dyke (National Trust). which in Montgomeryshire stretches from Carreghofa in the north to Castlewright in the south. with the exception of about three miles under the Breidden hills where the Severn took its place. By the time of Domesday Book the English had crossed the dyke, but their place names are not found beyond the Severn.

The unification of Wales under Rhodri Mawr (d. 877) was of short duration and three principal divisions of the country emerged. of which Powys, which at one time stretched from Mold as far south as Glasbury-on-Wye, was the central one. About 1200 Powys became divided between two branches of the descendants of Bleddyn ap Cynfyn into Powys Fadog, north of the Berwyns, and Powys Wenwynwyn, corresponding closely to the modern Montgomeryshire. The coming of the Normans chiefly affected the eastern part of Powys; a line of motte-and-bailey castles thrust westward from Roger de Montgomery's stronghold of Shrewsbury and terminated in his castle at Montgomery (named from his Norman patrimony), built near the Roman site of the Forden Gaer to control the ford of Rhydwhiman, while Roger's possessions were flanked by the FitzAlan lordships of Oswestry and Clun to north and south.

The principal family on the borders of Powys in the middle ages was that of the Llortimers, while the interior was largely held by the Charltons and their successors as heirs through marriage of the old Welsh rulers. The whole area was mainly Yorkist in sympathy during the Wars of the Roses. The central and south Welsh marches remained unshired through the late mediaeval period and it was not until 1535 that the present county was formed, based physically on the old principality of Powys but administratively on the royal fortress of Montgomery on its extreme eastern border. During the middle ages the civilizing force of the Cistercian monasteries had been followed by the introduction of Flemish families in the 14th century and. as a result of the activities of both of these. Powys became one of the leading wool-producing and manufacturing regions of Wales; the flannel industry of the county maintained its pre-eminence until the end of the 19th century.

In the Great Rebellion the sympathies of the county were mainly with the king. but the principal royalist strongholds. Montgomery and Powis castles, put up little effective resistance. The predominant influences in the 17th, 18th and 19th centuries were

those of the Herberts and, in the north of the county the Vaughans of Llwydiarth and their heirs the Wynns of Wynnstay. These families and their connections held a practical monopoly of the parliamentary representation.

The county seat, held by the Liberals since 1880, was still held by them in the mid-1950s. The seat of the Montgomery boroughs was abolished in 1918. (J. D. K. L.)

Trade, Communications and Agriculture. — The late 18th and early 19th centuries witnessed a great development of means of communication, canals and coach roads within the county and trade increased rapidly. In 1794 the Montgomeryshire Canal act was passed, which provided for the construction of a branch canal from the Ellesmere canal to Welshpool, with a future extension to Newtown; the canal is now disused. The factory system and the new facilities for communication caused the flannel industry to gravitate to the larger centres; *e.g.,* Welshpool, Newtown, Llanidloes (*q.v.*) and Machynlleth (*q.v.*), but it later declined in all these places. The British railways (Western region) main line runs from Shrewsbury to Machynlleth and the west coast. There are several branch lines.

Another industry besides that of flannel manufacture which fell into decay was lead mining, formerly carried on extensively in the Llanidloes district in the south and in the neighbourhood of Llangynog in the north. Attempts have been made to resuscitate some mines and to get metal from the waste tips which disfigure many of the higher hill slopes. Slate quarrying was carried on at Llangynog and in the Machynlleth district, while hard stone for building and road mending is found in various parts.

Montgomeryshire has considerable areas of rich farm land in the valleys and east of the county, with rolling country rising to purely hill pastures in the west. Commercial cattle and sheep raising are important. Kerry Hill sheep are indigenous. Considerable milk is produced on the lowland farms. Rough grazings cover 40% of the county and 85% of the remaining area is under grass. Oats and mixed corn are the chief crops, and small family farms predominate. Montgomeryshire is said to be the best wooded of all the Welsh counties, hedgerow timber being specially characteristic.

The county was formerly a recognized source of oak timber for the navy. After 1880 there was much planting of soft woods on the hill slopes below 1,000 ft., the Kerry hills being thickly timbered before 1914. Extensive new areas of hill land. particularly in the southwest of the county on the Plynlimon slopes and in the northwest round the Liverpool corporation reservoir were being planted as state forests in the 1950s.

Population and Administration. — The population in 1951 was 45,990. The peak was reached in the mid-19th century (69,607 in 1841); since then the population has steadily decreased except for a temporary 6% increase between Sept. 1939 and Feb. 1941 caused by wartime movements. This increase however has continued in Newtown and Welshpool. Much Welsh is spoken in the mountain regions of the west and north but the towns and lowlands (except the Dyfi and upper Severn valleys) are almost exclusively English in speech.

Llanfyllin (pop., 1951, 1,421), Llanidloes (2,341), Montgomery (904) and Welshpool (6,036) are municipal boroughs, while Machynlleth and Newtown are urban districts. There are four rural districts and 62 civil parishes. The county is in the Wales and Chester circuit, assizes being held at Welshpool. (H. Cr.)

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MONTH. In astronomy, a month, or lunar month, is the period of time required for the moon to make a revolution with respect to some point in the heavens. The synodic (ordinary) month is measured with respect to the sun; it is thus the average interval between successive new moons. The modern calendar disregards the moon completely; for a discussion of calendar months, *see* Calendar. Other kinds of lunar month are defined as follows: tropical, the average period required for the moon to undergo an increase in orbital longitude of 360°, as measured from the equinox; sidereal, the average period of revolution of the moon with respect to the stars; anomalistic, the average interval between successive passages of perigee, *i.e.,* successive closest approaches of the moon to the earth; nodical, the average interval between successive northward passages of the moon across the ecliptic. Because of perturbations of the moon's orbit, the lengths of the months vary. Average values (in days) are: synodic, 29.530588; tropical, 27.321582; sidereal, 27.321661; anomalistic, 27.554550; nodical, 27.212220. *See* Moon. (W. Mz.)

MONTHOLON, CHARLES TRISTAN, Comte De (1782–1853), was born at Paris. He was trained for a military career, and in his tenth year shared in the expedition of Admiral Truguet to the coast of Sardinia. Entering the army in 1798, he rose with rapidity and avowed himself, when *chef d'escadron* in Paris at the time of the coup d'etat of Brumaire (Nov. 1790), entirely devoted to Bonaparte. He served with credit in the ensuing campaigns, and distinguished himself at the battle of Aspern-Essling (May 1809) when he was wounded. At the end of that campaign on the Danube he received the title of count and remained in close attendance on Napoleon, who confided to him several important duties, among others, a mission to the Archduke Ferdinand at Würzburg. He and his wife accompanied the former emperor to St. Helena. To Montholon chiefly, Napoleon dictated the notes on his career.

In a letter written to his wife he admitted that Napoleon had died of cancer, though he afterward encouraged the belief that death mas due to a liver complaint aggravated by the climate and by the restrictions to which Napoleon was subjected. After that event Montholon became reconciled with Sir Hudson Lowe; but this did not prevent him, on his return to France, from vilifying that much abused man. Col. Basil Jackson found him very frank as to the *politique de Longwood* which aimed at representing Napoleon as a martyr and Sir Hudson Lowe as his persecutor.

In 1840 he acted as "chief of staff" in the absurd "expedition" conducted by Louis Napoleon from London to Boulogne. He was condemned to imprisonment at Ham, but was released in 1847; he then retired to England and published the *Kecits de la captivité de Napoléon a Ste Hélène.* In 1849 he sat in the legislative assembly. He died on Xug. 21, 18j3.

MONTI, VINCENZO (1754–1828), Italian poet in the neoclassical tradition, author of a fine translation of the *Iliad,* was born at Alfonsine (Romagna), Feb. 19, 1754. He went to Rome in 1778 and wrote poems inspired by Catholicism and enthusiasm for the papacy (*Il pellegrino apostolico,* 1782; *La Bassvilliana,* 1793). When the French invaded Italy he became their supporter, attacking the papacy with *Il fanatismo* and *La superstizione* (publ. together, 1797), and singing Napoleon's victories (*Prometeo, Il bardo della Selva Nera, La spada di Federico II;* 1806). Napoleon rewarded him by appointing him professor of poetry at. the University of Pavia. After the fall of the empire, he extolled the Austrian government. He died in Milan, Oct. 13, 1828.

Lack of political conviction was the cause of Monti's many changes of mind. As a poet, he has considerable merit. Some parts of the *Bassvilliana* and of another early poem, *La bellezza dell'universo,* and many of his shorter lyrics, are excellent. But Monti's masterpiece is his translation of the *Iliad* (1810), which remains one of the achievements of the neoclassical age. The best edition of Monti's poems is by G. Carducci (1858–69).

See G. Reichenbach, *V. Monti* (1930). (F. Di.)

MONTICELLI, ADOLPHE JOSEPH THOMAS (1824–1886), French painter of Italian origin, noted for his mood-evoking use of colour and texture, was born in Marseilles on Oct. 14, 1824. After early studies in his native town, he worked in Paris under Paul Delaroche. But his real teachers were the great masters at the Louvre: the Venetians, Rembrandt, Watteau and Monticelli's personal friend Eugène Delacroix. He returned to Marseilles and remained about 15 years. His personal style developed toward 1860 and brought him considerable recognition in Paris, where he returned in 1863. He received from Napoleon III a commission for the Tuileries palace and sold to many foreign collectors, especially in Scotland. The war of 1870 obliged him to flee Paris and

he returned to Marseilles on foot. He died in Marseilles on June 29. 1886. Monticelli had memorial exhibitions: in Paris in 1908 and 1953; and in Marseilles in 1936. Later artists found his swirling impasto effects and violent colour particularly interesting. Examples of his works are in the Metropolitan museum, New York, and the Sational gallery. Washington, D.C.

See Armand Agrel and Emile Isnard, *Monticelli* (1926); Gustave Coquiot, *Monticelli* (1926). (M. N. B.)

MONTLUC (or MONLUC), **BLAISE DE LASSARAN-MASSENCÔME,** SEIGNEUR DE (*c.* 1502–157j), marshal of France. was born at Condom (Gers). He served first as a private archer and man-at-arms in Italy, with Bayard for his captain, fought all through the wars of Francis I. and was knighted on the field of Cérisoles (1544), to which victory he had brilliantly contributed as adviser to the young duke of Enghien. His chief feat was the famous defence of Siena (1555). which he has told so admirably. When the religious wars broke out in France, Montluc, a staunch royalist, held Guyenne for the king. Henry III made him in 1574 marshal of France. an honour which he had earned by nearly half a century of service and by numerous wounds. He died at Estillac near Agen in 1577. Montluc's eminence above other soldiers of his day is due to his *Commentaires de Messire Blaise de Montluc* (Bordeaux, 1592), in which he described his fifty years of service (1521–1574).

MONTLUÇON, a town of France, capital of an *arrondissement,* and the most important industrial centre in the *département* of Allier. Pop. (1954) 46.994. It is on the Cher, 50 mi. S.W. of Moulins by rail. The upper town has steep. narrow. winding streets with several buildings of the 15th and 16th centuries; the lower town. traversed by the Cher, produces glass, chemicals, sewing machines. and iron and steel, and trades in grain, wood, chemicals. candles, earthenware, marble, glass, pneumatics and artificial silk and woollen goods. The Commentry coal mines and Néris, a town with thermal springs, are to the southeast. Of the churches. Notre-Dame is of the 15th century and St. Pierre has a 12th century transept. The town hall. with a library. occupies the site of an old Ursuline convent. There is also the castle rebuilt by Louis II, duke of Bourbon, and taken by Henry IV during the religious wars. The town, which formed part of the duchy of Bourbon. was taken by the English in 1171, and by Philip Augustus in 1181; the English were beaten there in the 14th century.

MONTMORENCY, the name of one of the oldest and most famous French noble families. traceable to the 10th century, is derived from Montmorency (Seine-et-Oise). MATTHIEU I, sire de Montniorency, received in 1138 the post of constable (which a member of the family had held in 1060) and died in 1160. His first wife was Aline, the natural daughter of Henry I of England; his second, Adelaide of Savoy. widow of Louis VI and mother of Louis VII. He shared the regency of France with Suger. during the absence of Louis VII on the second crusade. MATTHIEU II was made constable in 1218 after fighting at Château-Gaillard and Bouvines. During the reign of Louis VIII he fought chiefly in the south of France. On the accession of Louis IX he supported the queen regent. Blanche of Castile.' He died in 1230. His younger son. Guy, in right of his mother, became head of the house of Montmorency-Laval. ANNE de Montmorency (*q.v.*) was the first to attain the ducal title (1551). His eldest son, FRANÇOIS de Montmorency (1530–79), was married to Diana, natural daughter of King Henry II; another son, HENRY I de Montmorency (1534–1614), who became duc de Montmorency on his brother's death in 1579, had been governor of Languedoc since 1563; he is generally known as Montmorency-Damville. As a leader of the party called the *Politiques* he took a prominent part in the French wars of religion. In 1595 he was made constable, but Henry IV showed some anxiety to keep him away from Languedoc. which he ruled like a sovereign prince.

HENRY II (1595–1632), son of Henry I. succeeded to the title in 1614, having previously been made grand admiral. He also was governor of Languedoc. In Sept. 1625 he defeated the French Protestant fleet under the duc de Soubise and seized the islands of RC and Oléron. but the jealousy of Cardinal Richelieu prevented his following up these advantages. In 1628–29 he was allowed to command against the duke of Rohan in Languedoc; in 1630 he defeated the Piedmontese and captured Prince Doria at Avigliana and took Saluzzo. In the same year he was created marshal. In 1632 he joined the party of Gaston, duke of Orléans, and placed himself at the head of the rebel army, which was defeated by Marshal Schomberg at Castelnaudary (Sept. 1); he was executed as a traitor at Toulouse on Oct. 30.

MONTMORENCY, ANNE, DUC DE (1493–1567), constable of France, was born at Chantilly, and was brought up with the future King Francis I. whom he followed into Italy in 1515, distinguishing himself especially at Marignano. In 1516 he became governor of Novara: in 1520 he was present at the Field of Cloth of Gold. He was made marshal of France in 1522, accompanied Francis into Italy in 1524, and was taken prisoner at Pavia in 1525. Released soon afterward, he was one of the negotiators of the treaty of Madrid, and in 1530 reconducted the king's sons into France. On the renewal of the war by Charles V's invasion of France in 13'36, Montmorency compelled the emperor to raise the siege of Marseilles: he afterward accompanied the king of France into Picardy, and on the termination of the Netherlands campaign marched to the relief of Turin. In 1538; on the ratification of the ten years' truce! he was rewarded with the office of constable, but in 13'41 he fell into disgrace, and did not return to public life until the accession of Henry II in 13'47. In 1548 he repressed the insurrections in the southwest, particularly at Bordeaux. with great severity, and in 1549–50 conducted the war in the Boulonnais.

His attempt to relieve St. Quentin resulted in his defeat and captivity (Aug. 10, 1557). He was treated with coldness by the new king, Francis II, and compelled to give up his mastership of the royal household—his son, however, being appointed marshal by way of indemnity. On the accession of Charles IX in 13'60 he resumed his offices and dignities, and played an important part in the Huguenot war of 1562. He fell into the hands of the enemy at Dreux, and was not liberated until the treaty of Xmboise (March 19, 1563). In 1567 he again triumphed at St. Denis, but was wounded, and died in Paris. on March 15. 1567.

MONTPELIER, the capital of Vermont, U.S., and seat of Washington county since 1811, is located on the upper Winooski river near the centre of the state, 7 mi. from Barre and 40 mi. E.S.E. of Burlington. It commands the best route through the northern Green mountains for many alternate routes out of the Connecticut valley. Montpelier citizens led in developing turnpikes. stage routes, railroads and federal highways and benefited by each, except the Central Vermont railway, which left the city on a spur.

Its economy has been based on state government, insurance, the granite industry, printing and local commerce, with minor specialties in clothespins. machinery and baking. Employment of white collar and professional workers in government and insurance offices raises the median of school years completed beyond that of the high school graduate. Vermont college, a Methodist college organized in Newbury in 1834 and moved to Montpelier in 1868, is a junior college for women. Because of official printing. Montpelier publishers steadily led the state in imprints. and 19th-century editors, notably of the Federalist–Whig–Republican *Watchman* (established 1806) and the Democratic *Patriot* (established 1826) were influential in state politics. In the 1950s Montpelier had the highest ratio of registered Republicans to Democrats of any Vermont town of more than 2.500 persons.

Named for Montpellier. France, the town was chartered in 1780 by 60 proprietors from Massachusetts and western Vermont; it established a town meeting in 1791 and was named the state capital in 1805. It defeated several attempts by Burlington and other towns to succeed it as the capital, climaxed in 1857 when fire left the state house a granite shell. Montpelier's greatest relative importance was in stagecoach days: it ranked second to Burlington in 1840. The village, incorporated in 1828 with less than a quarter of the original 23.040 ac., was detached in 1848 and the farming area became East Montpelier. Chartered as a city in 1895 in its period of maximum growth, it nearly doubled population from 1890 to 1910. World War I severely checked its economy, which

recovered gradually, in spite of a disastrous flood in 1927, with the expansion of state bureaus. Montpelier has a council–manager form of government, in effect since 1956.

For comparative population figures see table in VERMONT: Population. (T. D. S. B.)

MONTPELLIER, a town of southern France, capital of the *département* of Hérault, 31 mi. S.W. of Nîmes. Pop. (1954) 83,890. Montpellier rose into importance after Charles Martel destroyed hlaguelonne in 737. In the 10th century its two portions, Montpellier and Montpelliéret, were held from the bishops of Maguelonne by the family of Guilhem. The Guilhems were succeeded, through marriage. by the house of Aragon. a member of which in 1349 sold his rights to Philip of Valois. Montpelliéret having already in 1292 been ceded to the crown hy the bishops. In 1141 Montpellier acquired a charter afterward materially extended. and the same century saw the rise of its school of medicine. Several of the ablest teachers of that school were members of an important Jewish colony established in the town. Its school of law dates from 1160, and its university was founded by Pope Nicholas IV toward the close of the 13th century. Louis IX granted to Montpellier the right of free trade with the whole of the kingdom. The bishopric of hlaguelonne was transferred there in 1536. In the wars of religion the Protestants captured it in 1567, and it supported the duc de Rohan, only submitting after a long siege (1622). The town walls, except. the royal citadel then just built (1624), were razed (1628). Louis XIII made Montpellier the seat of one of the *généralités* of Languedoc, and the states of that province met there during the 17th and 18th centuries. Montpellier, the chief town of Languedoc, stands in a fruitful plain near the right bank of the small river Lez. Features of the town are a fine terrace with views of the Mediterranean, the Pyrenees and the Alps, and the famous Botanical garden. founded in 1593. The 14th-century Gothic cathedral. once the church of a Benedictine monastery, suffered severely during the religious wars. The monastery, after 1795. mas occupied by the famous medical school. A gallery with portraits of professors after 1239 contains one of Rabelais. The Musée Fabre contains collections of paintings and sculptures. The Lez canalized to connect Montpellier with the canal du Midi and with the sea at Palavas. The town has trade in wine. brandy and fruit. Candles, soap, chemicals, casks, chocolate and licorice are made.

MONTPENSIER, ANNE MARIE LOUISE D'ORLÉANS, DUCHESSE DE (1627–1693), generally known as La Grande Mademoiselle, was born at the Louvre on May 29, 1627. Her father was Gaston of Orléans (*q.v. See* also BOURBON), Monsieur. the brother of Louis XIII. She sympathized with the Frondeurs (see FRONDE, THE), and in the new or second Fronde she took nominal command of one of the armies on the princes' side. and in her own person took Orléans by escalade. She had to retreat to Paris. where she practically commanded the Bastille and the adjoining part of the walls. On July 2, 1652. the day of the battle of the Faubourg St. Antoine. between the Frondeurs under Condé and the royal troops under Turenne. Mademoiselle saved Condé and his beaten troops by giving orders for the gates under her control to be opened and for the cannon of the Bastille to fire on the royalists. She then installed herself in the Hôtel de Ville, and played the part of mediatrix between the opposed parties. She was for some years in disgrace and resided on her estates. In 1657 she reappeared at court. She was then nearly 40, when a young Gascon gentleman named Puyguilhem. afterward celebrated as M. de Lauzun (*q.v.*), attracted her attention.

In 1670. Mademoiselle demanded the king's permission to marry Lauzun. Louis at first gave his consent, but other members of the royal family prevailed on him to rescind it. Not long afterward Lauzun was imprisoned in Pignerol. and it was years before Mademoiselle was able to buy his release from the king by settling no small portion of her estates on Louis' bastards. They were then secretly married. But Lauzun tyrannized over his wife, and they were separated.

She lived for some years afterward. gave herself to religious duties and finished her *Mémoires,* which extend to within seven years of her death (April 9, 1693). These *Mémoires* (1729) are to be found in several collections of memoirs. Her *Eight Beatitudes* were edited by E. Rodocanachi as *Un Ouvrage* de *piété* in*connu* (1908).

MONTREAL, the largest city of Canada, is on Montreal Island in Quebec province, at the confluence of the St. Lawrence and Ottana rivers; it is about 180 mi. S.W. of Quebec and 121 mi. E of Ottawa, Ont. The island consists of nearly horizontal strata of Ordovician limestones. through which volcanic rocks erupted at the end of Devonian time. Subsequent erosion of the softer limestone has left the volcanic neck of Mount Royal, 769 ft. high, standing in the centre of the island. Minor surface features are the Pleistocene terraces.

Montreal started as a settlement by the St. Lawrence, near St. Paul street, and grew northward from the river; from there it spread around the mountain on both sides, encircling it and encroaching on its lower slopes. Pop. (1961) Montreal, 1,191,062; metropolitan area. 2,109,509. Important suburbs include Verdun (78,317), St. Michel (55,978), St. Laurent (49,805), Montreal North (48,433), Lachine (38,630) and LaSalle (30,904).

By origin the population of Montreal in 1961 was 67.6% French, 17.7% British and 14.7% other. For the Montreal metropolitan area the figures were 64.5% French, 21.8% British and 13.7% other. The French live mainly on the eastern side of the city (east of Park avenue) and the southern side (south of Sherbrooke street). The west side of the city. that is, Notre Dame de Grace, the area just south of the mountain, and the included city of \t'estmount, is predominately British.

By religion the city in 1951 was 78.6% Roman Catholic. 6.5% Jewish, 5.7% Anglican, 3.9% United Church and the rest various.

History.— Montreal Island with Mount Royal (Mont Réal), which he so named, was discovered by Jacques Cartier in 1535. Cartier was welcomed by a large band of Huron Indians who took him to their stockaded settlement of Hochelaga where he held prayers with them and read to them from the Gospel of St. John. The Indians guided Cartier to the top of the mountain where the view greatly impressed him. No other explorers arrived until Samuel de Champlain reached the island in 1603. His journals make no mention of Hochelaga which presumably had been obliterated by hostile Indians. In 1611 Champlain laid out beside the river the site of a settlement. Place Royale, but it was not then permanently occupied, although traders gathered every summer at the spot. Meantime Cartier's narrative had led to a desire in France to convert the savages, and an "Association of Montreal" was formed for this purpose, the word "Montreal'! having become a general name for the unknown district. In 1641 the association sent out Sieur Paul de Chomedey de Maisonneuve with about 50 associates, including Jeanne Mance, to found a mission station on Montreal Island. The mission was duly established May 17, 1642, under the dame of Ville-Marie de Montréal. The original site, at first a fort, was beside the natural harbour created by a projecting point of land, later the Pointe a Callières and a small island (Ilot Normandin; Market Gate Island), the island being later obliterated and the locality entirely altered by the later harbour construction. On the high bank above flood water the settlers built a hospital (Hôtel Dieu), its site on the present St. Sulpice and St. Paul streets, and a house for Maisonneuve, later the first Sulpician seminary.

Other houses were built nearby and the bush track connecting them became St. Paul street. The mission was harassed in its early years by constant Iroquois attacks, the whole period from 1642 to 1701 being one of intermittent Indian war and truce. The island was handed over in 1663 to the feudal proprietorship of the Order of St. Sulpice which had arisen out of the Montreal movement. Maisonneuve was removed from office (1664) and returned to France.

Progress in the 17th century was slow. The settlement had a population of 196 in 1650. 472 in 1660. 766 in 1667 and 3.492 in 1710. The town was roughly fortified with ramparts and palisades in 1685 and in 1123 with the systematic stone walls (18 ft.), bastions, gates and sally ports which henceforth forbade all Indian attack. In the old French regime from 1713 to 1754 (peaceful in Montreal, since the war of 1744–48 did not reach it) the

town became the great centre of organization of exploration and trade (Compagnie des Habitants. 1700; Compagnie d'Occident, 1717; the Vérendryes, etc.) and especially of the fur trade which absorbed the main energy of the colony to its later harm. The visiting Swedish naturalist, Peter Kalm (1749) described the town and adjacent country in glowing terms. The Seven Years' War brought desolation to all New France. After the fall of Quebec in 1759 Montreal still held out. It was invested in the autumn of 1760 by the converging armies under Jeffrey Amherst and was surrendered by the marquis de Vaudreuil, its last governor. along with all remaining posts in New France. Vaudreuil and his French forces were given transport to France along with many Canadian seigneurs and their families.

At the time of the conquest Montreal covered little more than the fortified area of high ground between the St. Lawrence river and the valley of St. Martin's Brook (later Craig street). But small suburbs (*faubourgs*) were already being settled outside the gates: the Quebec suburb (donnstream); St. Joseph (upstream); and St. Lawrence on the inland side. As the tonn splits the cardinal points of the compass the designations north and south, under the French regime, were exchanged officially in 1751 for east and west. The population of the city in 1750 was 8,244. The American Revolution led to an unsuccessful attack on Montreal (1775) by Ethan Allen and to the city's abandonment by Sir Guy Carleton and surrender to Gen. Richard Montgomery. It was occupied by the army of congress (Nov. 13, 1775–June 17, 1776). A congressional delegation to Montreal (Benjamin Franklin and two others) tried in vain to convert Canada to the American colonists' cause and retired on the approach of British forces, leaving behind a printing press, the first in the town. Following the conquest there had been an influx of British traders; after the war a great number of Loyalists swelled the British element in Montreal and opened up the adjacent eastern townships. In the troubles that arose in Lower Canada between French and English, Montreal became the centre of the agitation and open violence that preceded the rebellion in 1837–38. After the rebellion 12 rebels (les patriotes) were hanged in Montreal at a spot that has been marked with a monument beside the Jacques Cartier bridge. When the two Canadas were reunited (1840) Montreal became for a short time (1844–49) the capital but lost that position in consequence of the riots over the Rebellion Losses bill and the burning of the parliament buildings in 1849.

Montreal made great economic progress at this epoch. Steam navigation had begun in 1809 with the "Accommodation." an 85-ft. wooden paddle steamer built at Montreal by John Molson (1763–1836). the brewer and banker; the Molson family continued to be interested in steam navigation on the St. Lawrence until about 1860 Steam altered the entire aspect of river navigation, displacing Quebec in favour of Montreal. The opening of the Lachine canal (1825) connected ocean with inland steam navigation. Then began the prominence of the Montreal route under the Allan line and other steamship companies; but all St. Lawrence ships used sail and steam jointly until the end of the 19th century.

In the meantime railways were being built that would connect Montreal with Sen York, Portland, Me.. Boston. Mass., Toronto and Chicago. The Victoria bridge across the St. Lawrence was opened in 1860 by the visiting Prince of Wales. At confederation, 1867, Montreal was already the metropolitan city of Canada. It had a population in 1871 of 115,000. After confederation the history of Montreal merged into the general history of Canada but was locally marked by the Fenian raids (1870), the great floods (1886), the completion of the Mount Royal tunnel (1917) and the opening of the Harbour (later Jacques Cartier) bridge (1930). (See also CANADA: History.)

Sites and Shrines.––Among the chief points of historic and scenic interest in and around Montreal are the Place d'Armes, where stands the Maisonneuve monument and around which are grouped the Seminary of St. Sulpice (1685), the church of Notre Dame, built 1824 (original church, 1656). and the later building of the Bank of Montreal, etc. In the old French town also is the Chbteau de Ramezay, preserved as a public museum: it was the seat of one of the French governors (not the last) and of several British governors. Beside it is the Jacques Cartier square with a monument erected in honour of Lord Nelson. Nearer the river stands the famous Bonsecours church. The original church was erected in 1657 by Marguerite Bourgeoys, founder of the Congregation de Notre Dame The present church was built in 1771. The Bonsecours market dates from 1843.

The Champs de Mars, a military parade ground since the French regime, is used as a parking lot. Among sites of general interest in the city are the Museum of Fine Arts, the Roman Catholic St. James's cathedral. McGill university, the University of Montreal behind the mountain, the stone towers (dated 1694) of the Grand Séminaire and the Shrine of St. Joseph. Of chief interest is the vien from the top of the mountain, which is reserved as a public park

Navigation, Commerce and Industry.— Montreal as a port owes its prominence to the fact that it is at the head of 1,000 mi. of unimpeded navigation from the Atlantic ocean and that further direct navigation is blocked by the Lachine rapids beside Montreal Island. The rapids were early bypassed by canals; the oldest is the Lachine, now little used. The St Lawrence seaway (*q.v.*) completed in 1959. enables ships drawing 25.5 ft. to navigate between the head of the Great Lakes and the Atlantic ocean. Montreal is 2.760 mi. from Liverpool (via Strait of Belle Isle), as compared with 3.043 mi. between New Uork and Liverpool. The harbour extends 16 mi along the river. At its upper end is the Victoria bridge (railway and vehicles) and about two miles lower down the Jacques Cartier bridge (vehicles).

The port has 10 mi. of high level concrete piers and wharves, a harbour terminal railroad of 62 mi. of track, four grain elevators of a total capacity of 15,162,000 bu. and unrivaled grain and cargo apparatus. Chief commodities passing through the port are grain and petroleum. Navigation opens in April. Regular passenger schedules end in November but navigation carries on into December. Experts claim that conditions in the gulf below render a longer navigation season doubtful. Complementary to the facilities of the port are the existence of many large manufacturing plants in Montreal and its metropolitan area. The principal products are clothing, electrical apparatus, railway rolling stock and tobacco.

City Government.— Municipal government in Montreal, as in all Canadian municipalities, is under the control of the provincial legislature which creates, alters and abolishes at will. With one insignificant exception. elective representative government was unknown under the French regime. Under the British regime the town was governed by the military authorities and the justices of the peace. Between 1832. when Montreal mas incorporated as a city and 1940, various forms of city government were tried. none of which proved satisfactory. After 1940, as a result of amendments made to its charter. Montreal was administered by a municipal council whose meetings were presided over by a mayor elected by the whole of the taxpayers. and also by an executive committee composed of six city councilors. In 1945 the mayor became ex-officio a member of the executive committee and certain administrative poners were conferred on him.

Of the councilors, 33, designated "A" class councilors, were elected by property owners, 33 "B" class councilors were elected by property onners and tenants and 33 "C" class councilors were appointed by 11 designated public bodies. The office of "C" councilor was abolished following the referendum during the election of 1560. Bill 38 in 1940 also enacted that councilors should serve gratuitously. although the salaries paid to the mayor and chairman of the executive committee mere retained and those of the other five executive committee members were raised. Salaries for councilors were reintroduced in 1942.

The Champagne commission, appointed in 1960 to inquire into the city's electoral or political system and its administrative system, recommended a Canadian parliamentary form of government. the division of the city into 45 wards to be represented by one councilor each and the executive committee to become explicitly the supreme administrative authority

The Montreal metropolitan area, as defined by the dominion census, contains. in addition to the city of Montreal, 83 other

cities, towns and municipalities. The creation of the Montreal Metropolitan corporation in April 1959 was an early step toward a unified government. This corporation constructed the Metropolitan boulevard across the middle section of Montreal Island, regulates the closing hours of commercial establishments on Montreal Island and is empowered to control the finances of 14 of the municipalities on the island.

Education.— In Montreal. as throughout Quebec, the public-school system is separated from top to bottom between Roman Catholics and Protestants; most children of parents not affiliated with either religion attend the Protestant schools. In the 1960s there were almost 250 Roman Catholic schools with over 105,000 students and slightly over 40 Protestant schools with more than 25,000 students.

The University of Montreal, a French-language institution, is supported by the province and controlled by the Roman Catholic Church. Established in Montreal in 1876 as a branch of Laval university! it became autonomous in 1920; by the 1960s it had grown to include a considerable number of affiliated institutions (including a number of classical colleges. most of which are eight-year institutions offering four years of secondary educationj and other attached institutions. McGill university, a co-educational, privately endowed; nondenominational institution, is one of the largest English-speaking universities in Canada. It originated in a bequest for that purpose in the will of James McGill (1744–1813), a Scots emigrant who prospered in the fur trade; instruction began in 1829 in the faculties of arts and medicine. The women's college, Royal Victoria, the gift of Baron Strathcona, was opened in 1899 to provide teaching and residential facilities for women. Another integral part of the university is MacDonald college at Ste. Anne de Bellevue, about 25 mi. S.W. of Montreal; the gift of Sir William McDonald, it opened in 1907 and houses the faculty for agriculture, the school of household science and the institute of education. After about 1907 the university grew vigorously. Sir George Williams university (founded 1929; incorporated 1948) is an outgrowth of formal educational work of the Montreal Young Men's Christian association. It has an extensive evening division as well as regular daytime instruction. The bachelor's degree is the highest degree awarded by the university; the language of instruction is English.

See also references under "Montreal" in the Index volume.

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MONTREUIL-SOUS-BOIS, a suburb 4 mi. E. of Notre Dame de Paris in the *département* of Seine, on the slope and summit of a hill, about 1 mi. N. of Vincennes. Pop. (1954) 76,125. ilfontreuil is specially noted for its extensive peach orchards. The manufactures include paint, oils and varnish, glass and chemical products and biscuits.

MONTREUX, a town in the canton of Vaud, on the shore east of Lake Geneva, Switzerland. stretching from Clarens to Veytaux. The name includes the communes of the Châtelard and Planches. Pop. (1960) 12.222, mostly French speaking.

MONTREUX CONVENTION. This convention, signed on July 20, 1936, by the participants of a conference held in Montreux, Switz., established a new international regime of the Turkish straits replacing that of the Lausanne convention (see LAUSANNE, CONFERENCES OF). The Montreux convention continued in force, in the post-World War II era.

On its basis merchant vessels of all countries enjoy freedom of transit and navigation through the straits in time of peace and war, provided Turkey is not belligerent. If Turkey is a belligerent, only merchant vessels of a country not at war with Turkey enjoy this freedom (art. 2–7 and annex i). War vessels (defined in annex ii) enjoy freedom of transit only under limitations. The non-Black sea powers are restricted in time of peace to no more than nine light surface vessels in course of transit of a maximum aggregate tonnage of 15,000 tons (art. 10–14). The Black sea powers are not limited in tonnage, and even their capital ships may be sent through the straits. but only singly. They may also send their submarines constructed or purchased outside of the Black sea, if they travel on the surface (art. 11–12). In time of war, Turkey not being belligerent, freedom of transit remains the same for nonbelligerent powers. If Turkey is at war, or under threat of war. passage of warships is left to its discretion, under reservations (art. 20–21).

The convention established (art. 18) the Black sea regime for non-Black sea powers. Their aggregate tonnage. jointly, in that sea in time of peace is limited to a maximum of 30,000 tons, but may be raised up to a maximum of 45,000 tons, if the tonnage of the strongest Black sea fleet increases by at least 10,000 tons. No non-Black sea power, however, may have in the Black sea more than two-thirds of the aggregate tonnage, nor may it keep its vessels of war there longer than three weeks.

The convention abolished the International Commission of the Straits, and transferred its functions to the Turkish government (art. 24). Turkey was authorized to remilitarize the zone of the straits immediately. The convention was concluded for 20 years. If not denounced two years prior to the expiry of this period. it was to continue automatically. A new conference must be summoned in the event of denunciation (art. 28). A procedure was set up for amending the convention at the expiry of each period of five years; in most cases unanimity is required for such amendment. in some other cases a very strong majority (art. 29).

For the post-World War II efforts of the U.S.S.R. to amend the convention and for bibliography *see* STRAITS QUESTION. *See* also TURKEY: History; BOSPORUS. (M. SL.)

MONTROSE, MARQUESSES AND DUKES OF. David Lindsay, 5th earl of Crawford (*c.* 1440–95), was created duke of Montrose in 1488 (the first dukedom conferred in Scotland on a person not of royal blood) as a reward for loyalty to James III during the rebellion of Angus and Prince James. He was deprived of his dukedom by James IV, but it was restored in 1489 for life only.

In 150j, William. 4th Lord Graham, whose wife was the duke's niece, was created earl of Montrose; and this title was held by his descendants till 1644, when James Graham. jth earl. was created marquess of Montrose and earl of Kincardine. This was the celebrated marquess of Montrose (*q.v.*) of the Civil War, whose son. James (c. 1631–69), was known as "the good marquess." His grandson. the 4th marquess (d. 1742), was lord high admiral of Scotland in 1705, and lord president of the council in 1706. For his services in promoting the union of Scotland with England he was created duke of Montrose and marquess of Graham in 1707, becoming in the same year one of the first representative peers of Scotland in the parliament of Great Britain. He was one of the regents of the kingdom on the death of Queen Anne, and was appointed a secretary of state by George I. After suppressing the Jacobite rising in 1715, he was made keeper of the great seal in Scotland.

MONTROSE, JAMES GRAHAM, MARQUESS OF (1612–1650), became 5th earl of Montrose (*see* above) in 1626. He was educated at St. Andrews, and at 17 married Magdalene Carnegie, daughter of Lord Carnegie (afterwards earl of Southesk). Not long after the outbreak of the Scottish troubles in 1637 he joined the party of resistance to Charles I, signed the covenant in 1638, and successfully suppressed the opposition to the popular cause which arose in the north around Aberdeen and in the country of the Gordons, though he violated the safe conduct he had promised to Huntley, the leader of the rising, by taking him prisoner to Edinburgh. In 1639, after the signature of the treaty of Berwick, Montrose was one of the covenanting leaders who visited Charles. He wished that the clergy should confine themselves to their spiritual duties. and that the king. after being enlightened by open communication with the Scottish nation, should maintain law and order without respect of persons. In the Scottish parliament which met in September. Montrose found himself in opposition to Argyll, was opposed to Argyll's policy of making the three estates equal, thus making the middle classes and the Presbyterians a tool for his own ambition; but he failed

to win the support of Charles.

Rather than give way, Charles prepared in 1640 to invade Scotland. Montrose, who was the leader of the royalist party known as the "Plotters," which had arisen within the ranks of the covenanters, was of necessity driven to play something of a double part. In Aug. 1640 he signed the Bond of Cumbernauld as a protest against the "particular and direct practising of a few," in other words, against the ambition of Argyll. But he defended his country, and in the same month displayed his gallantry in the forcing of the Tyne at Newburn. After the success of the invasion, Montrose was summoned before the committee of estates charged with intrigues against Argyll, and in June was imprisoned in Edinburgh castle. After the king's visit to Scotland Montrose shared in the amnesty tacitly accorded to all Charles's partisans.

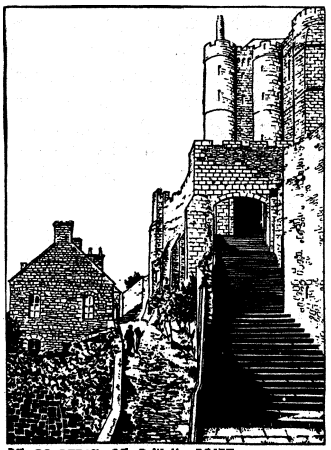
When the Civil War began in England *(see* **GREAT** REBELLION) Montrose constantly pressed Charles to allow him to make a diversion in Scotland. Hamilton's impracticable policy of keeping Scotland neutral for long stood in the way of Charles's consent. But in Feb. 1644, when a Scottish army entered England to take part against the king, Montrose, now created a marquess, was appointed lieutenant-general in Scotland. After his unsuccessful attempt in April to invade Scotland with about 1,000 men, disguised as a groom, he made his way in August to the Highlands, where the clans rallied to his summons. He defeated his opponents, with great military skill, at Tippermuir, Aberdeen, Inverlochy, Auldearn, Alford, Kilsyth and Dundee.

In the name of the king, who now appointed him lord-lieutenant and captain-general of Scotland, he summoned a parliament to meet at Glasgow with the object of organizing the Lowlands, on Oct. 20, but the parliament never met, for Charles had been defeated at Naseby on June 14, and Montrose was called to his help. David Leslie, the best of the Scottish generals, was promptly despatched against Montrose whom he discovered on Sept. 12, deserted by his Highlanders and guarded only by a little group of followers, at Philiphaugh. His conduct of the war had alienated the Lowlands. Montrose made his way to the Highlands; but he failed to organize an army. In Sept. 1646 he embarked for Norway. In 1647 he went to Paris, but could get no support from Henrietta Maria. Three years later, burning to revenge the death of the king, he was restored by the exile Charles II to the now nominal lieutenancy of Scotland. Charles however did not scruple shortly afterwards to disavow his noblest supporter in order to become a king on terms dictated by Argyll and Argyll's adherents. In December 1649 Montrose sailed for the Orkneys with 1,200 men, but 1,000 of them were lost by shipwreck. Reaching Scotland, Montrose tried in vain to raise the clans, and on April 27, was routed at Invercarron. After wandering for some time he was surrendered by Macleod of Assynt, to whose protection, in ignorance of Macleod's political enmity, he had entrusted himself. On May 20, he was sentenced to death and was hanged on the 21st. To the last he protested that he was a real covenanter and a loyal subject.

The principal authorities for Montrose's career are Wishart's *Res gestae, &c.* (Amsterdam, 1647; abridged trans, in the Stuart series, 1903); Patrick Gordon's *Short Abridgment of Britane's Distemper* (Spalding Club); Gardiner's *Great Civil War;* Napier, *Memorials of Montrose* (1856), containing Montrose's poetry, a selection of which has been edited by R. S. Rait (1901); H. Prpce, *The Great Marquis of Montrose* (1912) and J. Buchan, ***The*** *Great Marquis of Montrose* (1913).

MONTROSE, a royal and small burgh and seaport of Angus (Forfarshire), Scot., 30 mi. N.E. of Dundee by road. Pop. (1951) 10,762. The town, which is spacious and has plentiful trees and gardens, occupies a sandy peninsula and is bounded by the North sea, the North and South Esk, and by Montrose basin. a tidal lagoon about 7 mi. in circuit, which is a wintering place for pink-foot geese and other migratory water birds. In the mouth of the channel of the South Esk lies the island of Rossie, or Inchbrayock, connected with the burgh by means of a suspension bridge, and by a drawbridge with the south bank near the large fishing village of Ferryden. The harbour lies between the suspension bridge and the sea, and is provided with a wet dock. Montrose is a holiday town with fine links, including golf and putting courses. The spired church and the town hall are of the 18th century, There is some industry such as the making of jute and other fibre products, and pharmaceutical chemicals. The soft fruits of Angus, as well as imported fruit, are canned or made into preserves. Timber is imported and local beer is shipped to Newcastle. Montrose received its charter from David I and was made a royal burgh in 1352. It was destroyed by fire in 1244. There Edward I accepted John de Baliol's surrender of Scotland on July 10, 1296. From the harbour the Old Pretender embarked in 1716 for France. In 1745 the Jacobites gained possession of the town and had some successes against the government. Among famous names connected with the burgh are James Graham, 1st marquess of Montrose, born at Old Montrose; John Erskine who introduced the study of Greek into Scotland; Joseph Hume and Andrew Melville (*qq.v.*).

MONT ST. MICHEL, LE, a rocky islet of France, off the coast of the department of La Manche, some 6 mi. N. of Pontorson. Pop. (1946) 186. It forms a mass of granite about 3,000 ft. in circumference and 16j ft. in height, rising near the mouth of the Couesnon nearly a mile from the shore, to which it is united by a causeway. In the 8th century an oratory was established here by St. Aubert, bishop of Avranches, in obedience to the commands of an apparition of St. Michael. The place soon became a resort of pilgrims from France, Great Britain, Ireland and Italy. In 966 Richard I, duke of Normandy, founded in place of the oratory a Benedictine monastery. In 1203 the monastery was burnt by Philip Augustus, who afterwards furnished large sums for its restoration (La Merveille). St. Louis made a pilgrimage to Mont St. Michel, and afterwards supplied funds for the fortifications. During the last 30 years of the Hundred Years' War the abbey persistently resisted the English. In 1469 Louis XI instituted the Order of St. Michel which held its meetings in the salle des chevaliers. During the Wars of Religion, the Huguenots were not able to take the fortress, which opened its gates to Henry IV in 1595 after his abjuration. In 1622 the Benedictine monks of Mont St. Michel were replaced by monks of the Congregation of St. Maur. In the 18th and 19th centuries until 1863 the abbey was used as a prison for political offenders. The fortress-abbey crowns the more precipitous side of the islet towards the north and west, the sloping portion toward the east and south being occupied by houses. A machicolated and turreted wall surrounds the upper part of the rock. The northern and oldest portion of the ramparts dates from the 13th century; on the south they are pierced by a single 15th century gateway. The single street curves from the gateway up to the abbey, ending in flights of steps leading to the donjon or chbtelet. It is bordered by old houses, among which is one built by Bertrand du Guesclin in 1366, and contains a 15th century parish church. Limitations of space led to building of the abbey in three stories. The floor of the church, partly on the rock, partly upon foundations, and, at the east end, over a crypt, is on a level with the uppermost story of the monastic buildings. North of and below the apse is the building known as Belle-Chaise. It comprises the châtelet (15th century), a square machicolated entrance structure, the adjoining guard-room (15th century) with the salle des officiers above it and behind all the Tour Perrine. The Merveille (1203–64) on the north consists of two continuous buildings of three stories, on the east, one above the other, the hospitium (*aumônerie*), refectory and dormitory, on the west, the cellar, knights' hall (salle des chevaliers) and cloister. Of the fine Gothic apartments the chief are the refectory, divided down the centre by



BY COURTESY OF G.W.H. BRITT

THE STAIRWAY TO THE ABBEY OF WONT ST. MICHEL

columns and lighted by large embrasured windows, and the superb knights'hall, with a vaulted roof supported on three rows of cylindrical pillars. The 13th century cloister is surrounded by double lines of columns carrying pointed arcades, between which floral designs are carved. The exterior wall of the hferveille, 108 ft. high, is supported by 20 buttresses. The church, high above the other buildings, consists of transepts and four bays of the nave of Romanesque architecture and of a choir (1450–1521) in the Flamboyant Gothic style with a triforium surmounted by windows. In **1776** three of the seven bays of the nave were pulled down, and soon after the incongruous western front was added. The finest part of the exterior is the choir, ornamented with carved pinnacles and balustrading. The central tower terminates in a Gothic spire surmounted by a statue of St. Michael.

MONTSERRAT, an island in the former West Indies federation, one of the four presidencies in the former colony of the Leeward Islands. Pop. **(1960) 12.157,** mostly Negroes. It lies **27** mi. S.W. of Antigua, in 16° 45′ N. and 62° **7** W.; is 11 mi. long and **7** mi. broad, and has a total area of 32 sq.mi. The island is a serrated range of volcanic peaks rising from the Caribbean sea, their summits clothed with forests; the still active Soufrière (3,002 it) in the south being the highest point. The average temperature is 81° F., the hottest weather being usually tempered by cool sea breezes; the rainfall averages 94 in annually. Water is plentiful, and the roads are macadamized and well graded. The principal crop is cotton, and other products exported are tomatoes and raw lime juice. The legislative council of the presidency, as reconstituted in 1937, had three official members, tno nominated members and four elected members. Elementary education is compulsory and free in state-aided schools; the government maintains a secondary school for boys at Plymouth. the chief tonn (pop. [1960] 1,924), and subsidizes one for girls. The island was discovered in **1493** by Columbus, who named it after Monserrado, a mountain in Spain. It was colonized by the English under Sir Thomas Warner in **1632.** and was taken by the French in 1667. Restored to England in **1668,** it capitulated to the French in **1782,** but was again restored in **1784.**

MONTSERRAT, a mountain and monastery in Spain, 30 mi. N.W. of Barcelona. The mountain is of grey conglomerate; its main axis trends from west-north-west to east-south-east, and its circumference is about 18 mi. The loftiest point is the Turó de San Jeronimo, also called Mirador and La Miranda (4,054 ft.). On the east the base of the Montserrat is washed by the river Llobregat. The Montserrat consists of jagged pinnacles and spires (*peñascos*) rising abruptly from the base of the mass, which is cloven by ravines, and abounds with precipices. It is the *mons serratus* of the Romans, the *monte serrado* of the Spaniards, and is thus named either in allusion to its jagged appearance, or because it is split, as if sawn by the vast fissure of the Valle Malo. This occurred, say the Spanish legends, at the time of the Crucifixion, when the rocks were rent.

The monastery stands **2,910** ft. high on the edge of the Valle Malo. It owes its existence to an image of the Virgin, said to have been carved by St. Luke and brought to Barcelona by St. Peter in A.D. 30. When the Moors invaded the province in 71**7** the image was taken to hlontserrat and hidden in a cave. In 880 Gondemar, bishop of Vich, was attracted to the cave by sweet sounds and smells, and there found the image, which he determined to take to Manresa. But at a certain spot on the mountain the image refused to proceed farther; there it was consequently deposited, and a chapel was erected to contain it. Round the chapel a nunnery was built, and in 976 this was enlarged and converted into a second Benedictine convent. During the Napoleonic wars (1808–14) it was despoiled of treasures. In **1835,** as a result of the Carlist insurrection, the convent was deprived of its estates and the number of monks reduced to about **20.** In 1874 the convent, which by a grant of antipope Benedict XIII had been an independent abbey since 1410, was made subject to the bishops of Barcelona.

Nuestra Señora de bfontserrat, Patrona de Cataluña ("Our Lady of Montserrat, Patron Saint of Catalonia"), is one of the most celebrated images in Spain, and her church is visited annually by more than 60,000 pilgrims. The image is small, black and carved of wood, but possesses magnificent robes and jewels.

MONTT, MANUEL (1809–1880), Chilean statesman, was born on Sept. 5, **1809.** He had a distinguished career as a scholar, and was introduced into public life during the presidency **(1831-41)** of Arieto by Diego Portales. Montt distinguished himself by his courage in the crisis that followed upon Portales' assassination in **1837,** though only holding a subordinate post in the government. Afterwards he held several ministerial offices, and during the presidency (1841–51) of Bulnes he became minister of justice and public instruction, and later of the interior. He was elected president in 1851 and again in **1856.** Though the liberals chafed under his rule, and two revolutions, in **18**51 and **18**59, took place during his administration, he governed Chile with an energy and wisdom that laid the foundation of her material prosperity. He was ably assisted by his minister of the interior Antonio Varas, and it was from the union of the two statesmen that the well known ultra-conservative faction, the Montt-Varistas, took their name. His presidency was marked by the establishment of railways, telegraphs, banks, schools and training colleges. On giving up his post in **1861** he became president of the supreme court of justice, a position which he held up to his death on Sept. 20, 1880. His son Jorge (1847–1922) was president of Chile in 1891–96, and a younger son, Pedro (d. 1910), in 1906–10.

MONTT, PEDRO (1848–1910), Chilean statesman, son of Manuel Montt (*q.v.*), was born in Santiago, Chile, in **1848.** He graduated in law at the *Instituto Nacional* in **18**70, and four years later entered political life. In **1876** he was elected a member of the chamber of deputies, and in 1885 he became its president. During this period began his powerful influence in the public administration and also in the direction of the National party which Manuel Montt had founded. He voyaged to Europe to study the political institutions of the leading European nations. In **1886** he was appointed minister of justice and public instruction and in 1887 minister of industry and public works. In spite of holding these two cabinet offices in the government of President Balmaceda, Montt figured in the parliamentary opposition to him in 1890, and in **1891** took a very active part in the revolution which put an end to his Power. He went to the United States first as agent of the Revolutionary Junta and, after the recognition of the new government, remained as minister of Chile. In 1901 he was an unsuccessful candidate for the presidency, but in **1906,** as the candidate of the National Union ticket and supported by all important elements, he was elected by a large majority. During his term he helped to prevent armed conflict between Chile and Argentina, fostered railway development, worked for sound finances and for sanitation and health projects. He was greatly interested in education and during all his political career was a member of the council of public instruction. His interest in books led him to acquire a private library, the largest in Chile at the time of his death. In 1910, his health failing, he went to Europe to seek treatment and died on Aug. **16,** at Bremen, Germany.

MONTUCLA, JEAN ÉTIENNE (1725–1799), French mathematician, was born at Lyons on Sept. 5, 1725. In 1754 he published an anonymous treatise entitled *Histoire des recherches sur la quadrature du cercle,* and in 1758 the first part of his *Histoire des mathématiques,* the first history of mathematics worthy of the name. In 1778 he re-edited Jacques Ozanam's *Récréations mathématiques,* afterwards published in English by Charles Hutton (4 vols., London, 1803). He died on Dec. **18,** 1799. His *Histoire* was completed by J. J. Le F. de Lalande, and published at Paris in 1799–1802 (4 vols.).

MONTÚFAR, LORENZO (1823–1898), Guatemalan statesman and author, was born in Guatemala city on March 11, 1823. He studied law at the University of Guatemala and joined with other youthful leaders in publishing the radical periodical *Album Republicano.* Opposition to General Carrera led to forced suspension of the publication. Montúfar went to San José, Costa Rica, where he was named a magistrate of the supreme court. After being deprived of this office by force, he took his doctor's degree in law and obtained a professorship at the University of Costa Rica. During the presidency of Juan Ramón Mora he was minister of foreign relations in Costa Rica. He was later named

rector of the University of Costa Kica. Afterward he was forced to fly to San Salvador, which government made him minister to Peru.

When Carranza became president of Costa Kica he returned to take the position of minister of foreign relations. which he retained also during the presidency of Guardia. As minister he negotiated a number of treaties, notably the treaty delimiting the frontier with Colombia. He was later named envoy extraordinary and minister plenipotentiary of Guatemala to Spain. He was distinguished both as a writer and as a jurist.

His most important work is the *Reseña lzistorica de Centro-America* (7 vol., 1878–81). He also wrote *Apuntamientos sobre economía politico* (1887); *Walker en Centro-America* (1887) and was editor of the advanced periodical *Quincenal Josefino.* In 1891 he was an unsuccessful candidate for the presidency of Guatemala.

The *Discursos del Doctor Lorenzo Montúfar* (*R.* Montúfar, ed.) was published in 1923.

MONTYON, ANTOINE JEAN BAPTISTE ROBERT AUGET, BARON DE (1733–1820), French philanthropist. was born at Paris on Dec. 23. 1733. He rose rapidly in the legal profession, and held several important offices of state. He is best remembered for the numerous prizes which he established, and for the Montyon "prix de Statistique." founded in his honour. Though dealing with economic problems. his books are written mainly from the point of view of the philanthropist. and contain little that is of scientific value. During his life he spent his money freely in the alleviation of suffering, and at his death bequeathed 10,000 francs to each of the Parisian hospitals.

His most important works are:—*Recherches et considérations sur la population de France* (1778); *Quelle influence ont les diverses espèces d'impôts sur la moralité, l'activité et l'industrie des peuples* (1808); and *Particularités et observations sur les ministres des finances de France, les plus célèbres de 1690 à 1791* (1812).

See Lacrctelle, *Discours sur* M. *Montyon* in *Recueil de l'académie* (1820–29); Querard, *La France littéraire,* vol. vi (1834); F. Labour, *M.* de *Montyon d'après des documents inédits* (1880); G. Dumoulin, *Montyon* (1884); and L. Guimbaud, *Auget de Montyon* (1909).

MONUMENT: *see* MONUMENTS AND MEMORIALS.

MONUMENTS, NATIONAL (U.S.) : *see* NATIONAL PARK SYSTEM. THE.

MONUMENTS, PRESERVATION OF (Lat. *monumentum* or *monimentum;* from *monere,* to advise, bring to mind, remind; the German equivalent is *Denkmal*), literally, that which serves to keep alive the memory of a person, an event or a period. The word is thus applied to a column, statue or building erected for that particular purpose; to all the various memorials which man throughout the ages has raised over the buried dead, the barrows and cairns of prehistoric times, the representation of the living figure of the dead, brasses, busts, etc.. or the varying forms, allegorical or otherwise, taken by the tombstones of the modern cemetery.

In a wider sense "monument" is used of all survivals of prehistoric man—dolmens, menhirs. remains of lake dwellings, stone circles and the like, buildings large and small, with cities. castles, palaces, and examples of domestic architecture which have any interest, historic or artistic, as well as movable artistic or archaeological treasures either existing in private or public collections or newly discovered by excavation. etc.

In a more restricted sense the word "monument" is also applied to a comprehensive treatise on any particular subject, such as the *Monumenta typographica,* or an historical collection such as the *Monumenta Germaniae Izistorica.* In the English law of conveyancing a "monument" is an object fixed in the soil, whether natural or artificial.

The word "monument" is referred to in a document, and used as evidence for the delineation of boundaries or the situation of a particular plot of land, etc.

For a description of various kinds of monuments *see* such articles as ARCHAEOLOGY; EFFIGIES, MONUMENTAL; SCULPTURE; BARROW; etc.; many particular monuments such as STONEHENGE are treated under their respective names, or in the articles on the towns, etc., in which they stand; while the preservation of monuments in various countries is dealt with under the different headings of those countries, *e.g.,* EGYPT; GREECE.

The present article deals with the preservation. by government action, local or central. of the evidences and remains of past history and civilization; for reference to similar action extended to sites and places of natural beauty and interest. which are known in Germany as *Naturdenkmäler* (natural monumentsj, consult *Meyers Lexicon, s.v.*

In 1897 was issued a report (C. 8443, *Miscell. Reports,* 2) from British representatives abroad as to "the statutory provisions existing in foreign countries for the preservation of historical buildings"; while in 1905 *The Care of Ancient Monuments,* by *G.* Baldwin Brown, was published, containing an ample bibliography for each country and giving many references to various periodicals in different languages: reference may also be made to *The Core of Natural Monuments* (Cambridge, 1909) by H. Conmentz. Prussian state commissioner for the care of natural monuments.

The chief question at issue is, how far does the national artistic or historic interest of a monument, in the widest sense of the word; justify the interference of the state with the right of a private owner, whether cprporate body or individual, to do what he likes with his own? Nearly every European country has given a decided answer to this question, and it may be noticed, as showing the extreme reluctance to state interference in Great Britain, that a clause. laying on an owner of a monument scheduled under the Monument act of 1882 the obligation of offering it for purchase to the state if he wished to destroy it, was struck out of that act.

The main lines followed by legislation or regulation for the preservation of monuments may be briefly indicated. Central organizations of commissions and conservators. with a staff of architects, inspectors and archaeological or artistic experts for consultation, are established. These may have wide legal powers of enforcing their decisions or may act chiefly by advice or persuasion. The national treasures are catalogued and scheduled, and the value estimated in an exhaustive inventory, in many cases supplemented by local inventories. a course of procedure that has to a large extent prevented the continuance of the destruction of valuable monuments through ignorance of their value.

The Classement System. — Aspecial form of inventory, carrying with it legal consequences, is that known as the *classement* system; of this form the French is the typical example. In this only the outstanding monuments find a place, and such either become national property altogether, or the protection and preservation is undertaken by the state, or may be left in the hands of the private owner; but in any case the monument cannot be destroyed, restored or repaired without the consent of the central authority.

The *classement* system has been criticized as tending to depreciate the consideration paid to such monuments as do not appear in the list—*monuments non-classés.* Great Britain adopted a narrow kind of *classement* in the schedule attached to the 1882 act. Most states have powers of expropriation or compulsory purchase of private property on grounds of public utility, and English law is no exception—as in the case of the compulsory purchase of land for railways—and now the majority of states have made the protection of monuments a matter of public utility. Further, the exportation of artistic or historic treasures, *i.e.,* movable monuments. has been controlled by the state, notably in the case of Italy and Greece, Turkey and Egypt.

Connected with this side of the question is the control by the state of excavations undertaken by private persons, even on their own property. In Germany considerable protection is effected by the powers given to municipalities to make bylaws, respecting not only the preservation of the monuments, but also the erection of new buildings that may interfere with the monuments or with the general characteristic appearance (*Stadtbild*) of the town. This is also the case in Italy, where there are frequent regulations as to

town-planning *(piano regolatore)*.

Great Britain. — In Great Britain the existing law is contained in the Ancient Monuments Consolidation and Amendment act, 1913.

Under the Consolidating act of 1913 Ancient Monuments boards were set up for England, Scotland and Wales whose duty is to advise the commissioners of works with reference to the treatment of monuments and to report to the commissioners when they have reason to believe that any monument of national importance is in danger of destruction or removal, or danger from neglect or injudicious treatment. A "monument" or "ancient monument" is defined as including any structure or erection (except an ecclesiastical building for the time being used for ecclesiastical purposes) the preservation of which the commissioners of works consider to be a matter of public interest because of its historic, architectural, traditional, artistic or archaeological importance. The commissioners, however, may not accept the guardianship of, or issue a preservation order relating to, any monument occupied as a dwelling-house by any person other than the caretaker thereof. They are bound to prepare and publish a list of all monuments the preservation of which is reported by any of the Ancient Monuments boards to be of national importance, and to inform the owners of their intention to include them and of the penalties incurred for injury or defacement. This is called "scheduling" a monument. The owner of such a monument is thereafter bound to give the commissioners one month's notice before he proceeds to demolish, remove (either whole or in part), alter structurally, or make any addition to the monument.

The commissioners of works, or any local authorities within the meaning of the act, have power (1) to acquire ancient monuments by purchase; (2) to accept the ownership of an ancient monument under a deed of gift or a will; (3) to assume the guardianship of any ancient monument offered to them by the owners.

Where the commissioners or a local authority acquire or accept a monument they become the legal owners of the buildings and the land on which they stand. Where the commissioners only assume guardianship, the ownership remains vested in the original owners, though the commissioners or the local authority, as the case may be, have powers of control and maintenance over it as an ancient monument apart from the owner. The commissioners of works may, in the case of any monument of which they are not owners or where they are not guardians, issue a preservation order if the Ancient Monuments board concerned reports to them that any monument which the board considers to be of national importance is in danger of destruction, removal or damage from neglect.

Towards the making of a national inventory the first step taken was the appointment in 1908 of three royal commissions, for England, Scotland and Wales respectively, "to make an inventory of the ancient and historical monuments and constructions connected with or illustrative of the contemporary culture, civilization and conditions of life of the people from the earliest times" to the year 1700 in the case of England and 1707 in that of Scotland (for Wales no date is specified), and "to specify those which seem worthy of preservation." The Housing Town-planning act and the Development and Road Improvement Funds act (both 1909), excepted the sites of ancient monuments or of other objects of historical interest from compulsory acquisition for the purposes of those acts. The Finance act of 1896 granted a qualified exemption from estate duty to pictures, prints, books, mss., works of art, scientific collections and other things not yielding income, as appear to the treasury to be of national, scientific or historic interest; this exemption only extends where such property is settled to be enjoyed in kind in succession by different persons; if the property is sold or is in the possession of a person competent to dispose of it, it becomes liable to estate duty The Finance act of 1909 extended the exemption to legacy and succession duty, removed the restriction to settled property and added "artistic" to "national and historic interest."

Apart from the numerous national and local (usually county) archaeological societies whose proceedings contain invaluable accounts of practically every monument of interest throughout the kingdom, there are three societies directly formed with the object of monument preservation in its widest sense, the Society for the Protection of Ancient Buildings, founded in 1877, the Ancient Monuments society, with headquarters at the John Rylands library, Manchester, and the National Trust for Places of Historic Interest or Natural Beauty, which was founded in 1895 with the object of generally promoting the preservation — and particularly the acquisition by gift or purchase — of places of historic interest or natural beauty and holding them in trust for the nation. The last named was incorporated by the National Trust act in 1907 and was by that act empowered to acquire by gift, purchase or devise, sites and buildings to be held in perpetuity for the benefit of the public. It possesses more than 150 properties, amounting to nearly 30,000 acres, and including 30 interesting buildings.

In 1926 the government of Northern Ireland passed an act modelled very largely on the British act of 1913.

In the Report of the Ancient Monuments Advisory committee issued in 1921, it is stated that "legislation for the protection of national monuments in this country [Great Britain] is a thing of very modern growth, as may be realized from the fact that 20 years ago the State could only exercise a very ineffective control over a limited class of prehistoric monuments, while for the care of the great architectural monuments of the country there was no State provision of any kind. The Acts of 1910 and 1913 have considerably improved the position. But even at the present day the conception of the nation's interest in, and consequent duty towards, national monuments is far behind what is embodied in the legislation of other countries, and numbers of monuments of the very first importance are entirely without protection, as far as statutory powers are concerned. The existence, however, of these Acts is in itself a recognition of the principle that the nation has an interest in Ancient Monuments apart from, and in some respects superior to, the interests of the legal owners of the monuments." In the summary of their conclusions, the members of the advisory committee said, "It appears that while the definition of a monument is everywhere much the same, a distinction is made in practice between monuments in private ownership and those belonging to public or corporate bodies. The British distinction between monuments in use and those no longer used is not recognized [on the Continent], and we are of the opinion that on logical and practical grounds the advantage is with the Continental conception. Other provisions which are not found in the British law are (1) control of movable objects, (2) preservation of scenery where it affects the amenities of a monument, (3) financial help to private owners for the preservation of monuments in their possession and (4) compensation."

France. — In France a monument is defined as any movable or immovable object the preservation of which is of public interest from an historical or artistic point of view. If a monument is in danger and the owner will take no action to preserve it, it may be placed under the direct control of the state. This function is termed scheduling and is performed by the ministry of fine arts, becoming immediately operative on notification. If the owner objects, the scheduling must be confirmed by a decree of the council of state, and compensation is payable if considered due. The owner must lodge his objection within six months. A scheduled monument, if belonging to a public body, may not be alienated without permission, and whether public or private may not be in any way damaged. Penalties are provided.

The ministry of fine arts, or departments or communes, may, if it seems to them necessary, expropriate monuments of public interest at an agreed price; but confirmation of this is necessary within six months by a decree of the council of state declaring public benefit.

Germany. — In Germany, all objects arc included which are characteristic of their times, are of value for the understanding of art and its historical development and of history in general or serve to record important historical events. Monuments may be movable or immovable, and everything which is not the property of private persons may come under the law, including all churches and public buildings and the property of universities

and other corporate bodies recognized by the state. Private property is dealt with under the general laws governing building, the State inspectors having to take care that no scheme for new buildings. or building operations of any importance. shall cause damage or disfigurement to ancient monuments. Grants of money are sometimes made to public or private owners to assist them in preserving their monuments, the state reserving, in such cases, a certain amount of control and supervision over the monument for the future.

India. — The Archaeological Survey of Upper India was established in 1862, with a director-general at its head, and surveys for other parts of India were also begun later. The chief object of these was the making of an inventory, and the preservation of the monuments was neglected. In 1878 a curator of ancient monuments was appointed. A period of activity with regard to monument preservation set in during the viceroyalty of Lord Curzon (1899–1904); this culminated in the Ancient Monuments Preservation act (1904). (S. H. H.; X.)

United States.—With regard to the remains of prehistoric man, earthworks, barrows, etc., some of those states which are especially rich in such monuments, have particular laws protecting individual remains. The sites of battlefields and statues, etc., erected in commemoration of U.S. wars, are preserved by various methods — by state or municipal regulations, by the action of incorporated bodies or trustees, etc. Most of the states rely on statutory prohibitions of malicious damage to protect their monuments. The federal government has set aside various natural features and historic spots as national monuments.

See NATIONAL PARK SYSTEM, THE.

MONUMENTS AND MEMORIALS, broadly speaking, include all objects of whatever size or nature, that have been put on view for the primary purpose of recalling to mind specific events or personages. Their production is a distinctive characteristic of societies which put value upon the individual human being and hold an objective view of historical events. (See also RELIGIOUS ARCHITECTURE; EFFIGIES, MONUMENTAL.)

Early History.—Most of nhat are loosely referred to as monuments or memorials in ancient Egypt — obelisks, sphinxes, historical wall reliefs and the like — were not so much intended to recall to mind a past fact as to create a present situation by a process of collective solipsism. The pictorial and verbal statements they made about the power or divinity or military prowess of gods and Pharaohs mere intended to create history rather than commemorate it. By the act of tangibly stating them, they were to bring realities into existence. (See EGYPTIAN ARCHITECTURE; PYRAMID.)

It was in Mesopotamia, where true awareness of individual personality first appeared, that monuments and memorials proper seem to have originated. A typical, though late, extant example is the stele of Hammurabi in the Louvre (c. 1680 B.C.), which was set up to record and commemorate that king's codification of old Babylonian law. References are frequent in the Bible to a similar practice among the ancient Hebrews — a characteristic expression of their vivid consciousness of personal relationships between individuals (*e.g.,* the cairn commemorating an agreement between Jacob and Laban, Gen. xxxi, 44–54) and between man and God (*e.g.,* the Bethel pillar, Gen. xxviii, 18–19). Relatively simple types of inscribed stones like these remained the generally standard form of monuments and memorials until Greek times. Then, with the developing ideal of classical humanism as a stimulus. they became major vehicles for artistic expression. (See also PRE-HELLENIC ARCHITECTURE.)

Greece. — The most notable early Greek monuments and memorials were connected with the great national games which were established from the 8th century B.C. on (apparently as an outgrowth of primitive funeral games) at Olympia, Nemea, Delphi, on the Isthmus of Corinth and elsewhere. While the actual prizes offered were seldom substantial — tripods being commonest in early times and simple wreaths later — winners in the various contests had the important additional privilege of setting up monuments on the grounds to commemorate their victories. Such memorials, which might be anything from small models of discoids or chariots to life-size single figures and groups, in time furnished the occasion for creating some of the greatest works of Greek art. Typical is the "Bronze Charioteer," excavated at Delphi in the 19th century; it once formed part of a complete group of chariot, horses and the goddess Nike erected to commemorate a victory in the Delphic chariot races (c. 47 j B.C.). Similarly commissioned was the original "Discobolus" (discus thrower) by Myron, executed *c.* 460 B.C., which was so famed throughout antiquity that it has come down in several copies. **A** later example is the choragic monument of Lysicrates at Athens, erected 335–334 B.C. by Lysicrates to commemorate his victory in a choral contest. It consists of a square base and circular superstructure decorated with six engaged Corinthian columns, capped by a convex roof on which stood his tripod trophy supported on acanthus scrolls.

Victor monuments were, of course, only one of many types of memorial developed by the Greeks. From the 6th century on they began to commemorate their dead with steles — painted or carved slabs of stone first depicting figures of the departed and later, scenes from his life. Characteristic are the steles of Hegeso, representing a late 5th-century woman in the simple act of choosing a piece of jewelry from a box held by her servant, and of Dexileos, a young cavalryman killed in the Corinthian War of 394 B.C., shown in the act of striking down an enemy. Memorials to historical events and personages often took the form of columns — usually but not always with regular base, fluted shaft, and capital — on which were set figures or other significant objects. Examples are the three-sided tapering shaft set up at Olympia, probably to commemorate the battle of Sphacteria in 425, atop which stood the Nike of Paionios; and the twisted bronze serpent column once bearing a tripod, which was set up at Delphi to commemorate the battle of Plataea in 479 (now in Istanbul, Turk.).

The Hellenistic tendency to megalomania is well illustrated in the monuments and memorials of that age, which became increasingly large, lavish and pretentious. An important early example was the so-called mausoleum at Halicarnassus in Caria, begun c. 350 B.C.—an enormous structure surmounted by colossal figures of King Mausolus and his queen in a chariot. Later, all the great cities of the Hellenistic east (Alexandria, Antioch, Pergamon, Ephesus) were filled with large and lavish memorials to their rulers and to their history. Particularly notable for such monuments was the Island of Samothrace. through the munificent patronage of the Ptolemies and Macedonian rulers; best known of them is the "Victory (Nike) of Samothrace" in the Louvre. (See GREEK ARCHITECTURE; SCULPTURE: Greece.)

Achaemenid Persia. — Partly contributing to, and partly inspired by, Greek developments of the memorial theme, were the monuments of the Achaemenid kings of Persia (550–330 B.C.). One type is represented by the rock-cut tomb of Xerxes at Naqsh-i-Rustam near Persepolis (c. 465 B.C.), with a great sculptured façade depicting the king standing before a fire altar on two tiers of figures representative of 30 nations in his empire. A second and distinctively Achaemenid type is represented by monumental palaces, such as those of Xerxes at Persepolis (c. 480–465 B.C.) and Artaxerxes II at Susa (404–358 B.C.). These palaces, being almost covered with depictions of the conquests, possessions and activities of their builders, were to them memorials as much (or more) as places of residence.

Rome. — The most characteristic types of Roman memorials were statues of emperors, practically mass-produced for erection in every important community of the empire; triumphal arches (*q.v.*); and columns. The columns erected by Trajan and Marcus Aurelius to commemorate their victories over Teutonic barbarians still stand in Rome; capped by colossal statues of those emperors (now replaced by saints), they were decorated with spiral bands of relief sculpture depicting their military campaigns. No matter how these columns were originally placed, continuous friezes arranged in this manner must have been extremely difficult to follow intelligently, a fact which suggests that the Roman trend in monuments was away from objective communication. toward the primitive type of collective power symbol. Certainly this was true of the columns and colossal images erected by Constantine and his Byzantine successors, which show an almost Pharaonic spirit. (See ROMAN ARCHITECTURE; BYZANTINE ARCHITECTURE.)

Sassanian Persia.—The Sassanian kings of Persia (A.D. 226–642) raised monuments inspired both by the examples of their Achaemenid predecessors and those of their Roman and Byzantine conten~poraries. Like the earlier palaces of Xerxes or Artaxerxes, the great palace of Shapur (Taq-i-Kisra) at Cteisphon (A.D. 242–272) functioned as a great memorial to the king's glory, especially his defeat of the Roman emperor Valerian. Unlike the flat-roofed palaces at Persepolis and Susa, however, a barrel vault with an 84-ft. span ran through the centre of the Taq-i-Kisra, creating a great free spatial vista similar to that achieved in the contemporary architecture of Roman Syria. The Sassanian kings carved in cliffs huge memorials to themselves, like the Achaemenids, but the style shows Hellenistic and Roman influences; *e.g.,* the great relief showing Bahram II (A.D. 276–293) fighting on horseback.

Middle Ages.—Medieval monuments and memorials were not so much calculated to preserve the memory of individual personalities as to inspire emulation of their good works: "give us grace so to follow their good examples. that with them we may be partakers of Thy heavenly kingdom." They were embodied, therefore, in the most diverse forms. Memorials on the 12th-century pilgrimage roads from France to Santiago in Spain, for instance, included: a tall marble column at Arles near the Rhône, stained with the blood of the martyred St. Genest; a magnificent gold sarcophagus at St. Gilles, which recalled the miracles of St. Giles in Gaul; a huge cross at Ostabat, commemorating Charlemagne's campaigns against the Moslems in Spain; and, of course, many churches specifically built as memorials to the life and work of particular saints: as St. Front in Périgueux, St. Martin in Tours and Ste. Foy in Conques.

A famous example of a somewhat different but still characteristically medieval type of memorial is that erected by Pope Calixtus II in 1122 to commemorate the concordat of Worms. Destroyed in 1747 but known from drawings and descriptions, it consisted of a chapel and two contiguous rooms built inside the Lateran palace, in Rome. It was decorated with mural paintings depicting, in one place, seven popes whose successive struggles with the Holy Roman emperors over rights of investiture had been triumphally concluded and, in another, seven legitimate popes seated on thrones, with prone figures of their rivals, schismatic antipopes, beneath their feet. This monument was a fruitful source of late iconography.

The commonest medieval memorials were those marking burial places, particularly in churches. These belong in the category of tombs, but insofar as they served to recall the good works of those who had gone to paradise, they can be considered as commemorative monuments. In form they varied all the way from simple inscriptions to elaborate sculptural groups. One of the most telling indications of the spread of the Renaissance spirit was the marked change of conception that appeared in them during the later middle ages. From depicting the deceased living in paradise or asleep and awaiting the last trumpet, they came in the course of the 15th and 16th centuries to represent first, corpses and then, episodes from life—a revival in short, of the classical type of memorial dedicated to preserving the earthly fame of specific people and events. This change may be seen most effectively in London's Westminster abbey. By c. 1700 the suggestion of death had for the most part disappeared from the monuments there; both figures and inscriptions relate almost exclusively to the individual's accomplishments in worldly society. (See TOMB).

Renaissance.—No classical forms were better calculated to appeal to Renaissance individualistic humanism than monuments: they were among the earliest classical motifs to be revived. Alberti, for instance, adapted the triumphal arch as the dominant element in his mid-rjth-century church façades of S. Francesco at Rimini and of S. Andrea at Mantua; he made the former church, in effect! a personal monument to his patron Sigismondo Malatesta. At the same time Donatello was reviving. in his great bronze statue of Gattamelatta in Padua (c. 1445), the classical type of equestrian monument, on the model of the Marcus Aurelius statue which now stands on the Capitoline hill in Rome. Classical monument types had been revived even earlier in painting. as in the "Hall of Illustrious Men," in Padua, decorated between 1367 and 1369 in imitation of the monument-lined effect of Greco-Roman streets, temples and houses (the subjects were drawn chiefly from Petrarch's De viris *illustribus;* repainted, 16th century). By the 15th century they mere a common subject for painters (*e.g.,* the equestrian portrait of Sir John Hawkwood in Florence cathedral, by Uccello. 1436) and had become one of the roots of the developing Renaissance art of portraiture.

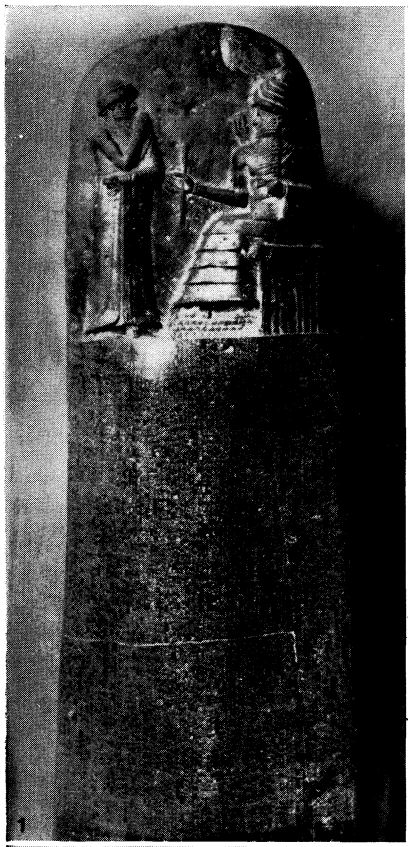
All these precedents were co-ordinated and given majestic expression by Leonardo da Vinci, particularly in the monument he designed early in the 16th century for Gian Giacomo Trivulzio, ruler of Milan. Never executed, but known from Leonardo's preparatory drawings, it consisted of a heavy base complete with frieze, cornice and architrave, a tomb for Trivulzio in its side and atop it a life-size figure of him on a horse, rearing upward to crush a crouching enemy.

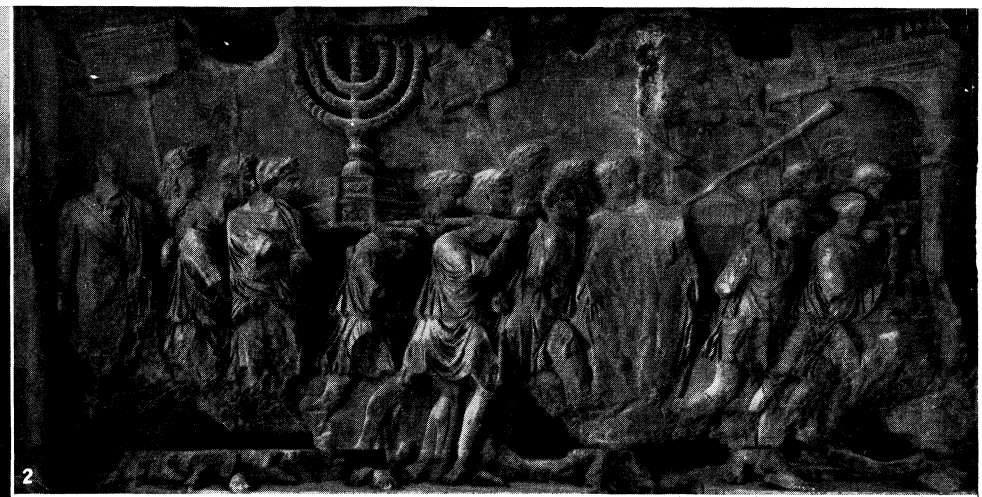
In the work of Michelangelo the concept of a memorial was broadened into a more general, allegorical type of expression. His magnificent tomb monument to Pope Julius II, first projected in 1505, was to have included, in addition to a great figure of the pontiff, over 47 free-standing statues ranged around a massive architectural base. Except for the figures of Moses and several slaves, it was never completed as planned, but something of its spirit may be realized from the Medici chapel in S. Lorenzo in Florence, begun 1520 and substantially complete by 1532. There Michelangelo went far beyond the simple commemoration of two rather obscure members of the Medici family to create a profound allegory on the nature of human life, the architecture in three zones corresponding to Hades (the lowest range, with the tombs), heaven (the upper area, with its dome) and earth (the intermediate area, with its clearly articulated architecture). The figures of Giuliano and Lorenzo de'Medici represent the active and passive aspects of human life; those of Dawn, Dusk, Day and Night symbolize the natural limits and conditions of human power.

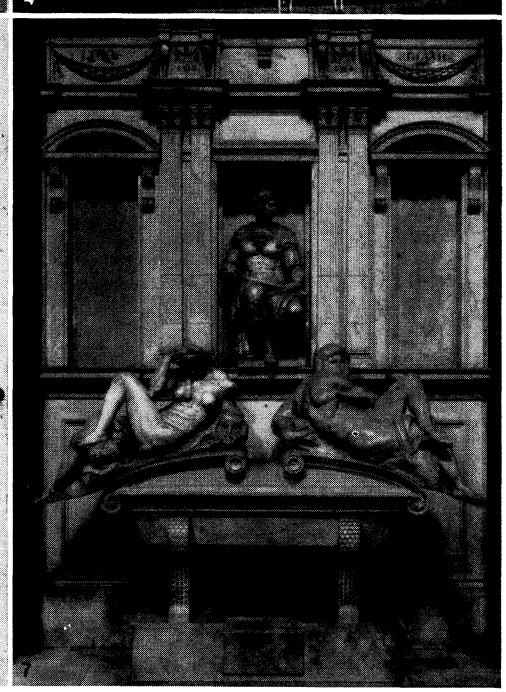
Baroque.—Michelangelo's lead was followed on a grand scale in the baroque age, large allegorical monuments and memorials being among its most characteristic manifestations. Those by Gian Lorenzo Bernini in Rome are perhaps most noteworthy. Typical are his allegorical monument to truth (1644), the colossal statue of Urban VIII (1642–47) and the equestrian monument to Emperor Constantine in the royal staircase (Scala Regia) of the Vatican palace (c. 1665). In a lighter vein are his fountains in the Piazzi di Spagna, Navona and Barbarini (see FOUNTAIN) and, in the Piazza Minerva, the famous obelisk carried by an elephant, a playful tribute to the "divine wisdom" of Pope Alexander VII. These were widely imitated and by the end of the 17th century had contributed a characteristically baroque air of grandeur and theatricality to almost every major city and palace in Europe.

Neoclassicism.—Even more than most art forms, monuments and memorials were strongly affected by the neoclassical revival of the 18th century. Although a baroque taste for allegorical themes persisted, details tended to be copied with increasing directness from specific classical models. The change in sculptural monuments can be traced particularly well in France, from its early manifestations in the numerous Roman-type monuments erected to Louis XIV at Versailles and elsewhere, through Houdon's classically draped statues of Voltaire and Washington of the 1780s, to the coldly and completely classical monuments executed by Canova in the Napoleonic era. German regions provide good examples of the development of monuments in classical architectural form; from the two imitations of Trajan's column erected in 1717 to flank Fischer von Erlach's church of St. Charles Borromaeus in Vienna, to Langhaus' Brandenberg gate in Berlin, built 1788–91 as a combination of the triumphal arch motif (the chariot group) with a reproduction of the propylaea (the jth century B.C. entrance to the Athenian acropolis).

Enthusiasm for classical monuments continued unabated into the first half of the 19th century. Characteristic are the many triumphal and memorial columns, such as that in the Place Vendôme, Paris; Nelson's in London; and Washington's in Baltimore, Md. Obelisks, like the Washington monument in Washington, D.C., were a popular variant on the column theme. Even in the 20th century the tradition of classical monuments remained strong





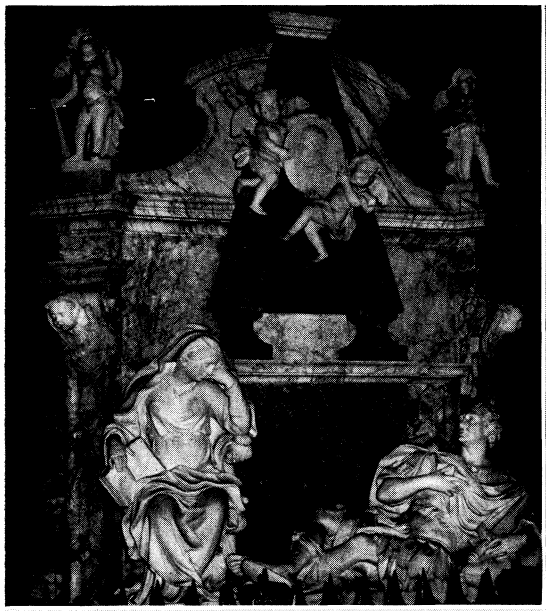


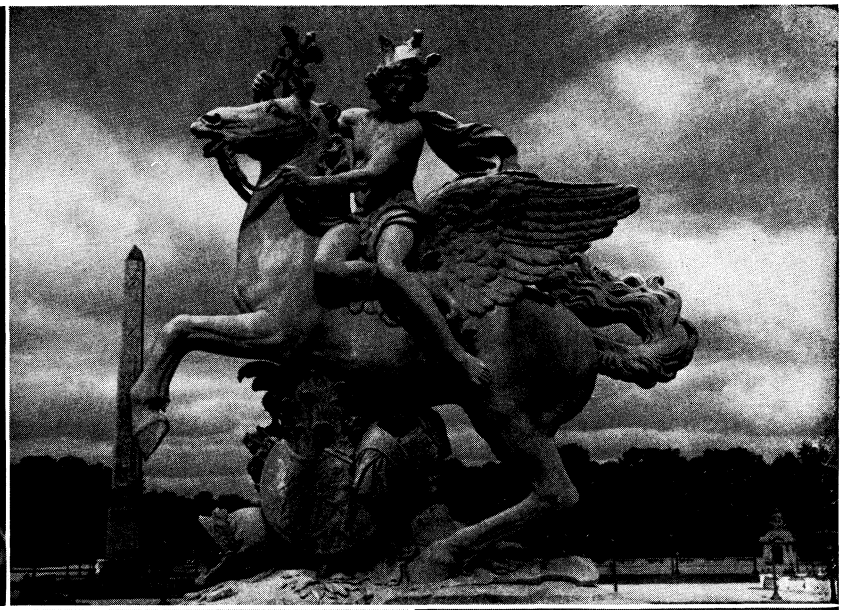
BY COURTESY OF. (4) MINISTERE DE L'INFORMATION, FRANCE (6) BY GRACIOUS PERMISSION OF HER MAJESTY QUEEN ELIZABETH II; PHOTOGRAPHS, (I) THE MANSELL COLLECTION, LONDON, (2, 3, 5. 7) ALINARI

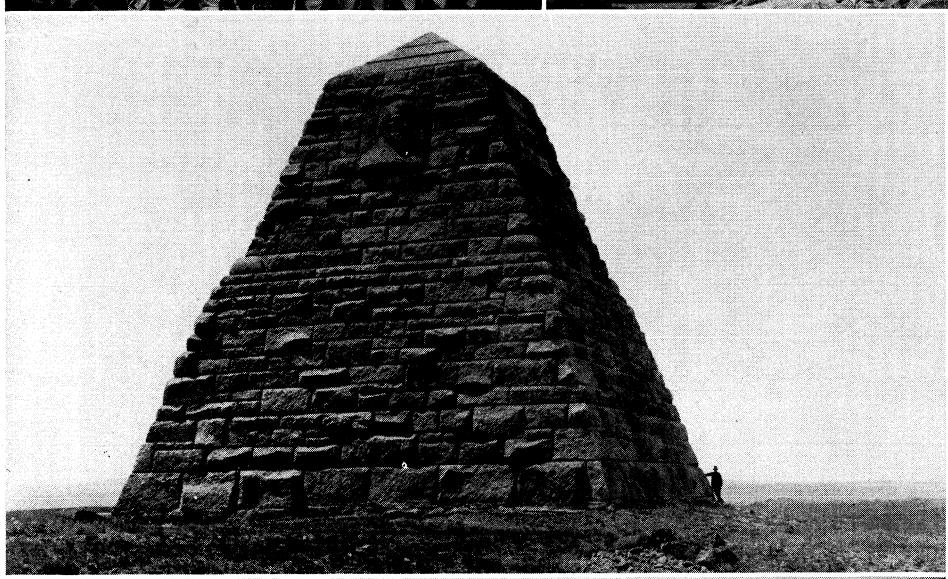
MONUMENTS AND MEMORIALS OF ASIA MINOR AND EUROPE

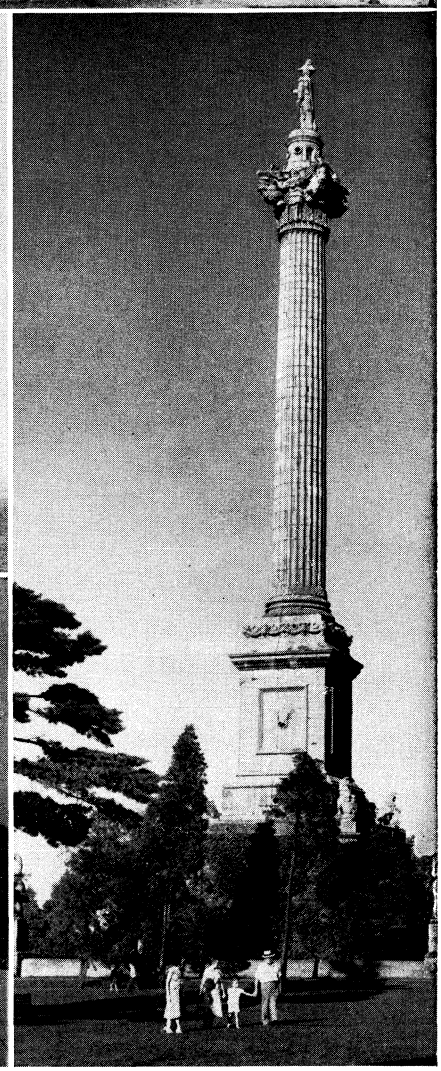
1. Stele of Hammurabi, c. 1700 B.C. In the Louvre, Paris
2. "Spoils From Jerusalem," detail of relief sculpture on the Arch of Titus erected in Rome to commemorate the capture of Jerusalem, 1st century A.D.
3. Choragic (in honour of the leader of a Greek chorus) monument of Lysicrates. Athens. 335 B.C.
4. "Calvary Monument" in Brittany. 15th century
5. Bronze charioteer, victory monument erected at Delphi c. 475 B.C. In the Delphi museum
6. Sketches by Leonardo da Vinci for the Trivulzio monument in Milan, early 16th century. In the library of the Royal castle, Windsor, Eng.
7. Memorial to Giuliano de' Medici in the new sacristy of S. Lorenzo, Florence. By Michelangelo, about 1520–32

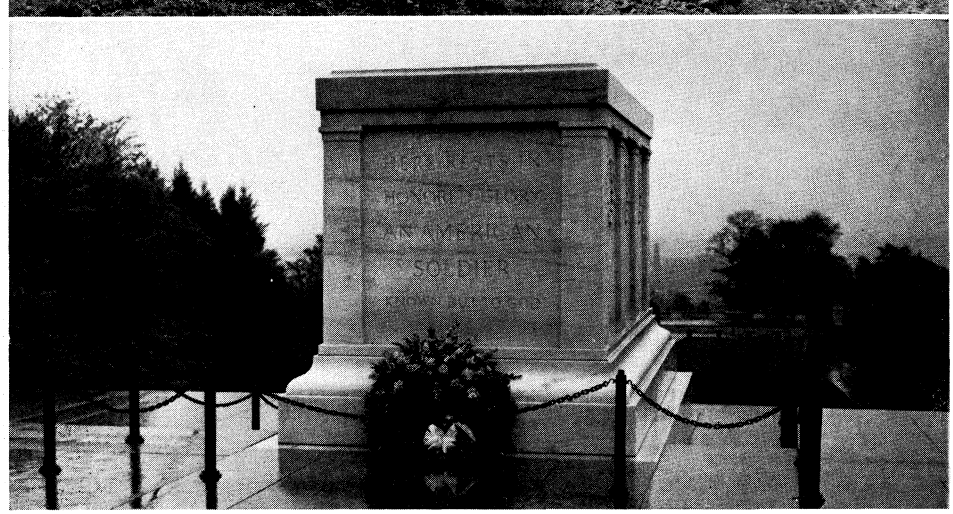
MONUMENTS AND MEMORIALS











BY COURTESY OF (TOP RIGHT) SERVICES DE L'INFORMATION, FRANCE, (CENTRE LEFT) UNION PACIFIC RAILROAD (BOTTOM RIGHT) DEPARTMENT OF TRAVEL AND PUBLICITY, ONTARIO: PHOTOGRAPHS. (TOP LEFT) TOM BROWLEY TAVISTOCK DEVON (BOTTOM LEFT) WIDE WORLD

MONUMENTS AND MEMORIALS IN EUROPE AND THE U.S.

Top left: Monument to Edward Eliot (d. 1722), in St. Germanus church, Cornwall, by John M. Rysbrack (1694–1770). The deceased is shown in Roman costume with an allegorical figure mourning

Top right: Luxor obelisk and the "Horses of Marly" by Guillaume Coustou, between 1740 and 1745. In the Place de la Concorde, Paris

Centre left: Monument to Oakes and Oliver Ames in Sherman, Wyo., 19th century. Designed by H. H. Richardson: relief by Auguste Saint-Gaudens

Bottom left: Tomb of the Unknowns, Arlington National Cemetery. Dedicated to the unknown dead of World Wars I and II and the Korean War

Bottom right: A neoclassical triumphal column, the monument to Sir Isaac Brock (d. 1812), Queenston Heights, Ontario

enough to produce one of the most impressive of all—the Lincoln memorial in Washington, D.C. (by Henry Bacon, 1914–22).

19th Century. — The Victorian period was a great age of monument and memorial building. Its pre-eminent emphasis on individual achievement, its prosperity (especially in countries such as England), its development of mass democracy, its romantic admiration of the past and its dominant taste for picturesque visual forms all contributed to a veritable efflorescence of monuments—most of which, unfortunately, were more lavish and expensive than aesthetically satisfying. Characteristic is the Albert memorial in London, erected in 18j2 on the designs of Sir Gilbert Scott. An ornate combination of the medieval shrine memorial and the baroque allegorical monument, its picturesque massing and variegated outline are recognizably and distinctively Victorian.

Perhaps the most elaborate monument of the age was that to Victor Emnianucl II in Rome, begun in 1885 by Sacconi—a great loggia with 48-ft. high columns, pedimented end pavilions supporting sculptural groups, and a great equestrian statue of the king culminating the whole.

An essentially new kind of monument developed during the late 19th century—the soldiers' war memorial. To commemorate the trade and dynastic wars of earlier times, fought by professional armies, it had been sufficient simply to erect monuments to commanding generals or to place cairns and crosses on battlefields. Wars fought by theoretically volunteer armies on the basis of appeals to individual conscience and patriotism, however, demanded memorials to the common soldier. It was in the United States, after the Civil War, that the first true memorials to citizen-soldiers were erected. Almost every U.S. community of any size, north or south, had at its centre a memorial to its dead in that conflict, consisting generally of a pedestal inscribed with their names and the battles in which they had fought, with one or more figures of soldiers ranged on or around it.

20th Century. — Of much the same type were most of the civic monuments erected later to the dead of World War I by all the combatant nations. This war probably produced far more monuments and memorials of all sorts than any other single event in history; but with some notable exceptions, the great majority of them consisted of pompous and uninspired reworkings of old classical themes — triumphal arches. temples. urns, cenotaphs. sarcophagi and the like. Perhaps for this reason (or perhaps because of the nature of contemporary sculpture or for more basically sociological reasons), there was an evident lack of enthusiasm for erecting similar memorials after World War II. At mid-century, the practice of commemorating people and events by memorial buildings. such as auditoriums, schools and town halls, was noticeably displacing the older types of sculptural monuments.

FAR EAST

India. — Among Indian monuments and memorials two types are outstanding: (1) the stupa (mound or tower) built during the centuries of Buddhist ascendancy and (2) the mausoleum of the succeeding Islamic period. In concept the stupa has a good deal in common with the medieval Christian type of memorial; that is, its purpose was to recall to mind and inspire emulation of a way of life more than to commemorate a specific personage. The stupa developed in response to instructions given by the dying Buddha in 483 B.C. that his body be cremated and the relics distributed beneath earth mounds to commemorate his nirvana. In form the stupa seems to have originated as a fusion of two distinct traditions of a divine world-shelter: one, the "four-cornered heaven" (Varenna), apparently introduced to India by the conquering Aryans; the other, a circular domical shape, derived from the primitive huts of the native Dravidian culture. In the classic type of Buddhist stupa (*e.g.,* the great stupa at Sanchi, 70–25 B.C.) these two elements may be recognized in the great dome (anda) and the square coffer (harmika) which caps it. Over the *harmika* a third element developed, a spire surmounted by first one. then three honorific umbrellas; it was this form which later inspired the pagodas of China, Tibet and Japan.

The most famous Islamic mausoleums of India are the 16th-century tomb of Humayūn at Old Delhi and, of course, the Taj Mahal (*q.v.*) at Agra, erected in the 17th century by Shah Jahan as a memorial to his wife. Standing on a platform 18 ft. high it is approached by a formally planted avenue; its great white dome rises 210 ft. in the air, and the whole is reflected in the Jumna river flowing beside it. This memorial has often been called the most perfect building in the world. (See also INDIAN ARCHITECTURE; MOHAMMEDAN ARCHITECTURE.)

China **and** Sapan. — Except for stone memorial steles erected to warriors and other notable persons from the Han period onward, the most distinctive monuments and memorials in China, as in India, were erected under the influence of Buddhism. Most important of them was the pagoda. The pagoda originated as a variant of the small memorial spire set on the *harmika* of Indian stupas; but under the influence of differing traditions, in building and symbolism, it soon came to dominate the other elements of the stupa, often, indeed, reducing them to mere vestiges. In form the Chinese pagoda seems to have been derived from small wooden watchtowers of the Han period; later examples were larger, and often in brick and stone (*e.g.,* the six-sided pagoda at She Shan, Kwangsi. built of white stone on a radial plan, begun c. 600 A.D.).

Following Chinese precedent, magnificent pagodas were also built in Japan, from the 6th century on; one of the finest is in the centre of the complex at Hōryūji.

See also CHINESE ARCHITECTURE; JAPANESE ARCHITECTURE.

(AN. G.)

MONVEL (JACQUES MARIE BOUTET) (1745–1812), French actor and author was born at Lunéville on March 25, 1745. He made his debut at the Comédie Française in 1770 and subsequently conquered his physical shortconlings (he mas a small, thin man without good appearance or voice) by developing an impeccable diction and stressing the intellectual penetration of his parts. A scandalous episode forced him to leave for Sweden (1781), where he was appointed reader to the king. He returned to Paris in 1788 and. having lost his status at the Comédie Française, acted for a while at the Variétés Amusantes du Palais-Royal. In 1791 he became a member of the Théâtre de la République. He sympathized with the revolutionaries and became engaged in political propaganda, which he regretted later. In 179j he was given a professorship for elocution at the Conservatoire. Monvel was the author of a score of plays and comic-opera librettos. He died in Paris in 1812. (A. M. N.)

MONZA (locally *Monscia*), city, Lombardia. Italy, in the province of Milano, by rail, 8 mi. N.N.E. of Milan, with which it is also connected by both steam and electric trams. It lies on the Lambro, a tributary of the Po, j32 ft. above sea level. Pop. (1951) 63,62j. Near the Porta d'Agrate is the nunnery in which the nun of Monza was enclosed. The cathedral (590) was enlarged at the close of the 13th century, and the black-and-white marble façade was erected in the 14th by Matteo da Campione. On the left is the brick tower, 278 ft. high (1592–1606). Within the church are the iron crown of Lombardy. supposed to have been beaten out of one of the nails used at the Crucifixion and the treasury containing the relics of Theodelinda (see LOMBARDS), comprising her crown, fan and comb of gold, and the golden hen and seven chickens, representing Lombardy and her seven provinces, and crosses: reliquaries, etc., of the Lombard and Gothic periods.

Monza (anc. *Modicia*) was a village until the time of Theodoric. During the period of the republics Monza was sometimes independent. sometimes subject to Milan. The Visconti built a castle in 1325. Monza has stood 32 sieges, and was repeatedly plundered — notably by the forces of Charles V. At Monza King Humbert I was assassinated on July 20, 1900; an expiatory chapel was dedicated in 1910.

MONZONITE, a name proposed by the Norwegian geologist Waldemar Christofer Brogger for plutonic rocks containing abundant and approximately equal amounts of plagioclasc and potash feldspar (*q.v.*), with subordinate biotite and hornblende (an amphibole) and sometimes minor quantities of pyroxene, usually orthorhombic. Quartz) nepheline and olivine are occasionally present; their presence is usually denoted by adjectival modifiers, viz., quartz-monzonite, but in the type region (Monzoni, Italian Tyrol)

they rarely occur as major constituents. In Monzoni, moreover, the plagioclase is often as calcic as labradorite (*q.v.*) and commonly it shows prominent zoning. Rocks similar to those of the type area have been described from Norway (as akerites), Montana (yogoite, shonkinite), Sakhalin Island off the Pacific coast of the U.S.S.R. and at numerous other localities throughout the world. The type is not to be regarded as rare. but its members ordinarily occur in rather small, heterogeneous masses associated with, and perhaps gradational to. diorites, pyroxenites or gabbros.

The name quartz-monzonite early achieved wide and completely unjustified acceptance in the United States as a name for the commonest type of granite. in which quartz is a major constituent, plagioclase is rarely as calcic as andesine and pyroxene is very rare and almost never rhombic. Such rocks may form rather large and often exceedingly homogeneous masses. Although gradually dying out. this confusing usage is deeply enshrined in the text and journal literature. The student, and perhaps most especially the casual reader, must be on his guard against it. (F. Cs.)

MOODY, DWIGHT LYMAN (1837–1899), **U.S.** evangelist, the foremost of the last quarter of the 19th century, who, though never ordained, conducted scores of mass evangelistic campaigns in the largest cities of the Cnited States and Great Britain, was born in East Korthfield; Mass., on Feb. 5, 1837. Moody left his mother's farm at 17 to work in his uncle's shoe store in Boston, where he was converted from Unitarianism to orthodox evangelicalism. Moving to Chicago in 1856, he prospered rapidly in the boot and shoe business until 1860, when he dedicated his life to Christian work. Between 1861 and 1873 Moody served on the Christian commission of the Young Men's Christian association, was president of the Chicago Y.M.C.A., founded the Moody church and engaged in Sunday school and slum mission work. In 1873 he began his first evangelistic meetings in Great Britain. His colourful, dramatic sermons and intense conviction, together with the pleasing baritone voice and moving gospel hymns of his choir director, Ira David Sankey, attracted wide attention. Thousands of persons professed conversion. Returning to the United States in 1875 he repeated his success. His most successful revivals were those in Edinburgh, Glasgow, London, New York, Philadelphia, Chicago and Boston. In addition to conducting revivals, he founded in Northfield, Mass., the Korthfield seminary for girls in 1879 and the Mount Hermon school for boys in 1881, the Rloody Bible institute, Chicago, Ill., in 1889, and directed annual Bible conferences at Korthfield.

Moody had no formal theological training and felt that sectarian doctrines were a divisive force among Christians. Deploring the higher criticism, the social gospel movement and the theory of evolution, Moody preached "the old-fashioned gospel," the literal Bible and the premillennial Second Coming. Although he worked ardently in various charitable activities, he insisted that social problems could be solved only by the divine regeneration of individuals. His city-wide revivals were financed by prominent Christian businessmen who sincerely believed that Moody would alleviate the hardships of the poor by converting them to honesty, sobriety, industry and piety. Evangelical ministers of all denominations co-operated with Moody, but there is little evidence that his revivals had much influence outside the ranks of the regular churchgoers. He died in Northfield on Dec. 22, 1899.

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MOODY, WILLIAM VAUGHN (1869–1910), U.S. poet-dramatist, whose greatest success, ironically, was a prose play, *The Great Divide*. Born in Spencer, Ind., July 8, 1869, in 1889 he entered Harvard, where he became an editor of the *Harvard Monthly*, in which his early poems appeared. After graduating, he taught for several years, first at Harvard (1894–95), then at The University of Chicago (1895–1901). Moody's mature work was done between 1900 and 1910, when many U.S. writers were striving toward greater freedom of form and subject. He first attracted attention by several outspoken poems on contemporary issues: "An Ode in Time of Hesitation," "On a Soldier Fallen in the Philippines" and "Gloucester Moors," later collected in *Poems* (1901). Increasingly interested in a poetic theatre, Moody nrote a trilogy of poetic dramas: *The Masque of Judgment* (1900), *The Fzre-Bringer* (1904) and *The Death of Eae* (incomplete). *The Great Divide* (1906) was a notable contribution to the U.S. stage; another prose play. *The Faith Healer* (1909), was less successful.

Moody's work is characterized by seriousness of purpose and artistic integrity. Questioning in spirit, it is nonetheless basically optimistic, affirming the beauty and dignity of human life and its ultimate significance. His poetry is marked by subtle rhythms, sensuous imagery and dramatic lyricism. In 1909 Moody married Harriet Tilden Brainard. He died of a brain tumour on Oct. 17, 1910.

Moody's other publications include: *The Poems and Plays of William Vaughn Moody* (1912); *Selected Poems of William Vaughn Moody* (1931); *Some Letters of William Vaughn Moody* (1913); *Letters to Harriet* (1935). Moody received an honorary doctor of letters from Yale and was elected to the American Academy of Arts and Letters (1908).

See D. D. Henry, *William Vaughn Moody, a Study* (1934). (W. L. A.)

MOON, in astronomy, the name given to the satellite of any planet, specifically to the satellite of the earth (a common Teutonic nord. *cf.* Ger. *mond,* Dutch *maan*, Danish *maane,* etc.. and cognate with such Indo-Germanic forms as Gr. *men,* Sanskrit *mās,* Irish *mi* , etc., Lat. uses *luna, i e., lucna,* "the shining one." *lucere,* "to shine," "for the moon," but preserve5 the nord in *mensis,* "month"; the ultimate root for moon and month is usually taken to be *me-,* "to measure," the moon being a measurer of time). The moon has been an object of worship to man (*see* particularly DIANA; SELENE; SIX) as well as one of his first guides to the regular measurement of time (*see* CALENDAR). Kumerous superstitions still survive attributing terrestrial effects to the influence of the moon, but only the movement of the earth's tides is directly affected by the moon. (*See* TIDES.)

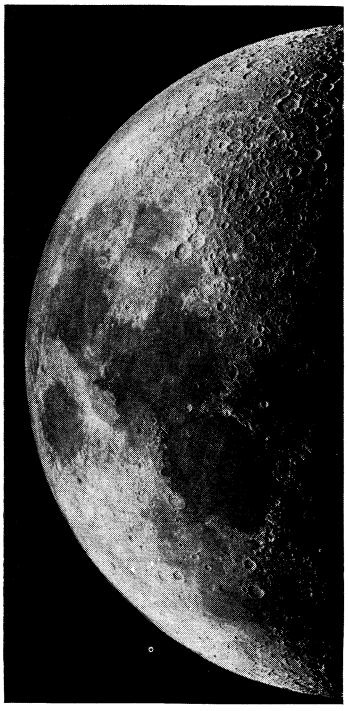
This article is divided into the following sections and subsections as follows.

I. Lunar Theory
  1. Historical
  2. Gravitational Theory
II. Physical Nature of the Moon
  1. The Apparent Motion of the Moon
  2. Moon's Surface
  3. Origin of Surface Features
  4. Origin of the Moon
  5. Rriphtness of the Moon
  6. Constants of the Moon's Size and Motions

I. LUNAR THEORY

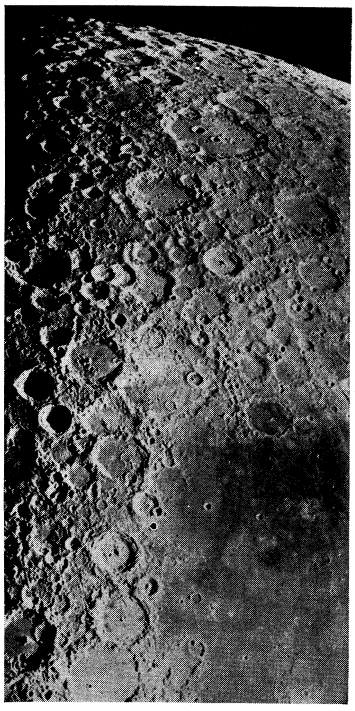
1. Historical. — In ancient times the moon was a very important body for night illumination and a great deal of attention was given to its motions. The observations made were of an exactitude far in advance of those in other physical sciences. Hipparchus (2nd century B.C.) discovered the eccentricity of the moon's orbit and the motion of the apse. The inclination of the orbit to the ecliptic and the motion of the node were also determined by him. He explained the motion of the moon as uniform in a circular orbit with the earth placed eccentrically, and this was amply sufficient for the observations of that time. The numerical values were derived from observations of eclipses. For fixing the quantities which require the lapse of long intervals of time for their accurate evaluation he made use of the oldest eclipse observations available. At the times of eclipses the inequality in longitude due to eccentricity cannot be separated from an important solar perturbation called the evection. Consequently, he got a value of the eccentricity in longitude (true value 6°.29) erroneous by the amount of the evection (1°.27). The latter inequality was discovered hy Ptolemy (fl. A.D. 140). No great improvement in the knowledge of the moon's motion was made, except for slightly improved accuracy in the mean motions till Tycho Brahe (1546–1601) discovered another inequality due to solar attraction, called the variation, which has greatest effect when the moon is 45° or 135° distant from the

MOON

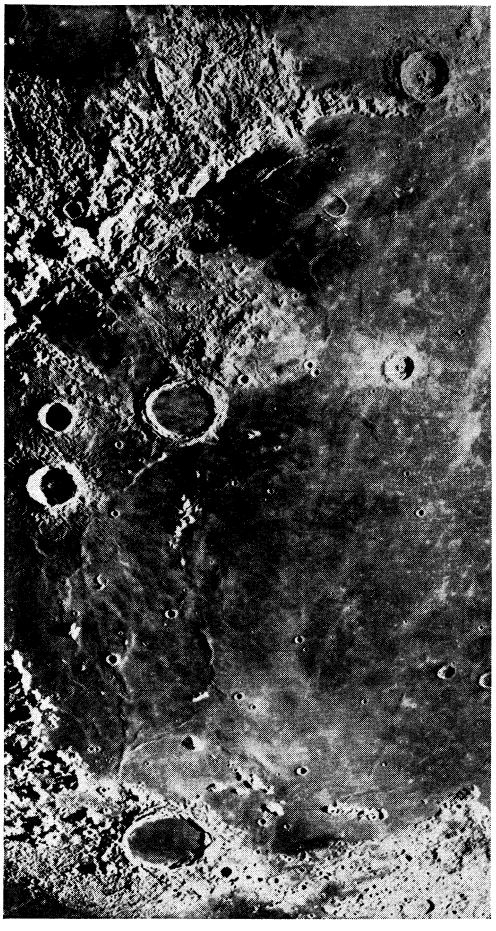


The moon at first quarter

Full view of the side of the moon visible from earth, a composite picture made from photographs of the first and last quarters. A photograph thus prepared shows details more clearly than a single picture taken at a full moon. The dark, smoother areas of the moon are called ***maria,*** or seas, although no water is present on the moon

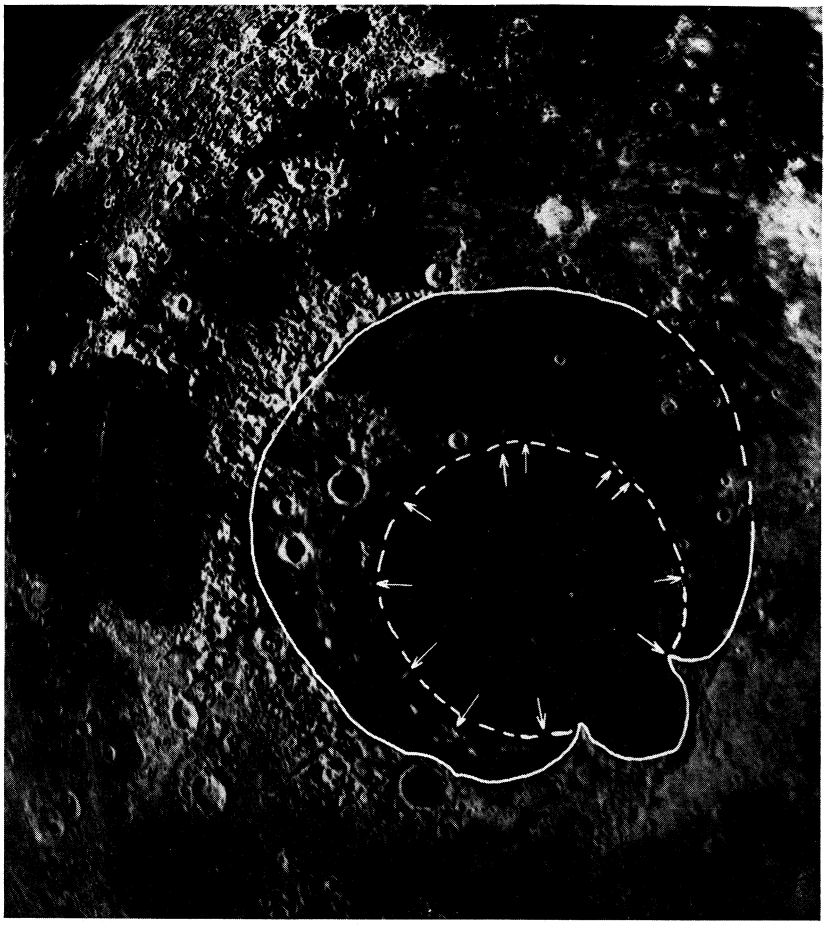


South pole and part of Mare Nubium



Mare Imbrium

NOTE. AS IS CUSTOMARY WITH PHOTOGRAPHS AND MAPS OF THE MOON, ALL PICTURES ON THIS AND THE FOLLOWING PAGE ARE ORIENTED WITH SOUTH AT THE TOP

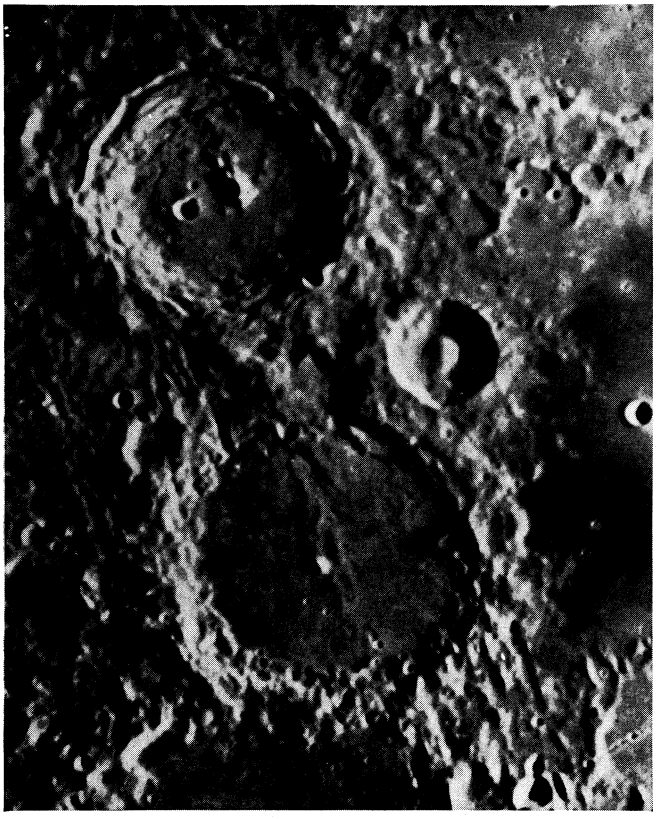


Mare imbrium with foreshortening eliminated. The ***mare*** is nearly circular with Sinus iridum at the bottom and slightly to the right. Broken line indicates collision area and arrows point to mountainous peaks on the periphery of this area. It appears that the colliding object came in through Sinus Iridum and produced the unsymmetrical area outlined

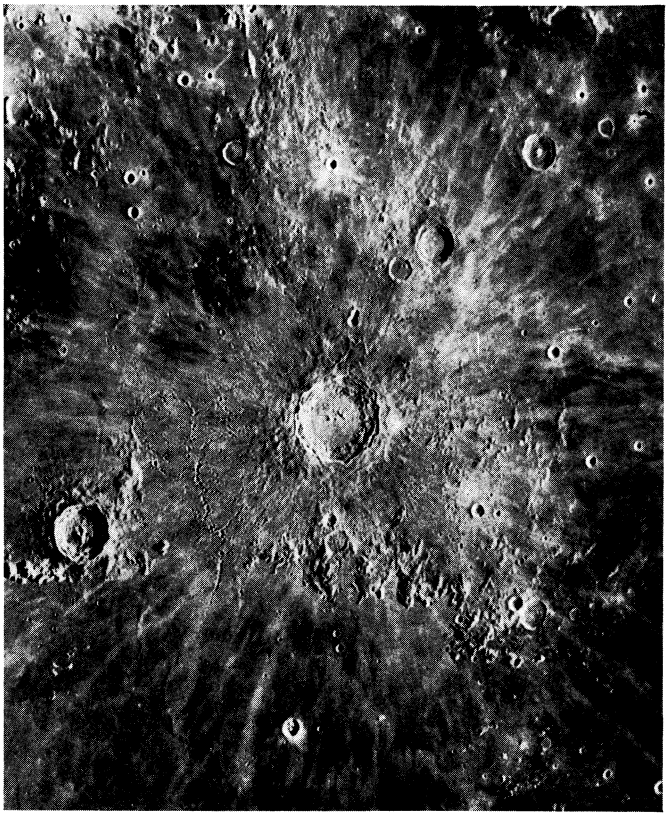
THE MOON AND ITS CRATERS

BI COURTESY OF (TOP LEFT) THE PARIS OBSERVATORY. (TOP CENTRE) LICK OBSERVATORY PHOTOGRAPH. (TOP RIGHT BOTTOM LEFT) THE DIRECTOR OF THE MOUNT WILSON OBSERVATORY, (BOTTOM RIGHT) HAROLD C UREY

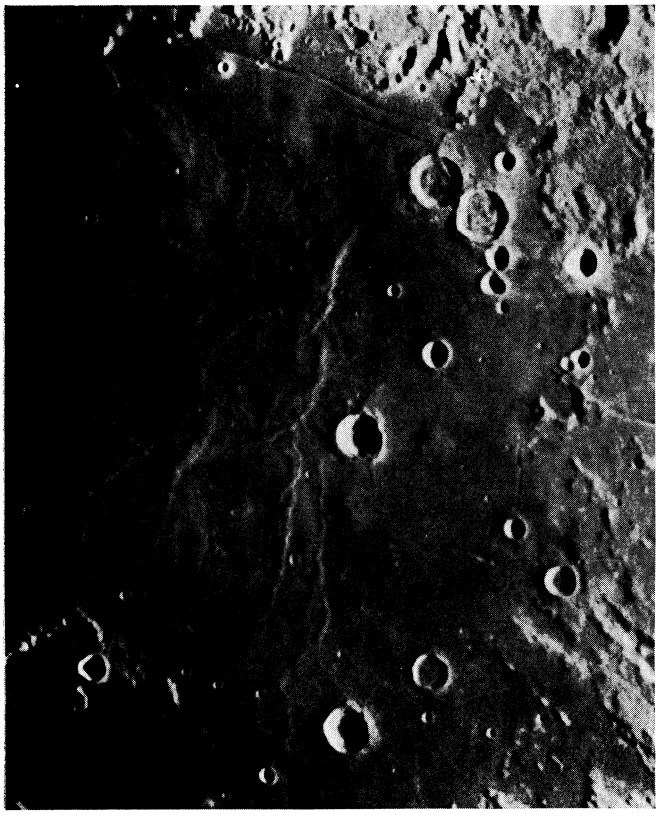
MOON



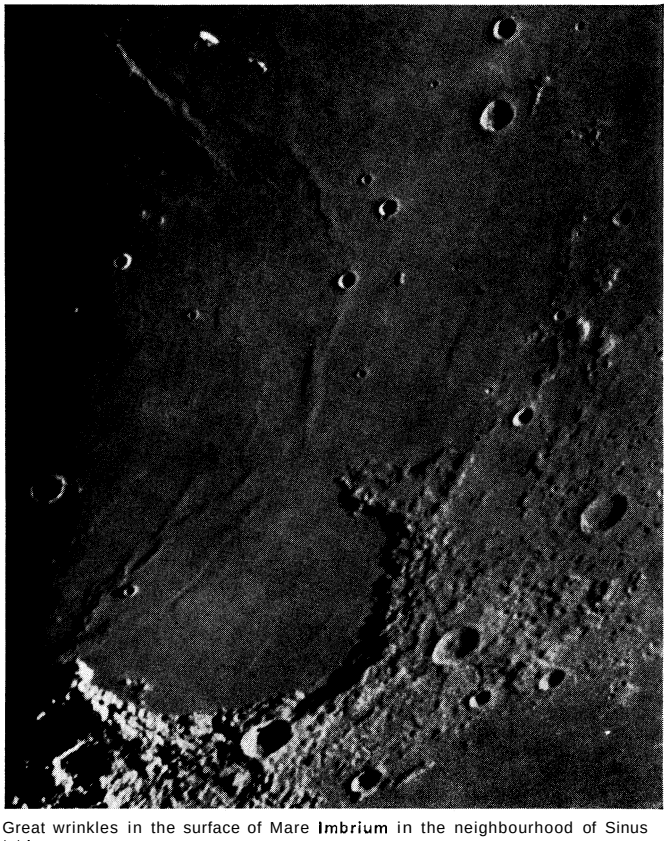
The craters Alphonsus, Arzachel and Alpetragus. The dark spots within Alphonsus indicate regions where gases may have escaped from the interior in the past



Area around the craier Copernicus



Eastern part of Mare Tranquillitatis showing the wrinkles on the surface of this mare



Great wrinkles in the surface of Mare Imbrium in the neighbourhood of Sinus Iridum

DETAILS OF THE MOON'S SURFACE

BY COURTESY CF (TOP LEFT. BOTTOM LEFT, BOTTOM RIGHT) G. P. KUIPER, (TOP RIGHT) LICK OBSEF

sun on either side. The coefficient of this term is 0°.66. The explanation of all these inequalities and the construction of an adequate theory of the moon's motion had to await the discovery of universal gravitation.

2. Gravitational Theory.—Newton's theory of gravitation was based largely on the comparison of the motion of the moon with that of bodies falling freely on the earth. The portion of the *Principia* that specially refers to the motion of the moon is contained in propositions 22, 25–35 of book iii. Newton succeeded in proving that the principal periodic inequalities as well as the mean motions of the perigee and node were due to the sun's action, and he added some other inequalities which had not been deduced previously from observation. The result which he obtained for the mean motion of the perigee was only about half the observed value, but it appears from manuscripts that are extant that he succeeded later in explaining the observed motions within 8%. Newton's results were given in a geometrical form but he probably first obtained them by the method of fluxions (*q.v.*). No substantial advance was made on Newton's work till Alexis Clairaut developed his analytical theory 60 years later. Clairaut's work was followed by that of d'Alembert, Euler and Laplace in the 18th century.

The problem of the lunar motion is solved in two steps. In the first step, or "main problem," it is assumed that the sun, earth and moon behave as mass particles and that the centre of gravity of the earth-moon system moves in a fixed ellipse about the sun. After the solution of the main problem, the remaining forces are treated by introducing small variations in the main solution. These additional effects include: the variation in the elliptic orbit of the sun caused by perturbations of the moon and planets; the direct perturbation of the moon by the planets; the elliptical shapes of the earth and moon; and relativity effects.

The solution of the main problem gives the co-ordinates as harmonic series where the arguments are linear functions of the time involving the four fundamental frequencies, n, n', π, ☊, ahich designate the mean motions of the moon, the sun. the moon's perigee and its node, respectively. In practice the arguments are expressed in terms of the angles D, l, l' and F nhose motions are n–n', n–w, n' and n–☊ respectively. The coefficients are power series in the arbitrary parameters: e the eccentricity of the moon's orbit, about 0.055; e' the eccentricity of the earth's orbit, about 0.017; γ the sine of half the inclination of the moon's orbit, about 0.046; m the ratio of the mean motions of the earth and moon, about 0.075; and a the ratio of the mean distances of the moon and sun, about 0.0025. The parameters e, e', γ, m and α are determined from observation. The planetary perturbations introduce new terms involving the periods of the planets in the arguments, and they introduce secular changes in the fundamental arguments and in the coefficients resulting from the solution of the main problem.

The development of the equations can be made algebraically with all the parameters appearing explicitly. After the expansions are completed the numerical values of the parameters are substituted. This method is elegant and facilitates changes in the parameters; it is however very laborious. An easier method of obtaining a given accuracy is to substitute numerical values of the parameters at the outset. Small changes in the parameters are then made from approximate algebraic developments.

The three most recent lunar theories are those of P. A. Hansen, of C. E. Delaunay and of G. W. Hill and E. W. Brown.

Hansen made a numerical development and obtained results of much greater accuracy than any preceding. His results mere used internationally from 1862 to 1922. Corrections by S. Newcomb were applied after 1883.

The most complete algebraic developments of the lunar theory is the monumental work of Delaunay. His results were not quite accurate enough for comparison with observations. but they have been of great value in many theoretical studies including the examination of other theories, and in the second half of the 20th century in the discussion of the orbits of artificial satellites.

Toward the end of the 19th century Hill re-examined the methods previously used in the lunar theory and developed methods by which results of a given accuracy could be obtained with much less labour than before. His methods have been effective in the discussion of the general problem of three bodies (see THREE BODIES. PROBLEM OF) and in the practical solution of the lunar problem. Two of his conclusions mere: (1) that the expansion should be algebraic except for m, the numerical value of which should be substituted at the outset since this parameter is the most accurately known and is the one that gives by far the most trouble in the algebraic developments; and (2) the co-ordinates should be referred to rotating rectangular axes as introduced by Euler. His method of determining the motion of the perigee is elegant and effective. J. C. Xdams used a similar method to determine the motion of the node.

After 1923 the co-ordinates of the moon generally used were computed from the developinents of Brown, who employed the methods developed by Hill and Adams. The series for the co-ordinates contains about 1,500 terms—about five times as many as were employed by Hansen. The following are excerpts from Brown's expressions. The epoch is 1899. Dec. 31, Greenwich mean moon, from which T is computed in Julian centuries of 36,525 days; r denotes a revolution or 360°.

Mean longitude	$= 270°26'11''.71$
	$+ 1336^r\ 307°53'26''.06\ T$
	$+ 7''.14\ T^2 + 0''.0068\ T^3$
Empirical term	$+ 10''.71 \sin (240°.7 + 140°.0\ T)$
Longitude of perigee	$= 334°19'46''.40$
	$+ 11^r\ 109°2'2''.52\ T$
	$- 37''.17\ T^2 - 0''.045\ T^3$
Longitude of node	$= 259°10'59''.79$
	$- 5^r\ 134°8'31''.23\ T$
	$+ 7''.48\ T^2 + 0''.008\ T^3$

The following are all the periodic terms in the moon's longitude nith a coefficient over 212″, as given in Brown's tables. The parallactic erm is included because of the attention it has attracted. The iargest of the planetary terms, due to Venus, has a coefficient of 14″.27 and a period of 273 years. The next largest planetary terms are two or three of the order of 1″.

$+ 22639''.500 \sin l$	Largest terms in equation of centre.
$+ 769.016 \sin 2l$	
$- 4586.426 \sin(l-2D)$	Evection.
$- 125.154 \sin D$	Parallactic inequality.
$+ 2369.902 \sin 2D$	Variation.
$- 668.111 \sin l'$	Annual equation.
$- 411.608 \sin 2F$	Reduction to ecliptic.

The computation of a precise ephemeris of the moon by evaluating the series involves considerable calculation, and to assist in this work Hansen and his predecessors and Brown prepared voluminous "tables." Brown's tables fill 6jo quarto pages, and even with the tables a man working full time could extract the data just fast enough to keep up with the moon.

The advent of the electronic calculator made feasible the direct evaluation of the formulas and the tables were no longer needed; moreover, the tables were not as accurate as the series, so the direct calculation gives improved accuracy. The direct calculation of the co-ordinates for the years 1952–71 were compiled by W. J. Eckert. Rebecca Jones and H. K. Clark; the results are contained in the *American Ephemeris* and *Nautical* Almanac and other national ephemerides beginning with 1960, and for the years 1952–59 in a supplemental volume. In this calcularion the empirical term was omitted and the following correction applied to the mean longitude: $- 8''.72 - 26174\ T - 11''.22\ T^2$.

When Brown's solution was completed the accuracy was more than equal to that of the best observations, but recent improvements in observing techniques have surpassed the accuracy of the theory.

Because of the moon's nearness to the earth and its rapid angular motion, it has long played an important part in the formulation of physical theory. In addition to the motion of the moon providing the key to the discovery by Newton of his law of gravitation, more recently it led to the discovery of the irregular rate of rotation of the earth. When the rotation of the earth is used to measure the time of observation of a celestial object, any ir-

regularity in the earth's rotation is reflected in the difference between the observed and computed position of the object. The magnitude of the effect is greatest for the most rapidly moving object, and first appeared in the motion of the moon. It was of course kno n that the ocean tides are slowing down the rotation of the earth. but the discrepancies were of a more irregular nature. Newcomb found that the discrepancies during the 18th and 19th century could be well represented by a sine term with a coefficient of about 10″ and a period of 260 years. and this is essentially the "empirical term" in the mean longitude used by Brown. For some time it was thought that this term might be due to an oversight in the theory, but it was later established that it is due to irregularities in the earth's rotation; the motion of the moon is now used to correct the time determined by the rotation of the earth.

An interesting aspect of the lunar motion is the rapid rotation of the ellipse and of the plane of the orbit. The annual motion of the perigee is approximately 146,000″ and that of the node 70,800″. In each case all but about 10″ results from the effect of the sun, and the remainder from the shape of the earth, the action of the planets, the relativity effect and the shape of the moon.

(W. J. ET.)

II. PHYSICAL NATURE OF THE MOON

1. The Apparent Motion of the Moon. — The sidereal month is 27.32 days and in this interval the moon makes on the average a complete revolution relative to the stars. In the meantime, the earth is moving in its orbit round the sun and it is not till after the lapse of an additional 2.21 days that the moon is in the same position relative to the sun's direction; the synodic month being 29.53 days.

The moon being an opaque body, shining by reflected light, only that portion of the hemisphere that is illuminated and turned toward the earth can be seen. At new moon, M^1, (see figure) the hemisphere turned toward the earth is wholly unilluminated by sunlight, while at full moon, M^5, the fully illuminated hemisphere is turned toward the earth. At intermediate phases the hemisphere turned toward the earth is only partially illuminated. Near new moon (on both sides) the moon appears as a narrow crescent with the horns turned away from the sun; near full moon the defective edge is that farthest from the sun's direction; *i.e.*, before full moon the eastern side (left in northern hemisphere) and after full moon the western side. In the diagram the plane of the paper may be taken as that of the earth's motion round the sun. The moon's orbit does not lie exactly in this plane but is inclined to it at an angle of about 5°. If this were not so the moon would eclipse the sun at every new moon and would itself be eclipsed by the earth at every full moon. The line NN^1 may be taken as representing the line of intersection of the two planes. This line, known as the line of nodes, is in slow rotation, making about one revolution against the arrows in about 18.6 years. At two seasons each year the sun is near the direction of NN^1 as seen from the earth, and at these seasons eclipses occur. (See ECLIPSE.)

To understand the positions in which to expect the moon at any time it is most convenient to consider its position relative to the sun. When the moon is new it is in the same direction as the sun. Consequently it rises and sets with the sun, crosses the meridian with the sun and cannot be seen from the earth. Relatively to the stars the sun moves eastward about 1° per day, while the moon moves about 13° in the same direction. The moon, therefore, appears about 12° farther east of the sun day by day, and 13° farther east of the stars in its neighbourhood. When the moon is one day old it will lie about 12° east of the sun, it will be due south about 48 minutes after the sun and it will describe in the sky the same arc as the sun will do about 12 days later. if it is assumed, as is approximately true, that the orbital planes of the sun and the moon coincide. Similarly when the moon is at first quarter or 90° east of the sun it will be due south 6 hours after the sun and it mill describe in the sky the same arc that the sun will describe in three months' time. Consider the case of a moon a week after new on March 21. On that day the sun will rise six hours before noon and set six hours after. At sunset the moon is due south and in the position occupied by the sun at noon on June 21. Consequently, for observers in the northern hemisphere, it will be more than 12 hours above the horizon, rising more than 6 hours before it souths. In the latitude of London it will rise about 8½ hours before it souths, *i.e.*, about 9:30 A.M., and it will not set till about 2:30 the next morning. As is well known, in fairly high north latitudes, the moon near the full rises at nearly the same hour for several nights in the autumn, giving rise to the phenomenon of the harvest moon. The explanation of this is very simple. The full moon in the autumn is in the same part of the sky as the sun is in the spring. Now, in the spring, the time the sun is above the horizon is steadily increasing from day to day. This increase is happening for the autumn full moon 13 times as fast. Consequently, although on the average the moon is 48 minutes later day by day in southing, its rising is not retarded by anything like this amount. In the spring the phenomenon is reversed, and the rising of the full moon is delayed by more than 48 minutes from day to day. Referring to the diagram, it will be seen that when the moon is near the position M^1 although the hemisphere turned toward the earth is not illuminated directly by sunlight it is illuminated indirectly by light from the illuminated hemisphere of the earth. This light is about 50 times as bright as the full moon and consequently near the time of new moon, after twilight. the whole hemisphere of the moon can be seen faintly illuminated by "earthshine," (*q.v.*). This phenomenon can be observed very well in a small telescope.

The moon always presents nearly the same face to the earth, from which it follows that, when referred to a fixed direction in space, it revolves on its axis in the same time in which it performs its revolution. The rate of actual rotation is substantially uniform, while the arc through which the moon moves from day to day varies somewhat. Consequently, the face which the moon presents to the earth is subject to a corresponding variation, the globe, as seen from the earth, slightly oscillating in a period nearly equal to that of revolution. This apparent oscillation is called libration and its amount on each side of the mean is commonly between 6° and 7°. There is also a libration in latitude, arising from the fact that the axis of rotation of the moon is not precisely perpendicular to the plane of its orbit. This libration is more regular than that in longitude, its amount being about 6° 44′ on each side of the mean. In consequence of the libration about six-tenths of the lunar surface may be seen at one time or another, while the remaining four-tenths are forever hidden from view. It is found that the direction of the moon's equator remains nearly invariable with respect to the plane of the orbit. and therefore revolves with that plane in a nodal period of 18.6 years. This shows that the side of the moon presented to observation is held in position, as it were, by the earth, from which it also follows that the lunar globe is more or less elliptical, the longer axis being directed toward the earth.

2. Moon's Surface. — The surface of the moon has been a subject of careful and continuous telescopic study from the time of Galileo's first observations with a telescope (1610). The earliest detailed map of the moon is in the *Selenographia* (1647) of Johannes Hevelius. Borrowing from geography and classical mythology, Hevelius assigned names to the different regions of the moon. Giovanni B. Riccioli in his Almagestum *novum* (1651) gave to the more conspicuous smaller features the names of famous astronomers and philosophers, and designated the dark areas as seas and oceans, with quite fanciful names, *Mare Imbrium, Oceanus* Procellarum, etc. This nomenclature has been retained. During the years following these works, more extensive and detailed maps and photographs were published (see bibliography below). By 1959 even the side of the moon facing away from the earth had been photographed by Russian observers. In 1959, Gerard P. Kuiper prepared an extensive atlas of the moon's surface using modern techniques.

The moon as seen by the naked eye is a beautiful object with bright and dark patches, but as seen in even a small telescope it is magnificent and the various formations stand out as in the photographs. The most interesting time to watch the moon with a telescope is near half moon. The boundary between the bright and dark portions, known as the terminator, then shows a very rugged

appearance and even a short stay at the telescope enables one to natch the sun's light catch new mountain peaks. The most striking formations on the moon are the craters, which are of all sizes up to 200 km. or more in diameter and are scattered over the surface with great profusion, frequently overlapping. These craters closely resemble the volcanic craters on the earth, and it is possible that they have a similar origin. They have, however, often so large a diameter compared with height that the analogy may not be so close as at first appears. The typical crater has a surrounding ring rising to anything up to 20,000 ft. above the general level. The floor of the crater may be higher or lower than the outside level. Often there may be a central peak or peaks within the crater. The darker areas of the moon which are not so much covered by craters have been considered to be seas of lava which have spread over the moon's surface at a later date than that of the formation of most of the craters. Other striking features on the moon are streaks of rays ahich radiate from a number of craters to many hundreds of miles.

E. Pettit and S. B. Nicholson found the temperature of the mid solar point of the full moon to be 134° C., and that of the limb (the edge of the disk of the moon) at the same time to be 67" C. During the lunar night the temperature falls to — 53° C. Similar changes occur during an eclipse, when the moon is plunged in darkness in about one hour. J. C. Jaeger and A. F. A. Harper showed that these thermal changes imply that the surface is covered with a highly insulating layer of dust lying on material with the thermal conductivity of dry soil or pumice, though the surface probably does not consist of either of these.

3. Origin of Surface Features. — The most important feature from the standpoint of the genesis of the moon's surface features, the great collision site in *Mare Imbrium,* was pointed'out by G. K. Gilbert in 1893. An object estimated by him to be 160 km. (100 mi.) in diameter must have approached the moon from the northeast at an angle less than the vertical. It plowed out a deep area in the moon and scattered fragments of its own body, and probably of the moon too, over the central region of the disk to a distance of about 2,000 km. from the point of collision. The illustration shows an outline of this region, and pictures of the moon in various phases show the many ridges and grooves radiating from the collision area. The debris fell on older craters and scarred the walls of others, *e.g.,* Ptolemoeus and Alphonsus. and other craters were subsequently formed. The collision of the object produced the great circular areas of broken up and shattered, or melted, rocky material that settled into the present configuration of the *mare* uith its many faults, piles of rubble and melted, granular or dusty materials. The markedly asymmetric aspect of the collision area indicates that the object struck with a velocity less than that of sound.

Other circular *maria,* Serenitatis, Crisium, Nectaris and Humorum. were formed in the same manner. The superpositions of craters and *maria* show that the events belong to a unified series; *i.e.,* some craters were formed, then a *mare,* more craters. then another *mare,* etc. These violently formed structures cover the entire surface of the moon and similar collisions must have occurred on the earth's surface. These terrestrial collisions should have been more numerous than the lunar ones because the greater gravitational field of the earth increases the numbers of objects captured and makes the collisions more energetic. Thus, no areas of the earth existing at the time of these collisions should have remained undisturbed, and the energetic collisions should have broken up all structures to considerable depths. Since appreciable areas of the earth of some 3×10^9 years of age are known, these lunar collisions must have occurred mostly before this time and are very old.

Other irregular smooth areas of the moon, also known as *maria,* do not have this circular shape, *e.g.,* Mare Tranquillitatis, Mare Fecunditatis, Mare Nubium. Oceanus Procellarum and many bays. Mare Tranquillitatis. in particular, looks like a very black lava flow, possibly from Mare Serenitatis. Its shape is very irregular and some old craters within the *mare* appear to be distorted, as though by a heavy liquid. Mare Nubium and Oceanus Procellarum also appear to be lava flows, though distortion of old craters

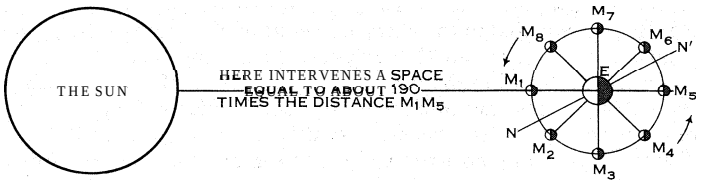


DIAGRAM OF THE PHASES OF THE MOON (M), SHOWN IN EIGHT POSITIONS
The part shown in white is illuminated by sunlight, and the phase of the moon is determined by the position of the illuminated hemisphere relative to the direction of the line joining the moon and the earth (E)

is not evident. Generally it has been assumed that the lava flowed from the moon's interior, as occurs on earth. Gilbert suggested that the appearance of lava was produced by great collisions and that melting heat was supplied by their kinetic energy. Z. Kopal pointed out that comet collisions could have provided the melting energy. R. B. Baldnin proposed that the object that fell in Mare Imbrium broke through a solid crust into a molten interior and lava flowed over the moon's surface. T. Gold suggested that all the *maria* consist of dust produced by erosion from light and particle radiations, and that this dust is now traveling over the surface. H. C. Urey accepted Gilbert's interpretation, but also suggested that great amounts of dust or sandy material could have been produced by the great collisions. Whether the craters are of volcanic or collisional origin has been a subject of controversy since the middle of the 19th century. Many small craters, such as those along a curved fissure west of Copernicus, can be positively identified as the results of plutonic effects, probably the escape of gases and some dust from the moon's interior. They are much broader and lower than terrestrial volcanoes. The largest of these craters can be compared in size only to terrestrial *caldera* which result from the collapse of the terrestrial surface into an underlying cavity from nhich lava has flowed. Nevertheless, the evidence for the collisional origin of most of the craters (of all sizes) is overwhelming.

N. A. Kozyrev was the first person to observe an eruption of any kind on the moon—in the neighbourhood of the central peak of Alphonsus. He reported the fluorescent spectrum of the C_2 molecule indicating that carbon compounds were leaving the moon's interior. It is probable that this occurs at many other points, and that other gaseous substances are being produced as well. In less than 30 years, for example, the crater Linnè all but disappeared. Where Bernhard Schmidt observed a crater 11 km. in diameter, D. Alter found only a diffuse whitish area with no discernible crater at all. These plutonic effects seemed to be more of the nature of hot springs than of volcanoes.

4. The Origin of the Moon. — At the end of the 19th century George H. Darwin advanced a theory of the moon's origin that attracted considerable attention for several decades. On the basis of the mathematical theory of the tides, Darwin suggested that the moon had been originally part of the earth, but was broken away by tidal action. and receded from the earth. F. R. Moulton showed that this theory nas most improbable, and his conclusion was later confirmed by H. Jeffreys. It is most difficult to find mechanically possible processes by which an object such as the moon could be removed from the earth. Darwin's theory was devised partly in order to account for the different densities of the earth and moon (j.52 and 3.34 grams per cu.cm., respectively), which difference is only partly explained by the high pressure and compression within the earth. It was supposed that the moon came from the outer parts of the earth and hence did not acquire metallic iron-nickel from the core.

Another popular theory of the genesis of the moon gained currency after the publication (1862) of Lord Kelvin's paper on the solidification of the earth. The moon and the terrestrial planets, generally. were believed to have been formed in a completely melted condition, and have cooled and solidified since. Kozyrev's observation that gases are now leaving the moon's interior constitutes very strong evidence to the contrary. The interior tempera-

ture of the moon seems to be increasing rather than decreasing. Harold C. Crey has shown that the more volatile elements are not highly concentrated in the surface regions of the earth as would be expected on the basis of the extremely high temperature origin.

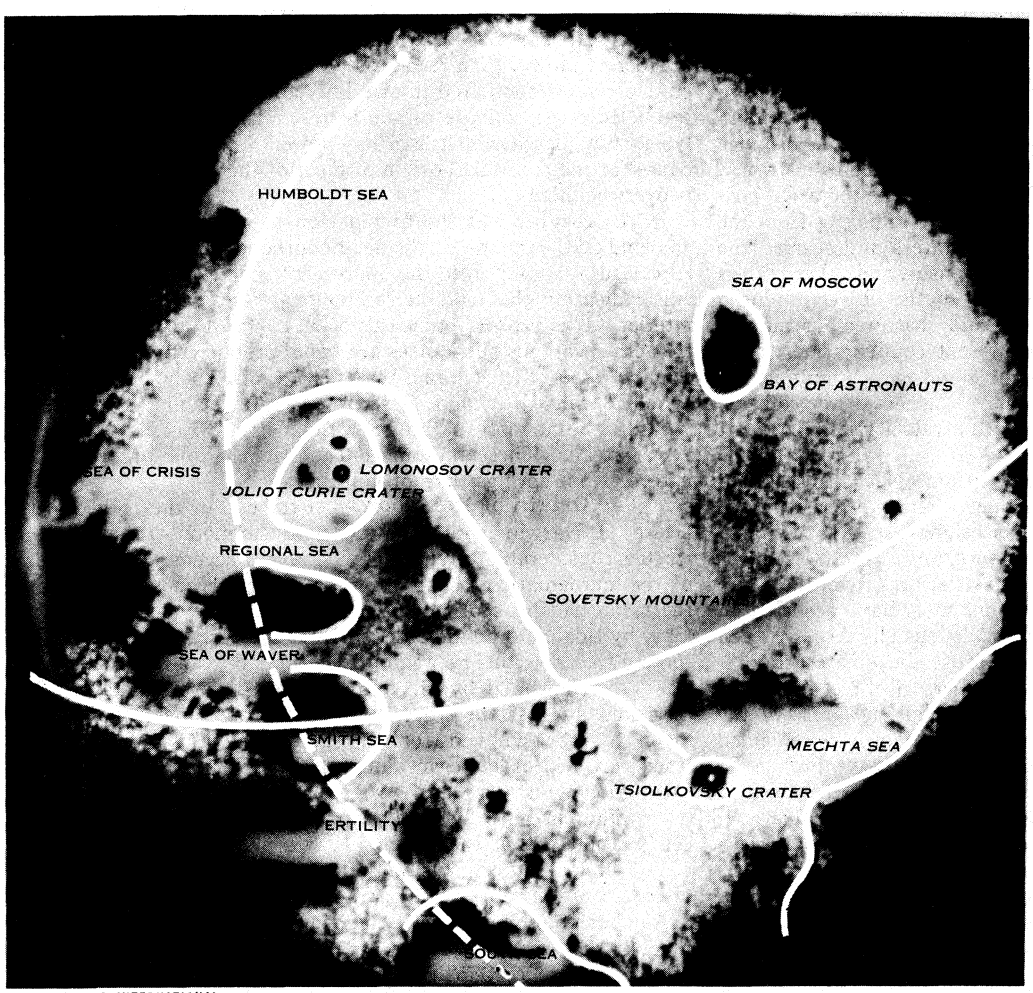
The most probable theory, then, is that the earth and the other terrestrial planets accumulated from solid objects, and that the moon is an object that was not assimilated by the earth as it grew. The meteorites are most probably representative of the primordial objects which accumulated into the planets. Though some fractionation of the elements in melting processes is evident in these objects, there is little or no evidence for systematic loss of the more volatile elements, other than gaseous substances, from them. The terrestrial planets apparently vary in composition to some extent, as indicated by their varying densities. Hence the solid materials were fractionated to some extent, probably by the loss of silicates with the large amounts of gaseous substances which are evidently not present in the planets in the proportions observed in the sun and stars. The moon has a low density, and calculations indicate that its ratio of iron to silicon and other non-gaseous elements is similar to these ratios in the sun. Thus the moon may be some primordial object which accumulated prior to the earth and other planets and did not go through all the heating and collisional processes to which the materials of the terrestrial planets were subjected.

5. Brightness of the Moon.—The sun is about 465,000 times as bright as the moon, with an observational error of about 20%. A real variation in brightness of 20% results from the moon's varying dislance from the earth and sun. The moon's albedo, the fraction of the light received that is reflected, is only 0.073. Because of the roughness of the moon's surface. the amount of reflected light decreases more rapidly with the phase than would be expected from the area of illuminated surface. The total brightness of the moon is equal to about 0.25 of a meter-candle, equal, that is, to a 100 candle-power lamp at a distance of 22 yards.

(H. C. U.)

6. Constants of the Moon's **Size** and Motion.—

Synodic month (relative to sun)	29.53059 days
Sidereal month (relative to stars)	27.32166 days
Tropical month (relative to equinox)	27.32158 days
Anomalistic month (relative to perigee)	27.55455 days
Nodal or draconic month (relative to node)	27.21222 days
Mean eccentricity	0.0549
Revolution of perigee (direct)	3232.6 days
Revolution of node (retrograde)	6793.5 days
Mean inclination of orbit to ecliptic	5° 8′ 43″
Maximum inclination of orbit to ecliptic	5° 20′
Minimum inclination of orbit to ecliptic	4° 57′
Inclination of axis of rotation to ecliptic	1° 31′ 22″ (Franz) 1° 32′ 6″ (Hayn)
Lunar parallax	57′32″.54
Mean apparent diameter	31′ 7″
Mean distance from earth	238,860 miles
Maximum distance	252,710 miles
Minimum distance	221,463 miles
Diameter	2159.9 miles
Diameter in terms of earth's diameter	.27227
Mass in terms of that of earth	1:81.29
Density in terms of water	3.33
Density in terms of that of earth	0.6043
Ratio of gravity to gravity at the earth's surface	0.165
Maximum geocentric libration in longitude	7° 54′
Maximum geocentric libration in latitude	6° 50′
Fraction of moon's surface always invisible	0.410



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PHOTOGRAPH OF THE FAR SIDE OF THE MOON CLAIMED BY THE U.S.S.R. TO HAVE BEEN TAKEN BY ITS SPACE SATELLITE "LUNIK III" IN OCT. 1959. TO THE LEFT OF THE DOTTED LINE ARE THE NAMES OF REGIONS AND LANDMARKS VISIBLE FROM THE EARTH. OTHER NAMES IN ITALICS ARE THOSE GIVEN BY SOVIET SCIENTISTS TO SURFACE FEATURES

See also Index references under "Moon" in vol. 24.

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(J. JN.; H. C. U.; W. J. ET.)

MOONEY, JAMES (1861–1921), U.S. ethnologist who became the best-read authority of his day on the early history of the Indian tribes north of Mexico, was born Feb. 10, 1861, in Richmond. Ind. From reporter on the *Richmond Palladium* he joined the staff of J. W. Powell's Bureau of American Ethnology at the Smithsonian institution in 1885, remaining until his death. He developed the tribal synonymy of F. **ll'.** Hodge's classic *Handbook of the American Indians* (1907). His *Siouan Tribes of the East* (1894) combined a historical and literary quality seldom reached in ethnographic writing. The Cherokee of the Great Smoky mountains of North Carolina were Mooney's favourite people: his *Sacsed Formulas of the Cherokee* (1892) and *Myths of the Cherokee* (1900), completed afterward by Frans M. Olbrechts as *The Swimmer Manuscript* (1932), represented but a fraction of his long participation in the life of the Eastern Cherokee; much remains in manuscript. He wrote an even more famous classic, *The Ghost Dance Religion and the Sioux Outbreak of 1890* (1897), a pioneer study in applied anthropology, and at his death Mooney was the leading authority on the Kiowa of the southern plains. He was a founder of the American Anthropological association and president of the Anthropological society of Washington (1914–1j). After Mooney's death on Dec. 22, 1921, J. R. Swanton edited and brought out *Aboriginal Population of America North of Mexico* (1928), which, though incomplete, was the first conservative tribe-by-tribe estimate for the continent. His manuscripts are in the Bureau of American Ethnology archive.

See J. N. B. Hewitt *et al.,* "James Mooney," *Amer. Anthrop.,* vol. 24, no. 2, pp. 209–214 ('April–June 1922). (W. N. F.)

MOONFLOWER, any one of four species of tropical and subtropical American twining herbaceous vines belonging to the genus *Calonyction,* a member of the morning-glory family (Convolvulaceae; *q.v.*). The leaves are heart-shaped or arrow-shaped and the flowers large, showy and fragrant. The latter are night blooming —hence the name moonflower—but may remain open the following morning, closing by noon. The flower's salverform shape (*i.e.,* the flaring portion of the corolla spreads at right angles to a long slender tube) distinguishes the moonflower from the common morning-glory, which has funnel-shaped blooms. *Calonyction aculeatum,* with white flowers three to six inches across, and C. *muricatum,* with purple flowers two to three inches across, are commonly cultivated for ornament. Although perennial in the tropics, the plants bloom the first year from seed and may be grown as annuals. (G. H. M. L.)

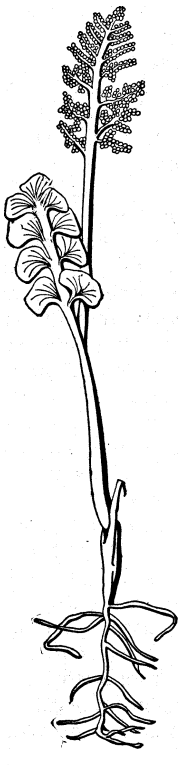
MOONSEED, the common name for woody vines of the genera *Menispermum* and *Cocculus* (family Menispermaceae). The Canada moonseed (M. *canadense*), found from Quebec to Manitoba and southward to Georgia and Arkansas, is a handsome plant with large reniform peltate leaves and yellowish flowers borne in profusion on long pendulous racemes. The Carolina moonseed (C. *carolinus*) is native in the southeastern United States.

MOONSTONE, an alkali feldspar exhibiting a bluish to white iridescent lustre or schiller or a milky opalescence, whence its value as a gem stone. Nearly all moonstones of commerce come from Ceylon. principally from Dumbara district, occurring in acid granulites and pegmatites and in gem gravels. Moonstones have macroscopically monoclinic or nearly monoclinic symmetry. The optical phenomenon of iridescence or opalescence is connected with a cryptoperthitic unmixing process on a submicroscopic scale of the potassium/sodium aluminum silicate of which it is composed. (K,Na) $AlSi_3O_8$, into regions respectively rich in $KAlSi_3O_8$ and $NaAlSi_3O_8$. _These are apparently shaped and so arranged that crystal planes (801) reflect the light most intensely. X-ray investigations indicate that the sodium-rich regions are nearly pure $NaAlSi_3O_8$ (triclinic) showing twinning on the albite and pericline laws (*see* also FELDSPAR). They can be of the low- or high-temperature state. Depending on this, among other factors, the time required for homogenization and consequent disappearance of the schiller phenomena by heat treatment near the melting temperature (≈1,050° C.) may be of the order of months or minutes.

The potassium-sodium ratio of different moonstones varies from approximately 85/15 to 40160. the Ceylon moonstones frequently having a ratio around 65/35.

Frequently feldspars showing bluish schiller and called moonstones by jewelers are in fact plagioclase (peristerites) or labradorite (*q.v.*). More detailed information on the unmixing of alkali feldspars is given under FELDSPAR: *Unmixing at Low Temperature.* (F. H. L.)

MOONWORT or MOON FERN, in botany, the popular name of a small fern (*Botrychium lunaria*) belonging to the family Ophioglossaceae. It has a fleshy rootstock and a stout fleshy glabrous frond three to six inches long, with a sterile and fertile portion; the former bears several pairs of close-set, semicircular or moon-shaped pinnae; the latter is pinnately branched and covered, on the face opposed to the sterile portion, with small globose spore cases which burst transversely. It is a widely distributed plant in the north and south temperate and cold zones and is found in pastures and grassy banks in Great Britain and largely throughout northern North America, from Labrador and Newfoundland to Alaska southward to Vermont, New York, Michigan, Colorado and California.



FROM STRASBURGER, "LEHRBUCH DER BOTANIK" (GUSTAV FISCHER)

MOONWORT (BOTRYCHIUM LUNARIA). A SMALL FERN HAVING THE SPORANGIA ARRANGED IN SMALL CRESTED CLUSTERS, WHICH FORM A LONG, LOOSE SPIKE

MOORCROFT, WILLIAM (*c.* 1770–1825), English traveler who made two notable journeys into central Asia in the service of the East India company, mas born in Lancashire about 1770. In 1812, crossing the Himalayan pass of Niti, he reached the lakes of Manasarowar in southern Tibet, and returned by way of Bhutan to Calcutta. In 1819 Moorcroft began a second journey to Kashgar and Turkestan. The commercial treaty which he made with the government of Ladakh virtually opened central Asia to British trade; in 1822 he was in Kashmir, in 1824 in Kabul and in 1825 at Bukhara.

On Aug. 27. 1825, Moorcroft died of fever at Andkhui in Turkestan, as did his companion. George Trebeck, a few days later. Another account, bv Évariste Huc, relates that Moorcroft reached Lhasa in 1826 and lived there 12 years, being murdered on his way back to India in 1838. In 1841 bfoorcroft's papers were obtained and published by the Asiatic society of Calcutta. (R. A. SN.)

MOORE, EDWARD (1712–1757), English dramatist and miscellaneous writer, the son of a dissenting minister, was born at Abingdon, Berkshire, on March 22. 1712. He was the author of the domestic tragedy of *The Gamester,* originally produced in 1753 mith Garrick in the leading character of Beverley the gambler. He produced clever imitations of Gay and Gray. and with the assistance of George. 1st Lord Lyttelton, Lord Chesterfield and Horace Walpole, conducted *The World* (1753–57), a weekly periodical on the model of the *Rambler.*

Moore collected his poems under the title of *Poems, Fables and Plays* in 1756.

Moore died in Lambeth on March 1, 1757. His *Dramatic Works* were published in 1788.

MOORE, GEORGE (1852–1933), novelist, eldest son of George Henry Moore, M.P. for Mayo, and his wife Mary Blake,

was born at Moore hall. County Mayo, Ire.. on Feb. 24, 1852. He was at school at Escott, but, like many other great artists. did not take kindly or long to formal education. At the age of 18 he had already decided that art in some form was his vocation. and in the year 1870, on the death of his father, he entered the art schools at Paris. Though he was not destined to become a painter. those early years left a permanent mark on his artistic consciousness. Not only did he acquire that penetrating knowledge of pictures which always distinguished him, but he learned. both from the study of line and from the brilliant painters and writers who became his friends. that relentless integrity of style, which gives each of his paragraphs something of the copper certainty of an etching. While in Paris and while still seeking for his medium he attempted poetry in *Flowers of Passion* (1878) and *Pagan Poems* (1882). Here again, though verse was not to be his method of expression, he still further prepared himself for his relentless economy of manner, more often found in poetry than prose.

Gradually. however, his true bent began to reveal itself, and he returned to England with the avowed intention of liberating English fiction from its Victorian shackles. *A Mummer's Wife* (1884) was in its way as startling a challenge to the contemporary novel as had been the first volume of *Poems and Ballads* to the poetry of its time. Moore took his place immediately as a rebel with a torch, not of an incendiary, but of a new luminary.

In his next considerable work. *Confessions of* a *Young Man* (1888; later ed. 1908), he took the first step on the path which was to lead to *Avowals* (1919 and 1926), *Hail and Farewell* (3 vol.. 1911–14) and *Conversations in Ebury Street* (1924), no less than the gift of a new form to Engiish prose. He turned from that to the three great novels of his prime: *Esther Waters* (1894), *Evelyn Innes* (1898) and *Sister Teresa* (1901). In these with quiet certainty he established the claim he had made in *A Mummer's Wife*. He believed that he had transplanted the French "philosophical" novel. What he had in fact done was to restore the Fielding tradition. He had given back honesty and clarity of vision, and an English almost flawless in its severe simplicity.

He had in the meantime also continued to express his artistic gospel in critical articles which were collected and published in 1891 and 1893, respectively. But the next landmark in his life was the return to Ireland in 1901, a return dictated in part by his detestation of the Boer War. He remained in Ireland until 1910, and though that period was not immediately productive (the only books in that time being *The Untilled Field* [1903], *The Lake* [1905] and *Memoirs of my Dead Life* [1905]) it renewed his artistic youth. Immediately on his return to London he began the publication of *Hail and* Farewell—those entrancing dialogues which are regarded (wrongly) in certain quarters as his masterpiece. They are not that, but they would have been a masterpiece for anyone but the author of *The Brook Kerith* (1916; 7th rev. ed., 1927) and *Heloise and Abelard* (1921). What turned Moore's mind to the gospel story as a subject for treatment is not clear, but at any rate in order to prepare himself for no less a task than recreating the story of Jesus he visited Palestine. A record of that pilgrimage almost in his own words may be found in *Dialogues and Monologues* (Humbert Wolfe). The result of the journey was *The Brook Kerith,* which. with *Heloise and dbelard,* touches a point of almost flawless artistry and nobility that has rarely been reached before in the history of English prose. In both these books he has reconstructed a period, and though to say so is almost hyperbole, in neither is his genius unworthy of its subject. Below these peaks, there were lesser though charming eminences in 1918 with *A Story-Tellev's Holiday,* in 1924 with a version of *Daphnis and Chloe* and in 1926 with an Irish story of the middle ages, *Click and Soracha.* All these, like a notebook of Rembrandt, are full of convincing glimpses of the master.

Having tried painting, poetry. dialogue and the novel. he mas not content till he had also attempted the drama. *The Coming of Gabrielle* (1920) was produced, but it was not till 1928, with *The Making of an Immortal,* that he had a success in the theatre. Moore died Jan. 21, 1933. (H. Wo.)

BIBLIOGRAPHY.—His other works are: *A Modern Lover* (1883); *A Drama in Muslin* (1886); *A Mere Accident* (1887; "John Norton," in *Celibates,* is a rewriting of this book); *Parnell and His Island* (1887); *Spring Days* (1888); *Mike Fletcher* (1889); *Vain Fortune* (1890); *Impressions and Opinions* (1891); *The Strike at Arlingford* (1893; a play); *Modern Painting* (1893); *Celibates* (1895); *The Bending of the Bough* (1900; a comedy); *Reminiscences of the Impressionist Painters* (1906); *Elizabeth Cooper* (1913; *a* comedy); *Lewis Seymour and Some Women* (1917; rewriting of *A Modern Lover); The Pastoral Loves of Daphnis and Chloe* (done into English by George Moore, 1924; later ed., 1927); *see* Susan L. Mitchell, *George Moore* (1916); *I. A.* Williams, *Bibliography of the Works of George Moore* (1921); J. Freeman, *Portrait of George Moore* (1022).

MOORE, GEORGE FOOT (1851–1931), U.S. biblical scholar, was born in West Chester. Pa.. Oct. 15, 1851. He graduated from Yale college in 1872 and from Union Theological seminary in 1877. In 1878 he was ordained and until 1883 was pastor of the Putnam Presbyterian church, Zanesville, O. He was Hitchcock professor of the Hebrew language and literature at Andover Theological seminary, 1883–1902. In 1902 he became professor of theology and in 1904 professor of the history of religion at Harvard university. His chief critical work dealt with the *Hexateuch,* and more particularly the *Book of Judges* (commentary, 1895; text, translation and notes, 1898; text with critical notes, 1900). He was also the author of *The Literature of the Old Testament* (1913), *History of Religions* (2 vol. 1913–19), *Metempsychosis* (1914) and *Judaism in the First Centuries of the Christian Eva* (2 vol., 1927).

MOORE, HENRY (1898–), regarded as the foremost English sculptor of modern times. was born in Castleford. Yorkshire. on July 30. 1898, a miner's son. After service in World War I, he studied at the Leeds School of Art and the Royal College of Art and became a teacher of sculpture. In 1940 life in bombed London inspired his "shelter drawings" and he became an official war artist. His fame grew with a major exhibition at the Museum of Modern Art. New York city (1946), and the award of the international prize for sculpture in Venice (1948). His concerns have been mastery of the nature of his materials, sculpture of spaces as well as solids and the presentation of intense psychological content The dominant reference of his works is to the human figure in its simplest positions; *e.g.,* standing, seated or reclining. Primitive art and surrealism are influences confirmed in Moore's illuminating essays and notes. included in *Henry Moore; sculpture and drawings,* introduction by Herbert Read, vol. 1 (4th ed., 1957) and vol. 2 (1955). (Js. W. F.)

BY COURTESY OF DIRECTOR OF THE TATE GALLERY LONDON

"FAMILY GROUP" BRONZE SCULPTURE BY HENRY MOORE. IN THE TATE GALLERY. LONDON

MOORE, SIR JOHN (1761–1809), British general, the son of John Moore, was born at Glasgow on Nov. 13, 1761. By the duke of Hamilton's influence Moore obtained an ensigncy in the 51st foot (1776), learned his drill at Minorca and in 1778 was appointed captain-lieutenant in a new regiment raised by Hamilton for service in the American Revolution. Moore remained in America to the peace of 1783, after which the Hamilton regiment was disbanded.

In 1784 Moore was returned by the Hamilton interest as member of parliament for the united boroughs of Lanark, Selkirk, Peebles and Linlithgow. In parliament. though he never spoke, he seems to have taken his duties very seriously, and to have preserved an independent position. in which he won the friendship of Pitt and the respect of Burke, and (more important still) the friendship of the duke of York. In 1787 he became major in the 60th (later king's royal rifles)! but in the following year he was transferred to his old corps, the 51st. In 1792 Moore sailed with his corps to the Mediterranean. He was too late to assist at Toulon. but was engaged throughout the operations in Corsica, and won particular distinction at the taking of Calvi,

where he was wounded. Soon after this he became adjutant general to Sir Charles Stuart, with whom he formed a close friendship, After the expulsion of the French Moore became very intimate with many of the leading Corsican patriots, which intimacy was so obnoxious to Sir Gilbert Elliot (later Lord Minto) that Moore was eventually ordered to leave the island in forty-eight hours, though Elliot wrote in warm terms of his ability. Pitt and the duke of York thought still more highly of Colonel Moore, who was soon sent out to the West Indies in the local rank of brigadier-general. Here he came under the command of Sir Ralph Abercromby, whose most valued adviser and subordinate Moore soon became. In the Santa Lucia expedition he won further distinction by his conduct at the capture of La Vigie and Morne Fortuné, and when Sir Ralph left the island he appointed Moore governor and military commander. In 1798 he accompanied Abercromby to Ireland as a major-general, and during the rebellion was actively engaged in command of a corps in the south, defeating a large force of the Irish, and saving Wexford from destruction after the battle of Vinegar Hill (June 21). His services were in universal request, and Abercromby had him appointed to the command of a brigade destined for the expedition to Holland. At the action of Egmont-op-Zee, on the 2nd of October 1799, his brigade lost very heavily, and he himself was wounded for the fourth time, on this occasion severely. On his return from Holland he was made colonel of the 52nd regiment, with which he was connected for the rest of his career, and which he made one of the finest regiments in Europe.

Throughout the Egyptian expedition he commanded the reserve. The 28th and 42nd regiments in this corps gained great distinction at the battle of Alexandria, where Moore himself was again wounded. He returned to duty, however, before the surrender of the French forces to General Hutchinson, and added so much to his reputation by his conduct in this brilliant campaign that after the short peace came to an end he was appointed to command the force assembled at Shorncliffe camp (1803) as a part of the army intended to meet the projected invasion of Napoleon. Here were trained some of the best regiments of the service, amongst others the 43rd, 52nd and 95th Rifles, the regiments which afterwards formed the famous "Light Division" and won in the Peninsula an unsurpassed reputation, not only for the skilful performance of the duties of light troops, but also for invincible steadiness in the line of battle. These corps (now represented in the army by the 1st and 2nd battalions of the Oxfordshire Light Infantry and the Rifle Brigade) bore the impress of Moore's training for thirty years and more.

While at Shorncliffe he renewed his intimacy with Pitt, who was then residing at Walmer Castle, and his close friendship with Lady Hester Stanhope led to the erroneous belief that he was betrothed to her. On his return to office Pitt caused Moore to be made a Knight of the Bath, and about the same time came his promotion to lieutenant-general. Fox, when he succeeded to office, showed the same appreciation of Moore, and in 1806 sent him to the Mediterranean as second-in-command to his brother, H. E. Fox. When Fox went home Moore became commander-in-chief of the British army employed in the Mediterranean.

In 1808 Moore was ordered to the Baltic, to assist Gustavus IV, king of Sweden, against Russia, France and Denmark. The conduct of the king, who went so far as to place Sir John Moore under arrest when he refused to acquiesce in his plans, ruined any chance of successful co-operation, and the English general returned home, making his escape in disguise. He was at once ordered to proceed with his division to Portugal, where he was to be under the command of Sir Hew Dalrymple and Sir Harry Burrard. In the excitement caused by the convention of Cintra, Dalrymple and Burrard were ordered home, Moore was left in command of the largest British army that had been employed since the commencement of the war.

It was not long before the Spaniards summoned Sir John Moore's army to assist them against the advance of Napoleon, and the troops were marched into Spain, Salamanca being their rendezvous. There Moore remained for a month. Soon, however, the overwhelming success of the emperor's attack threatened to isolate him, and it was then that he formed the magnificent resolution of marching northwards against the French line of retreat (*see* PENINSULAR WAR). Moore's advance paralysed the emperor's victorious armies. Napoleon himself turned against the British army, which was soon in grave danger, but Spain was saved. Under these circumstances took place the famous retreat which ended with the glorious battle of Corunna (Jan. 16, 1809), where, early in the day, Sir John Moore received his death wound. By his own wish he was buried, before dawn on the 17th, in the ramparts of Corunna.

For many years controversy, largely political, raged over the events of the Corunna campaign, and only at a later period has any examination of Moore's merits and services been made in a dispassionate spirit. Mistakes were made in the retreat, but Napoleon's view was that they were probably inseparable from the difficulties with which Moore was surrounded. His greatest claim to renown is, however, independent of his conduct of armies in the field. He was the finest trainer of men that the British army has ever known. The history of the Light Division is sufficient in itself to indicate the results of Moore's training on the rank and file.

See, besides the works mentioned in the article PENINSULAR WAR, J. C. Moore, *Life of Sir John Moore* (1834); *The Diary of Sir John Moore* (ed. by Sir J. F. Maurice, 1904) and the Records of the 52nd (Oxfordshire Light Infantry).

MOORE, MARIANNE CRAIG (1887–), U.S. poet, whose work from the first was marked by originality of substance and method, accuracy of insight and observation, critical and moral severity, human compassion and lyric intensity. She was born in St. Louis, Mo., on Nov. 15, 1887. Graduated from Bryn Mawr college (Pa.) in 1909, she then studied commercial subjects and taught them at the U.S. Indian school in Carlisle, Pa.; was an assistant librarian in the New York Public library; and was acting editor of *The Dial* (1925–29), then the leading U.S. journal of literature and arts.

Her early poems were printed in college publications, but she did not begin to publish periodicals until about 1915. In 1921, as a gift of friends, her first book, *Poems*, was published in London by the *Egoist* press. Her first U.S. volume. *Observations* (1924), won the Dial award. After 1929, living in Brooklyn, N.Y., she devoted herself to poetry and criticism, contributing to many journals in the U.S. and England, and publishing several books of verse. *Collected Poems* (1951) was awarded a Pulitzer prize, a Bollingen prize, and a National Book award, as well as the Gold Medal for Poetry of the National Institute of Arts and Letters. Her translation of *The Fables of La Fontaine* was published in 1954; a volume of critical papers, *Predilections*, in 1955; a collection of poems, *Like a Bulwark*, in 1956; and another volume of poetry, *O To* Be *a Dragon*, in 1959.

MOORE, THOMAS (1779–1852). Irish poet, was born in Dublin on May 28, 1779. His father was John Moore, a prosperous grocer and wine merchant, and his mother's maiden name was Anastasia Codd. In 1793 Tom Moore's name first appeared in print. as a contributor of some verses "To Zelia," to a Dublin periodical, the *Anthologia Hibernica*. In the same year Roman Catholic students began to be admitted to Trinity college. Dublin, and in 1794 Moore's name was entered on the books, curiously enough, as a Protestant. At Trinity he made friends with Robert Emmet, and was nearly dragged into the plots of the United Irishmen. The events of 1798 and the execution of Emmet in 1803 made a deep impression on him. The words of Emmet's address to his judges, asking the charity of silence — "Let no man write my epitaph" — are enshrined by Moore in one of his lyrics, "Oh, breathe not his name!" (*Irish Melodies*, 1808). The next song in the same collection — "When he who adores thee" — also owes its inspiration to Emmet's fate, and the conscientious orientalism of *Lalla Rookh* does not conceal the preoccupation of the writer with the United Irishmen when he writes of "The Fire Worshippers," and with Emmet and Sarah Curran when he describes the loves of Hafed and Hinda, especially in the well-known song, "She is far from the Land where her young Hero sleeps." In 1798 Moore graduated, and in the next year left

for England to keep his terms at the Middle Temple.

He was a social success in London. He had brought with him from Ireland a translation of the *Odes of Anacreon,* and the prince of Wales accepted its dedication. It was issued in 1800 with notes and a list of distinguished subscribers. Moore's social successes involved him in expenses far beyond his means. His publisher had advanced him money, and he resolved to pay his debt by the anonymous publication of his juvenile poems, *The Poetical Works of the Late Thomas Little, Esq.* (1801), a collection of love poems which Moore afterwards regretted. Through Lord Moira's influence he was, in **1803,** appointed registrar of the admiralty prize-court at Bermuda. But he soon tired of the monotonous life, and in **1804,** after appointing a deputy, returned to England by way of the United States and Canada. In **1806** he published *Epistles, Odes and other Poems,* chiefly dealing with his impressions of travel. The volume contained the "Canadian Boat Song" ("Faintly as tolls the evening chime"), and some love poems of the same kind as those connected with the name of "Mr. Little."

The success of the satirical epistles in the 1806 volume encouraged Moore to produce further work of a similar kind, *Corruption and Intolerance, Two Poems* (1 808), and *The Sceptic. a Philosophical Satire* (1809), but the heroic couplet and the manner of Pope did not suit his talents. At the end of 1806 he went to Dublin, and, with the exception of about six months in 1807 spent at Donington Park, the next three years were spent in Ireland. Here he met Miss Elizabeth Dyke, an actress, who became his wife in March 1811. They lived at first in London, but soon removed into the country, to Kegworth, near Lord Moira's seat, and then to Mayfield Cottage, near Ashbourne, Derbyshire. Moore had to spend much of his time in London, for the popularity of his songs led to an agreement with his publisher to increase the success of these by singing them himself at great houses. The inception of his *Irish Melodies* dates from **1807,** and many of the best were written during the three years of his Irish visit. He had already published separate songs, some of them set to music of his own, when William Power suggested to him in **1807** the task of fitting words to a series of Irish airs supplied by Sir John Stevenson. He could not have found a task more exactly suited to his powers, and for a quarter of a century he enjoyed a regular income of £500 a year from Power for writing words to music. The first number of the *Irish Melodies* appeared in 1808, and contained some of his best and most popular work. The rest appeared between 1808 and 1834. In **1816** Stevenson and Moore published *Sacred Songs,* followed by a second number in **1824.** The first number of *National Airs* (Melodies from other Nations) appeared in 1818, and was followed by others in 1820, **1822, 1826** and **1827.**

After **1812** he broke ground in a new field—political squib-writings. His first butt was the prince regent, once his friend and patron, whose foibles, fatness, love for cutlets and curaçao, for aged mistresses and practical jokes, were ridiculed with the lightest of clever hands. His earlier political poems appeared in the *Morning Chronicle,* but in **1813** he published a thin volume of *Intercepted Letters: The Twopenny Post Bag.* Other volumes of squibs, most of which passed through several editions, followed: *The World at Westminster* (1816), *The Fudge Family in Paris* (1818), *The Journal of a Member of the Pococurante Society* (1820), *Fables for the Holy Alliance* (1823), *Odes on Cash, Corn, Catholics and other Matters* (1828), *The Fudge Family in England* (1835). The only failure among his satirical writings was *Tom Crib's Memorial to Congress* **(1819)** for which he had made an elaborate study of thieves' argot.

In 1814 he contracted with the firm of Longmans, for 3,000 guineas, to supply a metrical romance on an Eastern subject. Moore retired to a cottage in the neighbourhood of Donington Park, where with the help of Lord Moira's library he read himself slowly into familiarity with Eastern scenery and manners. But he was forestalled by Byron in *The Giaour* and again in *The Bride of Abydos.* The publication of *Lalla Rookh* was deferred until **1817.** It was an immediate success. After the completion of *Lalla Rookh,* Moore removed with his family to Sloperton Cottage, Wiltshire, where he was close to Bowood, Lord Lansdowne's country seat. Moore's plans were interrupted by the embezzlement of some £6,000 by the deputy he had left in Bermuda, for whose default he was fully liable. To avoid a debtors' prison Moore retired to the Continent. He visited Byron in Italy, and in Oct. **1819** received from him the first part of the *Memoirs.* The continuation was sent to Moore in Paris the next year, with Byron's suggestion that the reversion of the ms. should be sold. Moore did not remain long in Italy, but made his home in Paris, where he was joined by his wife and children. He was not able to return to England until **1822,** when the Bermuda affair was compromised by a payment through Longmans of £1,000.

During his exile he had written another oriental poem, *The Loves of the Angels* (1822), which was hardly less popular than *Lalla Rookh.* He became *a* contributor of satirical verse to ***The*** *Times,* the connexion lasting until **1827.** He now wrote his ***Memoirs*** *of the Life of Sheridan,* first contemplated in **1814,** which appeared, after some delay, in **1825.** The *Memoirs of Captain Rock* (1824), in which he gives a humorous but convincing account of English misgovernment in Ireland, was the result of a tour with Lord Lansdowne in western Ireland. His prose tale, ***The Epicurean,*** appeared in 1827, and the *Legendary Ballads* in 1830. In 1831 he completed his *Life and Death of Lord Edward Fitzgerald,* probably his best piece of prose work.

The death of Byron in 1824 raised the question of the publication of his *Memoirs.* Moore had parted with them in **1821** to John Murray for £2,000. After they had come into Murray's possession, Moore began to have doubts about the propriety of publishing them, and an arrangement was therefore made that the £2,000 should be regarded as a loan, to be repaid during Byron's lifetime, and that the ms. should be retained as a security. When Byron died the *Memoirs* were still unredeemed, and the right of publication therefore rested with Murray. Moore now borrowed the money from Longmans and induced Murray to give up his claim. The money was paid, and, after a heated discussion with Byron's executors, the ms. was burnt. It was partly the Pressure of the debt thus contracted, and partly the expressed wish of Byron, that induced Moore to undertake for Murray ***The Letters and Journals of Lord*** *Byron,* ***with*** *Notices of his Life* (1830).

In 1830 he undertook to write a *History of Ireland* which he left unfinished. After the death of his last child in **1845,** Moore became a total wreck, but he lived until Feb. 25, **1852.** He left sufficient provision for his wife in the *Diary* which he kept chiefly on her behalf.

His other works are, ***A Letter to*** *the Roman Catholics* ***of Dublin*** (1810); ***A Melologue upon National Music*** (1811); an operetta, M.P. *or The Blue Stocking* (1811); *A Set of Glees* (1827); ***The Summer Fête*** (1831); *Evenings in Greece* (1826–28); *Travels of an Irish* ***Gentleman*** *in Search of a* ***Religion;*** ***Alciphron,*** ***a Poem*** (1839).

See *Memoirs, Journal and Correspondence* **of** *Thomas Moore (8* vols., 1853–56), ed. by Lord John Russell, which contains an immense quantity of biographical material; *Tom Moore's Diary* (1925); ***The*** *Poetical Works of Thomas Moore, Collected by Himself* (10 vols., 1840–42); also *Notes from the Letters of Thomas Moore to his Music* ***Publisher,*** *James Power* (1854); and *Prose and Verse, Humorous, Satirical and Sentimental by Thomas Moore, with suppressed passages from the memoirs of Lord Byron . . .* (1878), which includes Moore's contributions to the *Edinburgh Review* (1814–34). Among modern editions of Moore's *Poetical Works* may be mentioned that by Charles Kent (the Centenary ed., 1879), and that by W. M. Rossetti (1880). Memoirs of Moore are prefixed to these editions. There are many contemporary references to him, especially in the journals and letters of Byron. There is an excellent life, by Stephen Gwynn, *Thomas Moore* (1905), written for the "English Men of Letters Series."

MOOR HEN or WATER HEN, one of the Rallidae and a common bird throughout the Old World. One species, *Gallinula chloropus,* is about the size of a bantam hen, dark olive-brown above, iron-gray below, with white tail coverts which are conspicuous as it swims, and a scarlet frontlet in both sexes. It haunts rivers, streams, lakes and ponds, building a nest of flags, reeds, etc., on a clump of rushes, in or under a bush or on a tree, usually near the water, but occasionally some distance from it. The eggs, **7** to **11** in number, are dull buff with reddish spots. The bird

swims well but in a jerky fashion, runs fast and, though taking wing with difficulty, is capable of prolonged and rapid flight. The American *G.* galeata, distinguishable by its larger frontal helm, is closely allied, and other species inhabit Africa, Asia and Australia. G. nesiotis of Tristan da Cunha has lost the power to fly. The purple water hens or sultanas (*Porphyrio*) are an allied genus, species of which inhabit Europe, Africa, S. America and Australasia. The flightless *Notornis* hochstetteri of New Zealand and the purple gallinule or mud hen (Porphyrula *martinica*) of S. and Central America and southern United States are other relatives.

MOORISH IDOL (*Zanclus* cornutus), a bizarre. Indo-Pacific tropical fish, found about coral reefs from Zanzibar to islands off the west coast of America; allied to the Chaetodontidae, but usually placed in a distinct family (Zanclidae). It is about 8 inches long when full grown, and has a deep, much compressed body which is somewhat rhombic in outline, with one angle in the middle of the back, where its dorsal fin begins, thence continues down the slant toward the tail. This fin is high and pointed in front, its initial ray exserted as a long thread-like filament. The snout is produced to resemble a short beak, and there is a slight angle before the eye which may carry a pair of short, stout horns. This fish has scales so small as to be almost invisible, and in colour it is no less striking than in shape. A broad black band extends downward from the front of the back, to include the eye, and over the breast, a second begins on the dorsal fin and crosses the body onto the anal fin below it. a third occupies most of the tail fin, which is slightly forked. Otherwise its colours are mostly yellow and white. (J. T. N.)

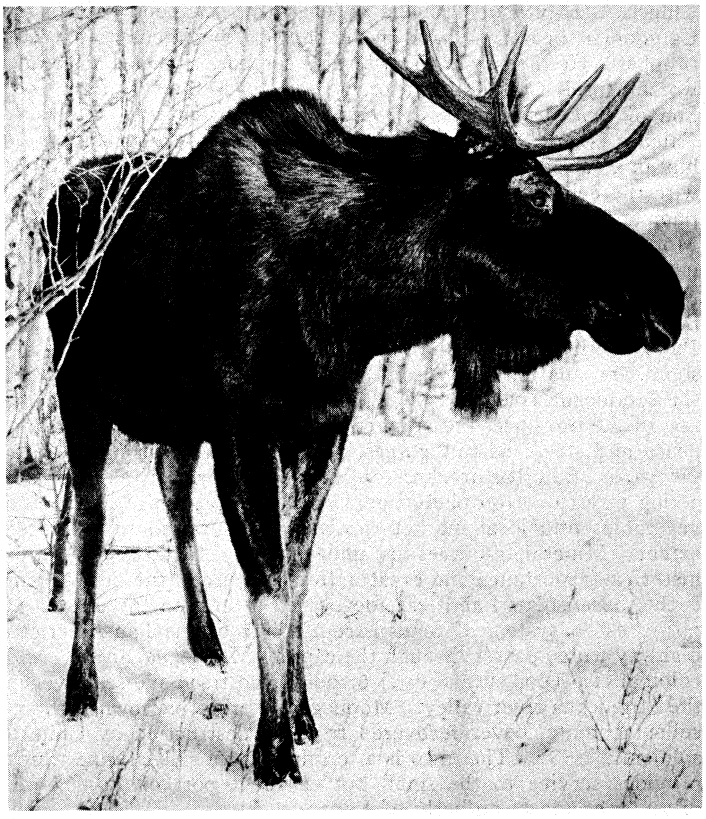
MOORS (MAURES), a long-headed, fine-featured people of medium height with oval faces, hooked noses and slender, supple limbs, inhabiting Mauritania and the Northern Sudan, and descended from the Zenaga Berbers of southern Morocco who occupied Adrar and Tagant and later Hodh and Azaouad. In the 11th century they formed the Almoravide sect which conquered Morocco and Spain.

In the 16th century Kounta Arabs placed the southern tribes in subjection. Later, the Beni Hassan Arabs subjugated Tagant, Hodh and then the right bank of the Sénégal. Principal tribes in Mauritania are the Trarza, Brakna and Oulad Mbarck; in the Sudan, the Kounta, Berabich, Regeibat, Mejdouf, Oulad Delim and Oulad Nassen. Fanatical Muslims, they obey Koranic law. Polygamy is rare, and divorce frequent; marriage is between members of the same caste.

The following castes can be distinguished: (1) warriors or Hassane, descendants of the Arab invaders; (2) Marabout priests, commentators on the Koran! traders, doctors; (3) Zenaga, descendants of the early Berbers; (4) Harratine or liberated captive~. They are nomads practising very little agriculture, and are held to be treacherous.

MOOSE, in America, or elk in Europe, *Alces alces* is the largest member of the deer family, Cervidae (see DEER). (The term elk in America is applied to the wapiti, *q.v.*). Moose are heavy-bodied, long-legged, short-necked ruminants, standing higher at the shoulders than at the hips. The muzzle is somewhat inflated and pendulous. A fleshy dewlap, up to three feet long, hangs from the throat. The enormous antlers in the males are characteristically palmate with projecting tines, although the degree of palmation varies with age, health and diet. The coat is coarse and shaggy, especially in winter, and particularly over the foreparts. The colour is dark brown, becoming grizzled in old animals.

Moose occur in the northern parts of North America and Eurasia. They live from coniferous forests northward to the tundra and southward to the limits of larch and birch forests. They prefer being near water, and often wade into forest-edged lakes and streams to feed on submerged aquatic vegetation. They also eat a variety of grasses, herbs and bark. Usually solitary, in America moose often assemble in small bands in winter and tramp the snow firm in a small area to form a moose yard. Their normal gait is a stiff-legged, graceless, shuffling walk, which, however, enables the animals to cover the ground with surprising speed; they sometimes trot, but seldom do they run. Moose are usually shy, but



EWING GALLOWAY

BULL MOOSE (ALCES ALCES)—THE ELK OF EUROPE

tend to be unpredictable and belligerent. Many an unoffending angler has been treed by a moose whose stream he has entered.

Moose breed in autumn, at which time the male fights fiercely for the female's favour. One (sometimes two or three) ungainly, almost grotesque young is born after a gestation of 240–250 days. The mother cares for the calf until the birth of another is imminent.

Because of their antlers and large size, moose are sought as trophies by hunters. Sometimes the males can be called within gunshot range with a horn of bark by means of which the gruntihg call of a cow moose may be approximated. Moose calling is a locally popular sport in parts of Canada. Moose are also killed for their meat, which is beeflike but some hat dry. The fat is very strong tasting. The meat, or venison, is commonly available in restaurants in Alaska and Canada. The pressure of hunting substantially reduced the numbers of moose and virtually eliminated them from the southern parts of their range, especially in the United States. They are now generally protected by law in both North American and European nations, however, and are reappearing in haunts from which they have long been absent. (K. R. KN.)

MOOSE JAW, a city and electoral division of Saskatchewan, Can. Pop. (1961) 33,206. It is at the confluence of the Moose Jaw and Thunder Creek rivers and is a divisional point of the Canadian Pacific railway, about 400 mi. W. of Winnipeg, and owes its importance chiefly to its railway connections. The principal industries include flour mills, oil refinery, iron works, an abattoir and packing plant.

There is a municipal airport and connection of Trans-Canada with northern air services.

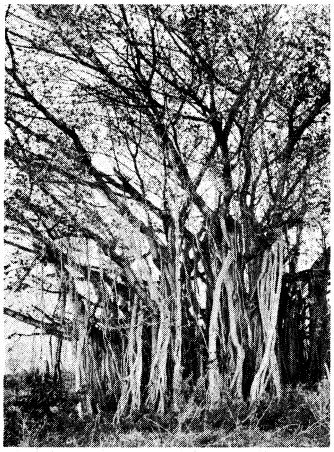
MOOT, the common term for the assemblies of the hundred, borough, etc., in the history of early English institutions,. and especially for the national assembly or council, the Witenagemot. The name survives in "moot hall," the term still applied to town halls and council buildings in some English towns. From its meaning of assembly, the word was applied to a debate or discussion, in particular to the discussion of hypothetical cases by law students at the Inns of Court.

MOPSUS, (1) Son of Ampyx (or Ampycus) and the nymph

Chloris, a Lapith of Oechalia in Thessaly. He took part in the Calydonian boar hunt, and accompanied the Argonauts as their prophet. He died from the bite of a serpent. He was afterward worshiped as a hero and an oracle was consecrated to him. (2) Son of Rhacius (or Apollo) and Manto, daughter of Teiresias. Calchas is said to have died of chagrin because Mopsus outdid him in a contest of divination. Mopsus founded Mallus in Cilicia with the help of Amphilochus; he also is said to have built Colophon and his name is preserved in the place names Mopsou Hestia Mopsou Krene. He was worshiped as a god by the Cilicians and had two famous oracles at Colophon and Mallus.

MOQUEGUA, a maritime department of southern Peru, bounded north and east by the departments of Arequipa and Puno. south by Tacna and west by the Pacific ocean. Area *6.245* sq.mi.; population *(1958* est.) *49,457.* It includes the valley of the Moquegua river and the upper tributaries of the Tambo, the rest of the province consisting of barren sierra with great volcanic peaks and steep, narrow gorges, and the desert coast area. The vineyards and olive orchards of Moquegua, formerly famous, are giving way to cotton plantations. Other crops, maize, fruits and vegetables find local markets. Livestock is raised to a limited extent. Mineral resources are undeveloped. In fact, in spite of historical importance and great natural resources, the department is the most isolated and least developed of any on the coast. It possesses no system of roads except a link of the Pan-American highway which passes through the capital, Moquegua, an Inca and colonial city (pop. [1958 est.] 6,200) *4,500* ft. above sea level in the Moquegua river valley. Moquegua, a primitive town with excellent climate, never recovered from its destruction by Chilean soldiers in *1881.* The town is a terminus for a railway line which provides service to the small but excellent port of Ilo, *63* mi. distant, the most southerly of Peru.

MORACEAE, a plant family of dicotyledons, belonging to the order Crticales, to which belongs also the nettle family (Urticaceae, *q.v.*). It contains about *73* genera with more than 1,000 species, mostly trees or shrubs, widely distributed in the warmer parts of the earth. The largest genus, *Ficus* (the fig, *q.v.*), contains about *600* species spread through tropical and subtropical regions and includes the common fig of the Mediterranean region *(Ficus carica).* the banyan *(F. benghalensis)* and the india-rubber plant *(F. elastica)*; many of the species are epiphytic. sometimes clinging so tightly round the host plant with their roots as to strangle it. *Morus* (mulberry, *q.v.*) contains ten species of trees or bushes in north temperate regions and in the mountains of the tropics. *Artocarpus,* including *A. altilis* (*A. incisa*) (breadfruit, *q.v.*) and *A. heterophylla* (A. *integrifolin)* (jack tree), has *40* species, chiefly natives of the Indian archipelago. The plants are rich in latex which may be very poisonous. as in *Antiaris toxicaria,* the upas tree of Java, or sweet and nutritious as in *Brosimum galactodendron,* the cow tree (*q.v.*) of Venezuela. The latex often yields caoutchouc as in species of *Ficus* (*e.g*, *F. elastica*). *Cecropia* (*q v.*), a tropical American genus with 30 to *40* species, and others.



EDGAR AUBERT DE LA RÜE

BANYAN TREE (FICUS BENGHALENSIS) ON REUNION ISLAND

In eastern U S. the family is represented by *Morus* (mulberry) and one species of *Maclura* (osage orange), the latter being much planted for hedges. In the western U.S. (Rocky mountain region) there are no native representatives of the family. From the evidence of leaf fossils. it is probable that the genus *Ficus* existed as far north as Greenland in the Cretaceous era and was generally distributed in North America and Europe in the Tertiary period up to Miocene times.

MORADABAD, a city and district in the Rohilkhand division of Cttar Pradesh, India. The city (pop. *198,081* in 1961), on the right bank of the Ramganga river, *93* mi. W. of Delhi, comprises the municipal area and the railway settlement. It was founded in *1625* by Rustam Khan, who built the fort which overhangs the riverbank and the fine Jama Masjid or great mosque *(1631).* The city has a special industry in ornamental brassware, sometimes plated with lac or tin, which is then engraved. Cotton weaving and printing is also carried on.

MORADABAD DISTRICT lies east of the Ganges and west of Rampur district. Area, *2,288* sq.mi. It is traversed by the Ramganga and the Sot. The eastern tract is submontane. The central part consists of a level plain descending at each end into the valleys of the Ramganga and the Sot. The western section has a gentle slope toward the Ganges, with a rapid dip into the lowlands a few miles from the bank of the great river. In addition to Moradabad the principal towns are Sambhal *(61,429* [1951]), Amroha (59,-105) and Chandausi *(36,689).*

Moradabad passed into the possession of the British in *1801.* The population in *1961* was 1,971,135. Muslims are more numerous than in any other district of the province, forming more than one-third of the total population. Crops include wheat! rice, millet. pulses, sugar cane and cotton.

MORAINE, a term adopted from the French for the rocky material carried downward by a glacier; according to the position of the moraine on the glacier different names are applied to it. The *lateral* moraine occurs at the glacier side as a long mound, and when two glacial valleys converge into one valley two lateral moraines unite and form a *median* moraine in the resultant broader glacier. The material carried by the glacier is deposited where the glacier ends and forms the *terminal* moraine, frequently in the form of a crescentic dam across the valley.

The material pushed forward beneath the glacier is sometimes called the *ground* moraine. *See* GLACIER.

MORAIS, FRANCISCO DE (c. *1500–1572*), Portuguese romance writer, called O Palmeirim because of his authorship of the famous romance of chivalry *Palmeirim de Inglaterra,* was treasurer of the household to King John III and was also for a time in Paris in the suite of the Portuguese ambassador. In *1572* he was assassinated, for obscure reasons, at Évora. He appears to have written his book in France (perhaps in Paris) in *1544,* but the first extant Portuguese edition came out in *1567.* The *Palmeirim de Inglaterra* belongs to another branch of the same cycle as the *Amadis de Gaula* (*q.v.*); the two romances, which achieved great popularity, are the best representatives of their class, and for their merits were spared from the auto-de-fé to which Cervantes condemned other romances of chivalry in *Don Quixote.* Both the plot and the characters of the *Palmeirim* have failed to stand the test of time, however; its surviving merit is its style.

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MORALES, LUIS DE (called EL DIVINO) (*c. 1509–1586*), Spanish painter. who was given his nickname because of his emotional religious paintings, which appealed to the people. His favourite subjects. "Ecce Homo," "Pietà," "Christ at the Column" and "Mater Dolorosa." were repeated many times and often copied. He was the first Spanish artist of pronounced national character and one of the few Spanish painters who were summoned by Philip II to help in the decoration of the Escorial; but his picture "Christ Carrying the Cross" did not please the king and was removed to the church of San Jerónimo at Madrid. The story goes that the king met the artist again at Badajoz in *1581,* a few years before his death, and. seeing that he was old and poor, allowed him a pension.

Morales' chief works are 20 panels with scenes from the life of Christ, painted for the church of Arroyo del Puerco (*1563–68*). One of his finest and most moving pictures is the "Pietà" in the Academy at Madrid. The Hispanic Society of America, in New Pork city. has a number of his works, and others are at Dresden,

London (National gallery), Dublin, Madrid (the Prado) and Paris.

MORALITY, PRIMITIVE. Philosophers have had little comparative experience in the study of primitive morality and anthropologists, preoccupied with more concrete problems, also sometimes considered that primitive peoples were controlled by an automatic obedience to custom with little need for moral choice. Some early anthropologists indeed held that primitive peoples were essentially nonmoral in their way of life, but it has since been made clear that all peoples have moral concepts and rules governing their behaviour.

The languages of primitive peoples employ terms involving concepts which can be translated as good and bad, right and wrong, true and false. Such categories refer not only to correctness of statement or expediency of action, but also to a moral quality; *i.e.*, one involving social approval or disapproval by reference to some standard outside the immediate issue. Primitive peoples are rarely concerned with the origin of such standards and the validity of judgments made by reference to them. They rather assume that such statements are self-validating. The anthropologist, however, sees them as related to the society concerned.

In many respects the rules of primitive morality accord fairly closely with those observed in a sophisticated civilized society. But while no human group approves, for example, of indiscriminate lying, cheating or stealing, societies differ in their reasons for disapproval and in their definition of the conditions under which lying or stealing is forgivable or tolerable or perhaps even demanded.

The Navaho regard truth and honesty as virtues but do not appeal to abstract morality or to divine principles; they stress practical considerations. "If you don't tell the truth, your fellows won't trust you. You will shame your relatives. You will never get along in the world that way." They also appeal to loyalty to tradition — lying goes against the old Navaho custom. R. Redfield has pointed out that the traditional morality of the Indians of Chan Kom, a Mexican village, resembles notably that of the American pioneers as represented by De Tocqueville — respect for the ties of marriage, orderliness of family life, emphasis upon industry, care for sobriety, honesty being taken for granted. Yet this traditional morality mas not puritan; it frowned upon sexual indulgence but did not get excited about it and did not regard concupiscence as a major sin. To deny the flesh was not a good in itself or a means of grace except insofar as yielding to passion was incompatible with certain sacred ceremonies.

While sharing some moral values with civilized society, peoples in so-called primitive societies operate these values in their own way. The rules of primitive morality are not usually formulated in an abstract style, or expressed systematically. Nor is it common for primitive morality to be directly attributable for its general validity to any supernatural being or other religious entity. Specific rules may have supernatural sanction and in some communities, such as Manus in the Admiralty Islands, the elaborate moral code is guided in its observance by fear of ancestral intervention. But in most communities with developed ancestor cults, the spirits of the dead are believed to be interested primarily in the behaviour of their descendants toward them and are not regarded as arbiters of the moral conduct of everyone. Moreover, the religious sanction for morality is not usually concerned with everyday conduct in matters of lying, thieving or aggressive behaviour, but in the more serious breaches of social relations, such as incest. In such cases, as in Tikopia, moral disapproval, though privately strong, may not be publicly expressed; the primary punishment for such a sin may be believed to lie in supernatural action.

The operation of the moral code varies considerably according to the conditions in which the act is committed — the group factor being very important. In the case of homicide, for example, the killing of a person belonging to another hostile group may be a matter of indifference or of congratulation, unless it draws vengeance upon the group of the killer. On the other hand, the killing of a person within one's own group may be a matter of such abhorrence that no action at all is taken and the killer is left either to expiate his sin or to be punished supernaturally. Judgment on conduct may also vary according to the relative status of the parties concerned. In a society with a well-developed system of chieftainship, everyone may think it right for the chief to behave in what would ordinarily be an oppressive way toward other members of his community.

The moral judgments of primitive peoples apply the concept of responsibility in varying forms. As a rule the principles are not regarded as having an abstract, universal character: the moral code applies only to members of one's own community or persons in immediate contact with it. On the other hand, responsibility may not be highly individualized. If someone should damage the goods or person of another, then not only the offender but also members of his kin group may equally share the odium and the responsibility, and acts of retribution or restitution may be directed against them. In judgment on the morality of actions, again, intention of the actor often is disregarded — it is the effect of the action that is taken to be significant and in this sense primitive morality is in some cases more "realistic" than that of western society.

There are some spheres of action in which moral judgment in primitive societies is markedly differentfrom that in modern western society. One of these is witchcraft. Witches are believed to exist, to have real power and to exercise that power in an evil way to the detriment of other members of the society. But the moral disapproval really may be leveled against a suspected witch on other grounds as, *e.g.*, a misplaced protest against misfortune. Other actions involving seemingly strange judgments are infanticide and suicide. Traditionally in some societies, both literate and preliterate, infanticide has been regarded as no more than a painful necessity, as morally right in order to mitigate pressure of population on subsistence. In such societies the decision whether a newborn infant should be deprived of life is usually left to the father, and society casts no blame upon him for his decision. The basis of this attitude is that human life, especially a life which has just begun, has as such no absolute value. It may have some small sentimental value for members of its own family, but the preservation of it is judged as right or wrong according to the social and economic situation, as among the Eskimo. An analogous view is often held about suicide. There may be a strong sentimental regard for a person by his family and community; there may also be an opinion that it is unnecessary. malicious or ill-judged for him to put an end to his life in the circumstances. But, as among the Hopi of Arizona, there is not the attitude of moral disapproval that is found in a western society. Disposal of one's life is regarded in somewhat the same light as disposal of one's property — others may have an interest, even a right — but suicide is not in itself a morally wrong act.

Moral concepts and rules are closely related to the structure of society, and morality is therefore relative in the sense that, as the ends of each society vary, so do the standards of right and wrong. But as E. Westermarck, L. T. Hobhouse, M. Ginsberg and others have shown, all human societies have some standards of right and wrong and are sensitive to judgments in such terms. Moreover, behind the variations is some real measure of uniformity.

See also PASSAGE RITES; RELIGION: *Primitive Religion;* RITUAL; SHAMANISM; SOCIAL ANTHROPOLOGY; SUPERSTITION; TABU; TOTEMISM; WITCHCRAFT.

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MORAL REARMAMENT, variously known as Buchmanism and the Oxford Group, is a vigorous modern revivalistic movement founded by Frank N. D. Buchman (1878–1961), born of pietistic Pennsylvania German parents in Pennsburg, Pa. After graduation from Mount Airy Lutheran seminary in Philadelphia in 1902, Buchman combined pastoral responsibilities with social work. A difference with the trustees of a Philadelphia youth hostel run by him caused his resignation. Later he worked successfully as

secretary of the college Young Men's Christian association at Pennsylvania State university, which led to his appointment as lecturer in personal evangelism at the Hartford Seminary foundation at Hartford, Conn., and also to evangelistic work, mostly among college students. Following friction at Hartford he resigned in 1922 to "live by faith" and launch a world-wide evangelistic campaign based on God's guidance, moral absolutes and the "life-changing" of individuals through personal work. The centre of Buchman's operations was shifted to the campus of Princeton university, where he encountered even sharper opposition and where the authorities finally asked him in 1926 to cease his work. Subsequently he was successful in winning influential support at Oxford university, and the movement gradually became known as the Oxford Group (not to be confused with the Oxford Movement). During the next ten years it held increasingly successful conferences or "house parties," attended often by thousands of people, in England, the Netherlands, America, South Africa and other countries.

Up to this point the movement had been largely Protestant Christian in emphasis, but with the tensions leading up to World War II, it began to change its name to Moral Rearmament and to widen its appeal to include all faiths. On this account a number of its supporters withdrew, while many outsiders criticized it for alleged Nazi sympathies. Its appeal to the popular mind declined during this period.

After World War II the group acquired and renovated a run-down hotel at Caux, Switz., and this tended to become its international headquarters, though meetings also were held annually at Mackinac Island, Mich., and "task forces" were sent to all corners of the free world to do evangelistic work, in part through plays emphasizing co-operation, honesty and mutual respect between opposing groups.

Buchman and his followers have always stimulated sharply opposing opinions. One study at least indicated that the majority of those whose lives were "changed" by the movement subsequently testified that the experience was personally beneficial and religiously vitalizing. At the same time these persons tended to disapprove the movement as a whole and to cease to support it. often because of its oversimplified and overgeneralized theology. Though it has by no means exclusively cultivated the upper classes, nevertheless it has always shown much interest in converting the influential and the rich, the "up-and-outs" as Buchman called them. It has steadfastly opposed Communism, though otherwise it has to its credit solid and highly publicized successes in reconciling nations, races, management and labour. It should also be noted that the group influenced the founding of Alcoholics Anonymous. The Group's reports of its work must be evaluated critically. It does not publish membership figures, but there is little doubt that it has been the most vital interfaith religious movement of the age.

See Walter Houston Clark, *The Oxford Group: Its History and Significance* (1951); Allan W. Eister, *Drawing-Room Conversion: a Sociological Account of the Oxford Group Movement (1950)*

(W. H. CK.)

MORAL SENSE: *see* ETHICS; ETHICS, HISTORY OF.

MORAN, EDWARD (1829–1901), U.S. painter of marine subjects. was born Aug. 19. 1829. at Bolton, Lancashire. Eng., but went to the United States about 1845. He studied in Philadelphia with James Hamilton and Paul Weber and at the Royal Academy, in London. From 1872 he lived in New York city, where he died June 9. 1901. Best known for seascapes, he also painted a famous series illustrating the maritime history of America. THOMAS MORAN (1837–1926), noted for his evocative landscapes depicting the American west, was a brother. Another brother, Peter, and Edward's two sons. Percy and Leon, also won recognition as artists. (D. H. W.)

MORAN, PATRICK FRANCIS (1830–1911), cardinal archbishop of Sydney, was born at Leighlinbridge, Ire., on Sept 16. 1830, and was educated in Rome, from the age of 12, at the Irish college of St Agatha. where he later became principal (1856–66). He was ordained a priest on March 19, 1853. From 1866 to 1872 he was secretary to his uncle, Cardinal Cullen, archbishop of Dublin. In 1873 he became bishop of Ossory, and in 1884 archbishop of Sydney. He was consecrated cardinal at Rome in Aug. 1885. He paid many visits to Rome, and as primate of Australia presided over the plenary councils of 1885, 1895 and 1905. He died on Aug. 16, 1911, at Manby palace, Sydney.

Cardinal Moran's uncompromising attitude on religious questions provoked much controversy, but he did good work in the educational sphere and arranged for the building of many schools, as well as churches and hospitals. He was active in Australian politics and a supporter of Australian federation. His most important works are the *History of the Catholic Archbishops of Dublin* (1864) and *Spicilegium Ossoriense* (3 series, 1874–84).

MORAND, PAUL (1888–), French writer, author of some of the best short novels in the language, and a perceptive witty observer of the modern world, was born in Paris, March 13, 1888. He joined the diplomatic service in 1912, served as attaché in London, Rome and Madrid and became director of an economic department of the Quai d'Orsay. He was head of the French economic warfare mission in Britain (1939–40); minister plenipotentiary in London, 1940; minister at Bucharest, 1943; and ambassador at Berne, 1944.

Because of Morand's collaboration with the Vichy government, he was dismissed from the diplomatic service in 1945, and his candidature for entry to the Académie française was opposed.

His works include *Ouvert la nuit* (1922; Eng. trans., Open *All Night*, 1923), *Fermé la nuit* (1923; Eng. trans., *Closed All Night*, 1924), *Lewis et Irène* (1924; Eng. trans.. 1925), *Vie de Maupassant* (1942), *Montociel* (1947), *Journal d'un attaché d'ambassade 1916–17* (1948). (A. PE.)

MORANDI, GIORGIO (1890–). Italian painter and etcher who profoundly influenced succeeding Italian graphic artists, was born in Bologna on July 20, 1890. Educated in his native city, he first exhibited there, together with the Futurist painters, in 1914. Associated in 1918–19 with the Scuola Metafisica, a movement centring on Giorgio de Chirico and Carlo Carrá, he developed a contemplative approach to art which, directed by a highly refined formal sensibility, gave his quiet landscapes and disarmingly simple still-life compositions a characteristic delicacy of tone and extraordinary subtlety of design. Morandi was instructor of etching at the Academy of Fine Arts in Bologna from 1930.

See G. Scheiwiller, *Giorgio Morandi* (1945); Lamberto Vitali, *Giorgio Morandi, oprra grafica* (1957). (J. C. T.)

MORANT, SIR ROBERT LAURIE (1863–1920), British civil servant, was born at Hampstead on April 7, 1863. He was educated at Winchester and at New college. Oxford, and on leaving the university was for a few years a schoolmaster. Later he went to Siam as educational adviser. and was entrusted by King Chulalongkorn with preparing an educational plan for the whole country. In a few years he returned to England, and after some experience of social work in the east end of London, was appointed in 1895 to assist in the direction of the office of special inquiries and reports in the board of education. He became private secretary to successive ministers, and on him devolved a great deal of the preparation of Balfour's Education act of 1902. In 1903 he was appointed permanent secretary of the board of education. In this capacity he proved himself a most efficient administrator, and in 1907 he was created knight commander of the Bath. In 1912, on the introduction of the National Insurance bill: Morant was appointed chairman of the insurance commission, a position which led naturally to his appointment as secretary to the ministry of health on its formation in 1919. He died in London, after a few days' illness. on March 13. 1920, leaving a name in the civil service as one of the greatest administrative officials of his time.

MORAT (Ger. MURTEN), a small town on the east shore of the Lake of Morat, in the Swiss canton of Fribourg. and 14 mi. N. of Fribourg or 18¼ mi. W. of Bern by rail. It is also connected by rail to Solothurn. Neuchâtel. Yverdon and Lausanne. Pop. (1950) 2,79j. In 1264 it exchanged its position as a free imperial city (from 1218) for the rule of the count of Savoy. In 1475 it was taken by the Swiss at the commencement of their war with

Charles the Bold. duke of Burgundy, whose ally was the duchess of Savoy; in 1476 it was besieged by Charles (see SWITZERLAND: History). Morat was ruled in common from 1475 to 1798 by Berne and Fribourg. being finally annexed to Fribourg in 1814. The Lake of Morat has an area of 10½ sq.mi , and is connected with that of Neuchâtel by the Broye canal. It is overlooked by the 13th-century castle and the tower of the Rathhaus, while it is still surrounded by its 15th-century walls studded at intervals with watchtowers.,

MORATIN, LEANDRO FERNÁNDEZ DE (1760–1828), Spanish dramatist. born at Madrid. March 10, 1760, who inherited from his father, Nicolas Fernández de Moratin. also a dramatist and poet. a respect for neoclassical decorum and a prejudice against Spanish baroque drama and poetry. In his comedies, like his model. Molière, he ridiculed the vices of men in society. He constantly tried to reform the theatre and in La comedia *nueva* (1792) satirized the absurd characters and plots of the popular plays of his time. His other masterpiece. El *sí* de las *niñas* (1805), ridiculed ill-assorted marriages of convenience. Moratin represented the Spanish Enlightenment in his European culture, gained abroad. and in his sympathy with the views of the French Encyclopaedists. Like many Spanish intellectuals, he collaborated with the Bonapartist regime (1808) and after the restoration of Ferdinand VII (1814) lived in exile in France, where he died, in Paris, on July 21, 1828. A master of prose in his best plays. and in his satirical and critical works, travel notes and correspondence, and a poet of exquisite taste, Moratin was one of the outstanding Spanish writers of his time.

His Teatro was edited by Ruiz Morcuende (1933) and Obras *póstumas* (3 vol.) were published in 1867. (EH. F. H.)

MORATORIUM, a term used to express a legal authorization postponing for a specified time the payment of debts or obligations.

The term is also sometimes used to mean the period over which the indulgence or period of grace stretches, the authorization itself being called a moratory law. Conspicuous instances of moratoria were the Herbert Hoover moratorium on debts arising out of World War I and the bank moratorium in the U.S. in 1933, to prevent runs on deposit banks (see BANKING; INTER-ALLIED DEBTS; REPARATIONS).

MORAVIA, ALBERTO (pseudonym of ALBERTO PINCHERLE) (1907–), the best-known Italian novelist after World War II, was born in Rome, Nov. 28, 1907. He became famous in 1929 on the appearance of his first novel, Gli indifferenti. His fame was confirmed by the novels which followed (including Agostino, 1944; La *romana,* 1947; La disubbidienza, 1948; La ciociara, 1957) and by his short stories (La *bella* vita, 1935; L'imbroglio, 1937; Racconti *romani,* 1954).

Moravia traveled widely before World War II and afterward settled in Rome, where he became editor of the periodical Nuovi *argomenti.*

Moravia's skill as a novelist lies in his power to portray with analytical precision the life of the Roman bourgeois society to which he belongs but for which he has no sympathy. His minute interest in the sex life of his characters, which he describes with crude lack of reserve, and the indifferentism which leads him to represent vice and virtue without passing judgment on them have been criticized as obsessive and amoral. In his later work he showed increasing concern with working-class life. He is a master of the technique of the short story.

Most of Moravia's works are available in English translations.

See P. Pancrazi, *Scrittori d'oggi* (1952), "Inchiesta sul romanzo" in *Ulisse* (Dec. 1956). (*F.* DI.)

MORAVIA (Czech MORAVA, German MÄHREN), a central region of Czechoslovakia. For its physical features, see CZECHOSLOVAKIA.

Area and Population. — Before 1914, when it was an Austrian margravate (see History), Moravia covered an area of 8,555 sq.mi. Within Czechoslovakia its area extended to 8,612 sq.mi. In addition, in 1927 part of Austrian Silesia which was incorporated into Czechoslovakia was added to Moravia to form a single province (zeme) nith an area of 10,351 sq.mi.

The population of this province in 1930 was 3,565,010, including 2,616,969 (73.4%) Czechs and 823,730 (23.1%) Germans. By religion its people were 86% Roman Catholic, 4.9% Protestant, 4 5% Czechoslovak National Church and 1.5% Jewish; 3% were without any confession. After World War II the greater part of the German population was transferred to Germany. The "numbering" of May 22, 1947, revealed a total population in Moravia and Silesia of 3,135,800. In 1949 the province was subdivided into administrative regions. Thus Moravia ceased to exist as a political unit. (X.)

History. — The earliest known inhabitants of Moravia were Celtic tribes: the Boii. whose name is perpetuated in the name Bohemia, and the Cotini. These were succeeded about 15–10 B.C. by the Germanic Quadi, a Suebian tribe. The Germanic races were pushed back from the middle Danube by the coming of the Avars (*q.v.*) in A.D. 567. The exact date of the arrival of the Slavs in Moravia, as in Bohemia (*q.v.*), is uncertain; but by the late 8th century Moravia was filled with Slav settlers, who acknowledged no particular tribe, but took the general name Moravians from the Morava river. When Charlemagne destroyed the Avar empire (c. 796), he rewarded the Moravians for their help by giving them a part of it, which they held as a fief from him. They thus became loosely tributary to him for all their lands, but their princes enjoyed much independence, and repeatedly made war on him and on his heirs, Louis the Pious and his son Louis the German. By the first half of the 9th century, Moravia had become a united kingdom, under Prince Mojmir. It probably included, besides Moravia, the northern part of what later became Austria and the western part of modern Slovakia. Mojmir was succeeded (c. 846) by Rostislav (Rastislaus) who further extended the kingdom.

German influence upon Moravia and Bohemia was partly political and partly religious. Christianity had been brought to these lands by Bavarian priests, and Morayia owed allegiance to the archbishop of Salzburg and the bishop of Passau. Rostislav, anxious to counteract this western pressure and also to ensure that his people should learn the new faith in their own tongue, asked the Byzantine emperor to send missionaries. Cyril (Constantine) and Methodius (*qq.v.*), who arrived in about 863, had prepared for their mission by translating the chief liturgical texts into Slavonic, and they Christianized both Bohemia and Moravia. After Cyril's death, Methodius was appointed head of a province which included the whole of Moravia, and with the support of Rostislav, he resolutely maintained this position. despite persecution from the German priests and a period of imprisonment in Germany. In 869, however, Rostislav himself fell into the hands of Louis the German, who blinded and deposed him. He was succeeded by his nephew Svatopluk, who extended his kingdom, which became known as Great Moravia, to the Oder in the west and the Gran in the east. At first Svatopluk supported Methodius, but later he allied himself with the Frankish clerics, who used the Latin liturgy and opposed the use of Slavonic. In 885, after the death of Methodius, Pope Stephen V forbade the use of the Slavonic liturgy, and Methodius' followers were driven out. The downfall of Great Moravia was not long delayed; Svatopluk died in 894, and the quarrels between his three sons were encouraged by the emperor, who intrigued with the Magyars to bring about the invasions which finally destroyed the so-called Moravian empire. The exact date of the first Magyar invasion and of the decisive battle near Posonium (Pressburg or Bratislava) is uncertain; but by 906 the conquest was complete. and the name Moravia was restricted to the area later incorporated into Czechoslovakia. After long disputes between Poland. Hungary and Bohemia. in 1029 Moravia was incorporated in Bohemia, thus becoming part of the Holy Roman empire. In 1182 it was made into a separate margravate, but in 1197 it was restored as a fief of Bohemia and was henceforth usually assigned to younger sons of the royal house.

From 1349 to 1375 Moravia was ruled by John Henry of Luxembourg, the brother of Charles I of Bohemia (the emperor Charles IV), and after his death it passed to his son, Jost. This line became extinct on his death in 1411, and Moravia fell to the

Bohemian king. Vaclav (Wenceslaus), Jost's cousin. His heir was his brother. Sigismund of Hungary, who in 1423 relinquished Moravia to his son-in-law, Albert of Austria, who became king of Bohemia in 1437. His son, Ladislas Posthumous. paid homage to the Moravian estates before being crowned in Bohemia (1453), and when on his death in 1457 the Bohemian estates elected George of Podebrady (Podebrad) as king, he also became ruler of Moravia. In 1478, however. Moravia was again separated from Bohemia by the peace of Olomouc (see BOHEMIA), which assigned Moravia, with Silesia and Lusatia, to the king of Hungary during his lifetime; on his death in 1490, the king of Bohemia, Vladislav, was elected king of Hungary and thus reacquired Moravia. In 1526 when Louis, Vladislav's son! who had succeeded his father in 1516, was killed fighting against the Turks, Moravia, with Bohemia and Silesia, was claimed by Ferdinand, archduke of Austria who had married Anne, Louis' sister. Unlike Bohemia, Moravia readily accepted Habsburg rule, and as a consequence suffered less in the religious and civil struggles which followed. Religious toleration led to a flowering of Protestantism in Moravia under Ferdinand and Maximilian, and although henceforward Moravia shared Bohemia's fortunes in general, there was less friction between Czechs and Germans there, partly because its people were more backward and therefore slower to make nationalist demands.

In 1849, after the 1848 revolutions. Moravia was made a separate Austrian crownland, and in Nov. 1918 it became part of Czechoslovakia. In 1927 it was united with southern Silesia to form an administrative province, but in 1949 this province ceased to exist as an administrative unit.

Industrial **Development.**—Moravia's mineral wealth is considerable. Coal is mined principally in the district of hloravska Ostrava. part of the Sjlesian field; lignite is mined at Hodonin. Iron ores are extracted in the Moravian-Silesian borderlands.

Industrially Moravia is advanced. It shares the important iron and steel working of Silesia, and has foundries at Vitkovice. Machinery is manufactured at Brno and Blansko. The cloth industry dates from the 14th century and has its centre at Brno; silks are manufactured in northern hloravia, hats at Prostejov and Novy Jicin and leather goods at Brno, Prostejov and Jihlava. After World R7ar I a new industrial town, Zlin (Gottwaldov), was founded in eastern Moravia. During the industrial transformation under the Communist regime (see CZECHOSLOVAKIA), new iron and steel works were started at Kuncice, near Moravska Ostrava. (E. WI.)

MORAVIAN CHURCH (UNITAS FRATRUM), a Christian communion founded in Bohemia: growing out of the reform movement of John Huss, influenced by the teachings of John Wycliffe and the Lollards. After Huss's death (1415) the movement split into two parties from whose conflicts the more moderate one, later known as Utraquists, emerged victorious (see HUSSITES). But there were also smaller groups more insistent on reform and purity of morals, and opposed to war. One such group found an influential leader in Peter of Chelcic (Peter Chelcicky; 1390–1460); another group under Brother Gregory gathered in Prague and in 1457 founded a refuge in the village of Kunwald. This group (sometimes known as the Bohemian Brethren) shared some of the views of Peter, but preferred to base themselves directly on New Testament teaching, calling themselves *Fratres Legis* Christi. Their simple Christian teaching and exemplary moral life and industry attracted many recruits; new circles sprang up calling for pastoral care by an ordered ministry. To deal with this a synod was held at Lhota in 1467. They sought to re-establish the simplicity of apostolic days which they felt had been lost in the existing churches, whether Roman or Utraquist. Believing that among the Waldenses (*q.v.*) there was a ministry of apostolic tradition and also of purity of life, they obtained from a Waldensian bishop, later always reputed to have been Bishop Stephen, the consecration of Brother Michael Bradacius, elected by synod as first Moravian bishop. They gave their community the Czech name *Jednota* Bratrska (*i.e.,* Fellotvship of the Brethren), in Latin *Unitas Fratrum.* The name indicated what was foremost in their minds as the mark of the Christian Church. With the Bible as the one rule of faith and life, no attempt was made to construct a special confession of faith till the Confessio Bohemica (1564) when a basis was required for negotiations for a union with Lutherans in Bohemia. They remained insistent on genuine practical Christian life, the maintenance of which was secured by a strict church discipline that later gained high commendation from Martin Luther. They displayed, without ever asserting it as a dogma, the priesthood of all believers. The constitution was generally presbyterian in character; chief authority was exercised by an elected body, the inner council; congregations were under the care of elders; members were carefully tested as to their sincerity and graded according to their progress in Christian faith and conduct into three classes: beginner, proficient, perfect.

Bishop Luke (1460–1528) introduced theological training. Use was made of the press; a catechism and formularies for worship were issued. The first Protestant hymnbook to appear was printed in 1501; and most important of all, the Bible was translated into Czech and issued complete in 1593, being known as the Kralitz Bible (the New Testament was that translated by Jan Blahoslav in 1565). Meantime the church had grown rapidly, gaining much support among the nobility. By 1600 its membership formed half the Protestants in Bohemia and more than half in the adjoining land of Moravia, in spite of constant opposition and repeated cruel persecutions. These led, around 1550, to emigration of many members to Poland, where they founded a branch of the *Unitas* that survived about 200 years. In Bohemia and Moravia, however, the Catholic Counter Reformation gathered strength nith the active support of the Habsburg emperors. In 1618 the Thirty Years' War broke out; the battle of White mountain (1620) brought the rout of the Protestants, followed by the beheading of their leading nobles and the imperial rescript in 1627 prohibiting Protestantism. The *Unitas Fratrum* was destroyed with all its churches, Bibles and hymnbooks; its members were forcibly "catholicized" or driven into exile. As an organized body it ceased to exist.

Yet secretly its old life persisted in concealed corners and secluded spots in deep forests. Faithful souls would gather for worship, their hopes sustained by Bishop Johann Amos Comenius (*q.v.*) who as an exile in northern countries laboured by his writings, by collection of money for the sufferers and by public appeal for the restoration of liberty for his beloved country (and apart from this activity, gaining a European reputation as an educational reformer). His hopes were disappointed by the peace of Westphalia, but he still believed that in the underground movement which persisted there might lie a "hidden seed" from which might issue a renewal of the *Unitas.* This happened; not in Bohemia, however, but in Germany.

Some of the "hidden seed" in Moravia escaped over the northern border and received from Count Zinzendorf (*q.v.*) leave to settle on his estate in Berthelsdorf in Saxony (1722). This settlement, Herrnhut, was joined by various German Lutherans. The count came to live in the community and to organize it with "statutes" which resembled the discipline of the old *Unitas.* A remarkable unifying experience of fellowship at a special communion service on Aug. 13, 1727, dispelled all tendency toward dissension from the community and created lasting evangelistic zeal. In these events the refugees from Moravia saw nothing less than the renewal of their old *Unitas Fratrum* whose traditions they had brought with them; and from their home country the new brotherhood derived the name Moravian Church, now in common use. The final step in this development was taken in 1735 when Zinzendorf accepted the episcopal order of the *Unitas* as handed down in succession through Comenius and his grandson Daniel Ernst Jablonski. Herrnhut became famous as a model for other settlements on estates of friendly nobles.

Zinzendorf however had other ideas than the revival or extension of an independent church. His great concern was the use of this body in missionary or evangelistic service; he assessed the value of a settlement by its power to furnish evangelists. In 1732 foreign missions were begun that have remained ever since the predominant concern of the Moravian Church, which was the first among Protestant churches to treat this work as a responsibility

of the church as a whole instead of leaving it to societies of specially interested persons. In countries nearer home Zinzendorf pursued similar evangelism among the existing churches, not to secure from them members for the Moravian Church, but to help them where spiritual life seemed to be at a low ebb by arousing that devotion to Christ as Saviour which he felt to be the vital source of genuine Christianity, and therefore the real bond of unity between all denominations whatever their variety of theology or ritual. The number of messengers sent out was remarkable, their destinations often distant; *e.g.,* the Orthodox Church in Russia, the Copts in Egypt, as well as in Germany, Switzerland, Holland and Scandinavia. This particular kind of evangelism was called diaspora, or dispersion (I Pet. i, 1), brethren ministering among the "scattered" in all churches without drawing them into the Moravian Church. This feature still prevails on the continent; the importance of the Moravians must therefore be measured by their influence on other Christian bodies rather than by their numbers. World War II led to loss of German territory and of flourishing settlements in the east; those remaining mere hampered by the division between east and west, but in both the work continues with unabated spirit.

In Great Britain. — The first visit of the Moravians to England was occasioned by the emigration of part of the Herrnhut congregation to the American colonies (1735) with the double purpose of securing a place of refuge in case the hostility of the church and state in Saxony made the continuance of Herrnhut impossible, and of founding a mission among the American Indians. On this journey, John Wesley (*q.v.*) made his first acquaintance with the Moravians whose influence prepared the way for his final "conversion" (1738). Further contacts with members of Wesley's circle led to requests for the placing of Moravian workers in England. From this there followed formation of the first Moravian congregation in London (Fetter lane) and participation in the Evangelical revival; Yorkshire, Wiltshire and Ireland became the chief areas of activity; John Cennick the most powerful evangelist. Zinzendorf made London his headquarters for a few years and had friendly relations with the archbishop of Canterbury and other bishops; their support gained in an act of parliament in 1749 the recognition of the Moravian Church "as an ancient Protestant episcopal Church" uith certain privileges in the colonies. Enforcement of Zinzendorf's diaspora policy, however, discouraged the extension of the church beyond the formation of a few settlements; it was not until 100 years later that this policy was discarded. By that time something of the original intensity of spiritual fervour had been lost and other free churches had occupied the ground. Between 1850 and 1950 about ten new congregations were formed, chiefly in places where shifting of the population gave the opportunity. The Moravian Church has always had friendly relations, including intercommunion, with other free churches and is a member of the Free Church Federal council of Great Britain. Relations with the Church of England have also been friendly (for the Moravian Church was not formed through "dissent" from the Church of England), but negotiations for some still closer association have had no result. (C. H. S.)

In the United States. — The first Moravian venture in the Americas was a mission among Negro slaves in the West Indies in 1732. Both the mission motive and political uncertainty in Europe brought the Moravians to Georgia in 1735. Zinzendorf saw in America a haven from possible suppression and an opportunity to evangelize the Indians. Unsuccessful in Georgia, the Moravians went to Pennsylvania in 1740.

Zinzendorf himself was in America in 1741–43 and introduced the program of religious activity then prevailing among Moravians in Europe. For about a century, only church members lived in the communities, including Bethlehem. Nazareth and Lititz in Pennsylvania and Salem in North Carolina. From these centres missionaries circulated among the Indians and primitive peoples abroad, and diaspora evangelists worked among neighbouring European settlers. Many children from outside the church came to the settlements to be educated in Moravian boarding schools. Closed communities, European control and a diaspora rather than denominational outlook kept the church small. Extensive growth did not come until the mid-19th century, when a reorganization of the international body gave the Americans more autonomy.

The two provinces (see below) of the Moravian Church in America have a common board of foreign missions, a common theological seminary, the same hymnal and work together on many matters. They maintain missions in Alaska, Nicaragua. Honduras, British Guiana and the West Indies. Several schools and seminaries are maintained.

More than half of the Moravians in the world live in North America. By the latter 1950s there were some 56,000 members in 160 churches. North Carolina, Pennsylvania, Wisconsin and New York have the greatest number of churches. The denomination is affiliated with the National Council of Churches and the World Council of Churches.

Another U.S. Moravian group, the Evangelical Unity of the Czech-Moravian Brethren in North America, grew out of congregations established by Czech and Moravian immigrants in Texas in the 1850s and became an evangelical union in 1903. Membership at mid-20th century was about 5,000. A third, much smaller group was organized in Iowa in 1858. (J. R. WK.)

Organization. — The Moravian Church forms an international unity organized from six self-dependent provinces: Great Britain; continental Europe, comprising Germany, the Netherlands, Switzerland and Denmark; United States Northern Province; United States Southern Province; Czechoslovakia; South Africa West. Each of these is self-governing in its area through its provincial synod; they are linked together by a general synod composed of representatives of all provinces and of the mission fields. This "Unity Synod" is authoritative in all matters of doctrine and constitution common to the whole church. The Moravians adhere to their old principle that "the Holy Scriptures are our only rule of faith and practice," but at the same time declare that their interpretation of Scripture agrees substantially with the great Christian creeds.

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MORAVSKA OSTRAVA (OSTRAVA, OSTRAU; German, MÄHRISCH-OSTRAU), a city of Czechoslovakia, on the Ostrawitz river, in the Ostrava region, near the Polish border. According to the 1950 census the population was 183,662, in 1957 it was 221,-831. On March 1. 1950, the city of Slezska Ostrava nas annexed to the city of Moravska Ostrava to form the city of Ostrava. Fourth largest of the cities of Czechoslovakia, following Prague, Brno and Bratislava, Ostrava had a rapid growth in the 20th century as an industrial centre. In 1900 its population was only 30,-125. Its growth was largely the result of industrialization and its location in the largest coal fields of the country. This coal, of an excellent coking variety. goes mostly to the nearby steel foundries of Vitkovice. The city itself has large steel works and also manufactures brick and tiles and petroleum. During the crisis which preceded the pact of Munich in 1938, Moravska Ostrava was the scene of disturbances between Czechs and Sudeten Germans agitating for incorporation of the Sudetenland into nazi Germany.

MORAY, THOMAS RANDOLPH, EARL OF (d. 1332), Scottish warrior and statesman, was the only son of Thomas Randolph of Nithsdale, sometime chamberlain of Scotland. by Isabel, sister of King Robert Bruce. He was captured at the battle of Methven in 1306 but was released on becoming the man of Edward I. In 1308, however, he mas taken prisoner by Sir James Douglas and made his submission to King Robert. In 1312 he was created earl of Moray and, later, lord of Man and Annandale. By a brilliant feat of arms he captured Edinburgh castle early in 1314. On the eve of the battle of Bannockburn he defeated an attempt by a body of English horse under Robert Clifford. Henry Beaumont and Thomas Gray to enter Stirling castle.

In 131j Randolph took part in Edward Bruce's expedition to Ireland, returning with King Robert two years later. With Sir

James Douglas he seized Berwick in 1318 and the next year they raided the northern English counties as far as York. after which a truce was made for two years with Edward II. In 1320 Randolph mas a signatory of the Declaration of Arbroath; in 1322 he shared in Douglas' exploit at Byland abbey (see DOUGLAS).

The earl was one of the ambassadors who concluded the 13-year truce with England in 1323 and was sent the same year to Avignon. where he persuaded the pope to acknowledge Bruce's right to the throne. In 1326 he negotiated at Corbeil a treaty of alliance with France. With Douglas he again invaded England in 1327 but the next year took a leading part in connection with the treaty of Northampton and the marriage at Berwick of David Bruce to Joanna, the sister of Edward III.

On the death of Robert Bruce in 1329 he became regent of Scotland for the young David II. He died at Musselburgh on July 20, 1332, leaving two sons who succeeded in turn to the earldom and who were killed at Dupplin and Neville's Cross respectively. He also left two daughters. (E. W. M. B.-M.)

MORAY or ELGINSHIRE (Gaelic "among the seaboard men"), a northern county of Scotland. bounded north by the Moray firth. east and southeast by Banffshire. south and southwest by Inverness-shire, west by Nairnshire. It comprises only the eastern portion of the ancient province of Moray. which extended from the Spey to the Beauly and from the Grampians to the sea, embracing an area of about 3,900 sq.mi. The area of the county is 476 sq.mi. Pop. (1951) 48,218. The county is divided between lowland and hill country. The lowland of the coast and its hinterland is the Laiqh of Moray, a fertile tract 30 mi. long and 5–12 mi. broad. of Old Red Sandstone and Triassic strata, with a wide distribution of glacial deposits. which were carried from the heights in an easterly and southeasterly direction along the present Moray firth. The sandstones at and near Quarryn-ood are of geological interest because of their remarkable series of Triassic (and possibly. in the lowest portion. Permian) reptilian remains. The hilly south-central division of the county reaches a height of 2,329 ft. in the Cromdale hills on the Banffshire border. The division belongs to the area of the crystalline schists of the central highlands, with granite between Lochindorb and Grantown.

The two most important rivers, the Spey (*q.v.*) and the Findhorn. have their sources in Inverness-shire. About jo mi. of the Spey are in Moray, to which it may be roughly said to serve as the boundary line on the southeast and east. The Findhorn rises in the Monadhliath mountains which form the watershed for several miles between it and the Spey. Of its total course of nearly 72 mi. only the last 12 are in the county, before it enters the Moray firth in Findhorn bay on the northeastern shore. The Lossie rises in the small lakes on the flanks of Carn Kitty and pursues a winding course of 34 mi. to the Moray firth. The Spey and Findhorn are famous for salmon. Lochindorb, 6 mi. S.N.W. of Grantown, is the largest lake. In the upper end. on an island believed to be artificial. stand the ruins of Lochindorb castle. the 14th-century stronghold of the Wolf of Badenoch, and aftern-ard successively the property of the earl of Moray, the Campbells of Cawdor and the earl of Seafield. In the southern half of the county are several fine glens, including Rothes, Lossie, Gheallaidh. Tulchan and Beag. Strathspey is a broader valley.

History. — There is a prehistoric stone circle at Viewfield. Christianity, introduced under the auspices of Columba (from whose time the site of Burghead church has probably been occupied). flourished for a period until the Columhan church was expelled in 717 by King Nectan. Thereafter the district was given over to internecine strife between the northern and southern Picts, until the crushing victory of Kenneth MacAlpin, which resulted in the kingdom of Pictavia being superseded by the principality of Moravia. Later the Norsemen raided the country first under Thorstein and then under two Sigurds. It was in the time of the second Sigurd that the firth was fixed as the northern boundary of Moray. In spite of such interruptions as the battle of Torfness (Burghead) in 1040, in which Thorfinn. earl of Orkney and Shetland. overthrew the Scots under King Duncan, the consolidation of the kingdom was being gradually accomplished. After Macbeth ascended the throne the Scandinavians held their hands. Though Macbeth and his fainéant successor, "daft" Lulach. were the only kings whom Moray gave to Scotland. the province continued under the rule of its own mormaor. or great steward, until the dawn of the 12th century. when as an entity it ceased to exist. With a view to breaking up the power of the mormaors. David I and his successors colonized the seaboard with settlers from other parts of the kingdom. but from time to time the clansmen and their chiefs descended from their fastnesses and plundered the Laigh.

Meanwhile. the church had become a civilizing force. In 1107 Alexander had founded the see of Moray and the churches of Birnie. Kinnedar and Spynie were in turn the cathedral of the early bishops, until in 1224 under the episcopate of Andrew of Moray (de Moravia), the church of the Holy Trinity in Elgin was chosen for the cathedral.

In his effort to stamp out Scottish nationality Edward I came as far north as Elgin in 1296. Sir William Wallace. however, was well supported by Sir Andrew Moray of Bothwell. Robert I ("the Bruce") recognized the assistance he had received from the men of the north by erecting Moray into an earldom on the morrow of Bannockburn and bestowing it upon Thomas Randolph. Henceforward the history of the county resolved itself in the main into matters affecting the power of the church and the ambitions of the Moray dynasties. There was strife between Covenanters and the adherents of episcopacy until, prelacy itself being abolished in 1689. the bishopric of Moray came to an end after an existence of j81 years. Other celebrated Moray families who played a part in local politics were the Gordons. the Grants and the Duffs. In 1644, during the Civil War, the marquess of Montrose ravaged the villages which stood for the Covenanters, but most of the great lairds shifted in their allegiance. Charles II landed at Garmouth on July 3. 1650, on his return from his first exile in Holland. The fight at Cromdale (May 1, 1690) shattered the Jacobite cause, for the efforts in 1715 and 174j were too spasmodic and halfhearted to affect the loyalty of the district to Hanoverian rule. A few weeks before Culloden, Prince Charles Edward stayed in Elgin for several days. and a month afterward the duke of Cumberland passed through and administered the *coup* de *grâce* to the Young Pretender's cause on Drummossie moor in Inverness-shire.

Elginshire has tnice been the scene of terrible catastrophes. In 1694 the barony of Culbin — a fine estate, comprising 3,600 ac. of land, so fertile that it was called the granary of Moray, a mansion, a church and several houses — was buried under a mass of sand in a severe storm. This sandy waste. now known as the Culbin sands, lying northwest of Forres, measures 3 mi. in length and 2 in breadth; there has been some afforestation of them. The other calamity was the Moray floods of Xug. 2 and 3. 1829. The Findhorn inundated an area of 20 sq.mi.: the Divie rose 40 ft.; and the Lossie flooded all the low ground around Elgin.

Agriculture, Industries and Administration. — Considering its latitude and the limited extent of its arable land the standard of farming in Moray is high. 'Ihe rich soil of the lowlands is well adapted for oats and barley. The breeding of livestock is profitable and some of the finest specimens of short-horned and polled cattle and of crosses between the two are bred. On the larger farms in the Laigh Leicester sheep are kept all the year round, but in the uplands the Black-faced take their place. Horses and pigs are also raised.

Whisky is the chief product. There are woollen mills, distilleries. sawmills and iron foundries at Elgin; woollen mills, distilleries and chemical works at Forres; and distilleries at Rothes. Because of the absence of coal, what little mineral wealth there is (iron and lead) cannot he remuneratively worked. The sandstone quarries. yielding a building stone of superior quality. are practically inexhaustible. The plantations mainly consist of larch and fir and, to a smaller extent. of oak. The firth fisheries. comprising haddock. cod. herring, etc.. are of considerable value.

Pop. (1951) 48,218. Gaelic and English were spoken by 268 persons. The small burghs are Elgin (pop., 1951, 10,624) and Forres (4,463), both of which are royal burghs, and Burghead (1,368), Grantown-on-Spey (1,541). Lossiemouth and Branderburgh (4,947) and Rothes (1.211). There are six county districts. In conjunction with Nairnshire the county returns one member to

parliament. Moray is included in one sheriffdom with Inverness and Nairn, and there is a resident sheriff substitute at Elgin. There are an academy, a school of science and art and a technical school at Elgin.

MORAY, any eel of the family Bfuraenidae, typically found in coral reefs of tropical seas. *(See* MURAENA; *EEL.)*

MORBIHAN, a *département* of western France on the Atlantic seaboard, formed of part of Lower Brittany, and bounded *S.E.* by the *département* of Loire-Atlantique, E. by that of Ille-et-Vilaine. N. by Côtes-du-Nord, and W. by Finistère. Area, 2,738 sq. miles. Pop. (1954) 520,978. The *de'partement* is formed of the denuded folds of the Armorican system, which have axes of granitic rocks running for the most part E.S.E. to W.N.W. The most northerly of these stretches into the *de'partement* from the Montagnes Noires of S. Finistere, and in Morbihan reaches a height of 974 ft. The next ridge to the south runs across the centre of the *ddpartement* and dies down on its east and west borders; it forms the barren Landes de Lanvaux, about 1 to 3 mi. wide and 31 mi. long. Parallel lines of granite and Archaean rock also form most of the coast. The Blavet river on the west runs across the structural lines. The Oust is a tributary of the Vilaine, which it joins at the cast end of the Landes. The great feature of the *de'partement* is its coastline. with a number of estuaries, formed through invasion of river valleys by the sea, and the Morbihan, or "little sea," studded with islands, which are classic ground for the student of prehistoric archaeology. The Morbihan is separated from the sea outside, the Mor Braz, by the peninsula of Ruis, save for a tide-race at the end of the peninsula. To the west is the peninsula of Quiberon, which is joined to the mainland by a long sandspit. Off the coast lie the islands of Groix, Belle-Île-en-Mer (*q.v.*), Houat and Hoedik. The climate of Morbihan is moist and mild. Unproductive heath occupies more than a quarter of the *de'partement,* about a third of which is arable land. The shores of the estuaries are rich in southern plants, figs, rose-laurels, aloes, etc. Rye, buckwheat, wheat and oats, potatoes and mangels are the chief crops; hemp and flax are also grown. Horned cattle are the chief livestock and bee-keeping is important. Seaweed is used for manure. Lorient (*q.v.*) is a shipbuilding centre, while the sardine, oyster (Auray, St. Armel, etc.), anchovy and lobster fisheries are important, as is fish-preserving. Hennebont makes sheet-tin for sardine-boxes. There are slate-quarries, and minor industries, including lace-making by hand.

The *ddpartement* is served by the Orléans railway and the canal from Nantes to Brest uses the Oust; the Blavet is also canalized. It is divided into three *arrondissements,* namely: Vannes, Lorient, and Pontivy—with 38 cantons and 261 communes. The capital Vannes is the seat of a bishopric of the province of Rennes. The *ddpartement* belongs to the region of the XIth army corps (Nantes) and to the académie (educational division) of Rennes, where also is its court of appeal. The principal places are Vannes, Lorient, Ploermel, Pontivy, Auray, Hennebont, Carnac and Locmariaquer, the last two famous for megalithic monuments, as are Erdeven and Plouharnel; Elven, with two towers of the 15th century, remains of an old stronghold; Quiberon, associated with the disaster of the French *émigrés* in 1795; Sarzeau, near which is the fortress of Sucinio (13th and 15th centuries).

MORDVMIANS, otherwise called MORDVA, MORDVS, MORDOVIANS or MORVINS, a people speaking a Finno-Ugrian language who inhabit the Middle Volga region of the U.S.S.R. Their settlement in this area is of long standing. Under the Soviet regime they were given a measure of autonomy in 1928, and the Mordvinian Autonomous Soviet Socialist Republic, with its capital at Saransk, was created in 1934. About one-third of the Mordvinians live in the republic: the rest are interspersed among the Russian population in surrounding districts, and even in the republic itself Russians are in the majority. The Mordvinians were computed to number 1,451,429 in 1939. There are two groups with different dialects, Erzya and Moksha. The Moksha, the southern branch, have a darker skin and darker eyes and hair than the northern. A third branch, the Karatai, found in Kazan, appears to be mixed with Tatars, while the Teryukhane, another branch, have been russified. The Mordvinians mostly have dark hair, blue eyes (usually small and rather narrow) and are generally roundish-headed, finely built, rather tall, strong and broadchested. Their chief occupation is agriculture, and they are also masters of apiculture. They have maintained a good deal of their old national dress, especially the women, whose profusely embroidered skirts, original hairdress, large earrings (sometimes merely haretails) and numerous necklaces (covering the whole chest and consisting of all possible ornaments) easily distinguish them from Russian women. They have a considerable literature of popular songs and legends, some of them recounting the doings of King Tushtyan, who lived in the time of Ivan the Terrible. They preserve much of their own mythology, which they have adapted to the Christian religion. According to some authorities, they have preserved also, especially the less russified Moksha, the practice of kidnapping brides, with the usual battles between the party of the bridegroom and that of the bride. The worship of trees, of water (especially the water divinity that favours marriage), of the sun or Shkay, who is the chief divinity, of the moon, of thunder and of the frost, as well as that of the home divinity Kardazserko, still exists among the Mordvinians; and a small stone altar or flat stone covering a small pit to receive the blood of slaughtered animals can be found in many houses. Their burial customs seem founded on the ancestor cult: on the 40th day after death the dead person is supposed to return home; one of his household represents him and, coming from the grave, speaks in his name.

The language, which uses the Cyrillic alphabet, is treated in M. Y. Yevsevyev's *Osnovy mordovskoy grammatiki* (Moscow, 1931). *Information on the history, customs and religion of the people is to be found in the writings of V. I. Maynov, I. N. Smirnov, A. A. Shakhmatov and others and in the publications of the Société Finno-Ougrienne (Helsinki).*

MORE, SIR ANTHONY (known as ANTONIO MORO, originally ANTHONIS MOR) (*c.* 1512–1575), Dutch portrait painter, was born at Utrecht in 1512, according to some, but in 1525 according to Karl van Mander. Moro studied his art under Jan Schoreel, and after making a professional visit to Italy he began to paint portraits in the style of Hans Holbein. His rise to eminence was rapid. In 1552 (or 1542?) he was invited to Madrid by the emperor Charles V. Two years later he was in London painting the portrait of Queen Mary for her bridegroom, Philip II of Spain. This picture (Prado museum at Madrid) is his masterpiece. For it an annual salary and, supposedly, the honour of knighthood were conferred upon him. From 1555 to 1559 Moro lived in Utrecht. In Aug. 1559 he accompanied King Philip to Spain, returning to Utrecht in 1560. He died at Antwerp in 1575.

The Hispanic Society of America, New York city, exhibits several of Moro's pictures; they may also be seen at, among other galleries, the National Gallery of Art, Washington, D.C.; the Philadelphia Museum of Art; the Art Institute of Chicago; and the National gallery, London.

MORE, HANNAH (1745–1833), English religious writer, was born at Stapleton, near Bristol, on Feb. 2, 1745. She may be said to have made three reputations in the course of her long life: first, as a clever verse-writer and witty talker in the circle of Johnson, Reynolds and Garrick; next, as a writer on moral and religious subjects on the Puritanic side; and lastly, as a practical philanthropist. She was the youngest but one of the five daughters of Jacob More, who, though a member of a Presbyterian family in Norfolk, had become a member of the English Church and a strong Tory. He taught a school at Stapleton in Gloucestershire. The elder sisters established a boarding-school at Bristol, and Hannah became one of their pupils when she was 12 years old. Her first literary efforts were pastoral plays, the first being written in 1762 under the title of *A Search after Happiness* (2nd ed. 1773). Metastasio was one of her literary models; on his opera of *Attilio regulo* she based a drama, ***The Inflexible Captive,*** published in 1774. She gave up her share in the school on contracting an engagement of marriage with a Mr. Turner. The wedding never took place, and Hannah More accepted from Turner an annuity which had been settled on her without her knowledge. This set her free for literary pursuits, and in 1772 or 1773 she went to Londpn. Some verses on Garrick's *Lear* led to an acquaintance with the actor-playwright; Miss More

was taken up by Elizabeth Montague; and her unaffected enthusiasm, simplicity, vivacity, and wit won the hearts of the whole Johnson set, the lexicographer himself included, although he is said to have told her that she should "consider what her flattery was worth before she choked him with it." Garrick wrote the prologue and epilogue for her tragedy *Percy,* acted at Covent Garden in Dec. 1777. Another drama, *The Fatal Falsehood,* produced in 1779 after Garrick's death, was less successful. The Garricks had induced her to live with them; and after Garrick's death she remained with his wife. In 1781 she met Horace Walpole, and corresponded with him from that time.

Hannah More published *Sacred Dramas* in 1782, and it rapidly ran through 19 editions. These and the poems *Bas-Bleu* and *Florio* (1786) mark her gradual transition to more serious views of life, which were fully expressed in prose in her *Thoughts on the Importance of the Manners of the Great to General Society* (1788), and *An Estimate of the Religion of the Fashionable World* (1790). She was intimate with Wilberforce and Zachary Macaulay, with whose evangelical views she was in entire sympathy. She published a poem on *Slavery* in 1788. In 1785 she bought a house, at Cowslip Green, near Wrington, near Bristol, where she settled down to country life with her sister Martha, and wrote many ethical books and tracts: *Strictures on Female Education* (1799), *Hints towards forming the Character of a Young Princess* (1805), *Coelebs in Search of a Wife* (only nominally a story, 1809), *Practical Piety* (1811), *Christian Morals* (1813), *Character of St, Paul* (1815), *Moral Sketches* (1819). The tone is uniformly animated; the writing fresh and vivacious; and there was an originality and force in her way of putting commonplace sober sense and piety that accounts for her popularity.

The most famous of her books was *Coelebs in Search of a Wife,* which had an enormous circulation. The model Stanley children were said to have been drawn from T. B. Macaulay and his sister. She also wrote many spirited rhymes and prose tales, the earliest of which was *Village Politics* (1792), by "Will Chip," to counteract the doctrines of Tom Paine and the influence of the French Revolution. The success of *Village Politics* induced her to begin the series of "Cheap Repository Tracts," which were for three years produced by Hannah and her sisters at the rate of three a month. Perhaps the most famous of these is *The Shepherd of Salisbury Plain,* describing a family of phenomenal frugality and contentment. This was translated into several languages. Two million copies of these rapid and telling sketches were circulated in one year, teaching the poor in rhetoric of most ingenious homeliness to rely upon the virtues of content, sobriety, humility, industry, reverence for the British Constitution, hatred of the French, trust in God and in the kindness of the gentry.

Perhaps the best proof of Hannah More's sterling worth was her indefatigable philanthropic work for the children in the mining districts of the Mendip hills. The More sisters met with a good deal of opposition. The farmers thought that education, even to the limited extent of learning to read, would be fatal to agriculture, and the clergy, whose neglect she was making good, accused her of Methodist tendencies. In her old age, philanthropists from all parts made pilgrimages to see the bright and amiable old lady, and she retained all her faculties till within two years of her death, dying at Clifton, where the last five years of her long and, for the most part, singularly happy life were spent, on Sept. 7, 1833.

See H. Thompson, *The Life of Hannah More, With Notices of Her Sisters* (1838). The article in the *Dict. Nat. Biog.* is by Sir Leslie Stephen. The *Memoirs* of *Hannah More,* letters with a connecting narrative, was first published in 1834 by William Roberts in 4 vol. *See* also *Hannah More* (1888), by Charlotte M. Yonge, in the "Eminent Women" series, and other lives by "Marion Harland" (1900) and Miss Meakin (1911). *Letters of Hannah More to Zachary Macaulay* were edited (1860) by Arthur Roberts. The contemporary opposition to her may be seen in an abusive *Life of Hannah More, With a Critical Review of Her Writings* (1802), by the "Rev. Archibald Macsarcasm" (William Shaw, rector of Chelvey, Somerset).

MORE, HENRY (1614–1687), English philosopher of the Cambridge Platonist school, was born at Grantham in 1614. Both his father and his mother, he tells us, were "earnest followers of Calvin," but he himself "could never swallow that hard doctrine." In 1631 he was admitted at Christ's college, Cambridge, about the time Milton was leaving it. He immersed himself "over head and ears in the study of philosophy," and fell for a time into a scepticism, from which he was delivered by a study of the "Platonic writers." He was fascinated especially by Neoplatonism, and this fascination never left him. The *Theologia germanica* also exerted a permanent influence over him. He took his bachelor's degree in 1635, his master's degree in 1639, and immediately afterwards was chosen fellow of his college. Fifteen years after the Restoration he accepted a prebend in Gloucester cathedral, but only to resign it in favour of his friend Dr. Edward Fowler, afterwards bishop of Gloucester. He would not accept the mastership of his college, to which, it is understood, he would have been preferred in 1654, when Cudworth was appointed. He drew around him many young men of a refined and thoughtful turn of mind, but among all his pupils the most interesting was Lady Conway, at whose country seat at Ragley, Warwickshire, More continued at intervals to spend "a considerable part of his time." Amidst the woods of this retreat he composed several of his books. The spiritual enthusiasm of Lady Conway was a considerable factor in some of More's speculations, none the less that she at length joined the Quakers. She became the friend not only of More and Penn, but of Baron van Helmont and Valentine Greatrakes, mystical thaumaturgists of the 17th century. Ragley became a centre not only of devotion but of wonder-working spiritualism *(cf.* the account in the novel *John Inglesant* ch. xv.). From this, his genius suffered, and the rationality which distinguishes his earlier is much less conspicuous in his later works. He was a voluminous writer both in verse and in prose. His most notable work, the *Divine Dialogues* (1688), summarizes his general view of philosophy and religion.

Henry More represents the mystical and theosophic side of the Cambridge movement. The Neoplatonic extravagances which lay hidden in the school from the first came in his writings to a head, and merged in pure phantasy. Mystical elevation was the chief feature of his character, a certain radiancy of thought which carried him beyond the common life without raising him to any artificial light, for his humility and charity were not less conspicuous than his piety. He died on Sept. 1, 1687, and was buried in the chapel of the college he loved.

Before his death More issued complete editions of his works, his *Opera theologica* in 1675, and his *Opera philosophica* in 1678. The chief authorities for his life are Richard Ward's *Life* (1710); the prefatio generalissima prefixed to his *Opera omnia* (1679); and also a general account of the manner and scope of his writings in an *Apology* published in *1664.* The collection of his *Philosophical Poems* (1647), in which he has "compared his chief speculations and experiences," should also be consulted. An elaborate analysis of his life and works is given in Tulloch's *Rational Theology,* vol. ii. *(1874);* *see* also R. Zimmermann. *Henry More und die vierte Dimension des Raums* (Vienna, 1881). *See* ETHICS.

MORE, PAUL ELMER (1864–1937), U.S. writer and critic, one of the leading defenders of humanistic principles, was born in St. Louis, Mo., Dec. 12, 1864. He was educated at Washington university and Harvard, was assistant in Sanskrit at Harvard (1894–95) and associate in Sanskrit and classical literature at Bryn Mawr college (1895–97). He served as literary editor of the *Independent* (1901–03) and the *New York Evening Post* (1903–09) and as editor of the *Nation* (1909–14). Like Irving Babbitt (*q.v.*), his associate and leader of the humanists, More was an uncompromising advocate of traditional critical standards in a time of radical departures (typified by the work of H. L. Mencken; *q.v.*) in literature and politics.

Among More's works are *Shelburne Essays,* 11 vol. (1904–21); *Life of Benjamin Franklin* (1900); *Nietzsche* (1912); *Platonism* (1917); *The Religion of Plato* (1921); *Hellenistic Philosophies* (1923); and *New Shelburne Essays* (1928–36).

See L. H. Hough, *Great Humanists* (1952).

MORE, SIR THOMAS (1478–1535), English lord chancellor and author of *Utopia,* was born in Milk street, in the City of London, on Feb. 7, 1478. He attended St. Anthony's school in Threadneedle street, at that time under Nicolas Holt, and at 13 was early placed in the household of Cardinal Morton, archbishop of Canterbury. Young Thomas More obtained this

privilege through the influence of his father, Sir Thomas, then a rising barrister and afterwards a justice of the court of king's bench. About 1492 young More was sent to Canterbury Hall, Oxford, afterwards absorbed in Christ Church, where he is said vaguely to have had Colet, Grocyn and Linacre for his tutors. All More himself says is that he had Linacre for his master in Greek. More's father, who intended his son to make law his career, feared the influence of the "new learning," and removed him from the university about 1494, and entered him at Sew Inn. In February 1496 More was admitted at Lincoln's inn. In his professional studies More early distinguished himself and was appointed reader-in-law in Furnival's inn; but he would not relinquish the studies which had attracted him in Oxford. Erasmus says that he tried his hand at "little comedies," and he studied Pico della Mirandola. Among his friends were Lily and Colet, the latter of whom became his confessor and exercised great influence over him. The balance of his faculties seemed to be restored by a revival of the antagonistic sentiment of humanism which he had imbibed from the Oxford circle of friends, and from Erasmus. More's acquaintance with Erasmus might have begun during Erasmus's first visit to England in 1497. Tradition has dramatized their first meeting into the story given by Cresacre More—that the two happened to sit opposite each other at the lord mayor's table, that they got into an argument during dinner, and that, in mutual astonishment at each other's wit and readiness, Erasmus exclaimed, "Aut tu es Morus, aut nullus," and the other replied, "Aut tu es Erasmus, aut diabolus!" The scquaintance rapidly ripened into warm attachment. This contact with the prince of letters revived in More the spirit of the "new learning," and he returned with ardour to the study of Greek. He acquired facility in the Greek language, from which he made and published some translations. His Latin style, though wanting the inimitable ease of Erasmus, is yet in copiousness and propriety much above the ordinary Latin of the English scholars of his time.

At about this time More desired to give himself over to an ascetic life. He took a lodging near the Charterhouse, and subjected himself to the discipline of a Carthusian monk. He wore a sharp shirt of hair next his skin, scourged himself every Friday and other fasting days, lay upon the bare ground with a log under his head, and allowed himself but four or five hours' sleep. This phase lasted for some four years 1499 to 1503. He then abandoned all idea of leaving the world, but to the end of his life he was scrupulous in the observance of his religious duties.

More sat in the parliament of 1504, when he contested Dudley's demand on behalf of the king for an "aid" in money on the marriage of Princess Margaret. More's speech is said to have moved the house to reduce the subsidy of three-fifteenths which the Government had demanded to £30,000. Henry VII. revenged himself upon More's father, who was sent to the Tower, and only released on payment of a fine of £roo. Thomas More found it advisable to withdraw from public life for a time. During this period of retirement the old dilemma recurred. One while he devoted himself to the sciences, "perfecting himself in music, arithmetic, geometry and astronomy, learning the French tongue, and recreating his tired spirits on the viol," or translating Greek epigrams; another while resolved to take priest's orders.

But at this time he made acquaintance with the family of John Cult of New Hall, in Essex. The "honest and sweet conversation" of the three daughters attracted him, and though his inclination led him to prefer the second he married the eldest, Jane, in 1505, not liking to put the affront upon her of passing her over in favour of her younger sister. The newly-married pair settled in Bucklersbury, and lived a life of unbroken domestic felicity. At Bucklersbury he was visited by Erasmus, and on a second visit in 1508 the great scholar wrote the *Moriae Encomium*, dedicated to his friend and host. His wife died in 1511, and he married, within a month, Alice Middleton, a widow with one daughter. They moved to Crosby place, Bishopsgate.

The death of the old king in 1509 restored More to the public career for which his abilities specially fitted him. From this time there was scarce a cause of importance in which he was not engaged. His professional income amounted to £400 a year, equal to £4,000 in present money, and, "considering the relative profits of the law and the value of money, probably indicated as high a station as £10,000 at the present day" (Campbell). In 1509 he was elected a bencher of Lincoln's inn, and in 1510 was appointed under-sheriff of London. He soon attracted the attention of the young king and of Wolsey. It was during a residence in Antwerp that he met Peter Giles (Aegidius), a friend of Erasmus, and sketched out the idea of *Utopia*. He was repeatedly employed on embassies to the Low Countries, and was for a long time stationed at Calais as agent in the shifty negotiations carried on by Wolsey with the court of France. The spirit with which he pleaded before the Star Chamber in a case of The *Crown* v. *The* Pope marked him out for employment. More obtained in this case judgment against the Crown. Henry, who was present in person at the trial, had the good sense not to resent the defeat, but took the counsel to whose advocacy it was due into his service. In 1518 More was made master of requests, and sworn a member of the privy council. He was now compelled to resign his post of under-sheriff to the city and his private practice at the bar. In 1521 he was knighted and appointed sub-treasurer to the king, and was again sent on mission to Calais and the Low Countries. In the parliament of 1523 he was elected Speaker on Wolsey's nomination. The choice of this officer rested nominally with the house itself, but in practice was always dictated by the court. Many apocryphal stories have grown round More's speakership. In fact the records of the House do not justify Roper's account of his independent attitude.

In 152j More was appointed chancellor of the duchy of Lancaster, and no pains were spared to attach him to the court. The king frequently sent for him into his closet, and discoursed with him on astronomy, geometry and points of divinity. This growing favour, by uhich many men would have been carried away, did not impose upon More, who understood the fickleness of royal favour. Then the king began to come himself to More's house at Chelsea (he had bought his house there in 1523) and would dine with him without previous notice. William Roper, husband of More's eldest daughter, mentions one of these visits, when the king after dinner walked in the garden by the space of an hour holding his arm round More's neck. Roper afterwards congratulated his father-in-law on the distinguished honour which had been shown him. "I thank our Lord," was the reply, "I find his grace my very good lord indeed; and I believe he doth as singularly favour me as any subject within this realm. Howbeit, son Roper, I may tell thee I have no cause to be proud thereof, for if my head would win him a castle in France it should not fail to go." As a last resource More tried the expedient of silence, dissembling his wit and affecting to be dull. This had the desired effect so far that he was less often sent for.

But it did not alter the royal policy, and in 1529, when a successor had to be found for Wolsey, More was raised to the chancellorship. He was the first layman to hold the office. The selection was justified by More's high reputation, but it was also significant of the modification which the policy of the court was then undergoing. It was a concession to the rising popular party, to which it was supposed that More's politics inclined him. The public favour with which his appointment had been received was justified by his conduct as judge in the court of chancery. Having heard causes in the forenoon between eight and eleven, after dinner he sat again to receive petitions. The meaner the suppliant was the more affably he would speak to him and the more speedily he would despatch his case. Business was despatched with unprecedented regularity. One morning being told by the officer that there was not another cause before the court, he ordered the fact to be entered on record, as it had never happened before. He usually, but not always, refused all the customary gifts, and did not permit his connections to interfere with the course of justice. One of his sons-in-law, Heron, having a suit in the chancellor's court, and refusing to agree to any reasonable accommodation, because the judge "was the most affectionate father to his children that ever was in the world," More thereupon made a decree against him. On the other hand he appears to have been merciless in his treatment of heretics. In the epitaph

which he wrote, he described himself as *hereticis molestus*, and, although the accusations of Protestants may be discounted, his own words and unimpeachable documents bespeak his severity.

But in raising More to the chancellorship, the king had counted upon his support in his desired divorce from Queen Catherine and in the church policy to which he was driven by that desire. More signed the articles of Wolsey's impeachment, but he had no share in the proclamation which ordered the clergy (Feb. 11, 1531) to acknowledge Henry as the supreme head of the church, "so far as the law of Christ will allow." As Henry's policy developed further, More found himself increasingly at variance with it. The divorce was a point upon which he would not yield. And, as he saw that the marriage with Anne Boleyn was determined upon, he petitioned the king to be allowed to resign the Great Seal, alleging failing health. The resignation was accepted, on May 10, 1532. More left office, as he had entered it, a poor man. His necessitous condition was so notorious that the clergy in convocation voted him a present of £5,000. This he peremptorily refused, either for himself or for his family, declaring that he "had rather see it all cast into the Thames." Yet the whole of his income after resigning office did not exceed £100 a year.

But although More strictly abstained from public activities Henry resented his absence from court and his silence. More refused to attend the coronation of Anne Boleyn, and from that moment was marked out for vengeance. A first attempt made to bring him within the meshes of the law failed. He was summoned before the privy council to answer to a charge of receiving bribes in the administration of justice. The charge was easily refuted. A bill was brought into parliament (Feb. 21, 1534) to attaint the friends of Elizabeth Barton (*q.v*), the "Holy Maid of Kent." Barton turned out to have been an impostor, but she had duped More, and he had given his countenance to her supernatural pretensions. His name, with that of Fisher, was accordingly included in the bill as an accomplice. When he came before the council it was at once apparent that the charge of treason could not be sustained, but he was asked why he had not expressed his approval of the king's attitude towards the papal see. He replied by repeating the substance of conversations with the king on the subject. The revelation was disconcerting, and unlikely to help More's cause in the end. But the charge of treason being too ridiculous to be proceeded with, More's name was struck out of the bill. When his daughter brought him the news, More is reported to have said, "I' faith, Meg, quod differtur, non aufertur: that which is postponed is not dropt."

In March 1534 the bill vesting the crown in Anne Boleyn's issue, and imposing an oath abjuring any foreign potentate and, in the case of clergy, the authority of the pope, was passed and the oath ordered to be tendered. More was sent for to Lambeth, where he offered to swear to the succession, but steadily refused the oath of supremacy as against his conscience. Thereupon he was given in charge to the abbot of Westminster, and, persisting in his refusal, was four days (April 17) afterwards committed to the Tower. More was well treated by his gaolers, and, though he suffered in health from his confinement, he was witty and gay when his family were allowed to visit him, and he wrote cheerfully to his friends. In June 1535 he was found to be in communication with his fellow-prisoner, Fisher. He was then rigorously isolated, and was denied the use of pen and ink. He was brought to trial before a special commission and a picked jury at Westminster Hall on July 1. Rich, the solicitor-general, quitted the bar and presented himself as a witness for the Crown. Being sworn, he detailed a confidential conversation he had had with the prisoner in the Tower. He affirmed that, having himself admitted in the course of this conversation "that there were things which no parliament could do—*e.g.*, no parliament could make a law that God should not be God," More had replied, "No more could the parliament make the king supreme head of the Church." By this act of perjury a verdict of "guilty" was procured.

The execution of the sentence followed within the week, on July 7, 1535. The head was fixed upon London Bridge. Tradition says that it was eventually rescued by his daughter, and that it was buried with her at St. Dunstan's, Canterbury. The vengeance of Henry was not satisfied by this judicial murder of his friend and servant; he enforced the confiscation of what small property More had left, expelled Lady More from the house at Chelsea, and even set aside assignments which had been legally executed by More, who foresaw what would happen before the commission of the alleged treason. More's property was settled on Princess Elizabeth, later queen, who held it till her death.

Sir Thomas More was twice married, but had children only by his first wife, who died about 1511. His only son, John, married an heiress, Ann Cresacre, and was the grandfather of Cresacre More, Sir Thomas More's biographer. His eldest daughter, Margaret (1505–1544), married to William Roper (1496–1578), was a woman of high intelligence, whose devotion to her father has become a legend.

More was lawyer, wit, scholar and a great amateur of the arts. He was an intimate friend of Holbein, who first came to England as a visitor to More at Chelsea, where the painter is said to have remained for three years and probably first met Henry VIII. Holbein painted portraits of Sir Thomas and his family. More was beatified in 1886, and canonized by Pius XI in 1935.

The *Epistola* ad *Dorpium* exhibits More emphatically on the side of the new learning. It contains a vindication of the study of Greek, and of the desirability of printing the text of the Greek Testament—views which were condemned by the party to which More afterwards attached himself.

In the *Utopia*, published in Latin in 1516 (1st English translation, 1551), More wrote a delightful satire on government and society. In it he relates the conversation of himself and Peter Giles with a fictitious mariner Ralph Hythlodaye, who has sailed with Amerigo Vespucci. Hythlodaye had visited England, and has much to say of the evils of poverty and the luxury of the rich. This description is compared with that of the island of Utopia where community of goods, a national system of education, the rule of work for all, and a philosophy under which the good of the individual is sacrificed to the common good, makes an ideal state. Slavery and monarchy, however, have their place in Utopia. The book derives from Plato, and has had numerous successors, but none more witty and satirical.

For a bibliography of More's numerous works *see* the article in the *Dict. Nat. Biog.* and the Catalogue of the Alfred Cock collection of books and portraits of or relating to Sir Thomas More which is preserved in the Guildhall Library, London. The more important of his works and their editions are here given. *Luciani dialogi . . . compluria opuscula ab Erasmo Roterodamo et Thoma Moro . . . traducta* (Paris, 1506 and 1514; Venice, Aldus, 1516, etc.) was accomplished by Erasmus and More in 1505. *The Lyfe of John Picus, earle of Mirandula . . .* printed by Wynkyn de Worde in 1510, translated by More from the Venice ed. of 1498, was edited by J. M. Rigg for the Tudor Library in 1890. *Historie of the pittiful Life and unfortunate Death of Edward the Fifth and the then Duke of York with . . . Richard the Third* was written, according to Rastell, in 1513, and first printed in a corrupt version in Grafton's continuation of Harding in 1543; it is included by Rastell in his 1557 edition of More's *Workes*, but it has been suggested that the Latin original was by Cardinal Morton; as the *History of King Richard III.* it was edited by J. R. Lumby for the Pitt Press in 1883. The *Libellus vere aureus . . .* better known as *Utopia*, was printed at Louvain in 1516, under the superintendence of Erasmus, and appeared in many subsequent editions, the finest being the Basel edition of 1518 produced by the Froben press under the eye of Erasmus and adorned with illustrations by Holbein. It was translated into the chief languages of Europe, and into English by Ralph Robinson as *A fruteful and Pleasaunt Worke of the best State of a Publyque Weale, and of the newe Yle called Utopia* (Abraham Nell, 1551); many modern editions of which the most famous is that produced by William Morris at the Kelmscott Press (1893). Other translations of *Utopia* are by Gilbert Burnet (1684) and by A. Cayley (*Memoirs of More*, 2 vols., 1808). Against Luther and Tyndale Sir T. More wrote *A Dyaloge of Syr Thomas Afore, Knt.*, written in 1528 and printed by John Rastell in 1529; *Sir Thomas More's Answere to the fyrste parte of the Poyson'd book . . . The Souper of the Lorde* (William Rastell, 1532) with a "Second Parte" in 1533. The *Apologye of Syr Thomas More*, written in 1533, is a defence of his own polemical style and of the treatment of heretics by the clergy. *A Dyaloge of Comfort agaynst Tribulacion*, printed by Rastell in 1533, was destined primarily for More's family.

More's English works were collected by William Rastell and published as *The Worke of Sir Thomas More Knyght* by Cawood, Waly and Tottel in 1557; his Latin works *Thonzae Mori . . . Lucubrationes* were partially collected at Basle 1563 and in 1566 (*omnia opera) at*

Louvain; a fuller edition drawn chiefly from these two appeared at Frankfort and Leipzig in 1689. His correspondence with Erasmus is partly included in the editions of the Letters of Erasmus, and much of his correspondence is calendared in Gairdner's *Letters and Papers of Henry VIII.*, the letters written to his family in his last days being found in vol. viii.

The Mirror of Vertue in Worldly Greatness; or, the Life of Syr *Thomas More* was written by his son-in-law William Roper about the ehd of Mary's reign. It was preserved in ms. during the reign of Elizabeth, and handed down in copies, many of which were carelessly made. It was not given to the press till 1626, with the date of Paris. Reprints were made by Hearne (Oxford, 1716), by Lewis (1729, 1731), who added an appendix of documents, and by Singer (1817, 1822) and for the King's Library (1902). Roper's *Life* is the source of all the many subsequent biographies. More's *Life* in ms. (Harleian 6253 and elsewhere), anonymous, but by Nicolas Harpsfield, was also written in Mary's reign. All that is material in this ms. is taken from Roper. The preface is signed Ro. Ba. (Robert Barnstaple?). William Rastell's *Life of More,* of which fragments are preserved in the Arundel Coll. (Brit. Mus.), is unhappily, lost. Thomas Stapleton *Tres Thomae, s. res gestae S. Thomae apostoli, S. Thomae archiepiscopi Cantuariensis, Thomae Mori* (Douay, 1588; Cologne, 1612) and the *Vita Thomae Mori* (separately) (Gratz, 1689) translates Roper, interweaving what material he could find scattered through More's works and letters and the notices of him in the writings of his contemporaries. Cresacre More, great-grandson of Sir Thomas, compiled a new life about the year 1627. It was printed at Paris without date, but, according to the editor, J. Hunter, in 1631. The title of this edition is: *The Life and Death of Sir Thos. More, Lord High Chancellour of England,* and with new title-page 1642, 1726, 1828. The later lives of Sir Thomas More have been numerous the best being those by G. T. Rudhart *Thomas Morus, aus den Quellen bearbeitet* (Nuremberg, 1829); by Father T. E. Bridgett, *Life and Writings of Sir Thomas More* (1891); and by W. H. Hutton, *Life and Writings of Sir Thomas More* (1891). Anne Manning's *The Household of Sir Thomas More* (1851, reprinted in King's Novels, 1905) is an attractive reconstruction. The tragedy of *Sir Thomas More,* edited by *A.* Dyce for the Shakespeare Society in 1844, and connected by some commentators with Shakespeare, was written about 1590, and therefore gives a nearly contemporary view of More. A later playwright, James Hurdis, made More's career the subject of a play in 1792.

MORÉAS, JEAN (1856–1910), French poet, born at Athens, was the grandson of Papadiomontopoulos, one of the heroes of Missolonghi. He was one of the leaders of the symbolist movement in French poetry, but his early volumes of poems, *Les Syrtes* (1884), *Les Cantilènes* (1886), and *Le Pèlerin passionné* (1891) won recognition beyond the limits of this school. In the *XIXe sikcle* (Aug. 11, 1885) he formulated the principles of the symbolists, defending them from the appellation of "decadent," and in the literary supplement of the *Figaro* (Sept. 18, 1886) he published a manifesto justifying the innovations of the new school as the natural development of the prosody of Baudelaire, Mallarmé and Verlaine. As time went on he repudiated the licence claimed by the symbolists, and became the leader of an offshoot from the main body known as the *école romane,* the chief members of which were Raymond de la Tailhède, Maurice du Plessys, Ernest Raynaud, and Charles Maurras. Moréas and his new followers returned to the traditional severity of French versification, and to the classical and antique tradition. His later volumes are *Poésies, 1886–1896* (1898), *Stances* (6 vols, complete ed. 1905), indispensable for the student of his work, *Histoire de Jean de Paris, roi de France* (1902), *Voyage en Grkce en 1897* (1902), *Contes de* la *vieille France* (1903), and a classic drama in verse, *Iphigénie à Aulis* (1904), in close imitation of Euripides, which was presented, Aug. 24, 1903, in the ancient theatre of Orange, and subsequently at the Odéon in Paris.

Moréas died March 31, 1910.

See Anatole France, *La Vie littéraire,* 4th series (1892); A van Bever and P. Léautaud, *Poètes d'aujourd'hui, 1880–1900,* 11th ed (1905), P. Berthelot's article, "Symbolisme," in *La Grande encyclopédie;* and *J.* de Gourmont, *Jean Moréas, biographie critique* (1905).

MOREAU, GUSTAVE (1826–1898), French Symbolist painter of erotic subjects, was born in Paris on April 6, 1826. His father was an architect. The only influence that really affected Moreau's development was that of the painter Chassériau (1819–56). Moreau's first picture was a "Pietà" (1852), now in the cathedral at Angoulême. In the Salon of 1853 he exhibited a "Scene From the Song of Songs" and the "Death of Darius," both conspicuously under the influence of Chassériau. From that time he exhibited regularly, with an interval in 1869 to 1876, receiving many honours and prizes. His colour is luminous, like enamel, and his subjects are strange and mysterious. Moreau succeeded Elie Delaunay as professor at the École des Beaux-Arts, and his teaching was highly popular. He was the teacher of some of the artists of the *Fauve* movement, including Matisse and Rouault.

Moreau died on April 18, 1898, leaving to the state his house, containing about 8,000 pictures, water colours, cartoons and drawings, which form the Moreau gallery in Paris.

MOREAU, HEGESIPPE (1810–1838), French lyric poet, was born in Paris. He was habitually homeless, and exposed himself to the dangers of a cholera hospital in the great epidemic of 1832 simply to obtain shelter and food. It was only just before his death that he succeeded in getting his collected poems published, selling the copyright for £4 sterling and 80 copies of the book. This volume, *Myosotis,* was received not unfavourably, but the author's death on Dec. 20, 1838, in a refuge of the destitute, created an excessive interest in it.

Moreau's work has a strong note of imitation, especially in his earlier songs, distinguished from those of his model, Béranger, chiefly by their elegiac note.

MOREAU, JEAN VICTOR MARIE (1763–1813), French general, was born at Morlaix in Brittany on Feb. 14, 1763. As a law student at Rennes he formed his fellow students into an armed band, which took part in daily affrays between the young *noblesse* and populace of the town. He served under C. Dumouriez with the volunteers of Ille-et-Vilaine, and in 1793 his merits secured his promotion as general of brigade. Carnot promoted him to be general of division early in 1794, and gave him command of the right wing of the army under C. Pichegru, in Flanders. The battle of Tourcoing established his military fame, and in 1795 he was given the command of the Army of the Rhine-and-Moselle, with which he advanced into Germany. He won several victories and penetrated to the Isar *(see* FRENCH REVOLUTIONARY WARS), but at last had to retreat before the archduke Charles. The skill he displayed in conducting the retreat greatly enhanced his own reputation; he brought back with him more than 5,000 prisoners. In 1797 after difficulties caused by want of funds and material he again crossed the Rhine, but was checked by the conclusion of the preliminaries of Leoben between Bonaparte and the Austrians. At this time he discovered the correspondence between his old comrade and commander Pichegru and the émigré prince de Condé. Too late to clear himself, he sent the correspondence to Paris and issued a proclamation to the army denouncing Pichegru as a traitor. He was dismissed, and was only re-employed in 1799 when the advance of Suvárov made it necessary. He commanded the Army of Italy for a short time before being appointed to the Army of the Rhine, and remained with Joubert, his successor till the defeat of Novi. Joubert fell in the battle, and Moreau then conducted the retreat of the army to Genoa, where he handed over the command to Championnet. When Bonaparte returned from Egypt he found Moreau at Paris, greatly dissatisfied with the Directory, and obtained his assistance in the *coup d'état* of 18 Brumaire. The First Consul again gave him command of the Army of the Rhine, with which he forced back the Austrians from the Rhine to the Isar. On his return to Paris he married Mlle. Hullot, a creole of Josephine's circle, an ambitious woman who gained a complete ascendancy over him, and after winning the victory of Hohenlinden (Dec. 3, 1800) he settled down to enjoy the fortune he had acquired during his campaigns. His wife collected around her all who were discontented with the aggrandisement of Napoleon. This "club Moreau" annoyed Napoleon, and encouraged the Royalists, but Moreau, though not unwilling to become a military dictator to restore the republic, would be no party to an intrigue for the restoration of Louis XVIII. This was well known to Napoleon, who seized the conspirators. Bonaparte procured Moreau's condemnation with great difficulty, and then treated him with a pretence of leniency, commuting a sentence of

imprisonment to one of banishment. Moreau lived in obscurity for some years at Morrisville, Pennsylvania, until the destruction of the *grande armée* in Russia. Then, probably at the instigation of his wife, he committed the last and least excusable of his political errors. Negotiations were set on foot with Bernadotte. who, being now crown prince of Sweden and at the head of an army opposing Napoleon, introduced Moreau to the tsar Alexander. In the hope of re-establishing popular government in France. Moreau advised the allied sovereigns on the conduct of the war. He was mortally wounded while talking to the tsar at the battle of Dresden on Aug. 27, 1813, and died on Sept. 2. He was buried at St. Petersburg.

Moreau's fame as a general stands very high; his combinations were skilful and elaborate. his temper always unruffled. He was a sincere republican, though his father was guillotined in the Terror.

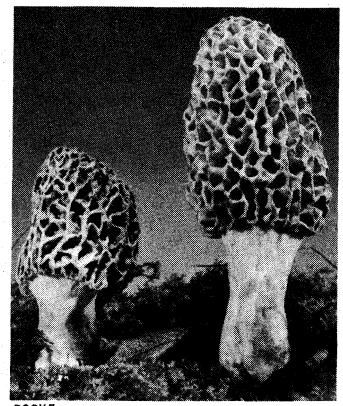
See C. Jochmus, *General Moreau—Abriss einer Geschichte seines Lebens und seiner Feldzüge* (1814), a standard work; A de Beauchamp, *Vie politique, militaire, et privée du Général Moreau* (tr. *by* Philippart, 1814); Picard, *Bonaparte et Moreau* (1905); and Daudet, *L'exil et la mort du général Moreau* (1909).

MOREAU DE SAINT MÉRY, MEDÉRIC LOUIS ÉLIE (1750–1819), French politician. was born at Fort de France, in the island of hfartinique, on Jan. 28. 1750. He came to Paris at the age of 19, and became an *avocat* at the parliament of Paris. He returned to Martinique to practise law, and in 1780 was appointed member of the colonial council of Santo Domingo. Returning to Paris in 1784, he was commissioned to study the legislation of the French colonies. In 1789 he was president of the assembly of the electors of Paris and represented Martinique in the constituent assembly. His moderate ideas caused his arrest after Aug. 10, 1792, but he escaped to the United States, and opened a bookseller's shop in Philadelphia. Returning to France in 1799, he became historiographer to the navy and councilor of state. In 1802 he was appointed by the first consul administrator of the duchies of Parma. Piacenza and Guastalla, but was dismissed in 1806 and lived on a pension paid him by the empress Josephine (a kinswoman) until his death.

See Fournier-Tescay, *Discours prononce' aux obsèques de Moreau le 30 Janvier 1819;* Silvestre, *Notice sur Moreau* (1819).

MORECAMBE AND HEYSHAM, a municipal borough, seaside town and seaport in the Morecambe and Lonsdale parliamentary division of Lancashire, Eng., on Morecambe bay. 4 mi. W.N.W. of Lancaster. Pop. (1961) 40,950. Area 5.9 sqmi. A promenade 49 mi. long extends along the sandy shore; there are a quay, two piers and a winter garden. Catering for visitors is the main industry, but plastics and razor blades are made and there is an oil refinery. The shrimps from the shallow Morecambe bay dre famous. Heysham harbour is a sea terminus from Belfast. Morecambe was incorporated in 1902 and Heysham urban district was added in 1928.

MOREL, the surname of several French classical scholars and printers of the 16th and 17th centuries. known for their editions of classical authors and the Fathers of the Church. (1) GUILLAUME MOREL (1505–1564) was born at Tilleul in Normandy. He became king's printer in 1555. His most important work was *Thesaurus vocum omnium latinarum,* containing quotations from Greek authors. taken from hitherto unpublished manuscripts in the Paris library. (2) FÉDÉRIC MOREL, surnamed the Elder (1523–1583), was born in Champagne. About 1550 he married the daughter of the famous printer. Michel de Vascosan, in 1557 set up in business in the rue Saint Jean de Beauvais and in 1571 was appointed printer to the king. His chief publrcations were the *Declamationes* of Quintilian and *L'Architecture* de *Philibert Delorme.* (3) FÉDÉRIC MOREL. son of the preceding, surnamed the Younger (1558–1630), was one of the greatest Greek scholars of his time. He succeeded to his father's business. and was also professor of eloquence at the Collège de France. Special mention may be made of his revised edition of Amyot's translation of *Plufarch* and his Latin translations of some of the dissertations of Maximus of Tyre, of Libanius, Hierocles and Theodoret. (4) CLAUDE MOREL (1574–1626), also published editions of many of the Fathers and other authors. (5) CHARLES MOREL (1602–1640) was printer and secretary to the king. He issued the works of Clement of Alexandria. Gregory of Nazianzus, Cyril. Synesius and Chrysostom, and the *Concilia generalia et provincialia* of Severin Bini. (6) GILLES MOREL, brother of the preceding (dates unknown). His chief publication is the *Grande bibliothèque des pères* (17 vol., 1643).



ROCHE

MOREL (MORCHELLA ESCULENTA)

MOREL (*Morchella*) is a fungus of the class Ascomycetes (*see* FUNGI): less than a dozen species are known. They appear in the spring and are best recognized by their fleshy consistency and the pitted head on a stalk. Although they rate among the best of all edible fungi, they have not been grown commercially with success. Fungi with wrinkled heads, somewhat similar in appearance. belong in the genus *Helvella.* Not all species of *Helvella* are edible. (AR. H. S.)

MORELIA (formerly Valladolid), a city of Mexico and capital of the state of Michoacán, 125 mi. direct and 234 mi. by rail W. by N. of the city of Mexico. near the southern margin of the great Mexican plateau, 6,398 ft. above sea level: in lat. 19° 42' N., long. 100" 54' W. Pop. (1960) 101,395, partly Indians and mestizos. Morelia is served by the Mexican National railway. The city is built on a rocky hill rising from the Guayángareo valley. It has a rectangular plan, with several squares and straight, well-paved streets.

Facing the *plaza mayor,* called the Plaza de los Mártires because of the execution there of the patriot Mariano Jlatamoros in 1814, is the cathedral, a fine specimen of Spanish Renaissance church architecture in Mexico.

Opposite the cathedral is the government palace, which also contains the public library. The municipal government is housed in a tobacco factory converted to public uses. and an old Capuchin convent now serves as a public hospital. The Paseo, or public park. is distinguished for its trees and flowers. The Morelianos are noted for their love of music, and musical competitions are held each year, the best band being sent to the city of Mexico to compete with similar organizations from other states. The public water supply is brought into the city over an aqueduct (3 mi. in length, carried on arches), which was built in 1785 by the bishop of the diocese as a famine relief work.

The University of San Nicolás de Hidalgo is an important regional culture centre. Easily accessible by highway and with excellent climate and hotels. hforelia is a tourist attraction as well as a local commercial hub for the fertile southern and western hinterland. Its manufactures include cotton. woolen and silk textiles, cigars and cigarettes, and a variety of sweets. *dulces.*

Founded by Viceroy Antonio de Mendoza in 1541, Valladolid replaced Patzcuaro as Michoacán's capital in 1582. In 1828 its name was changed to honour José María Morelos y Pavón, a locally born hero of the Mexican wars of independence; it also was the birthplace of Augustín de Iturbide, first emperor of independent Mexico. It is strongly clerical and conservative.

MOREL-LADEUIL, LÉONARD (1820–1888), French goldsmith and sculptor. was born at Clermont-Ferrand in 1820, and died at Boulogne on March 15, 1888. He was apprenticed first to Morel, a manufacturer of bronzes, under whom he became one of the most expert chasers, or *ciseleurs,* in France, and then to Antoine Vechte, to acquire the art of *repoussé* (*q.v.*)—the art in which he was to excel. He studied further under J. J. Feuchère and was commissioned by the French government to produce the "Empire shield." The trade. annoyed that a craftsman should obtain commissions direct, boycotted the young artist. He was encouraged nevertheless by a foreign dealer in Paris. Marchi, who employed him on statuettes, until 1859, when Messrs. Elkington engaged him to work in Birmingham in *repoussé,* assuring him a free hand. His beautiful plateau, "Dreams," was subscribed

for by Birmingham as the town wedding gift to the prince and princess of Wales. Morel-Ladeuil remained with the firm for 23 years, the first result being his masterpiece the "Milton Shield: Paradise Lost" (in *repoussé* steel and silver), which was bought by the English government for £3,000. His "Helicon vase," in steel, silver and gold, priced at £6,000, was presented by the ladies and gentlemen of the royal house to Queen Victoria on her first jubilee. His total work, apart from the productions of his youth, numbers 35 pieces.

See *L'Oeuvre de Morel-Ladeuil, sculpteur-ciseleur,* by *L.* Morel (1904).

MORELLET, ANDRE (1727–1819), French economist, miscellaneous writer and academician (1785), was born at Lyons. He was educated by the Jesuits in his native town and at the Sorbonne; he then took holy orders, but his designation of abbé was the chief thing clerical about him. He had a ready and biting wit, and Voltaire called him "L'Abbé Mord-les." A year before his death in Paris (Jan. 12, 1819) he brought out four volumes of *Mélanges de littkrature et de philosophie du XVIII" sidcle,* composed chiefly of selections from his former publications. His valuable *Mémoires sur le XVIII" sidcle et la Révolution* (2 vol., 1821), appeared posthumously.

A bibliography of his numerous works is given in Quérard's *La France littéraire,* vol. vi; *see* also Sainte-Beuve, *Causeries du lundi,* vol. i.

MORELLI, GIOVANNI (1816–1891), Italian patriot and art critic, whose methods of direct study became basic for Subsequent art criticism. was born at Verona on Feb. 16, 1816. As a Protestant, he was sent to Munich university, where he acquired so great a command of German as to write his principal works in that language, although he pretended that they were translations from the Russian of "Ivan Lermoliev"; *i.e.,* an anagram of Morelli with a Russian termination. He studied medicine but never practised, and he took part in the war of 1848, after which he devoted much of his time to politics. In 1861, although a Protestant, he was elected deputy for Bergamo in the first free Italian parliament. Later, he became alarmed by increasingly democratic tendencies and in 1870 resigned his seat, but he was made a senator in 1873.

His principal achievement was to secure the passing of an act (named after him) prohibiting the sale of works of art from public or religious institutions, and the appointment of a commission to nationalize and conserve all major works which could be regarded as public property, thus undoubtedly saving many masterpieces. One of his principal assistants was G. B. Cavalcaselle (*q.v.*), but they later quarreled. Morelli had a tendency to sarcasm which, in his books, made him many enemies; he admitted that the history of art was more intelligently studied in Germany than anywhere else at that date, but his sallies against the pedantry of German professors were not, perhaps, invariably justified.

His first book, *Italian Masters in German Galleries* (1880; Eng. trans. 1883) marks an epoch in 19th-century art criticism. The so-called "Morellian method" was followed in this and his later *Critical Studies;* essentially 19th century in its scientific rigorousness, it consisted of the apparently simple thesis that the evidence presented by the pictures themselves is superior to all other evidence, whether documentary or traditional. Further, the crux of the method was that all painters, however great, tend to fall back on a formula for rendering such details as the ear or the fingernails, and that these minor details are therefore the most characteristic parts of a picture and the surest guide to attribution. Both Morelli himself and his principal follower. Bernard Berenson, have corrected hundreds of false attributions, but the dangers of his method are obvious and did not pass unnoticed at the time; nevertheless, "it would be as absurd to return to a pre-Morellian period of criticism, as it would be to study natural science without profiting by the discoveries of Darwin" (Claude Phillips, 1890). The parallel is singularly apt.

Morelli died in Milan on Feb. 28. 1891, leaving a fine collection of pictures to his adopted city of Bergamo.

See the memoir *by* Sir A. H. Layard prefixed to Morelli's *Italian Painters: Critical Studies of Their Works. Borghese and Doria-Pamfili Galleries in Rome (1892).* (P. J. My.)

MORELOS, an inland state of Mexico on the southern slope of the great Mexican plateau, lying south of the federal district, with the states of Puebla on the east and southeast and Guerrero on the south. Pop. (1950) 272,842, including a large percentage of Indians and mestizos. Area 1,917 sq.mi. Its surface is roughly broken by mountain ranges forming many valleys. It is drained by the Amacusac river, a northern tributary of the Mescala, or Balsas. There is a wide variation of climate for so small a territory, the higher elevations of the Sierra de Ajusco being cold and humid; the lower spurs mild, temperate and healthful, the lower valleys subtropical, hot and unhealthful. The rainfall is light in the lower regions and irrigation is generally employed. Morelos is one of the most flourishing agricultural states of Mexico, producing sugar, rice, Indian corn, coffee, wheat, fruit and vegetables. Although the state is supposed to have several of the minerals found in this part of Mexico (silver, cinnabar, iron, lead, gold, petroleum and coal), its mining industries have been undeveloped and neglected.

Morelos is named after José Maria Morelos (1765–1815), one of the heroes of Mexico's War for independence. Important towns in the state are the capital, Cuernavaca, pop. (1950) 30,597, site of the famous Borda gardens and of Cortés's palace with its Diego Rivera murals, and Tepoztlbn, pop. (1950) 3,900, an Aztec Indian village made famous by the studies of Robert Redfield and Stuart Chase. Lake Tequesquitengo, a resort, was formed by the subsidence of a large area in the middle of the 19th century. The state is crossed by a superhighway, rail and air lines. (J. A. Cw.)

MORELOS Y PAVÓN, JOSÉ MARÍA (1765–1815), Mexican patriot under whom Mexico's first constitution was proclaimed, was born near Valladolid (now Morelia, Michoacán) on Sept. 30, 1765, of a lower-class family. Until 1790 he worked for his uncle as a cow hand. At 25 he began study for the priesthood in Valladolid and later held various curacies in the area. In 1811 he joined Miguel Hidalgo in his revolution against Spain and upon Hidalgo's death assumed leadership of the movement. Between 1812 and 1813 he controlled most of Mexico southwest of Mexico City, holding at one time or another Acapulco, Oaxaca, Tehuacán and Cuautla. He called a congress at Chilpancingo in 1813 to form a government and a constitution. In Nov. 1813, the congress declared the independence of Mexico and in Oct. 1814, at Apatzingan, promulgated the constitution. But Morelos' power was already waning. He was captured by the Spanish in Oct. 1815. Like Hidalgo he was degraded from the priesthood, and an Dec. 22, 1815, in San Cristobal he was shot as a traitor. (R. E. Q.)

MOREPORK, the name given to two birds, from a fancied resemblance of their calls to these words. One is the Australian species of frogmouth (*q.v.*), related to the goatsuckers and nighthawks. The other is a small brown owl of New Zealand (*Spiloglaux novae-zealandiae*), still fairly common, which haunts the clumps of Maori bush and calls in the twilight. Maori names for this owl are *ruru* and *koukou,* both being attempts to turn his cry into words; he plays a lively part in Maori bird lore.

MORESNET, a small area of Belgium on the German border, southwest of Aachen. *See* Eupen and Malmédy.

MORETON BAY CHESTNUT, a tall tree known botanically as *Castanospermum australe* (family Leguminosae), native of Queensland and New South Wales. The pods are almost cylindrical, about 9 in. long and 2 in. broad, and are divided interiorly by a spongy substance into three to five cells, each of which contains a large chestnutlike seed. The seeds are roasted and eaten by the natives; the timber, which somewhat resembles walnut, is soft, fine grained, and takes a good polish, but is not durable.

MORETO Y CAVAÑA, AGUSTIN (1618–1669), Spanish dramatist and brilliant plagiarist. His adaptations are remarkable for their charm and skill; the most celebrated is *El Desde'n con el Desde'n,* whose episodes are taken from four separate plays of Lope de Vega.

MORETTO (Moretto da Brescia, originally Alessandro Bonvicino or Buonvicino) (*c.* 1498–1554), leading Italian painter of the Brescian school, was probably born at Brescia.

Moretto's works display the influence of Titian, of Raphael and of other contemporary masters, but he had a distinctive style

of his own characterized by a cool, silvery tone. As a portraitist he went beyond the rendering of external form, penetrating into the character and disposition of his sitters. He worked chiefly in Brescia, where his paintings can best be studied. In 1529 he was in Bergamo, and in 1540–41 in Milan and Verona. He died at Brescia on Dec. 22. 1j54.

Moretto's earliest picture may be the "Ascension" in S. Francesco della Vigna, Venice. dated 1516, but neither it nor the one of 1518 in Bergamo is universally accepted as his. The frescoes in the Corpus Domini chapel of S. Giovanni Evangelista at Brescia are datable 1521–24. In the decoration of this chapel he collaborated with G. Romanino, another leading painter of Brescia. Among his first paintings are the ceiling fresco representing the "Vision of Moses," and other paintings in the Galleria Martenengo at Brescia. The churches of Brescia possess many altarpieces by him, among which the "Coronation of the Virgin," in SS. Nazzaro e Celso, is perhaps the most notable. In the church of Paitone, near Brescia, is "The Virgin Appearing to a Shepherd Boy," and there is a large "Christ in the House of Levi" in the nuns' gallery of Sta. Maria della Pieta in Venice, dated 1544. The Vienna gallery has a "St. Justina," perhaps his finest work. The National gallery, London, has three fine portraits, including a full-length portrait of a man, dated 1526, which is one of the earliest Italian full-length portraits, and several other works. The Johnson collection in Philadelphia has a "Madonna and Donors"; the Metropolitan Museum of Art at New York a "Christ in the Desert" and an "Entombment," dated 1554, which is his latest known work. Moretto's foremost pupil was Giambattista Moroni.

BIBLIOGRAPHY—J. A. Crowe and G. B. Cavalcaselle, *History of Painting in North Italy,* vol. iii (1912); G. Gombosi, *Moretto da Brescia* (1943). (P. J. MY.)

MORET Y PRENDERGAST, SEGISMUNDQ (1838–1913), Spanish politician, was born at Cádiz on June 2, 1838. He was educated at the Central university, Madrid, and became professor of political economy there. In 1863 he entered the Cortes as a Liberal, took part in the revolution of 1868 and in the constituent assembly of 1869. Colonial secretary in 1870 under General Prim, and later finance minister, he was for a few months in 1872 Spanish ambassador to Great Britain, and after resigning this post accepted the directorship of a large London bank. A year later he returned to Spain. He re-entered Parliament in 1879, and helped to found the Democratic dynastic party. He was minister for foreign affairs under Sagasta in 1885 and again in 1893–94, minister of the interior 1885–88, and minister of colonies 1897. In this capacity he advocated the, grant of autonomy to Cuba and Puerto Rico, and was opposed to the war with America of 1898. He was Prime Minister in 1905–06 and again in 1909, and at the time of his death in Madrid on Jan. 28, 1913, was president of the Chamber.

MORGAGNI, GIOVANNI BATTISTA (1682–1771), Italian anatomist and pathologist, author of a work that made pathological anatomy a science and diverted the course of medicine into new channels of exactness, was born on Feb. 25, 1682, at Forli. After, graduating in 1701 at Bologna in philosophy and medicine, he acted as prosector to A. M. Valsalva (one of the distinguished pupils of M. Malpighi), whom he assisted in preparing his celebrated *Anatomy and Diseases of the Ear* (1704). When Valsalva was transferred to Parma, Morgagni succeeded to his anatomical demonstratorship, but after a time gave up his post and spent two or three years at Padua, where in 1710 he succeeded his friend Domenico Guglielmini as professor of medicine. In 171j he was promoted to the chair of anatomy. He was honoured by various academies, by cardinals and popes, and was elected patron of the German students of the university. Morgagni died at Padua on Dec. 6, 1771.

Although his *Adversaria anatomica* (1706–19) had established his reputation as an accurate anatomist, it was not until 1761, when he was in his 80th year. that Morgagni brought out his great work, the *De sedibus et causis morborum per anatomen indagatis* (often reprinted, Eng trans. 1769). It treats of the morbid conditions of the entire body, and contains records of about 640 dissections, the symptoms during the course of the malady and other antecedent circumstances being always prefixed with more or less fullness. Although he was the first to demonstrate the absolute necessity of basing diagnosis, prognosis and treatment on a comprehensive knowledge of anatomical conditions, Morgagni made no attempt to exalt pathological anatomy into a science disconnected from clinical medicine and remote from practical needs.

MORGAN, a family of U.S. financiers, ultimately the foremost leaders of finance and international banking in the United States, was founded by JUNIUS SPENCER MORGAN (1813–1890), born in Holyoke, Mass., April 14, 1813. He was a partner in the largest drygoods business in the United States, and founder of J. S. Morgan and company, in London, Eng. His son, JOHN PIERPONT MORGAN (1837–1913) was born in Hartford, Conn., April 17, 1837, and was educated at the University of Gottingen. He began his banking career in 1857 with Duncan, Sherman and company in New York city. From 1860 to 1864 he mas agent in New York city for George Peabody and company, and its successor J. S. Morgan and company, of which he became head. In 1864–71 he was a member of the firm of Dabney, Morgan and company, which dissolved in 1871, when Morgan became a partner in the firm of Drexel, Morgan and company. In 1895 this firm was organized as J. P. Morgan and company, and largely through Morgan's ability, it became one of the most powerful banking houses in the world. It carried through the formation of the United States Steel corporation, General Electric, and International Harvester, harmonized the coal and railroad interests of Pennsylvania, and reorganized numerous railroads including the Chesapeake and Ohio, the Northern Pacific and the Baltimore and Ohio.

Morgan was a leader in transforming industrial conditions in the United States by the process of eliminating atomistic competition. It has been estimated that by 1902 he had about 5,000 mi. of U.S. railroads under his financial control. In 1895 the house of J. P. Morgan and company supplied the United States government with $62,000,000 in gold to restore the treasury gold reserve to $100,000,000. In the 1907 panic, Morgan headed a group of bankers who were primarily responsible for stemming the tide of panic and preserving the solvency of major banks and corporations. He was a director in many US. corporations, and was one of the greatest art and book collectors of his generation. He died in Rome on March 31, 1913, leaving an estate of about $70,000,000.

JOHN PIERPONT MORGAN, JR. (1867–1943), son of John Pierpont Morgan, was born at Irvington, N.Y., Sept. 7, 1867, and graduated from Harvard in 1889. He became a member of his father's firm in 1891, working in the London branch for eight years. He succeeded his father as head of the house of Morgan in 1913. In 1914 he organized a syndicate to make a $100,000,000 loan to New York city to preserve its credit. The British and French governments enlisted his services as purchasing agent for several billion dollars worth of supplies in World War I. He helped finance a great part of the Allied requirements for credits in the United States by floating $1,500 000,000 in Allied bonds. After the war his firm floated loans of nearly $1,700,000,000 for European reconstruction work. Between 1919 and 1933 the Morgan firm handled more than $6,000,000,000 in securities. Morgan served on the war reparations commission in 1922. He was a director of many corporations. In 1933 the Securities act compelled his firm to separate its investment banking and commercial banking activities into Morgan, Stanley and company (investment banking) and J. P. Morgan and company (commercial banking). Like his father, J. P. Morgan, Jr. gave generously to charities. He died in Boca Grande. Fla. on March 13, 1943. Sons of J. P. Morgan, Jr. were JUNIUS SPENCER MORGAN, born in New York city, March 1j, 1892, a partner in the business after 1915, and HENRY STURGIS MORGAN born in London, England, Oct. 24, 1900, who became a partner of Morgan, Stanley and company.

See H L. Satterlee, J. *Pierpont Morgan* (1939). (J. R. LT.)

MORGAN, DANIEL (1736–1802), American Revolutionary general. who won a brilliant victory at Cowpens, was born in Hunterdon county, N.J., in 1736, of Welsh ancestry. Having moved to Virginia in 1753, he was commissioned a captain of Virginia riflemen in June 1775. During the following winter he accompanied Gen. Benedict Arnold to Canada, and in the assault on

Quebec (Dec. 31) Morgan and his riflemen penetrated well into the city, where he was hemmed in and forced to surrender. Late in 1776 he was released, and soon after commissioned colonel. In Sept. 1777 he joined Gen. Horatio Gates, then engaged in the campaign against Gen. Burgoyne, and took part in both battles of Saratoga. Morgan resigned from the army in July 1779 and retired to Virginia. After the battle of Camden, however, he joined Gates at Hillsborough, N.C., took command of a corps and was made brigadier general. Cornwallis and Tarleton attempted to entrap him in Jan. 1781, but at Cowpens (Jan. 17) he defeated Tarleton and then escaped from Cornwallis into North Carolina. In Nov. 1794 Morgan commanded troops sent to suppress the Whisky insurrection in western Pennsylvania. He was a Federalist representative in congress from 1797 to 1799, and died in Winchester, Va., July 6, 1802.

MORGAN, SIR HENRY (*c.* 1635–1688), Welsh buccaneer and deputy governor of Jamaica, was born, probably in 1635, at Llanrhymni on the borders of Monmouthshire and Glamorganshire. He is said to have been kidnapped as a boy at Bristol and sold as a servant at Barbados, thence making his way to Jamaica. In 1666 he commanded a ship in Edward Mansfield's expedition which seized the island of Providence or Santa Catalina, and shortly afterward was chosen by the buccaneers as their "admiral." In 1668 he mas commissioned by Sir Thomas Modyford, the governor of Jamaica, to capture some Spanish prisoners in order to discover details of the threatened attack on Jamaica. He took Puerto Principe and Portobelo on the mainland, but was persuaded to withdraw on payment of a large sum by the governor of Panamá. Entrusted with another expedition by Modyford against the Spaniards, he ravaged the coast of Cuba and in 1669 sacked the town of Maracaibo, and afterward Gibraltar at the head of Lake Maracaibo. Returning to Maracaibo, he found three Spanish ships waiting to intercept him; but these he destroyed or captured, recovered a considerable amount of treasure from one which had sunk and exacted a heavy ransom for evacuating the place.

On his return to Jamaica Morgan was commissioned commander in chief of all the ships of war in Jamaica, to levy war on the Spaniards. He recaptured Santa Catalina in Dec. 1670, retook Portobelo and in 1671 took Panamá. Meanwhile, on July 8, 1670, a treaty had been signed betneen Spain and England, and both Modyford and Morgan were ordered home under arrest. Morgan, however, soon gained the king's favour, and in 1674 was appointed lieutenant governor (*i.e.*, deputy governor) of Jamaica and was knighted, leaving England in December. He was charged by Lord Vaughan, afterward earl of Carbery, the governor, soon after his appointment, with encouraging privateering. Finally, on Oct. 12, 1683, he was suspended in Jamaica from all his employments. He died in Jamaica in Aug. 1688.

See A. O Exquemelin (one of Morgan's buccaneers), *Buccaneers of America,* 2 vol. (1684–85); J. A. Morgan, *History of the Family of Morgan* (1901); C. H. Haring, *The Buccaneers in the West Indies in the 17th Century* (1910); J. L. Phillips, "Sir Henry Morgan—Buccaneer" in *Historical Sketches of Glamorgan,* vol. 2 (1912).

MORGAN, JOHN (1735–1789), noted U.S. physician, teacher and military surgeon, was born on June 10, 1735, in Philadelphia, Pa., studied medicine under John Redman and graduated from the College of Philadelphia in 1757. After three years as surgeon in the French and Indian War he continued his studies in London, Edinburgh (M.D., 1763) and Paris. Returning to Philadelphia, he became professor of medicine in the college in 1765. Morgan's *Discourse Upon . . . Medical Sclzools* (176*j*) proposed two reforms: the separation of medicine from surgery and drug selling, and the requirement of a liberal education for medical students. Both were premature and failed. As director general of hospitals in the Continental army, Morgan tried to bring the nearly autonomous regimental surgeons under general army control, but congress would not reorganize the system. In 1777 he was summarily dismissed as responsible for the heavy mortality in the army. though congress vindicated him two years later.

Morgan died in Philadelphia on Oct. 15, 1789.

Morgan's practice was considerable; he corresponded with learned men, encouraged domestic manufactures and was a connoisseur of art. Besides his doctoral dissertation (on formation of pus) he wrote *Recommendation of Inoculation. . .* (1776), *Vindication* (1777), communications to the American Philosophical society and a journal of travels. (W. J. BL.)

MORGAN, JOHN HUNT (1825–1864), American Confederate soldier, mas born in Huntsville, Ala., on June 1, 1825, and brought up near Lexington, Ky. In the Mexican War he was a first lieutenant of a cavalry regiment. On the outbreak of the Civil War he joined the Confederate army and, being an able scout, was made commander of a cavalry squadron. He was commissioned a colonel after the battle of Shiloh, and in July 1862 made the first of his famous raids, threatening Louisville and Cincinnati. In August and September he took part in Gen. Braxton Bragg's invasion of Kentucky, and again threatened Ohio. In December he defeated the Union garrison at Hartsville, Tenn., was commissioned brigadier general for this success, and soon after again raided Kentucky. To cover Bragg's movement from Tullahoma to Chattanooga Morgan made, in July 1863, his raid into Indiana and through Ohio, though Bragg had instructed him to confine himself to Kentucky. With 2,460 men he crossed the Cumberland, near Burkesville, Ky., on July 2; on the 5th he captured a garrison at Lebanon, and on the 13th entered Ohio near Harrison. The regular cavalry was now close behind him. He marched through the Cincinnati suburbs on the night of the 13th and on the 18th reached Portland, near Buffington Island, where in a sharp battle he lost 600 or more men, and as many more surrendered. On the 26th he surrendered to General Shackelford at New Lisbon. He was imprisoned in the penitentiary at Columbus, from which on the night of Nov. 27 he escaped. In the spring of 1864 he was put in virtual command of the department of southwestern Virginia, and late in August took command at Jonesboro, Ga. On Sept. 4 he was shot in Greenville, Tenn., having been betrayed, it appears, to the Federals.

See Basil W. Duke, *History of Morgan's Cavalry* (1867).

MORGAN, LEWIS HENRY (1818–1881), U.S. ethnologist, a pioneer in the comparative study of kinship systems, was born Nov. 21, 1818, near Aurora, N.Y. He graduated from Union college, Schenectady, in 1840, went to Rochester, N.Y. about 1844 and there practised law for many years. He made intensive studies of the social organization and material culture of the Iroquois Indians, published in 1851 as *The League of the Ho-dé-no-sau-nee, or Iroquois.* This was followed by field trips to the Great Plains, Hudson's Bay territory and the southwest. In a monumental work, *Systems of Consanguinity and Affinity of the Human Family* (1871), he founded the scientific study of kinship *(see* KINSHIP TERMINOLOGY). In 1877 he published *Ancient Society; or Researches in the Line of Human Progress from Savagery through Barbarism to Civilization,* which became a Marxist classic and was the subject of Friedrich Engels' *The Origin of the Family, Private Property, and the State* (Eng. trans., 1902).

Morgan's theory of the evolution of the family, from promiscuity to monogamy, has long been obsolete, but much of his work remains valid and significant, notably, his compilation of data on kinship terms and the thesis that they are to be interpreted in terms of social institutions; his distinction between primitive society and civil society; and his theory of cultural evolution in terms of technology, particularly as regards subsistence. Morgan was elected to the National Academy of Sciences and was president of the American Association for the Advancement of Science (1880). He was active in state politics, serving as assemblyman (1861) and senator (1868–69). He died in Rochester, N.Y.. on Dec. 17, 1881.

Among his other works are *The American Beaver and his Works* (1868); *Houses and House-Life of the American Aborigines* (1881); L. A. White (ed.), *Pioneers in Anzerican Anthropology: The. Bandelier-Morgan Letters, 1873–1883,* 2 vol. (1940), "Extracts from the European Travel Journal of Lewis H. Morgan," *Rochester Historical Society Publications,* xvi (1937); and *Lewis Henry Morgan: The Indian Journals, 1859-1862,* (1959).

See Carl Resek, *Lewis Henry Morgan* (1960); Leslie A. White, "Lewis Henry Morgan: Pioneer in the Theory of Social Evolution," in *An Introduction to the History of Sociology,* ed. *by* Harry Elmer Barnes (1948). (LE. **A.** W.)

MORGAN, LADY SYDNEY (née OWENSON) (1776–1859), Irish novelist who was one of the most vivid and hotly discussed figures of her generation, was born in Dublin on Dec. 25, 1776. Her father, Robert Owenson, was an actor. A precocious volume of poems (1801) was followed in 1802 by *St. Clair,* a novel of ill-starred love and impassioned nature worship showing the influence of Goethe and Rousseau. But the book which made her reputation was *The Wild Irish Girl* (1806), in which she appeared rather as a patriot than a novelist, extolling the beautiful scenery, the natural wealth and the noble traditions of Ireland. Admirers called her "Glorvina," the name of her heroine, and she was lionized in London. She was invited to become companion to the marchioness of Abercorn, who in 1812 persuaded her to marry her own surgeon, Thomas Morgan. The marquess had already arranged for his immediate knighthood.

Books continued to flow from her pen. Her best novel, *O'Donnell* (1814), contains realistic descriptions of the Irish working class, which she understood thoroughly., In 1817 appeared *France,* 2 vol., a lively and partial study of French society which resembles modern journalistic reporting, and which was savagely attacked in the *Quarterly,* which accused her of impiety, Jacobinism, falsehood and licentiousness because she had praised the French Revolution. In France she also gave offense by her inability to appreciate French classical drama. Madame de Stael, however, greatly admired her *France.* Lady Morgan revenged herself in her novel, *Florence Macarthy* (1818), in which a *Quarterly* reviewer is insulted with feminine ingenuity. Among many other works is *Passages from my Autobiography* (1859; ed. by W. Hepworth Dixon, 1862). She died in London, April 16, 1859.

See L. Stevenson, *The Wild Irish Girl* (1936); *M.* I. Moraud, *Lady Morgan* (1954).

MORGAN, THOMAS HUNT (1866–1945), U.S. biologist and discoverer of the chief principles of genetics, following the discoveries of J. G. Mendel (*q.v.*), was born at Lexington. Ky., Sept. 25, 1866. His early training in zoology (State College of Kentucky and Johns Hopkins university, Ph.D., 1890) was followed by professorships at Bryn Mawr college (1891) and Columbia university (1904–1928). His early work was in experimental embryology; but at Columbia, about 1909, his skepticism about the reality of particulate bodies, genes, as responsible for the transmission of heredity led him to undertake breeding experiments with the small vinegar fly *Drosophila melanogaster.* These experiments were so successful that by 1915 he and his students, A. H. Sturtevant, H. J. Muller and C. B. Bridges, had proved not only the reality of genes as corporeal elements with specified locations in the chromosomes of the cell nucleus *(see* CYTOLOGY), but were able to describe this system of genes as the *Mechanism of Mendelian Heredzty,* the title of their joint book (1915). The collective principles derived from the combined results of breeding experiments and cytological observations were referred to as the "chromosome theory of heredity" or as in the title of Morgan's culminating book on this subject, *The Theory of the Gene* (1926). In the elaboration and proof of this comprehensive theory of the system of hereditary transmission, Morgan considered himself as leader of a team of younger men, all working in close collaboration. Subsequent research in genetics and applications of the theory to problems of evolution and development have been based on the foundation laid by the "Morgan school." For this accomplishment Morgan received the Nobel award in medicine in 1933. He left Columbia in 1928 to establish and direct the Kerckhoff Laboratories of Biological Sciences, California Institute of Technology, Pasadena, which became a leading centre of research in genetics. There his interests returned to experimental embryology, especially problems of fertilization and self-sterility. His chief books other than those cited above indicate the wide range of his biological interests: *Development of the Frog's Egg* (1887); *Heredity and Sex* (1913); *The Physical Basis of Heredity* (1919); *Evolution and Genetics* (1925); *Experimental Embryology* (1927); *The Scientific Basis of Evolution* (1932); *Embryology and Genetics* (1933). Morgan was president of the National Academy of Sciences (1927–1931), of the American Association for the Advancement of Science (1930) and of the Sixth International Congress of Genetics (1932). (L. C. D.)

MORGANATIC MARRIAGE, a form of marriage in which the contracting parties are not by birth of equal status or rank, and under which the wife, if not of equal rank, does not take the rank of her husband, and the children, whether it be the wife or husband that is of lower rank, have no right of succession to the dignities, fiefs or entailed property of the parent of higher rank. Marriage in this form was properly peculiar to the German peoples, from whom it was adopted by the royal families of other countries. In Great Britain the regulations as to the marriages of members of the royal family are contained in the Royal Marriage act 1772 *(see* MARRIAGE).

MORGANTOWN, a university city and river port in north central West Virginia, U.S., about 60 mi. S. of Pittsburgh, Pa., on the Monongahela river; the seat of Monongalia county. The first settlement, in 1758, was wiped out by Indians, but in 1767 Col. Zackquill Morgan, son of the first settler of West Virginia, founded the community which bears his name. Morgantown was chartered as a town in 1785 by the Virginia assembly and as a city by the West Virginia legislature in 1905. In 1921 it adopted a council-manager form of government. It is the seat of West Virginia university, chartered in 1867 as Agricultural College of West Virginia and renamed the following year. With the opening in 1959 of a new, fully planned medical school, the university began a modernization program which included moving the entire physical plant to a new location about 3 mi. from the old campus. Morgantonn has a large river traffic and ships much coal from the rich mines in the vicinity. Limestone is also quarried nearby. Manufactures include glass products, textiles, chemicals, construction materials and pottery. Among the recreational facilities available are Cooper's Rock State forest and Mont Chateau State park, located a few miles northeast of the city. For comparative population figures *see* table in WEST VIRGINIA: *Population.*

(K. K. McC.)

MORGENSTERN, CHRISTIAN (1871–1914), German lyric poet, born in Munich on May 6, 1871, one of a family of painters, is famous for his nonsense verse, which, however, implies a deeper meaning. This metaphysical humour is found in his collections of lyrical poetry, *Galgenlieder* (1905), *Palmstronz* (1910), *Palma Kunkel* (1916), *Der Gingganz* (1919); a selection appeared in English translation (1919). Tuberculosis ended his studies at the University of Breslau and caused his death in Merano, Italy, on March 31, 1914. In 1909 he met Rudolf Steiner (*q.v.*), the anthroposophist, who influenced him greatly. His humour mainly relies on the incongrous juxtaposition of human experiences and on the subtle but skeptical exploration of the possibilities of language. Several volumes of more plodding serious poetry were also published. *Stufen* (1918) is a collection of aphorisms.

See M. Bauer, *Morgensterns Leben und Werk,* 3rd ed. (1941); M. Bauer and M. Morgenstern, *Christian Morgenstern, ein Leben in Briefen* (1952). (*H. S.* R.)

MORGENSTIERNE, GEORG VALENTINE VOM MUNTHE AF (1892–), Norwegian philologist, specialist in the Indo-Iranian border languages and professor of Indian language and literature in the University of Oslo since 1937, was born at Kristiania (Oslo) on Jan. 3, 1892. He studied Indian literature and philology in Kristiania, Bonn and Berlin, subsequently visiting Afghanistan (1924), Baluchistan and the North-West Frontier (1929). In 1927 appeared the *Etymological Vocabulary of Pashto,* and, in 1929, "Parachi and Ormuri," the first of three volumes of *Indo-Iranian Frontier Languages.* Morgenstierne's articles, often giving a comprehensive survey of the language dealt with, have appeared mostly in the *Norsk Tidsskrift for Sprogvidenskap* (N.T.S.); as a result of a tour in 1949, a description of the Waigali language appeared in vol. xvii of N.T.S. Morgenstierne has allied his knowledge of the ancient languages (*cf.* "Orthography and Sound-System of the Avesta," N.T.S., vol. xii) with an ability to record the features of the living frontier languages. His work represents an invaluable collection of historical and phonological studies. (J. E. B. G.)

MORGENTHAU, HENRY, JR. (1891–), U.S. pub-

lic official, was born May 11, 1891, the son of Henry Morgenthau, ambassador to Turkey during World War I. He was intimately associated with Gov. Franklin D. Roosevelt as conservation commissioner for New York and as chairman of the Governor's Agricultural Advisory committee. In 1933 he was appointed by President Roosevelt successively to be chairman of the Federal Farm board, governor of the Federal Farm Credit administration and undersecretary of the treasury. On Jan. 1, 1934, he became secretary of the treasury, and he held that post until he resigned in July 1945. Morgenthau had much to do with the enormous problem of financing the waging of World War II.

MORGHEN, RAFFAELLO (1758–1833), Italian engraver, was born at Naples on June 19, 1758. He studied first under his father, and then under Giovanni Volpato. He assisted this master in engraving the famous pictures of Raphael in the Vatican, and the print that represents the miracle of Bolsena is inscribed with his name. He married Volpato's daughter, and moved to Florence to engrave the masterpieces of the Florentine gallery. He died at Florence on April 8, 1833.

MORIAH, a place name of ancient Palestine with two distinct connotations. (1) A land entirely unknown, on a mountain in which Abraham offered Isaac (Gen. xxii, 2). Traditionally, "the land of Moriah" is identified with the site of the Temple at Jerusalem, except by the Samaritans and a few western scholars who accept their belief that the mountain was Gerizim. (2) The upper part of the hill of Ophel, the threshing floor of Araunah, upon which Solomon erected the Temple, was once called Mt. Moriah (2 Chron. iii, 1). Whether this name be derived from the corruption in Genesis or not cannot be definitely decided.

MORICZ, ZSIGMOND (1879–1942), Hungarian novelist and a master of realism, was born at Csécse on June 29, 1879. He became one of the leaders of the progressive writers associated with the review *Nyugat,* of which for some years he was the editor. From 1940 until his death in Budapest, on Sept. 4, 1942, he edited *Kelet Népe,* the peasant writers' review.

Moricz found his subjects in the life of the villages and country towns he knew and his novels portray the peasant, fighting for his emancipation, as in *Sárarany* ("Gold in the Mire"; 1910) and *A boldog ember* ("The Happy Man"; 1935); the collapsing way of life of the decaying provincial nobility, as in *Kivilágos kivirradtig* ("Till the Small Hours of Morning"; 1924), *Uri muri* ("Gentry Spree"; 1927) or *Rokonok* ("Relatives"; 1930); or the failure of those who work for the happiness of the people, as in *A fáklya* ("The Torch"; 1917). In Moricz's world marriage and family life are pregnant with bitter conflicts, but he also evokes pure, and even idyllic, loves as in *Pillangó* ("Butterfly"; 1925). He wrote the finest children's book in Hungarian, *Légy jó mindhalálig* ("Be Good till Death"; 1920), and also two monumental historical novels, *Erdély trilógia* ("Transylvania, a trilogy"; 1922–35), and *Rózsa Sándor* (1940–42). In his novels finely characterized types of Hungarian society come into collision, and as a result their fierce energies collapse or degenerate into murderous passion. Some of his works are veritable Dances of Death of the morbid and doomed elements of society. He is a master of Hungarian, his style absorbing elements of both the old language and the dialects. (T. Ky.)

MORIER, JAMES JUSTINIAN (*c.* 1780–1849), English writer and diplomat, the author of books which formed English opinion on Persia for many years. He was born in Smyrna about 1780, his father being consul-general of the Levant company at Constantinople. In 1807 he entered the diplomatic service and was in Teheran in 1809 and during 1810–15, from 1814 as head of the embassy. He wrote two admirable and popular travel books on Persia, Armenia and Asia Minor (1812 and 1818) and some forgotten novels; but his fame rests on his sparkling picaresque novel *The Adventures of Hajji Baba of Ispahan* (1824) where he built up a picture of Persia which was long regarded as authoritative even in the highest quarters. The Persian translation (1905) was accepted in Persia as an original work with a satirical intention and influenced the development of the novel there. Morier's less successful *The Adventures of Hajji Baba of Ispahan in England* (1828) is largely a satire on English civilization. He died at Brighton on March 19, 1849.

James Morier has been confused with his elder brother JOHN PHILIP (1776–1853), secretary to Lord Elgin at Constantinople, who accompanied the grand vizier on the Turkish campaign (1800) against Napoleon's representative in Egypt.

See his *Adventures of Hajji Baba in Ispahan* with introduction by C. W. Stewart (World's Classics, 1923) and by R. Jennings (1949).

MORIER, SIR ROBERT BURNETT DAVID (1826–1893), British diplomat, was in his day the greatest English authority on German politics. He was born in Paris, March 31, 1826, son of David Richard Morier, British minister at Berne, recalled by Lord Palmerston in 1847. At Balliol college, Oxford, his life-long friendship with Benjamin Jowett (*q.v.*) began. He was attaché at Vienna and Berlin (1853–66), then accredited successively to the German princes in Darmstadt, Stuttgart and Munich (1866–76). He was a liberal and a free trader, the friend of German liberals and the trusted adviser of the crown princess, daughter of Queen Victoria, and the crown prince, later the emperor Frederick III. Morier analyzed authoritatively Germany's political and constitutional changes and reported in 1870 on public opinion in Alsace-Lorraine. He incurred Bismarck's hostility and his ultimate appointment to the Berlin embassy became impossible. As minister at Lisbon (1876–81) he prompted renewed assurances of Great Britain's interest in Portuguese independence; signed the Goa treaty (1878) concerning railways and trade in India; and obtained better facilities for British trade in Portuguese East Africa. An ambitious plan would have reciprocated Portugal's opening Lourenço Marques to British military traffic and building a railway thence to the Transvaal, with Britain's recognition of Portuguese claims to the African coast between Angola and the Congo. The two treaties (1879, 1884) were not ratified. As minister at Madrid (1881–85) he negotiated the Anglo-Spanish commercial treaty in 1885. He was ambassador at St. Petersburg (Leningrad) (1885–93). His power to conciliate and his belief in Russia's good faith helped negotiations on the Bulgarian and Egyptian questions. He succeeded in preventing recriminations from following Lord Rosebery's sharp protest (July 1886) against Russia's breaking the Berlin treaty by altering the status of Batum. From 1887 Morier encouraged unsuccessful attempts to open Siberia to British trade by way of the Kara sea. He discouraged plans for Anglo-Russian co-operation to develop Persia, but mitigated the results of rivalry for concessions there (1888–90). He handled skilfully the Pamir incident of 1891 when the Russians expelled two British officers from territory claimed by Britain for Afghanistan. Morier's most important success was the delimitation of the Russo-Afghan frontier by sustaining the flagging negotiations of 1885–87 and beginning those which led to the Pamir treaty of 1895. The Bazaine incident created some stir in 1888. Morier was unjustifiably accused in Germany, first privately to the prince of Wales (May), then in the *Kölnische Zeitung* (Dec.), of having forewarned Marshal Bazaine of Prussia's crossing the Moselle in 1870. Morier's dispatches were forceful and fluent. His vigorous private letters to successive foreign secretaries and colleagues argued about policy at large, those to Lord Salisbury notably urged the making of an Anglo-Russian understanding. He died at Montreux on Nov. 16, 1893.

See Rosslyn Wemyss, *Memoirs of Sir Robert Morier . . . to 1876,* 2 vol. (London, 1911). (A. R.)

MÖRIKE, EDUARD FRIEDRICH (1804–1875), German poet, born at Ludwigsburg on Sept. 8, 1804, was lecturer in literature at the Katharinenstift in Stuttgart from 1851 to 1866. He died at Stuttgart on June 4, 1875. Mörike is the most lyrically gifted of all the poets belonging to the so-called Swabian school which gathered round Uhland. His works include *Gedichte* (1838; 22nd ed., 1905); *Idylle vom Bodensee, oder Fischer Martin und die Glockendiebe* (1846; 2nd ed., 1856); *Klassische Blumenlese* (1840); and several novels, among them the subjective and romantic *Maler Nolten* (1832; 6th ed., 1901).

See Mörike's *Gesammelte Schriften,* 4 vol. (1878), and the *Volksausgabe,* 4 vol. (1905). Selections from his literary remains were published by R. Krauss in *Eduard Mörike als Gelegenheitsdichter* (1895), and his correspondence with Hermann Kurz, Moritz von Schwind and Theodor Storm, by J. Bächtold (1885–91); an edition of Mörike's

Ausgewählte Briefe, 2 vol., appeared 1903–04.

MORIN, JEAN (latinized JOANNES MORINUS) (1591–1659), French theologian whose fame rests on his *editio princeps* of the Samaritan Pentateuch and Targum, was born in 1591 at Blois, of Protestant parents. He learned Latin and Greek at Rochelle, and continued his studies at Leyden, subsequently moving to Paris. His conversion to the Roman Catholic Church is ascribed to Cardinal du Perron. In 1618 Morin joined the Congregation of the Oratory and in due course took priest's orders. In 1625 he visited England in the train of Henrietta Maria; in 1640 he was at Rome, on the invitation of Cardinal Barberini, and was received with special favour by Pope Urban VIII. He was soon recalled to Paris by Richelieu, and the rest of his life was spent in incessant literary labour. The *Histoire de la delivrance de l'église chrétienne par l'emp. Constantin* (1630), gave great offense at Rome, and a *De'claration* (1654), directed against faults in the administration of the Oratory, was strictly suppressed. So. too, his great work on penance gave equal offense to the Jesuits and to Port-Royal; even after his death in 1659, the polemical vehemence of his *Exercitationes biblicae* long led Protestants to neglect his work in which he destroyed the current theory of the integrity of the Hebrew text of the Scriptures. Morin's edition of the Samaritan Pentateuch and Targum, which appeared in the Paris Polyglott in 1645. gave the first impulse in Europe to the study of this dialect. He learned it without a teacher (framing a grammar for himself) from manuscripts then newly brought to Europe.

MORI ŌGAI (pseudonym of MORI RINTARŌ) (1862–1922), one of the creators of modern Japanese literature, was the eldest son of a samurai physician, and himself studied medicine, at first in Tokyo and from 1884 to 1888 in Germany. In 1889 he published *The Dancing Girl*, an account of the unhappy attachment between a German girl and a Japanese studying in Berlin. This was, in Mori's words, an *"Ich roman"—a* story closely based on his own experiences. It represented a marked departure from the impersonal Japanese fiction of preceding generations, and was the first of innumerable autobiographical revelations by Japanese writers. Another work closely connected with Mori's stay in Germany was his beautiful translation of Hans Christian Andersen's *Improvisatoren*. Mori's most popular work, *Gan (The Wild Goose*, 1911–13; part translation by B. Watson in Donald Keene, *Modern Japanese Literature*, 1956), is more "novelistic" than any other of his writings, but the suicide in 1912 of Gen. Maresuke Nogi after the death of the emperor Meiji moved Mori so profoundly that he abandoned fiction in favour of painstakingly accurate historical novels that depict samurai morality. The heroes of several of his works are warriors who, like General Nogi, commit suicide in order to follow their master to the grave. Despite his early "confessional" writing, Mori shared with his samurai heroes a reluctance (akin to traditional Japanese impassivity) to dwell on the emotions. His detachment, in part possibly the result of his scientific training, made his later works seem cold, but their strength and integrity were strikingly close to the samurai ideals he so admired.

See Yoshitaka Takahashi, *Mori Ōgai* (1954). (DD. K.)

MORIOKA, the capital and largest city of Iwate prefecture, northeastern Honshu, Japan, is located on the upper reaches of the Kitakami river southeast of the towering volcanic cone of Mt. Iwate (6,696 ft.). Still retaining the atmosphere of the feudal period, when it was the Nambu fief castle town, Morioka is primarily an administrative, commercial and cultural centre. It is well known for its iron kettle handicrafts and horse fairs in the spring and autumn. Morioka is served by the Tohoku railway line. Pop. (1955) 142,875. (J. D. EE.)

MORION, a light round-shaped headpiece or helmet (*q.v.*).

MORIORI. The Moriori, the aboriginal inhabitants of the Chatham Islands of New Zealand, were a Polynesian people of culture allied to but less highly developed than that of the Maori of the South Island. They lived on fern root, eels, fish, *karaka* berries and birds. Albatrosses were obtained by perilous expeditions to the outlying rocks where they nested. The clothing of the Moriori was of sealskin and rudely woven flax. Their social organization was similar to that of the Maori but they were a peaceful people, quarrels being settled by a duel with a kind of singlestick. Numbering a few hundreds when discovered in the late 18th century, they were easily conquered and enslaved by a warlike party of Maori in 1835 and were gradually assimilated.

BIBLIOGRAPHY.—A. Shand, *The Moriori People*, Mem. Polynesian Soc. II, 1911; H. W. Williams, "Language of the Chatham Islands," *Trans. N.Z. Inst.*, 51, 1918; and the excellent monograph of H. D. Skinner, *Moriori Material Culture*, Mem. Bishop Museum, vol. ix, No. 1, 1923.

MORISCOS (*i.e.*, "little Moors"), the name given to the Spanish Mohammedans who accepted baptism and to their descendants. Many if not most of them were in reality of the same race as the Christians, and were descended from converts to Islam. By the terms of the capitulation of Granada in 1492 freedom of worship was secured to the Mohammedans. But at the end of 1499 Cardinal Jimenez insisted on adopting coercive measures. A rebellion ensued, and the Mohammedans were suppressed. Want of power, or other obstacles, delayed the final extinction of tolerated Mohammedanism in all parts of Spain, but by 1525 it was everywhere suppressed. As they were dependent on the protection of the landlords, the Mohammedans were docile tenants, and their competition weighed heavily on the Christians. The same quality of industry remained to the Moriscos, and excited the envy of their Christian fellow countrymen. In 1568 the government of Philip II issued an edict, which ordered them to renounce all their Moorish ways of life and to give up their children to be educated by Christian priests. The result was a rebellion in Granada, which was put down with great difficulty, the Moriscos being finally expelled from the city and scattered over other parts of Spain. The expulsion of the whole body of Moriscos from all Spain was decided on in 1608. The edict was published on Sept. 22, 1609, and the expulsion was carried out with great cruelty. The number driven out has been variously estimated at 120,000 or at 3,000,000.

MORISOT, BERTHE (1841–1895), French painter of the Impressionist school, was born in Bourges on Jan. 14, 1831, the daughter of a high government official. She decided early to be a painter and pursued her goal with the seriousness and abnegation of a dedicated artist. At first attracted by Corot, under whose guidance she worked between 1862 and 1868, she subsequently fell under the spell of Edouard Manet who had a liberating influence on her and in whom she, in turn, aroused an interest in outdoor painting. Manet did several portraits of the attractive young woman who was to marry his brother Eugène. Unlike Manet, Berthe threw in her lot with the Impressionists, with whom she exhibited regularly and in whose struggles she courageously participated. Her delicate and subtle art. the freshness of her technique, her exquisite colours and her true originality won her the admiration and affection of her Impressionist colleagues, but also ridicule and contempt from ignorant critics. A woman of great culture and charm, she counted Mallarmé, Degas, Renoir, Monet and many others among her close friends. She died in Paris on March 2, 1895.

BIBLIOGRAPHY.—D. Rouart, *Correspondance de Berthe Morisot* (1950), *M.* Angoulvent, *Berthe Morisot* (1933); *J.* Rewald, *The History of Impressionism* (1946, 1951). (JN. R.)

MORITZ, KARL PHILIPP (1757–1793), German author whose novels had a place in the development of the romantic *Bildungsroman*, or biographical novel, was born at Hameln, Sept. 15, 1757. He was apprenticed to a hatmaker, became an actor and then studied philosophy. In Italy in 1786, he met Goethe who later invited him to Weimar. In 1789 he became professor of archaeology and aesthetics at the Academy of Arts in Berlin. He died in Berlin, June 26, 1793.

Moritz wrote on aesthetics, prosody, religion and philosophy. The most important of his theoretical works are *Über die bildende Nachahmung des Schonen* (1786) and *Die Götterlehre* (1791). His *Reisen eines Deutsclzen in England* (1783; Eng. trans., 1924) and *Reisen eines Deutschen in Italien*, 3 vol. (1792–93), reveal the detailed observation which distinguishes his novels. His *Blunt oder der Gast* (1781) is the first *Schicksaldrama*, or tragedy of destiny. He is best known by his autobiographical novels *Anton Reiser* (1785–90) and *Andreas Hartknopf* (1786), forerunners of

Goethe's *Wilhelm Meister,* which describe the development of an intellectual during the *Sturm und Drang* period.

See K. F. Klischnig, *Erinnerungen aus zehn letzten Lebensjahren meines Freundes Anton Reiser* (1794); R. Minder, *Die religiose Entwicklung von K. P. Moritz* **(1936).**

MORLAIX, a town of western France, capital of an *arrondissement* in the *département* of Finistère, 37 mi. E.N.E. of Brest on the railway to Rennes. Pop. (1954) 12,929. Coins found there suggest that Morlaix was probably occupied in the time of the Romans. The counts of Leon held the lordship in the 12th century, but the dukes of Brittany disputed possession with them, and in 1187 Henry II of England, guardian of Arthur of Brittany, besieged and took the town.

During the Hundred Years' War Morlaix was held by French and English in turn, and was pillaged by the latter in 1522. Mary Queen of Scots, on her way to be married to the dauphin, made solemn entry into Morlaix in 1548. The town having joined the Holy League, the castle was taken by storm in the name of Henry IV in 1594. Morlaix lies ½ mi. from the English channel in a narrow valley. Below the town the river Dossen widens into an estuary, the mouth of which is commanded by the Chbteau du Taureau, built in 1542 for defense against the English. The railway from Paris to Brest crosses the valley on a two-storied viaduct 200 ft. above the quays. Morlaix contains several wooden houses of the 15th, 16th and 17th centuries. These have large covered courts, with huge open fireplaces and carved wooden staircases, supported on pillars, leading from the court to the upper stories.

The town of Morlaix has a subprefecture, a tribunal of commerce and a chamber of commerce. Industries include the manufacture of tobacco, tanning, brewing and the manufacture of casks, wooden shoes and candles; there is an active trade in grain, agricultural produce, oilseeds, leather, wax, honey and in horses and other livestock. Fruit and vegetables are exported to Great Britain and the Channel Islands. The port, consisting of an outer tidal harbour and an inner basin, admits vessels drawing 16 ft. at spring tides and 11 ft. at neap tides.

MORLAND, GEORGE (1763–1804), English genre, landscape and animal painter, was born in London on June 26, 1763, son of the painter and picture restorer Henry Robert Morland. At the age of ten, Morland exhibited sketches at the Royal Academy, and he was bound apprentice to his father from 1777 to 1784. He drew from the antique and copied from George Stubbs' *Anatomy of the Horse,* from Gainsborough, C. J. Vernet and Reynolds. In 1780 his first signed engraving, "The Angler's Repast," was published, and a year later his first oil painting, "Hovel With Asses," was exhibited at the Academy; now also he began, unknown to his father, to paint *galanteries* (scenes of love and compliment) for a Drury Lane publisher, and to associate with the demimonde.

After his articles had expired, he studied briefly at the Royal Academy schools, and held his first one-man show of paintings on private premises, having previously rejected George Romney's offer to employ him as his studio assistant. Throwing off parental restraint, in 1785 he visited Calais and St. Omer, and rode as an amateur jockey at Margate, Kent. In July 1786 he married Anne Ward, sister to William, the engraver. Settled in lodgings in Marylebone, London. Morland painted the series "Laetitia, a Harlot's Progress" (engraved by J. R. Smith), and in 1787 he abandoned portraiture for sentimental rustic genre, which, through Ward's engravings, satisfied a steady public demand for the picturesque. Morland's deliberate flaunting of commissioned work in which the patron dictated the subject, scale and medium and his policy of selling through an intermediary anticipated the situation whereby artists sought to please a wide public with unexceptional, easily comprehensible works.

Morland's best work occurs between 1787 and 1794 and a typical example is the "Inside of a Stable" (National gallery, London) exhibited at the 1791 Academy, the year in which the artist's extravagances forced him, despite his successes, to flee his creditors. After 1794 his powers deteriorated. and he alternated between periods of dissipation and concentrated work until his arrest in 1799. Released by the Insolvent act, 1802, but enfeebled in health and still pursued by creditors, he escaped to his brother Henry's house in Dean street, Soho. This same Henry had, during the previous eight years, unscrupulously exploited him, selling nearly 500 of his paintings alone. Arrested again on Oct. 19, 1804, Morland died of a brain fever ten days later.

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MORLEY, HENRY (1822–1894), British man of letters, was born in London on Sept. 15, 1822. He was sent to the Moravian school at Neuwied, whose system strongly influenced his subsequent theories of education. After an experiment in medical practice, which failed through the dishonesty of his partner, he set up a small school for young children at Liscard, near Liverpool. His principle was to abolish all punishment, to make his pupils regard their work as interesting instead of repellent, and to form their character by appealing exclusively to higher motives. The scheme proved a complete success. In 1851 he settled in London, on the invitation of Charles Dickens, as a regular contributor to *Household Words.* He was also on the staff of the *Examiner,* which he edited from 1861 to 1867. Meanwhile he wrote admirable monographs on *Palissy the Potter* (1852), *Jerome Cardan* (1854), *Cornelius Agrippa* (1856), *and Clément Marot* (1870). His dramatic criticisms were reprinted in 1866 under the title of *The Journal of a London Playgoer, 1851–1886.* In 1857 he was appointed evening lecturer in English literature at King's College, and in 1865 succeeded David Masson as professor of English literature at University college, London He published in 1864 the first volume of a monumental history of English literature entitled *English Writers,* which he eventually carried in eleven volumes down to the death of Shakespeare. He was indefatigable as a popularizer of good literature. After editing a standard text of Addison's *Spectator,* he brought out a vast number of classics at low prices in Morley's Universal Library, Cassell's National Library and the Carisbrooke Library. In 1882 he became principal of University Hall, which was a place of residence for students of University college and the home of Manchester New college. Morley was an untiring advocate of a teaching university for London. In 1889 he resigned his offices and retired to Carisbrooke, Isle of Wight, intending to devote his leisure to the completion of his *English Writers.* But with his work only half achieved he died on May 14, 1894.

MORLEY [OF BLACKBURN], **JOHN MORLEY,** VISCOUNT (1838–1923), English statesman and author, was born at Blackburn on Dec. 24, 1838, the son of Jonathan Morley, surgeon. He matriculated at Lincoln college, Oxford, in 1856, and in 1859 came up to London to pursue a literary career. He became editor of the moribund *Literary Gazette,* which not all his ability could preserve from extinction. Gradually, however, he became known as a philosopher and a radical, and as one of the ablest and most incisive contributors to the literary and political press of the day. His sympathies as a thinker seem to have been at this time chiefly with positivism, and he acquired a reputation as an agnostic, which became confirmed in the popular mind when he somewhat aggressively spelt God in one of his essays with a small "g." From 1868 to 1870 he was editor of the daily *Morning Star.* In 1867 he succeeded G. H. Lewes in the editorship of the *Fortnightly Review,* which he conducted with brilliant success until 1883, when he was elected to parliament; he then assumed in exchange, but not for long, the editorship of *Macmillan's Magazine.* He had been connected with Messrs. Macmillan since the commencement under his editorship, in 1878, of the "English Men of Letters" series, in which nothing is better than the editor's own contribution, *Life of Edmund Burke,* an extension of his article in the 9th edition of this encyclopædia (1876). Since 1880 he had also been editor of the *Pall Mall Gazette,* which had been turned into a Liberal paper. *(See* NEWSPAPER.)

In 1883 Morley, who had twice unsuccessfully attempted to enter parliament, was returned for Newcastle-upon-Tyne at a by-election. The prestige thus acquired led to his presiding over a

great Liberal congress at Leeds in the same year; and, although the platform never seemed his natural element, the literary finish of his style and the transparent honesty of his reasoning rapidly gained him a prominent position in the House of Commons. When, in February 1886, Gladstone returned to office as a home ruler, Morley, who had never before held any public appointment, filled one of the most important posts in the cabinet as secretary for Ireland. He had always expressed his sympathy with the Irish Nationalist movement. He had no opinions to recant, no pledges to explain away. He is credited with an especial influence over Gladstone in the matter of home rule, and in particular with having kept him steady in the Bill of 1886 to his original purpose of entirely separating the Irish from the British legislature, a provision which pressure from their own party afterwards compelled both of them to abandon. After the severe defeat of the Gladstonian party at the general election of 1886, Morley led a life divided between politics and letters until Gladstone's return to power in 1892, when he resumed his former office. There was a strong current of disapproval in his own constituency of his attitude to the Eight Hours' Labour Bill, which he regarded as an interference with personal liberty, and to a less degree of his anti-Imperialist views. The result was that at the election of 1895 he lost his seat, but soon found another in Scotland, for the Montrose Burghs. He had during the interval taken a leading part in parliament, but his tenure of the chief secretaryship of Ireland was hardly a success. The Irish gentry, of course, made things as difficult for him as possible, and the path of an avowed home ruler installed in office at Dublin Castle was beset with pitfalls. In the intestine disputes which agitated the Liberal party during Rosebery's administration, and afterwards, Morley sided with Sir William Harcourt, and was the recipient and practically co-signatory of his letter resigning the Liberal leadership in December 1898.

Morley's activities were now again turned to literature, the political views most characteristic of him, on the Boer war in particular, being practically swamped by the overwhelming predominance of unionism and imperialism. As a man of letters his work was practically concluded at this period, and may briefly be characterized. His position as a leading English writer had early been determined by his monographs on *Voltaire* (1872), *Rousseau* (1873), *Diderot and the Encyclopaedists* (1878), *Burke* (1879), and *Walpole* (1889). His *Life of Oliver Cromwell* (1900) revises Gardiner as Gardiner revised Carlyle. The *Life of Cobden* (1881) is an able defence of that statesman's views rather than a critical biography or a real picture of the period. He had the true admiration of the philosopher for the man of action, Walpole and Cromwell fascinated him for this reason, and Stafford perhaps more than they. At the same time his political experience gave him a wider view of the necessities of practical statesmanship than, for instance, Acton. Morley's contributions to political journalism and to literary, ethical and philosophical criticism were numerous and valuable. They show great individuality of character, and recall the personality of John Stuart Mill, with whose mode of thought he had many affinities. As in letters, so in politics. A philosophical radical of a somewhat mid-19th-century type, and highly suspicious of the later opportunistic reaction (in all its forms) against Cobdenite principles, he yet retained the respect of the majority whom it was his usual fate to find against him in English politics by the indomitable consistency of his principles and by sheer force of character and honesty of conviction and utterance.

After the death of Gladstone Morley was principally engaged upon his biography. Representing as it does so competent a writer's sifting of a mass of material, the *Life of Gladstone* (1903), was a masterly account of the career of the great Liberal statesman; traces of liberal bias were inevitable but are rarely manifest; and in spite of the *a priori* unlikelihood of a full appreciation of Gladstone's powerful religious interests from such a quarter, the whole treatment is characterized by sympathy and judgment. In 1902 he received the new Order of Merit.

When Campbell-Bannerman formed his cabinet at the end of 1905 Morley became secretary of state for India. In this position he was conspicuous in May 1907 and afterwards for his firmness in sanctioning extreme measures for dealing with the outbreak in India of alarming symptoms of sedition, in which he was bitterly attacked by some of the more extreme members of the Radical party. At the same time he showed his popular sympathies by appointing two distinguished native Indians to the council, and taking steps for a decentralization of the administrative government. When Campbell-Bannerman resigned in 1908 and Asquith became prime minister, Morley retained his post in the new cabinet; but was transferred to the upper house, with the title of Viscount Morley of Blackburn. His subsequent career at the India Office will always be associated with his extensive remodelling (1908–1909) of the system of government in India so as to introduce more fully the representative element. (*See* INDIA.) In his tenure of this office he showed again something of the philosopher's leaning to despotism. He admittedly kept his private conclusions out of his public actions, to a certain extent. The author of the essay *On Compromise*, the very Gospel of dissent, was in practice convinced that "the first duty of a government is to govern," and there was never a secretary of state who treated his viceroy more despotically. (See MINTO, GILBERT JOHN MURRAY KYNYNMOND ELLIOT, 1ST EARL OF.) Similarly by communicating privately with the viceroy he tended to deprive the Council of State of information and influence on foreign policy. And though primarily responsible for the first great step towards Indian self-government, he disowned the Mbntagu-Chelmsford reforms as premature. Lord Morley held the seals of the India Office till Nov. 1910. One of his last official acts had been to resist the appointment of Kitchener to the vice-royalty, pressed strongly upon ministers by King Edward just before his death. Morley remained in the cabinet as lord president of the council, and was one of the four counsellors of state to administer the kingdom during King George's visit to India in 1911–12.

In the critical period of domestic politics which began with the budget of 1909 he played a somewhat prominent part. He defended that budget in the great debate of November 1909 and, while admitting that the Lords had the legal right of rejection said that to assert it was a "gambler's throw." Morley led the House of Lords during most of the session in which the Parliament bill, which he warmly supported, was passed; and it was he who read out to the House on the last night of debate that definite assurance from King George of his assent to a creation of peers which finally secured the exiguous but adequate majority of 17.

The entrance of Great Britain into the World War brought Morley's official career to an abrupt termination. He felt that his pacifist outlook was sufficiently well-known to make it unnecessary for him to give reasons for resigning; and he retired to Wimbledon, where he wrote his *Recollections* (2 vols. 1917). In 1921 his publishers brought out a complete edition of his works; and he was generally regarded, during his last years, as sharing with Mr. Hardy the position of *doyen* of English men of letters. He died at Wimbledon on Sept. 23, 1923.

See, in addition to the *Recollections*, Sardār 'Ali Khan, *Life of Lord Morley* (1923); J. H. Morgan, *John, Viscount Morley* (1924); F. W. Hirst, *Early Life and Letters of John Morley* (1927). Morley's *Memorandum on Resignation*, 1917, was posthumously published in 1928.

MORLEY, SAMUEL (1809–1886), English manufacturer and politician, was born on Oct. 15, 1809 at Homerton, the youngest son of a Nottingham hosier. In 1825 he entered his father's London warehouse, and when his father retired in 1840 became practical head of the London concern, and when his brothers retired in 1855 sole owner. In 1860 he was sole owner also of the Nottingham business, which grew rapidly, with huge mills at Nottingham and in Leicestershire and Derbyshire employing thousands of hands. In 186j Morley was elected Liberal M P. for Nottingham, and from 1868–85 sat for a Bristol division. He was one of the principal proprietors of the London *Daily News*. Morley was a deeply religious man, interested in the temperance movement, unstinting in charity, and a model employer. He died on Sept. 5, 1886.

See E. Hodder, *Life of Samuel Morley* (1887); F. M. Thomas, *I. and R. Morley: a Record of a Hundred Years* (1900).

MORLEY, THOMAS (1557–1603), English composer, was a pupil of William Byrd, but nothing is known as to his origin and very little as to the incidents of his career. He was organist of St. Giles. Cripplegate, in or before 1588, the year in which he was admitted Mus. Bac. at Oxford, and shortly after this he became organist of St. Paul's cathedral. In 1592 he was made a gentleman of the Chapel Royal (where he successively filled the offices of epistoler and gospeller) but continued to hold his post at St. Paul's. On Sept. 11, 1598, Morley received a licence for 21 years to print ruled music paper and sopg books in English, Latin, French or Italian. His rights under this grant were assigned to him by various publishers. On Ort. 7, 1602, his place in the Chapel Royal was filled up, and on Oct. 25, 1603, administration of his goods was granted to his widow,

Morley was incontestably one of the greatest of the secular Elizabethan composers. His madrigals. canzonets and ballets are remarkable for their beauty and admirable workmanship, and his *Plaine and Easie Introductione to Practicall Musicke* (1597; new ed. by R. Alec Harman, London, 1952), in spite of its frequent obscurity, is invaluable for the history of musical science in England. Besides his secular works, services, anthems, motets and virginal pieces by Morley are to be found in various collections, both printed and manuscript. He was the editor of the important book of madrigals *The Triumphs of Oriana* (1601), a collection of 25 compositions by different composers in praise of Queen Elizabeth.

MORLEY, a municipal borough in the Batley and Morley parliamentary division of the West Riding of Yorkshire, England, 5 mi. S.W. of Leeds. Pop. (1951) 39,787. Area 14.8 sq.mi. The town is on a spur of the Pennines, at an altitude of 450–600 ft. In the neighbourhood are the ruins of Howley hall, dating from 1580. Here. during the Civil War, the parliamentary army sustained a heavy siege from the Royalists. The chief industries are connected with the manufacture of woollen materials, but coal mining. stone quarrying, glass making. tanning and bookbinding are also carried on. Morley was chartered in 1885 and greatly enlarged in 1937. It is the birthplace of the earl of Oxford and Asquith (1852–1928).

MORMAOR or MORMAER, a title of the rulers of the seven provinces into which Celtic Scotland (*i.e.*, the part of the country north of the Forth and the Clyde) was divided (Gael. *mor,* "great," and *maor,* "steward" or "bailiff"). These seven mormaorships, or original "earldoms" of Scotland, as they were afterward called, were: Angus, Atholl with Gowrie, Caithness with Sutherland, Fife, Mar with Buchan, Moray with Ross and Strathearn with Menteith.

MORMONS: *see* LATTER-DAY SAINTS, CHURCH OF JESUS CHRIST OF.

MORMYR (Mormyridae), the name of a family of fishes restricted to the fresh waters of Africa. soft rayed fishes with abdominal pelvic fins, a small mouth with few teeth, small eyes, restricted gill openings and small scales. The brain is very large, with a great convoluted cerebellum. and enlargements in other regions that suggest that these fishes have the senses of taste and hearing particularly well developed. (V. Franz, *Zool. Jahrb. Anat. Abth.,* 1911.) A loosely attached bony plate on each side of the head covers a vesicle which communicates with the internal ear; paired electric organs of no great potency are present in the tail. About 120 species are known, strange-looking fishes, exhibiting great diversity, some having the mouth at the end of a long snout which resembles the trunk of an elephant. Most feed on small prey, or on weeds or organic debris. The Nile species are represented in ancient Egyptian mural paintings and hieroglyphics.

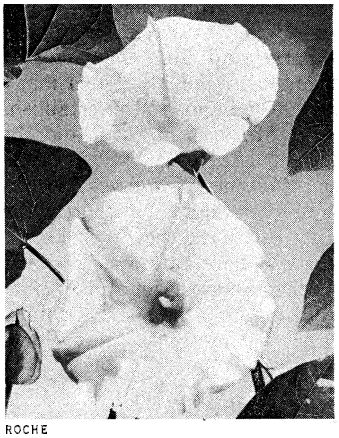
MORNAY, PHILIPPE DE (1549–1623), SEIGNEUR DU PLESSIS-MARLY, usually known as DUPLESSIS-MORNAY, French Protestant, was born at Buhy in Normandy on Nov. 3, 1549. His mother had leanings toward Protestantism. and he became a Protestant early in life. He completed his education at Heidelberg and at Pavia, studying Hebren and law. He then visited the Netherlands Offering his services to the Reformers in France, he began collaboration with Gaspard de Coligny in plans for war against Spain. After the massacre of Saint Bartholomew's day he took refuge in England. Having returned to France in 1573, he fought under Henry of Navarre, whose right-hand man he was to become. Taken prisoner on Oct. 10, 1575, he was ransomed for a small sum. Shortly afterward he married Charlotte Arbaleste at Sedan.

Subsequently he became more and more influential as adviser to the king of Navarre and as an outstanding Protestant leader (he was popularly known as "the Huguenot pope"). With the idea of uniting all Frenchmen under a religious system that would give free reign to the Reformed Churches or establish a national church on the Anglican model, he sought to turn royal policy against the Catholic league and against Spain. The reconciliation between Henry III of France and Henry of Navarre was to some extent due to him. On Henry III's death Mornay took part in all the campaigns that won the kingdom of France for Henry of Navarre as Henry IV; he was present at the siege of Dieppe (1589), at Ivry (1590) and at the siege of Rouen (1591–92). But his beliefs were too absolute for him to accept Henry's conversion to Catholicism, and he objected to the concessions made to the Catholic party and to the papacy. This impaired his good relations with Henry, to whom he found himself increasingly opposed as spokesman of the Reformed Churches.

Having been appointed governor of Saumur in 1589, he established there an academy or university that was to have a considerable influence on the development of the Protestant party in France. In 1598, however, he published a work on which he had long been engaged, *De l'institution, usage et doctrine du sainct sacrement de l'eucharistie en l'église ancienne,* containing about 5,000 citations from Scripture. The bishop of Evreux, Jacques Davy Duperron (*q.v.*) accused him of misquotation in this work; and a public disputation at Fontainehleau in 1600, which however was not impartially conducted, resulted in Mornay's discomfiture, the king himself putting the final touch to it. Mornay's difficulties increased in the years that followed, particularly under Louis XIII, when the government favoured a policy of *rapprochenzent* with the papacy and with Spain; and he made his opposition even clearer in the assemblies of the Protestant party during its revolt (1620 ff.). From 1621, when he was deprived of the government of Saumur, his disgrace was complete.

Mornay's numerous writings include political tracts such as the *Discours au roi Charles* (1572), *Remonstrances aux estats pour la paix* (1576) and *Remonstrances à la France* (1585), as well as specifically religious works, such as the *Trait6 de l'église* (1578), *De la vérité de la religion chrestienne* (1581), *De l'institution du sainct sacrement* (1598, *see* above) and *Le Mystère d'iniquité* (1611). He is thought to have helped compose the famous pamphlet *Vindiciae contra tyrannos* (1579; *see* LANGUET, HUBERT). His *Mémoires et correspondance* (coll. ed., 12 vol., Paris, 1824–25) supply information on French Protestant policy. *See* also his wife's biography of him, *Mdmoires de Mme Duplessis-Mornay,* in vol. i of *Mémoires et correspondance.* (R DT.)

MORNING-GLORY, the name given to the widely cultivated twining annual vine (*Ipomoea purpurea*), family Convolvulaceae (*q.v.*), native to tropical America. It bears broad, heart-shaped, short-pointed leaves and large funnel-form. blue or purplish flowers, two to three inches long.



ROCHE

WILD MORNING-GLORY OR BINDWEED (CONVOLVULUS ARVENSIS)

There are many races in cultivation, some with double flowers, and varying in colour. The hedge bindweed and the small bindweed (*Convolvulus arvensis*), especially when they become injurious weeds. are called wild morning-glory. For the wild morning-glory, or hedge bindweed, see HEDGE BINDWEED.

MORNY, CHARLES AUGUSTE LOUIS JOSEPH, DUC DE (1811–1865), French statesman, natural son of Hortense Beauharnais (wife of Louis Bonaparte) and Charles Joseph, comte de Flahaut (*q.v.*), and thus half-brother of Napoleon III, was born in Paris on Oct. 21, 1811, and registered as legitimate son of Auguste Jean Hyacinthe Demorny, described inaccurately as a landowner of San Domingo. The comte de Morny, as he was called. passed through the staff college and served in Algeria in 1834–35 as aide-de-camp to Gen. C. A. Trézel, whose life he saved outside Constantine. In 1838 he established a beetroot-sugar industry at Clermont in Auvergne. Soon there were few great commercial enterprises in Paris in which he did not have an interest. He sat in the chamber as deputy for

Clennont-Ferrand from 1842 onward and was heard with respect on industrial and financial questions. In 1849 he was admitted to the intimacy of Louis Napoleon, and he helped to engineer the coup *d'état* of Dec. 2, 1851. After six months as minister of the interior, he resigned and resumed his financial speculations. From 1854 until his death he was president of the corps *législatif,* a post in which he exercised great influence.

In 1856 Morny went as special envoy to the coronation of Alexander II of Russia; and he married Princess Sophie Troubetskoy while still in Russia. He encouraged Napoleon III's liberalizing policy after 1860 and was created a duke in 1862. He was the most intelligent of the emperor's supporters and his influence with him was great. He died in Paris on March 10, 1865.

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MORO, ANTONIO: see MORE, SIR ANTHONY.

MORO ("Moor"), a name given by Spaniards to the people of Sulu, an island and an archipelago between Borneo and the Philippines, because of their religion; but although the Moros are Moslems they were formerly Hindu in part, while the aborigines, probably of Dyak affinities, are traditionally related to have worshipped tombs and stones of various kinds and one genealogy starts with a prophet who sprang from a bamboo. Besides, Malays of Minangkubau (see MENANGKABAU), Bugis (*q.v.*) from the Celebes, Samals from Johore and Ilanuns from Mindanao have settled in Sulu, and the population has been mixed further by innumerable importations of slaves from all the islands in the Philippines; in Sulu itself there is a traditional division of the slave population into red-, white-, black- and blue-eyed in the four quarters of the island. The Moros have legal codes drawn up in Arabic. (J. H. H.)

MOROCCO, in French MAROC, an independent country of North Africa, lies between lat. 35° and 29° N. and between long. 10° and 1° W. Morocco is bounded on the north by the Mediterranean, on the west by the Atlantic ocean, on the south by the Spanish Sahara and on the east by Algeria. On the Algerian border, the treaty of 1845 between France and Morocco fixed the frontier over only about 60 mi. from the sea to the point called Teniet es-Sassi; beyond that there was merely an indication as to which tribes and *ksurs* or villages were Moroccan and which Algerian; in the Sahara all delimitation was considered superfluous. From this absence of definite boundaries and from the fact that France did not claim the natural frontier of the Moulouya many difficulties arose. They were brought to an end by the establishment of the French protectorate over Morocco in 1912. and the question lost much of its interest.

The geographical area of Morocco is divided as follows: Southern zone (former French zone), 154,054 sq.mi.; Northern zone (former Spanish zone), 7,589 sq.mi. (excluding the Spanish possessions of Ceuta, Melilla, Alhucemas, the Chafarinas and the Peñón de Vélez, 82 sq.mi., the southern Spanish zone in dispute between Morocco and Spain, 12,693 sq.mi., and the Spanish colony of Ifni, 741 sq.mi.);'and Tangier (*q.v.*) (formerly an international zone), 135 sq.mi.

PHYSICAL FEATURES

Physical Geography. — From the point of view of structure and relief, one may distinguish five great divisions: (1) the coastal massifs which border the Mediterranean, separated from the Atlas system by the depression of the Sebou and the Innaouen; (2) the plains and plateaus of western Morocco; (3) the High and Middle Atlas; (4) the country of the pre-Sahara; (5) eastern Morocco.

The coastal massifs correspond, from the political point of view, with the zone of Spanish influence. They comprise three regions, the Jebala in the west, the Rif in the centre and the Garet on the east. The western portion of the coastal massifs, as far as the valley of Wad Nkur and the Bay of Alhucemas, belongs to the Alpine fold system; crystalline and Palaeozoic rocks outcrop on the coast; then comes a much folded axial zone, made up chiefly of Liassic and Nummulitic limestones (Jebel Tiziren, 8,154 ft.); finally there is a frontal zone of southward-directed overfolds which constitute the pre-Rif. The chains are arranged in an arc of a circle, and form the counterpart of the Baetic cordillera (Sierra Nevada). The country is dissected by deep ravines which give it, in places, a chaotic aspect. The slopes toward the Mediterranean are sharp and the rivers rapid. The coast is mountainous and cut into arc-shaped bays; on the Straits of Gibraltar are Tangier, Ksar es-Serir and Ceuta; between Ceuta and the Nkur lie the bays of Tetuan, of Badis (Peñón de Vélez) and of Alhucemas. To the east of Wad Nkur the folds are well marked and the structure of the country much more simple; the dryness increases, and in the Garet the steppe reaches nearly to the coast. To the east of Cape Tres Forcas lies the Bay of Melilla, near to which stretches the sebkha of Bou-Erg, then comes the bay sheltered by the Cap de l'Eau, beyond which lie the Chafarinas, not far from the mouth of the Moulouya.

The plains and plateaus of western Morocco stretch from the Atlantic to the foot of the Atlas. They include two different regions: El Gharb and El Haouz (Hauz), or the ancient kingdoms of Fez and Marrakesh. El Gharb has a varied relief, the influence of the coastal massifs extending as far as Fez and the massifs of Zarhun and Zalagh; the hills of El Gharb frame the alluvial plains of the Lukkos and the Sebou (Sbu), on the estuary of which stand the ports of Larache and Mehdia, respectively. The great east-to-west depression which links Algeria and Morocco by Oujda (Oudjda, Ujda), Taza, Fez and Meknès and separates the coastal massifs from the Atlas opens on the Atlantic by the plain of the Sebou; it is the corridor of Taza. The coast is flat, bordered with dunes and marshes. The Sebou, rising in the Middle Atlas under the name of Oued (Wad) Guigo, receives the Innaouen, the Ouergha, the Oued Mikkès, Oued Rdom and Oued Beht. In its lower course the Sebou meanders and spreads among the marshes or *merdjas;* it has an average discharge of 40 cu.m. (minimum 12 cu.m.); it is tidal as far up as Port Lyautey and more or less navigable to Mechra-bel-Ksiri. The triangular stretch of country between the Atlantic coast from Rabat to Cape Guir and the Atlas constituted the Moroccan meseta, the subsoil of which is formed of anciently folded Archaean and Palaeozoic rocks incompletely covered by thin layers of Secondary and Tertiary age. The ancient rocks have been to some extent levelled down and form the dissected peneplain of Morocco's "Massif Central" (the country of the Zaer and the Zaïan), the hills of the Rehamna and the little mountains known as the Jebilet. They are covered by a thin layer of Upper Cretaceous and Lower Eocene on the "phosphates plateau" and sink under the recent alluvial deposits that constitute the inland plains of the Tadla and the Haouz of Marrakesh. The coastal plain (country of the Chaouïa, of the Doukkala and of the Abda), 60 to 80 km. wide, is very fertile, especially the black clay lands called *tirs;* further from the sea one passes gradually to the steppe. Then cultivation begins again at the foot of the Atlas, thanks to irrigation. The rivers of the meseta run in a small number of ravines deeply dissecting the plateau. The Bou Regrag, reaching the sea at Rabat, is unimportant. The Oum er-Rbia, on the contrary, is the largest river of northwestern Africa: rising in the Middle Atlas, it runs at first in a deep narrow tectonic valley as far as Khenifra, then crosses the plain of Tadla, receives the Oued el-Abid and the Tessaut, both rising in the High Atlas, encases itself deeply from Mechra-ben-Abbhou to Bou-Lauan and reaches the sea at Azemmour; its average discharge is more than 80 cum., minimum 35 cu.m. The much smaller Tensift drains the plain of Marrakesh; its left bank affluents, the wadis Rdat, Reraïa, Ourika and Nfis, bring it the drainage of the High Atlas. The coast of the meseta is extremely monotonous and even and is in general edged with dunes with several shallow lagoons. The surf is very strong, and before the French protectorate there were only open roadsteads.

The High Atlas, with its adjunct the Middle Atlas, forms the major mountain system of North Africa. Little mountains of limestone (Jurassic and Cretaceous), with undulation and faulting, rise first above the Atlantic. Then, between the Tizi

n-Mâchou, the Tizi n-Tichka (*tizi* is Berber for "pass") and the plains of the Haouz and the Sous, the western ranges of the High Atlas rise to heights of about 10,000 ft. (Jebel Toubkal, 13,665 ft.; Jebel Ouanoukrine, 13.386 ft.). The Oued Nfis valley and the Tizi n-Test divide it into two parts. There are cirques in places, bearing witness to a slight Quaternary glaciation; but most of the peaks are solid in appearance and make a contrast with the recent formation of the valleys and transverse ridges. In the eastern ranges of the High Atlas the Primary rocks are lost under thick Jurassic sediments, mostly limestone with folding. The peaks, which are still prominent toward the west (Mgoun, 13,356 ft.; Jebel Ayachi, 12,303 ft.), are lower toward the east between the high steppes of eastern Morocco and the Sahara, and drought increases from west to east. The Middle Atlas, a branching off of the High Atlas, rises between the Oued el-Abid and the Taza corridor. A massif consisting mainly of Jurassic limestone, it includes, in the northwest, plateaus (3,000–5,500 ft.) relieved by karstic features and dominated by Tertiary and Quaternary volcanic cones and coulees and also, to the south and east of the plateaus, moderately folded but prominent chains (Jebel Bou Naceur, 10,794 ft.). Because of its comparatively high precipitation and fine forests the Middle Atlas has been called "the water tower of Morocco."

Southern Morocco, pre-Saharan and Saharan, consists of Pre-Cambrian and Primary rocks of the "African shelf." This shelf rises to more than 6,500 ft. in the Anti-Atlas mountains, which are continued by the Jebel Sagho; these mountains dominate the depressions of the Sous and the Dadès (which have the volcanic massif of the Siroua between them), and fall toward the desert, intersected by ridges such as the Jebel Bani. To the south and the east, the ancient shelf is covered by the alluvial deposits of the wadis Draa. Gheris, Ziz and Guir (which make possible the irrigation of numerous oases) and by horizontal sediments (Cretaceous and Tertiary) forming desert plateaus known as *hamadas*.

Eastern hlorocco is in fact merely an extension of Algeria. East of the long depression of the Moulouya valley there are, as one goes from north to south, first the plains of the Triffa and of Oujda, which are separated by the massif of Beni Snassen; then plateaus and steppes covered with alfa grass; and finally the last links of the High Atlas chain, which is prolonged by the Ksour mountains of Algeria, with wide intervals such as that of the plains of Tamlelt.

Climate. — The climate of Morocco is a Mediterranean one, modified by the Atlantic. The climate is more favourable than that of the rest of Barbary because the country is bathed by two seas and its high mountains keep the snow longer than elsewhere. The temperature is equable and quite cool for the latitude on the west coast; at Mogador the January mean is 61.5° F. and the August mean 72.3° F. Toward the interior the climate rapidly becomes more continental, with increased winter cold and very great summer heat; at Fez the January mean is 50° and that of August 80.6°. The rainy season is from October-November to April-May; it becomes shorter and less severe as one goes south toward the belt of the trade winds. The mean annual rainfall is 37.6 in. at Tangier, 21.6 in. at Rabat, 16.7 in. at Casablanca, 13.9 in. at Mazagan, 11.1 in. at Mogador; on the coast the dew is very abundant. Toward the interior the rainfall diminishes (Marrakesh, 9.6 in.), but it is higher on the western slopes of the mountain massifs. The country of the Jebala, the western Middle Atlas, receives the highest rainfall; the regions of Meknès and of Fez, the corridor of Taza, open to the wet westerly winds, also have abundant precipitation (Meknès 23.7 in., Fez 22.8 in., Taza 28.2 in.). Eastern Morocco, on the contrary, cut off from the moist winds by the great chains, is less favoured (Melilla 15 in., Oujda 14.2 in., Berguent 7.3 in., Bou-Denib 4.2 in.). Snow falls several times a year at altitudes of more than 3,000 ft. and disappears from the high peaks only at midsummer.

Vegetation. — The vegetation reflects the diverse influences of the climate; it is clearly Mediterranean in character; in the south a certain number of plants from the Canaries are found. The presence in the southwest, from Safi to Oued Noun, of the argana (Argania sideroxylon), which belongs to the family Sapotaceae, is a remarkable botanical peculiarity. In the mountains, the vegetation takes on a more northerly character, many central European species and a certain number of Alpine plants being found there. The well-watered regions are covered by forest except where it has been destroyed by man, as is the case in the plains of the west. The dominant species are oaks and conifers. The cork oak constitutes the great forest of Mamora (309,000 ac.); in the Middle Atlas there are fine cedar forests (371,000 ac.); the evergreen oak, the Zen oak, the thuya and the juniper are widespread. The argana forms a widely spaced growth, a kind of forest-steppe. The forest passes into maquis, this into steppe, grassy when the rains are sufficient, and the steppe into desert. The fauna also is Mediterranean. The lion has disappeared; the panther and the macaque are common, as are also the jackal and the fox (fennec). Antelopes (gazelles) are numerous. (A. Be.; J.-J. Ds.)

HISTORY

Numerous archaeological remains, in particular a series of remarkable megalithic structures, prove the antiquity of human occupation in Morocco. But the earliest historical records relating to this region are those of Hanno's *Periplus*, which mentions that Carthaginian colonies were planted along the coast. In the last century B.C. Moroccan Berbers were supplying troops to Pompey or Sertorius, and later, under Augustus, they became incorporated in the Roman province of Mauretania (*q.v.*; see also Africa, Roman). But the Roman province reached only to the Bou Regrag, on which Sala, now Salé (Salli), was its outpost; Volubilis, near Meknès, of which impressive remains are still visible, being its principal, if not its only, inland city. In the 5th century A.D. the country became subject to the Vandals and its fortunes form part of the general history of North Africa.

THE FIRST MOSLEM DYNASTIES

The coming of the Arabs under 'Okba in 682 was a turning point in this history, though it was not till 20 years later that his successor, Musa ibn Nosair, undertook a successful expedition as far as Tafilelt and the Draa. The force of 10,000 Arabs and Egyptians with whom Tarik ibn Zaid held the Tangier district in 710 was trebled by the enrolment of the Berbers, who enabled him next year to invade Spain. But in 739 the Moroccan Berbers successfully revolted, setting up their first independent ruler, Maisara. Their kinsmen in Spain followed suit with equal success, and. though subdued for a time, they retained their independence in certain parts till the 11th century, when, as masters of Granada, they subjugated the Arabs; and finally, under the Almoravides and Almohades, conquered all Mohammedan Spain.

The recorded history of the Moorish empire commences with the settlement near the Roman ruins of Volubilis in A.D. 788 of Idris the Elder (Idris ibn Abdullah), one of the fugitive descendants of Mohammed, during the struggles between rival claimants of the caliphate. Islam at that time had been established in those parts for 80 years, and Idris and his son, Idris II, the builder of Fez, united the Berbers into a kingdom. Their line controlled a limited portion of northern Morocco for nearly two centuries, in part supplanted by the Miknasa in 922, until displaced by the Maghrawa in 988. These two dynasties were exterminated in 1061 by Yusuf I ibn Tashfin, founder of the Almoravide dynasty of Berbers, who annexed the remainder of Morocco and Tlemçen. Their principal existing monument is the city of Marrakesh. In 1149 the Almoravide power was overthrown by another religious leader, 'Abd ul-Mumin at the head of the Almohades, under whom the hloorish empire reached its zenith at the close of the 12th century. It then included, in addition to the Almoravide realm, modern Algeria, Tunisia and Libya, extending to the frontier of Egypt, which they were prevented from occupying by the rise of Saladin. Before the middle of the 13th century they had been driven out of Spain, and had lost all but what is now known as Morocco, whence, between 1217 and 1269, they were ousted by the Beni Marin (Marinides). (See Almohades; Almoravides.)

The new dynasty differed from the two which had preceded

it in being frankly part of a Berber tribe, the Zenata, who carved out a kingdom for themselves. Having assisted the Almoravides and Almohades, respectively, at the battles of El Arcos (1195) and Las Navas de Tolosa (1212), the defection of their amir on that occasion offered an opportunity for 'Abd ul-Hakk, the son of their general, to attempt the overthrow of the reigning house. At first the Beni Marin professed allegiance to Tunis, where the Hafsis, a branch of the Almohades, had thrown off the Moorish yoke and secured acknowledgement in northern Morocco and parts of Spain. But they were soon in a position to proclaim complete independence, and by the time that Abu Bakr, the third son of 'Abd ul-Hakk to succeed him, died, in 1258, they held sway over all that is now known as Morocco, and 1269 saw the death of the last Almohade prince.

On the death of Abu Bakr there succeeded Yakub II, one of the few amirs of Morocco who left a name for just administration and for philanthropic undertakings. Although of strict religious habits, he displayed no bigotry, studying philosophy and entering into friendly intercourse with Europeans, whom he encouraged to trade with Salé. He undertook successful expeditions to Spain in 1261, 127 j and 1277–79 and again in 1284, this time in alliance with Alphonso X of León against his rebel son Sancho. Alphonso dying during the struggle, Yakub found himself master of his country, and Sancho had to acknowledge his suzerainty. All Mohammedans within his realm were freed from all taxes, and all the Arabic manuscripts of the country — 13 loads — were dispatched to the college that he had built in Fez.

But Yakub did not live to reap the benefits of his conquest, which were enjoyed by his son, Tusuf IV (1286), who was courted by his father's old foes, entering into amicable relations with Tunis, Egypt, Arabia and the ncighbouring European states. With the contemporaneous Beni Zeiyan dynasty of Tlemçen, sworn foes of his house. however, he was still at war when stabbed (1307) in the new town of Tlemçen, which he had built while conducting a siege of the old town. A second siege was begun in 1335, and Tlemçen fell in 1337 to the fourth ruler of the dynasty, Ali V Abu 'l Hasan, better known as "the Black Sultan." Unsuccessful in his invasion of Spain and Tunisia, Ali eventually had to abdicate in 1351 in favour of his rebel son, Faris I Abu Ainan, who during a short reign recovered Algeria and Tunisia.

The Beni Marin were soon driven back, till a few years later Tlemgen alone remained to them, and this they held only till 1359 (see TLEMÇEN). Thereafter their empire became habitually divided between rival claimants, and the Portuguese began to obtain footholds on the coast. (B. M.)

The Wattasi dynasty which succeeded the Beni Marin was short lived (1471–1548), the reigns of its founder, Sa'id III al-Wattass, and of his son Mohammed VIII "the Portuguese" being marked by the conquest of Granada by Ferdinand and Isabella the Catholic (1492), the first expulsions of the Moors from Spain (1502) and the first conquests of Spain and Portugal in North Africa (Melilla, Peñón de Vélez and all the Atlantic ports, except Salk-Rabat). Tetuan was founded by the Moorish refugees from Europe.

As a reaction against the conquests of the Christians, a popular and religious movement gave its chance to a new family of sherifs, or nobles. more or less of Arab descent (as contrasted with the native Berber), and more or less related to Mohammed by the female side. The Sa'adi dynasty (1550–1668) rose in the Draa district, on the Sahara slope of the Atlas. They established themselves independently in Marrakesh from 1524, and their first act was to launch a jihad, or "holy war," against the Portuguese. By the end of the 16th century, they had reconquered most of the Atlantic ports.

After Abd ul-Malik—who perished at the famous "battle of the three kings," together with King Sebastian of Portugal and Mohammed XI (whom he had deposed) — Ahmed IV al-Mansur, also called Al-Dahabi, "the Golden," conquered Timbuktu and brought back great riches (especially slaves and gold, whence his name) from the Sudan. He also proved to be a good administrator, in so far, at least, as the makhzan system of government can be considered as good. It consisted principally in pitting certain tribes against the rest (*bled es-siba*) by exemption from taxes and tithes, a doubtful procedure of course, but one which finds an explanation and excuse in the geographical features of the country. in the natural anarchy of perpetually warring tribes and in the fundamental opposition—which can be traced all through the history of Morocco — between the settled urban population and the nomads. Al-Dahabi was also a great builder, erecting, among other monuments, the marvellous pavilion. containing the tombs of the dynasty, in the palace of El Bedi, at Marrakesh, which ranks to this day as one of the most wonderful works of art of northern Africa.

His most remarkable successor was Zidan, who reigned 20 years (1608–28), and also employed a number of European artisans in the palaces he constructed or completed.

THE EARLY FILALI

A fresh outburst of fanaticism partly provoked by the friendship for Europeans shown by Mohammed XIII (1636–54), the last but one of the Sa'adians, but particularly inflamed by a certain number of *marabouts* (Islamic saints), who have always played a great part in the political and religious movements of North Africa, favoured the ambitions of a new dynasty. The Filali or Hassani — Berbers, also (more or less) of mixed Arab descent — sprang from one of the oases of Saharan Morocco, the Tafilelt. Their first representative, Mohammed XIV, captured Fez in 1649. though the dynasty only established itself in Marrakesh (the home of its predecessors) in 1668. The dynasty is still on the throne.

The two brothers of the founder, Rashid II (1664–72) and especially Mulai Ismail "the Bloodthirsty" (1672–1727), solidly established their power. Ismail, who amply deserved his surname, had the attributes of a real sovereign. After his long reign of 55 years he left Morocco, notwithstanding many revolts, a more united empire than it ever was thereafter, until the French protectorate. This was due principally to his bodyguard (which exists to this day, though its role is no longer the same) of Negro slaves (abids). Some of these he settled close to his capital, Meknès, others he distributed in kasbahs (forts) throughout the country, furnishing them with Negro wives and giving a special position to their sons (a selection of whom were taught crafts); they were bound to him besides by a special religious tie: an oath on a copy of the book of *hadith* (sayings of Mohammed) by Al-Bukhari. Whence another name of the bodyguard: the Bukharis. He also employed a foreign legion of renegades. Many hundreds of sons and countless daughters were born to him in a harem rivalling that of Solomon, for which he even asked a French princess of royal blood, Mademoiselle de Blois, a daughter of Louis XIV by Louise de la Vallière and widow of the prince of Conti (1699).

His death was followed by a period of disorders which really ceased only under Mohammed XVI (1757–90).

European Interests. — Commercial relations were first established between Morocco and Europe in the 16th century. Though expelled from the other Atlantic ports conquered by it at the end of the 15th century, Portugal kept Mazagan up to the year 1769. Ceuta and Melilla were retained by Spain after the loss of its other settlements. Portugal had given Tangier up to England in 1662, but Mulai Ismail, who had reconquered Larache from the Spaniards, recovered it for Iblorocco in 1684. Notwithstanding the raids of the famous Salé rovers and other pirates and the many indignities to which thousands of Christians — sailors, merchants, peasants and women being often kidnapped on the Spanish or French coasts or even as far afield as Devon and Cornwall —were subjected as slaves in Morocco, economic intercourse never ceased; and it was considered of sufficient importance to pass over the supplementary humiliation of foreign envoys' being received on foot and bareheaded by mounted sultans under umbrellas. On the other hand, certain treaty privileges were conceded to foreign merchants, the coming of whom was encouraged by certain sultans at least. This was the origin of certain rights confirmed by treaties which survived into the 20th century and became the source of many difficulties among the foreign powers

themselves. The government of Louis XIV, which always took a resolute stand against the Turkish corsairs on the Algerian coast (Algiers was bombarded three times between 1682 and 1687), also dispatched a fleet to Salé. A treaty of commerce was signed with Mulai Ismail on the occasion of the first embassy he sent to France (1682). During the first half of the 18th century, Dutch and English trade was to the fore; the latter profiting greatly by the warehouses established in Gibraltar after its taking by Sir George Rooke in 1704. But French influence reasserted itself by the bombardment of Larache and Salé (1765), and a new treaty (176;) was concluded, confirming that of 1682 and giving the French consuls precedence over those of other nations.

THE 19TH AND EARLY 20TH CENTURIES

With Abd ur-Rahman I1 (1822–59) a new phase began, to which the conquest of Algeria by France in 1830 soon gave a particular leaning. The Moors renounced all claim on the kingdom of Tlemçen, a remnant. with the kingdom of Fez and the kingdom of Tunis. of the vast empire of the Moroccan Almohades. But infractions of the agreements then entered into led to the war of 1844, in which Marshal Thomas Robert Bugeaud de la Piconnerie distinguished himself at the battle of Isly. A bombardment of Salé in 1859 secured for the French the settlement of various claims. War with the Spaniards followed. Tetuan was taken in 1860.

The remainder of the reign of Mohammed XVII (1859–73) was uneventful That of his successor, Al-Hasan (1873–94), was marked by interior troubles, of which he gradually but with difficulty became master. Since 1856 British influence in Morocco had been on the ascent, thanks to the talent and the prolonged embassy (1844–85) of Sir Drummond Hay. He was not in favour of opening Morocco to European influences and tried to limit the "protection" accorded, especially by Spain and France, to certain Moorish subjects. The Madrid conference (1880) gave an exactly opposite result. The possibility of registering "protected" Moors in foreign consulates was extended from the towns to the country. and foreigners acquired certain property rights. Great Britain thereupon partly changed its policy. A special British embassy (1892) tried to obtain an extension of the rights of foreigners, but failed. The following year, incidents in the presidios. between the Rifi and the Spaniards, ended in an important Spanish expedition (25,000 men); and the treaty of 1894. while conceding only insignificant frontier rectifications to Spain, involved the sultan in the payment of about £650,000 indemnity.

The year 1894 saw the ascension of Abd ul-Aziz IV (1894–1908), whose chamberlain. Si Ahmed ben Musa, became vizier and exercised the real power till his death in 1900. The young sultan, who was desirous of reforms and had a taste for foreign arts, sought especially, under the advice of his mother, a Circassian slave, the friendship and advice of Great Britain. But he became the prey of schemers and speculators who pandered to his worst traits and squandered his treasure. The makhzan treasury had to be refilled, the taxes were increased and recovered, as usual, at the point of the sword. The natural consequence was local revolts, two of which were important, that of Jelali Zarboni, nicknamed "Bu Hamara" ("the Man on the Ass"), on the Algerian frontier, and that of a local sherif, Mulai Ahmed ar-Raisuli, in the district of Tangier.

As a result of the Entente Cordiale and in return for France's "disinteresting" itself from Egypt, Great Britain gave up its ideas of intervention in internal Moroccan affairs (April 8, 1904). Article 2 of the Franco-British treaty is important.

The French Government declares that it is not its intention to change the political status of Morocco On the other hand, H B M.'s Government recognizes that it belongs to France notably, as a Power conterminous with Morocco to a vast extent, to see to the tranquillity of the country, and to lend it her assistance for all the administrative financial and military reforms it is in need of. (Translated from the French text.)

The principle of the liberty of commerce mas guaranteed for 30 years, to be prolonged by periods of 5 years if not denounced (article 4). No fortifications were to be erected at Tangier (article 7; liberty of the Straits of Gibraltar). In a last article, the governments agreed to "give one another the aid of their diplomacies" for the carrying out of the clauses of the treaty.

Spanish adhesion to the Anglo-French agreement was not easily obtained But finally, on Oct. 3, 1904, Spain, while still refusing to sign the Anglo-French declaration itself, was induced to sign a separate declaration with France, in which it gave adhesion to it in general terms. On the same day Spain signed a secret treaty with France in which it was promised, if the authority of the sultan could no longer be maintained. a zone of influence covering the littoral massifs of northern Morocco up to the line of the Mediterranean-Sebou watershed and extending southward over a large part of the valley of the Ouergha (article 2). In southern Morocco Spain was assigned a sphere of influence stretching to the Oued Tazeroualt and the Oued Mera (article 4).

In 1905 came Germany's intervention. It had several times complained of being "ignored" in Morocco, though its direct and special "interests" may perhaps be questioned Russia's discomfiture in the far east in its war with Japan gave Germany its opportunity. The German emperor's spectacular disembarcation at Tangier (March 31, 1905) was followed by conferences with the ministers of Abd ul-Aziz. As a result, an official proposal by the makhzan, inspired by Germany, for the calling of an international conference. was launched, and France consented.

Théophile Delcassé (*q.v.*), who had been principally instrumental in the preceding treaties, was none the less forced by German pressure to resign office (June 6, 1905), an event which created the impression (several times renewed since by the Casablanca deserters affair, the Agadir incident, etc.) that Germany was bent on picking a quarrel. During the Algeciras negotiations themselves. Germany obtained from Abd ul-Aziz the concession of the building of the port of Tangier, which had already been promised to a French company. and a loan of 10,000,000 marks with a Berlin bank, in violation of an engagement taken with the French banks at the time of a loan contracted with them in 1904.

The Algeciras conference began on Jan. 16, 1906. In accordance with the 1904 treaty, the British delegates gave their loyal support to France, while Austria played the part of a "brilliant second" on the German side. The general act was signed on April 7, 1906 and accepted by the sultan on June 18. It consecrated the economic internationalization of Morocco, under the sovereignty of the sultan. Commercial equality for all was, once more, stipulated. but France's "special position" was recognized by Germany itself. The only two particular advantages obtained by France were: (1) the allowance of a predominant part in the capital of the Moroccan state bank, on account of the monetary advances already made by it to the makhzan; (2) the sharing with Spain of the police of the Moroccan ports. The diplomatic corps in Tangier was put in charge of the creation of the administrative and financial reforms stipulated at Algeciras (Moorish police in the ports; state bank; acquisition of land by foreigners; control of the customs administration; impartial adjudications—without reference to the nationality of the bidder—of public works and supervision of the public works administration, etc.).

Beginnings were difficult. The country was far from tranquil. In May 1906 a Frenchman was murdered at Tangier. At the end of the same year, a Franco-Spanish naval demonstration had to be prepared, because of the continued activities of Raisuli against Europeans in the suburbs of Tangier; Sir Henry Maclean himself, colonel of the sultan's bodyguard, was afterward a victim of Raisuli and had to be ransomed by the British government for £20,000. One of the sultans' mehallas finally put to flight the brigand-functionary. On March 19, 1907, Emile Mauchamp was murdered at Marrakesh. Oujda was then occupied by French troops pending satisfaction of the French demands. On July 30 nine European workmen employed in the Casablanca harbour works were killed, and, the passage of a detachment landed from the cruiser "Galilée" having been opposed and all the Europeans attacked, the town was bombarded. The occupation of the Chaouia district followed, the tribes opposing Gen. A. M. B. Drude and Gen. A. d'Amade and the fighting being heavy. By

June 1908 the district became quiet and the original force of 15,000 men mas reduced.

In Sept. 1908 the incident of the six deserters from the Foreign Legion (three of whom were Germans) occurred in Casablanca. They had a safe conduct from the German consul, 'but were arrested by a French patrol. The German government demanded that France express its regret before the facts were fully established. The case was submitted to The Hague court of arbitration, which decided substantially in favour of France (May 1909). The incident created some excitement in France and in Germany, but an agreement was reached between the two countries on Feb. 8, 1909, in which France reaffirmed its will to maintain economic equality and Germany its pursuance of economic interests only, recognizing France's special political claims.

In the meantime. Abd ul-Aziz had been defeated by his brother Mulai Hafid (1908), who had been proclaimed sultan by the ulema of Marrakesh the year before. But Mulai Hafid's power remained weak. The Rifian tribesmen revolted against Spain, which mas obliged to send an army of 50,000 men to reduce them to submission (Nov. 1909).

In 1910 Mulai Hafid obtained a loan of £4,000,000 chiefly from France, which had also given the new sultan a proof of its moderation by the promise of gradual evacuation of the Chaouia country and even of Casablanca, against the creation of a makhzan police force under French instructors and the payment of an indemnity by the Chaouia tribes. An agreement on somewhat the same terms was signed with the makhzan by Spain in Nov. 1910. But a revolt had already begun round Fez in October. It continued to spread and the town was besieged by the neighbouring tribes in March 1911. All the consuls called for help, and the sultan himself asked for it. A French expedition released the town. In June Spain occupied Alcázarquivir (Kasr al Kebir) and Larache (Al Araish).

Then, suddenly. there developed the crisis of Agadir; on July 1 the German gunboat "Panther" appeared before the town, "in order to protect German interests." War seemed imminent, but Great Britain stood firmly by the Entente and announced its formal opposition to Germany's obtaining political rights in Morocco. Complicated negotiations between France and Germany ended in the treaty of Nov. 4, 1911. France obtained from Germany a certain number of rights—to occupy, by agreement with the sherifian government, any points where the maintenance of order might render the occupation necessary; and to be the sherifian government's obligatory medium in its foreign relations. A resident general might be appointed, if necessary, at Fez, and France should have the right to control the sherifian finances in order to ensure the payment of foreign debts, etc. In exchange, the principle of economic equality for all, notably for the concession of mines, railways, etc., was reaffirmed. In a letter annexed to the treaty, a large slice of French Congo was handed over to Germany. On the other hand, though the word "protectorate" was not formally used in the body of the treaty itself, a near equivalent could be found in it; and, by a second letter, Germany agreed not to oppose it, if circumstances rendered it necessary. (HI. BR.; X.)

THE FRENCH PROTECTORATE

As soon as the Franco-German treaty had been ratified, France submitted it to the sultan and on March 30, 1912, signed another treaty with him, establishing a French protectorate over the sherifian empire. It was agreed that France should be allowed to introduce internal reforms of an extensive nature, though the Moslem faith and the "respect and traditional prestige of the sultan" were to be preserved (article 1). Special emphasis was laid on financial reform (article 7), and it was stipulated that all loans should have the authority of the French government (article 8). France was to be allowed to occupy the country militarily (article 2); to support the sultan in defense of his realm (article 3); and to propose legislation (article 4). Through the agency of a French resident general it was to be the sole intermediary of the sultan in his relations with foreign powers (article 5).

Spain refused at first to adhere to the Franco-Moroccan treaty. But Great Britain intervened, and the result was that another treaty mas signed between France and Spain on Nov. 27, 1912, in which Spain recognized. as Germany had done a year earlier, the right of France to assume a protectorate over the whole of Morocco. This treaty also recognized the existence of a Spanish protectorate in Morocco. But Spain was given less territory in 1912 than it had been promised in 1904. It had to renounce a rich strip of land on the right bank of the Ouergha and also much of the sphere of influence in southern Morocco that had been promised to it in 1904, the frontier being fixed on the Draa (see RIO DE ORO). Moreover, though Spain was given administrative autonomy within its own zone (article 2), this right was ceded to it directly not by the sultan but by France in its capacity as protecting power over the whole of the sultan's dominions and thus assumed the character of a sublease, in virtue of which Spain had also (article 1) to give special recognition to the French resident general's position under article 5 of the Franco-Moroccan treaty of 1912.

After the establishment of the protectorate Gen. L. H. G. Lyautey was made resident general, a post which he held until 1925 (see LYAUTEY, LOUIS HUBERT GONZALVE). Initial troubles in Fez caused by French reorganization of the Moroccan army were successfully put down. They were followed by the accession of a new sultan, Mulai Yusuf, who, thanks largely to Lyautey's tactful handling, co-operated loyally with the French until his death in 1927, when he was succeeded by his son Mohammed ben Yusuf.

By 1914 Lyautey had succeeded in pacifying central Morocco between Fez and Marrakesh nearly up to the Moulouya. and in May 1914 the junction of Fez and Oujda through Taza mas achieved. In the still unconquered regions of the High Atlas Lyautey maintained order through entente with the great caids.

On the outbreak of World War I Lyautey received instructions to send all his available troops to France, to abandon the interior of Morocco and to retire to the coastal towns; "The fate of Morocco," it was declared, "will be decided in Lorraine." In effect he sent two-thirds of his forces to France, but far from abandoning territory he actually increased that under French control between 1914 and 1918. This was a military and administrative success probably without parallel in history, all the more notable in view of the trouble fomented both in the north and in the south by German agents. The Germans also used Tetuan, in Spanish Morocco, as a centre for their intrigues, and from Larache there was constant and open signalling to German submarines at night.

In 1918 the regions that still remained to be pacified were the Franco-Spanish frontiers in the north, the southern slopes of the High Atlas and the regions round Tafilelt. Because of the demands of economy and demobilization after the war, Lyautey still had not a great number of troops at his disposal. Nevertheless, he succeeded between 1919 and 1922 in subduing the Khenifra area in the Middle Atlas, and in 1923 the Tache de Taza, overlooking the Taza corridor, mas pierced by a line of posts, though not actually subdued. At this point Lyautey was due to give up 12 battalions, leaving only about 10 available for active operations. But Abd el-Krim's revolt in the Spanish zone, which had broken out in 1920 and was now reaching formidable dimensions, precipitated a crisis in the Franco-Spanish frontier regions. and this led to their final and complete pacification by a joint Franco-Spanish force of 280,000 troops in 1926. It was through Lieut. Col. (later Gen.) Henri Giraud, then in command of the 14th Tirailleurs Nord-Africains, that Abd el-Krim made his final submission to Marshal Henri Philippe Pétain.

At a conference held in Paris between June 16 and July 10, 1926, a Franco-Spanish agreement was signed, providing for the delimitation on the ground of the French and Spanish zones, as defined in the Franco-Spanish treaty of Nov. 27, 1912.

While large French forces were still available, it was decided to make an end of resistance in the Middle Atlas and to clear up the Tache de Taza. There all opposition was effectually overcome by the end of 1926. About one-third of Morocco, compris-

ing the southern end of the Middle Atlas, the fastnesses of the High Atlas and the valleys of the Sous and the Draa, remained to be pacified after this. In 1932 the Middle Atlas was subdued. Between 1932 and 1934 a final three-year campaign effected the subjugation of the rest of the country, all of which then came for the first time under effective French control. The last operation, resulting in the pacification of southern Morocco, was carried out by two columns commanded respectively by Gen. Georges Catroux and General Giraud.

Government. — Under the protectorate, the sultan remained the nominal ruler of the country, as well as its supreme religious head. But all real power was placed in the hands of a French resident general. As an official of the Moroccan government, he directed the administrative services of the protectorate and commanded its land and sea forces. As an official of the French government, he approved and promulgated the sultan's legislation and acted as his sole intermediary with foreign powers. He was advised by four cabinets, a civil, a military, a political and a diplomatic, and was assisted by a delegate to the residency general and a secretary-general, with authority over the administrative services.

Legislation took the form of decrees issued in the sultan's name, which did not have the force of law until they were put into effect by the resident general. The sultan and his advisers could make revisions of any measure proposed by the French authorities. But in the event of any difference of opinion, the resident acted as arbiter.

The central organ of the sultan's government was the makhzan, a council composed of 60 Moroccan officials, presided over by the grand vizier, who was at once head of the Moroccan government and minister of the interior. There were two other viziers: the vizier of justice (concerned with the koranic law courts) and the vizier of *habous* (religious foundations). They met weekly and might be considered to form a sort of Moroccan cabinet.

Liaison between the makhzan and the residency was the function of the *direction des affaires chérifiennes,* which supervised the workings of the makhzan and drew up its budget. Its head, the *conseiller du gouvernement,* attended vizierial meetings, transmitted to the resident general the comments of the sultan and his ministers on French proposals and arranged a basis of agreement between them.

If the dualistic principle on which the protectorate was based had been rigidly observed, all public services would have had Moroccans at their head, merely controlled by French agents. But this was not always found practicable. The French therefore set up five departments of state staffed with a purely French personnel. These were the departments of finance; communications, industrial production and labour; agricultural production and supply; health and youth; and education.

The only attempt to form a central elected assembly was that which found expression in the *conseil du gouvernement.* This was originally instituted in 1919 at the request of French colonists and was representative of their interests only. But in 1923 and 1926 it was expanded to include not only a wider representation of French interests, on a functional basis, but also a certain representation of native interests. There were three elected French colleges and one nominated Moroccan college. Until 1939, however, this assembly exercised little influence.

French control of Moroccan local government was based on the region. A region was a large territorial unit superimposed on smaller and older ones of a traditional nature, the latter in turn being rather arbitrarily divided between new regional subdivisions. At first the control was exercised under the authority of a number of civil and military bodies and so was quite definitely decentralizing in tendency. But after these bodies had in 1936 been fused into a single *direction des aflazres politiques* under the immediate authority of the resident general, the control became highly centralized.

The regions originally grew from military districts, commanded by generals and then subdivided into territories, circles and annexes commanded by officers of decreasing rank. Though these officers were all recruited from the French regular army they belonged to the special *service des affaires indigènes,* in which they could obtain promotion quite independently of their ordinary military rank.

After a while certain regions were handed over to civil controllers and could then also be subdivided into civil circumscriptions, posts and annexes under subordinate civil controllers (the equivalent of district officers in British colonies), who were all metropolitan French officials, depending on the ministry of foreign affairs. It always remained a distinguishing feature of the Moroccan system, however, that military subdivisions could exist inside civil regions, just as civil subdivisions could exist inside military regions; and the two could also coexist side by side. In 1939 there were four civil regions, four military regions, four autonomous civil circumscriptions and two autonomous military territories.

Within this regional framework of French control, older Moroccan forms of local authority were allowed to subsist. The basic unit of Moroccan local life was the tribe. Arab or Arabicized tribes were administered by caids, with the help of a *djemaa* (council of elders), whose powers, however, were usually small. Berber tribes were controlled either by a *djemaa* alone, or else by a caid with the assistance of a *djemaa,* whose powers were usually large. Smaller towns were administered by caids; larger ones by pashas, who had somewhat more extensive functions. Both caids and pashas were appointed by the sultan.

Under the protectorate these appointments were not valid without the consent of the resident general. At the same time, caids, pashas and *djemaas* were all placed under the supervision of civil controllers or officers of the *service des aflazres indigènes.* In the towns the pashas were likewise controlled by a French *chef des services municipaux,* who took over many of their former functions and was the real authority in the municipality. He was himself assisted by a nominated municipal commission, in which Europeans and Moroccans were associated in varying proportions. But it was only in Fez and Casablanca that these had any real power.

Justice. — Before the establishment of the protectorate. a number of European powers and also the U.S. had obtained capitulations, enabling them to have their nationals judged in their own consular courts. By 1916 all these powers had renounced their capitulatory rights, except Great Britain and the U.S. In 1937 Great Britain abolished its capitulatory rights (though retaining them in Spanish Morocco), after similar action in Egypt the year before. The United States — which had, however, given formal recognition to the French protectorate, as a friendly gesture to a wartime ally, on Oct. 20, 1917 — was thus left as the only power with capitulations in French Morocco.

After the abolition of the consular courts, all foreigners in French Morocco (except, of course, U.S. nationals) were judged in French courts. They had exclusive competence in all matters affecting Europeans except where matters of Islamic personal status and unregistered landed property were in question.

Moslem justice, before the establishment of the protectorate, took two forms. In the Arabicized regions, uhich included the towns, the fertile plains of the west and north and the semidesert plains of eastern Morocco, all matters of personal status were judged, according to koranic law, in the courts of cadis who were appointed by the sultan. All other matters, civil, commercial or criminal, were judged in the courts of caids and pashas. In the Berber parts of the country, comprising the mountainous districts of the Middle Atlas, the High Atlas and the Anti-Atlas, the plains of the Sous and a small fringe of mountainous country bordering on the northern Spanish zone. it was always the *djemaas* uhich judged all except criminal cases. according to Berber customary law. Where a caid existed, he judged criminal cases. Where there was no caid, the *djemaas* judged criminal cases too.

The French preserved both these forms of Moslem justice, though with some important modifications. In the first place, two central appeal courts were set up at Rabat. one for koranic and one for secular justice. Secondly, the powers of the pashas and caids in criminal cases were restricted, at the same time as their

competence in civil and commercial matters was allowed to grow. Thirdly, a French *commissaire du gouvernement* was placed in their courts and given considerable powers of control over their proceedings. Among the Berber tribes, "customary tribunals," preserving all the essential features of the old *djemaas,* were set up, with authority in all civil and commercial cases. A *commissaire du gouvernement* was likewise placed in these tribunals.

Nationalist Movement. — The Moroccan nationalist movement. grouping the younger generation educated in French schools, appeared in 1934. A hloroccan Committee of Action was founded and its demands were for greater participation of Moroccans in the government of their own country, a Moslem national assembly and the end of all "direct" administration. Considerable nationalist agitation followed. which led to the committee's being dissolved in 1937. Two other nationalist groups which took its place were also dissolved. After this Gen. Auguste Noguks, resident general since **1936.** made serious efforts to meet some of the nationalists' grievances by founding new schools and hospitals and by throwing open certain administrative posts to Moroccans. In other matters, however, he went directly counter to them in buttressing the authority of the aristocratic pashas and caids, which had been somewhat diminished since Lyautey's day.

The capitulation of June 1940 did not increase France's prestige in Morocco. Immediate effects of Vichy rule were economic. Trade was paralyzed, and German requisitions rendered the position even harder than it mould otherwise have been. There was a brief resistance to the Allied landings in Nov. 1942, organized by General Noguks. who subsequently left the country.

Stimulated by the entirely misplaced beliei that they would receive British and U.S. support, the nationalists in Jan. 1943 formed the United Independence party (Istiqlal), which a year later demanded the complete independence of Morocco, with a constitutional form of government. under the sole and undivided authority of the sultan after only a short transitional period of French rule. After severe repression of riots, which broke out in some of the larger towns on the arrest of 15 leading nationalists, the French announced that they were embarking on a series of reforms. But the judicial powers of the pashas and caids, much criticized by the nationalists, were only slightly modified.

The sultan Mohammed V Ben Yussef acted as the acknowledged leader of the nationalists. During a visit to Tangier at the beginning of April 1947 he pointedly did not refer to France in his speech. The French government thereupon recalled the civilian resident general, Eirik Labonne, and sent out Gen. Alphonse Juin in his place. A modest administrative reform so modernized the higher Moroccan bureaucracy as to give the sultan a better chance of forming and expressing an opinion on the measures put before him for signature by the resident general's staff, but on the whole political change in Morocco was slight.

Mohammed ben Yussef and his advisers steadily refused to let Morocco enter the French union, and there was constant talk of abrogating the treaties of **1912.** The sultan had Istiqlal members in his secretariat and refused to dismiss them when General Juin expelled the elected Istiqlal members of the *conseil du gouvernement,* after a violent attack on the maintenance of the protectorate (Dec. 1950). For months the sultan refused to sign *dahirs* (decrees) prepared by the French, and therefore these could not be promulgated. In Feb. 1951, General Juin, playing pro-French Haj Thami el-Mezuari el-Glaoui (1876?–1956), pasha of Marrakesh, against the sultan, induced the latter to sign the *dahirs* and to dissolve his secretariat but did not obtain an explicit condemnation of the Istiqlal from him.

On March **14.** 1952, the sultan asked the French government to revise the protectorate statute, to set up a representative Moroccan government in order that the appropriate negotiations could be pursued, and to grant certain freedoms (notably to form trade unions). The French government proposed on Sept. **17** a plan of reform involving the participation of Frenchmen and of French authorities in the exercise of Moroccan sovereignty. In a speech on Nov. **18.** on the 25th anniversary of his accession. Ben Yussef revealed his disagreement with the French over this plan. The French then decided to obtain his abdication. To achieve this they again used El-Glaoui, who in their eyes represented the tribes of the *bled* (rural areas), and the traditional chiefs, opposed to the westernized middle class of the urban population. On Aug. 13, 1953, about 350 pashas and caids and more than **2.000** notables assembled around El-Glaoui at Marrakesh and declared their intention of deposing the sultan. On Aug. 20, the resident general. Gen. Augustin Guillaume, paid a visit to the sultan, who refused to abdicate but agreed to go abroad. He was forthwith removed to Ajaccio, Corsica, and later to Antsirabé, Madagascar. The next day Moulay Mohammed ben Arafa, nephew of the sultan's grandfather Moulay Hassan, was consecrated at Fez by the *ulemas* (doctors of koranic law), by the *sherifs* (descendants of the prophet) and by the notables. Attempts to assassinate him were made on Sept. 11, 1953, at Rabat, and on March 5, 1954, at Marrakesh. The situation was tense and the country suffered from an outbreak of terrorism and insurrection.

In the summer of 1955 the French government decided to change its Moroccan policy. On Oct. 1, Ben Arafa laid down his authority and went to live in Tangier. On Nov. 1, Ben Yussef arrived from Antsirabé at Saint-Germain-en-Laye, near Paris. Four days later the French government decided that Mohammed V Ben Yussef was the legitimate sultan of Morocco. On Nov. **6,** a joint statement by the sultan and Antoine Pinay, French minister of foreign affairs, announced that the new Moroccan government would start negotiations with France "to raise Morocco to the status of an independent state, united with France by the permanent links of an interdependence freely consented to and defined." On Nov. 8, at Saint-Germain-en-Laye, El-Glaoui begged forgiveness at the sultan's feet: "Cursed be those who have misled me!" he said. On Nov. **16,** Mohammed V returned by air to Rabat and was enthusiastically received by the population. On Dec. **7** he appointed a cabinet headed by M'Barek ben Mustafa el-Bekai. By relinquishing his absolute power, Mohammed V became Morocco's first constitutional monarch.

Independence Restored. — The negotiations decided by the statement of Nov. **6,** started in Paris in mid-Feb. 1956. Although not a member of the Moroccan delegation, the sultan was present in the French capital during the negotiation. On March **2** a joint declaration was signed by Christian Pineau, the French foreign minister, and M'Barek el-Bekai, the Moroccan prime minister. The two governments agreed that the Treaty of Fez of March **30, 1912.** which had established the protectorate, had become outdated and could no longer define Franco-Moroccan relations. Consequently, the French government solemnly confirmed its recognition of Morocco's independence, which implied a diplomatic service and armed forces of Morocco's own.

Another document signed in Paris on March 2 was a protocol covering the period of transition before the new Franco-Moroccan treaty, still to be negotiated, would come into effect. Legislative power in Morocco would henceforward be exercised by the sultan alone. which meant that he would no longer have to submit laws and decrees for approval by the French resident general. The French representative in Morocco would be called high commissioner and he would still have a right to see all decrees affecting Frenchmen or foreigners. France would help Morocco to form a national army, but in the meantime the status of the French army in Morocco would remain unchanged.

By signing the Paris declaration of March 2, **1956,** France pledged itself to help Morocco to recover the Spanish zone and Tangier. It should be recalled in this connection that with the exception of the so-called places of sovereignty (Ceuta. Melilla, etc.), which had been ceded in perpetuity by Morocco to Spain in 1767 or **1860** (Ifni), the Franco-Spanish convention of Nov. **27, 1912,** was the only legal basis for the existence of the Spanish protectorate in Morocco. It seemed that the Spanish government did not anticipate the French decision when in a statement published on Jan. **13, 1956,** it announced its Moroccan policy. It proclaimed Spain's willingness to fight for the unity and independence of Morocco. During a state visit to Spain paid by the sultan April 4–9, 1956, a joint declaration recognizing the independence, sovereignty and territorial integrity of Morocco was signed in Madrid on April **7** by Alberto Martin Artajo, the Span-

ish minister of foreign affairs, and El-Bekai, the hloroccan premier. The declaration made no reference to Ceuta. Melilla. Ifni and Rio de Oro to the south of Morocco. On Nov. 23, 19j7, a strained situation developed between Spain and Morocco consequent upon the invasion of the Ifni enclave by Moroccan irregulars.

As a consequence of the recognition of Morocco's independence and sovereignty the statute of Tangier had to be revised. On Oct. 8. 1956, the nine-power conference was opened formally at Fedala, near Casablanca. Besides Morocco the eight administering powers were represented. Mohammed V told the delegates that he was only consulting them about the means of safeguarding the national and foreign economic interests that had been developed in Tangier. The real work of the conference started two days later in Tangier. It ended on Oct. 29 with the signature of an eight-power declaration and of a protocol, the last-named signed also by Ahmed Balafrej, the Moroccan foreign minister. The declaration stated that the Tangier international regime was abolished and that the Moroccan government was to take possession of public and private property formerly administered by the international committee of control. The protocol stipulated that all existing laws would remain in force unless modified or cancelled by the Moroccan government. A royal charter was granted to Tangier on Aug. 30. 1957, confirming the maintenance of freedom of exchanges and of foreign trade and introducing a moderate fiscal system. (S. E. CE.)

SOCIAL AND ECONOMIC CONDITIONS

Population. — The indigenous peoples of hlorocco are Berbers; they call themselves *Imaziren.* The Berber name covers very different human types. There are three great groups of Moroccan Berbers, differing from one another in language. racial type and customs: the northern or Rifian people. who inhabit the coastal massifs; the central or Berber group. which inhabits the Middle Atlas; and the southern or Shleuh group. which lives in the High Atlas and in the Sous. All are Moslem. The Berbers in the plains have adopted the Arabic language, but 36% of the indigenous population of Morocco speak Berber dialects. The natives other than the town dwellers are divided between nomads and sedentary. Mode of life has no connection with race, for many Berbers are nomads; they have storecastles called *agadiv* for their harvests. The slave trade has introduced a large number of Sudanese, who have influenced the complexion of the populations of the south.

The population of the Southern zone (former French zone) of hlorocco was 6,245,200 in 1936 and 8,003,98j in 1952; the latter figure included 362.814 Europeans and 199,1j6 Jews. The population of the former Spanish northern zone was (19jo): 1,003,817; places under Spanish sovereignty in the north (1950) 133,251; Ifni territory 38,985; and the Spanish southern zone 5,914. Total pop. (1960) 11,626,470. The population of the former international zone of Tangier was 141,714 in 1960. Population is densest in the plains of the west and on the border of the mountain massifs. the regions with a great altitude not lending themselves to permanent habitation. The neighbouring regions of the Sahara and of Algeria, except in the limited areas where irrigation culture is feasible, permit only a low density. The populations of the chief towns of the Southern zone were as follows (1960 census): Casablanca 965,277; Marrakesh 243.134: Rabat (cap.) 227.445; Fez 216.133; Meknès 175,943; Oujda 128.645; Port Lyautey 86,775; Safi 81,072; Salé 75.799; Mazagan 40.302; Mogador 26.392. In the Northern zone (1960 census): Tetuan 101,352; Larache 30,763: Kasr al Kebir (Alcázarquivir or El-Ksar) 10.784. Melilla and Ceuta (Spain in Morocco) had a population in 1950 of 76,247 and 56,909 respectively.

In 1907, outside the ancient Spanish possessions, there were not more than 5,000 Europeans in Morocco. of whom 4,000 were in Tangier. European immigration was rapid after the French protectorate had been established. But this population was essentially urban: Casablanca had 133.690 in 1952, Rabat 40,747, Oujda 27.202. Meknks 21.283. Fez 15,768, Marrakesh 12.816 and Port Lyautey 8.868. The rural population of European extraction is represented by about 5,900 colonists (15,000 to 20,000 including their families) who live on their land.

Of the 362.814 Europeans in the Southern zone, 298.875 were French. including 31.767 people with formal French nationality, while 63.939 were foreigners (25.698 Spaniards. 13,337 Italians and 24,904 others). There were 84,716 Europeans in the Northern zone (1950), as well as the predominantly Spanish populations of the places of Spanish sovereignty. There were (estimated) 47,000 Europeans in the Tangier zone in 1951.

Education. — In 1956 there were in primary and secondary schools, both state and private. 450,728 pupils. including 80,780 Europeans and 36.960 Jews. The Institute of Higher Moroccan Studies at Rabat had more than 1,000 students. There is also a Moslem Kairoween university at Fez.

Agriculture. — Morocco is essentially an agricultural country. About one-fourth of the area is cultivable and in the Southern zone 4,800,000 ha. is effectively cultivated. The regions most favourable to agriculture are El Gharb, the Sebou valley, the provinces of the Chaouia and of the Doukkala, the districts of Meknès and of Fez and the Ouergha valley.

Cereals are by far the most important crop of the Southern zone of Morocco, covering 94% of the area under cultivation: but the yield is no more constant than the rainfall. The average figures (19jj–66) for areas sown and yields harvested were as follows: hard wheat, 955,700 ha. and 703,000 metric tons; soft wheat, 500,000 ha. and 352,200 metric tons and barley 1,864,500 ha. and 1,634,400 metric tons. Maize (a spring crop) covered 471,600 ha. and yielded 286,200 metric tons. Europeans cultivate 7% of the areas sown, particularly those under soft wheat. The natives own nine-tenths of the 12,000,000 olive trees, notably in the pre-Rif in the Fez and Meknès regions at the western foot of the Middle and High Atlas, around Marrakesh and in the Sous. They own nearly all the 10,300,000 almond trees. as well as 10,000,000 fig trees and the 3,124,000 palm trees of the oases irrigated by streams from the Atlas; *i.e.*, by the Draa. Todra. Gheris and Ziz (Tafilelt) and Oued Guir. Moroccan dates are of medium quality and are not exported. On the other hand, the vineyards are all European-owned; they covered 75,700 ha. around Fez and Meknks and in the north of the Chaouia and produced 1,650,000 hl. in 1955–j6. Most of the 6,950,000 citrus trees (34.700 ha.) mere also owned by Europeans in 1956. Market gardens occupied 60,700 ha.. half of that area being dependent on irrigation. They are found for the most part around the large towns and along the coast, notably on either side of Casablanca and in the Sous, where there are many European planters. Stock raising is almost entirely in native hands; (1956) cattle numbered 2,351,000 (in northern Morocco and the central massif), goats 9,000,000 (in the mountains) and sheep 15,400,000 (in the mountains and on the dry plains). Horses numbered only 219,000, but asses and mules 1,170,000. There were 230,000 camels in the desert and the eastern Moroccan steppes. European raisers had j7,000 pigs.

Industry. — Morocco is the world's second largest producer of phosphates, with a yield (1956) of 5,523,000 metric tons from the deposits of Louis Gentil and, particularly, of Khouribga. There is also a little iron (1956 production: 489.690 tons) in the Ait Amar deposits near Khouribga. as well as lead (120,047 tons) and zinc (70,921 tons) in the regions of Midelt (Aouli and Mibladen) and Oujda (Hassi Touissit and Boubker), manganese (421,409 tons) at Bou Arfa in eastern Morocco, and cobalt (6,438 tons) at Bouazzar in the Anti-Atlas.

Power is provided by imported coal and gasoline and also by anthracite (482,000 tons, 1956), a small amount coming from Djerada, south of Oujda, and by the petroleum found in small quantities along El Gharb (97,452 tons in 1956), as well as by electricity. Industries, mostly in the suburbs of Casablanca, use large amounts of electric energy (837,000,000 kw.hr. from hydraulic power and 90,800,000 kw.hr. from thermal in 1956).

Fisheries have become important: 99,015 tons of fish were caught in 1956, and 43,027 tons of sardines were canned, mainly at Safi and at Agadir and largely for export to Great Britain.

In the former Spanish zone the only important mines are the iron mines in the hinterland of Melilla; industries, using 57,100,000 kw.hr. (1954), are scattered over the towns; and there is some fishing.

Finance.—The 1954 Southern zone budget was balanced at 136,451,000,000 fr. The Moroccan franc is at par with the metropolitan franc. Note circulation in 1956 was 70,000,000,000 fr.

Foreign Trade.—Under article I of the Act of Algeciras (1906), French Morocco had to remain open to trade with a uniform ad valorem duty of 12½%. In 1956 imports amounted to 2,956,900 metric tons. valued at 160,737,000,000 fr.; exports to 8,455,900 metric tons, valued at 119,051,000,000 fr. Imports are mostly foodstuffs (sugar, dairy produce, rice, oil and tea). textiles (cotton goods), fuel, machinery and materials of construction. Exports comprise mineral produce (primarily phosphates: 5,560,204 metric tons in 1956; worth 20% of the total value of exports), followed by fish (32,525 metric tons of preserved fish, 15% of the total value exported) and then by agricultural produce (spring vegetables, citrus fruit and, when the year is good, cereals). Trade is mainly with the French union, including France (475% of the total value), then with the sterling and dollar areas (10% and 5%). In the Northern zone imports account for two-thirds of the foreign trade and consist essentially of foodstuffs. Exports are principally mineral products (more than 50%; in particular, iron), followed by foodstuffs (40%), notably preserved fish and fresh eggs.

Communications.—Morocco had about 6,000 km. of first-class roads and 4,674 km. of maintained tracks in 1956. The 1,612 km. of railways in 1956 (gauge 1.44 m.) included the line from Algiers to Marrakesh via Oujda, Taza, Fez, Meknès, Rabat and Casablanca, with its branch lines to Tangier, into the phosphate and iron country (Khouribga and the Aït Amar) and to Safi; and the eastern Moroccan line, serving the lead and anthracite mines south of Oujda, the manganese deposits of Bou Arfa and the Algerian coal mines of Kenadsa. Former Spanish Morocco had lines from Ceuta to Tetuan, Larache to Kasr al Kebir, and part of the Fez-Tangier line (315 km. in all).

The port of Casablanca has its vast docks protected from the open sea by a jetty of 9,185 ft. and a transverse jetty of 5,250 ft. It handles four-fifths of former French Morocco's overseas trade, dealing with imports of all kinds (2,174,000 tons in 1956) and with exports (6,281,000 tons) consisting mostly of phosphates but including also iron and all kinds of agricultural and even some industrial produce. Next in importance are Safi, the port of Marrakesh, which exports phosphates from Louis Gentil and preserved fish (exports 1,513,000 tons. imports 22.000 tons); Port Lyautey on the Sebou (exports 374,000 tons, imports 209,000 tons). Ceuta, Melilla and Tangier are secondary ports. The airport at Casablanca is important to lines between Europe and West Africa and South America; 6,877 aircraft landed at Moroccan airports in 1956.

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(A. BE.; J.-J. Ds.)

MORÓN DE LA FRONTERA or MORÓN (anc. Arumi), a town of southern Spain, in the province of Seville; 32 mi S.E. of the city of Seville. Pop. (1950) 30,168 (mun.). Morón occupies an irregular site upon broken chalk hillocks near the right bank of the Guadaira. It is connected by rail with Utrera. The chief public building of Moron is the large parish church, which dates from the 16th century.

MORON: see MENTAL DEFICIENCY.

MORONE, the name of two distinguished Italian painters, father and son, of the Veronese school.

DOMENICO MORONE (c. 1442–*c.* 1517) is represented by few surviving works. The frescoes he executed in S. Bernardino at Verona (1503) and in the little church of S. Niccolo di Tolentino at Paladon (now in the Museo Civico) are not well preserved. There are, however, a few signed works that reveal him as a spirited painter of much grace and decorative quality, one being the large canvas in the Reggia at Mantua, painted in 1483 for the marquis of Mantua and illustrating the fight between the Gonzagas and the Bonacolsi. Other works by or attributed to Domenico Morone may be seen in the National Gallery of Art, Washington, D.C.; in the Metropolitan Museum of Art, New York city; and at Oxford university.

FRANCESCO MORONE (c. 1471–1529), Domenico's son, after working as an assistant to his father, began work as an independent painter and in 1495 produced the "Crucifixion" in the church of S. Bernardino. His greatest work in fresco was the decoration of the walls and ceiling of the sacristy of Sta. Maria Organo with incidents freely adapted from Andrea Mantegna's "Camera degli Sposi" at Mantua. This work is one of the greatest monuments of local art. In the same church is an altarpiece (1503) of the Madonna enthroned between two saints, a work fine in colour and design and of remarkable finish. Francesco died on May 16, 1529.

MORONE, GIOVANNI (1509–1580), Italian cardinal, was born on Jan. 25, 1509 at Milan, where his father, Count Ieronimo Morone (d. 1529), was grand chancellor. His father, who had been imprisoned for opposing encroachments on the liberties of Milan by Charles V (whom he afterward cordially supported), removed to Modena. The son was educated there and at Padua. He was in 1527 nominated by Clement VII to the see of Modena, and consecrated in 1533 after a contest. From 1535 he was constantly entrusted by Paul III with diplomatic missions. In 1542 he was created cardinal, and was further nominated protector of England, Hungary, Austria, of several religious orders, and of the santa casa at Loreto. With the cardinals Paul Parisio and Reginald Pole he was deputed to open the Council of Trent (Nov. 1, 1542), the place of meeting having been a concession to his diplomacy. The legates arrived on Nov. 22, but no council assembled. The death of Paul III (1549) deprived him of a good friend. The views of the Reformers had spread in his diocese, and he was suspected of temporizing with them.

Morone resigned his see (1550), reserving to himself an annual pension and the patronage of livings. Julius III, at the instance of the duke of Milan, gave him (1553) the rich see of Novara (which he resigned in 1 j60 for the see of Albano) and sent him as nuncio to the diet of Augsburg (1555), from which he was immediately recalled by the death of Julius (March 23). In June 1557 Paul IV imprisoned him in the castle of St. Angelo (with others, including Pole and Foscherari), on suspicion of Lutheran heresy. The prosecution entirely failed, and Morone might have had his liberty, but refused to leave prison unless Paul IV publicly acknowledged his innocence. He remained incarcerated till the pope's death (Xug. 18, 1559), and took part in the election of Pius IV. Ochino, in the 28th of his Dialogi XXX, 1563, has a colloquy on the treatment of heretics, between Pius IV and Morone, in which the latter maintains: "Errantes in viam revocandi, non occidendi." This really hits the position of Morone, a sincere Catholic, to whom persecution was abhorrent. He presided at the Tridentine council from April 10 to Dec. 4, 1563. In 1564 he was reinstated in the see of Modena. On the death of Pius IV (1565) he came near to being elected pope. He died at Rome on Dec. 1, 1580.

See J. *G.* Frick, "De Joanne Morono," in J. G. Schelhorn's *Amoenitates literariae,* vol. xii (1730); "G. Moroni," *Dizionario di erudizione* (1847); *N.* Bernabei, *Vita del cardinale G. Moroni* (1885); M. Young, *Life and Times of Aonio Paleario* (1860); C. Benrath, in Hauck's *Real-encyklopadie* (1903); *G.* Constant, La *Ldgation du Cardinal Morone, 1563* (1922).

MORONI, (MORONE), **GIAMBATTISTA** (GIOVANNI BATTISTA) (c. 1525–1578), Italian portrait painter of the Brescian school, was born at Albino near Bergamo and became a pupil of I1 Moretto (Alessandro Bonvicino). His portraits are full of straightforward life and individuality, with genuine unforced choice of attitude and excellent texture and arrangement of draperies; there is a certain tendency to a violet tint in the flesh. Portraits by Moroni may be seen at many galleries in the United States, including those at Detroit, Minneapolis, Worcester, Mass., Cleveland, Chicago (Art institute), New York (Metropolitan Museum of Art), San Francisco (California Palace of the Legion of Honor) and Washington, D.C. (National Gallery of Art). He is represented also at the National gallery, London (the well-known

"A Tailor"), and at museums on the continent.

MOROSINI, a noble Venetian family which gave many doges, statesmen. generals and admirals to the Venetian republic, as well as many cardinals to the church. It first became prominent at the time of the emperor Otho II as a result of its rivalry with the Caloprini family, whom it succeeded in subjugating by the end of the 10th century.

DOMENICO MOROSINI (d. 1156), elected dope in 1148, waged war with success against the Dalmatian corsairs, recapturing Pola and other Istrian towns from them. MARINO MOROSINI (d 12 52) was elected doge in 1249; MICHELE was doge from June 1382 until his death in October ot the same year.

ANDREA MOROSINI (1558–1618) was a famous historian and was entrusted by the Venetian senate with the task of continuing Paolo Paruta's *Annali Veneti,* in Latin. His history of Venice was published by his brother in 1623, and translated into Italian by the senator Girolamo Molin (1782). Among his other works are: *Le Imprese ed espeditioni di terra santa, etc.* (Venice, 1627); *De iis quae veneta respublica ad Istriae oras gessit, etc.* (in the Corner-Duodo collection of manuscripts); *De forma reipublicae venetae* in manuscript in the Bibliothèque Nationale in Paris. His life has been written by Luigi Lollin (1623), by Niccolo Crasso (1621) and by Antonio Palazzoli (1620).

FRANCESCO MOROSINI (1618–94) was one of the greatest captains of his time. He fought against, the Turks and the pirates, and after distinguishing himself at the battle of Naxos in 1650 he was appointed commander in chief of the Venetian navy. He conducted a series of successful campaigns against the Turks. but was recalled in consequence of the intrigues of his rival the Provveditore Antonio Barbaro (1661). But when Candia was attacked Morosini mas sent to relieve it in 1667; the siege lasted 18 months, but Morosini was forced to surrender to save the surviving inhabitants. He was tried but acquitted of all blame, and on the renewal of the war with the Turkish empire in 1684 he was again appointed commander in chief, and after several brilliant victories he reconquered the Peloponnesus and Athens; on his return to Venice he was loaded with honours and given the title of "Peloponnesiaco." In 1688 he was elected doge, and in 1693 he took command of the Venetian forces against the Turks for the fourth time; the enemy, which had been cruising in the archipelago, withdrew at his approach, so great was the terror inspired by his name. He died at Napoli di Romania (Nauplia) on Jan. 6, 1694.

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MORPETH, a municipal borough in the Morpeth parliamentary division of Northumberland, Eng.. in a loop of the river Wansbeck. 15 mi. N. of Newcastle upon Tyne by road. Pop. (1951) 10,797. Area 3.5 sq.mi.

The manor of Morpeth is said to have been granted to William de Merlay soon after the Conquest and passed with the borough from his family to the earls of Carlisle. The town is a borough by prescription and was incorporated in 1662. It grew up around the castle, attributed to William de Merlay, of which only the 14th-century gatehouse remains. A curious clock tower, once a prison, faces the market place, and the church is largely 14th-century.

In the valley of the Wansbeck above Morpeth are fragments of Nemminster abbey, a 12th-century foundation; and a renovated manor house of the 17th century. A peel toner of the 1 jth century is at Cockle park. an experimental farm of the county council. Local industries include tanning. market gardening, iron and brass founding and the manufacture of agricultural implements.

MORPHEUS, in Roman mythology, one of the sons of Somnus, the god of sleep. In Ovid (*Metam.* xi, 63j). he calls up human shapes (*morphai*) of all kinds to the dreamer, nhile his brothers Phobetor and Phantasus assume the forms of all kinds of animals and inanimate things. It is possible that Ovid misinterprets his name and that it really means "dark," cj. *morphnos.* Whether he is a popular or a literary figure is uncertain.

See Jümpel in Roscher's *Lexikon, s.v.*

MORPHINE, the principal alkaloid of opium, was isolated by F. W. A. Sertiirner in 1806. It is used in the form of its hydrochloride, sulfate, acetate and tartrate and in various derivatives such as ethyl morphine, Dilaudid, Dicodid, eucodal and metopon. Morphine can also be converted into a diacetyl derivative, known as heroin, which shows a considerably higher euphoric effect and has such a powerful addicting capacity that its manufacture is prohibited,

Morphine relieves pain and produces deep sleep. In addition to its analgetic activity it possesses a euphoric effect and many undesirable side actions, which are manifested on the respiratory, the circulatory and the gastrointestinal systems. It has an emetic effect and is a general depressant. The most serious drawback to the drug is its addiction liability. It is most frequently administered by injection to secure rapid action. However, it is also effective if given orally.

In its power to relieve pain. morphine is without rival. However, because of its addicting potentialities it should be reserved for the more severe degrees of suffering such as gallstone or renal colic or when other analgesics have failed. In instances of metastatic cancer, if pain is severe, it is justified even to the point of addiction. Usually it is wiser not to inform the patient that morphine is being given. As a sedative it is a remedy of much value in cardiac asthma and certain types of cough, such as whooping cough. In bronchial asthma it is contraindicated because of its depression of the respiration. It is also used to allay vomiting and to check diarrhea; however, in the latter case preparations of opium are preferable. By its calmative effect it protects the system against exhaustion in debilitated conditions, as certain forms of typhoid fever. For the same purpose it is a valuable drug in treatment of internal hemorrhage, traumatic or other shock associated with pain, congestive heart failure and threatened abortion.

Physical and Chemical Properties. — Morphine, $C_{17}H_{19}O_3N$, crystallizes from alcohol in colourless prisms containing one molecule of water, which is lost at 100° C. The anhydrous alkaloid melts at 254° C. and has a specific rotation of $[\alpha]_D^{25}-132$ in methyl alcohol. One gram of the alkaloid dissolves in about 5,000 c.c. of water, about 1,100 c.c. boiling water, 210 c.c. alcohol and 1,220 c.c. of chloroform. It is freely soluble in alkalis because of its acidic character. It is also a monoacidic base, forming salts mhich crystallize readily. The most commonly used are the sulfate $(C_{17}H_{19}O_3N)_2\ H_2SO_4,\ 5H_2O$ and $C_{17}H_{19}O_3N$, HCL, $3H_2O$, the hydrochloride. When morphine or its hydrochloride is heated with hydrochloric acid to 150° C. under pressure, it is converted by loss of a molecule of water into apomorphine, $C_{17}H_{17}O_2N$, a substance which has lost the characteristic physiological action of morphine but has acquired that of a powerful emetic, for which it is principally used in medicine.

The preparations of morphine are incompatible with salts of iron, copper and mercury; also with alkaline earths and substances containing tannin With ferric chloride it forms a deep blue colour which is destroyed by acids, alcohol or heating (E. J. If'.)

The structure of morphine proposed in 1925 by J. M. Gulland and R. Robinson was confirmed in 1952 by its total synthesis. accomplished by M. Gates and G. Tschudi. Starting with Schaeffer's acid. a coal tar intermediate, they succeeded in preparing morphine by a process involving 27 steps. Their synthesis was considerably too long and complicated to be feasible commercially, and its principal value was as a scientific achievement. Synthetic organic chemistry also provided a number of substances. among them Demerol, methadone, I-isomethadone and Dromoran, uhich in part supplanted morphine as analgesics. (M Gs.)

MORPHOLOGY, a term used in zoology and botany to cover all those studies in which the centre ot interest is the form and structure of an organism largely without regard for the associated functions. Morphology is thus the antithesis of physiology (*q.v.*). In mineralogy it is the term given to the study of the crys-

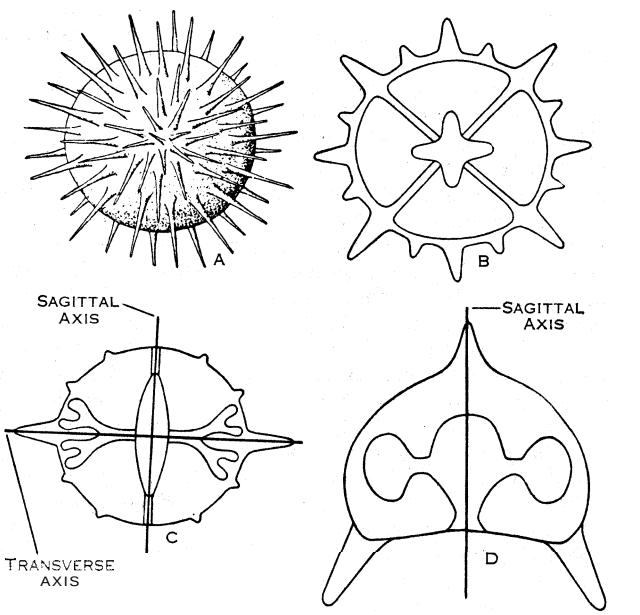
talline form of minerals (see CRYSTALLOGRAPHY). In philology. morphology is that branch of grammar which examines the forms of words as well as the principles of word formation and inflection. As the morphology of plants is treated under the article PLANTS AND PLANT SCIENCE, the present discussion will be confined to animals. It is possible to distinguish between the term morphology as dealing with the general form and arrangement of parts of an animal and the term anatomy as concerned with gross and microscopic structural details. but in actual practice among zoologists the two terms are used more or less synonymously.

Types of Animal Form. — Although at first glance the forms of animals appear multitudinous, they are in fact reducible to a few types, known as types of symmetry. Certain animals, especially most sponges and the ameboid Protozoa, lack definite symmetry. having either an irregular shape different for each individual or else undergoing constant changes of form. But the vast majority of animals exhibit a definite symmetrical form; *i.e.*, their parts are arranged according to a geometrical pattern. Four such patterns occur among animals: spherical, radial, biradial and bilateral.

In spherical symmetry, illustrated only by the protozoan orders Radiolaria and Heliozoa (see PROTOZOA), the body has the shape of a sphere and the parts are arranged concentrically around or radiate from the centre of the sphere. Such an animal has no ends or sides and any plane passing through the centre will divide the animal into symmetrical halves.

In radial symmetry. the body has the general form of a short or long cylinder or bowl with a central axis from which the body parts radiate or along which they are arranged in circular fashion. The main axis is heteropolar; *i.e.*, with unlike ends, one of which bears the mouth and is termed the oral or anterior end. and the other of which, called the aboral or posterior end, forms the rear end of the animal and may bear the anus. The main axis is hence termed the oral-aboral or anteroposterior axis. Any plane passing through this axis will divide the animal into symmetrical halves. Radial symmetry is found in the phyla Coelenterata and Echinodermata.

In biradial symmetry, in addition to the anteroposterior axis, there are also two other axes or planes of symmetry at right angles to it and to each other, namely, the sagittal, or median vertical longitudinal, and transverse. or cross, axes. Such an animal therefore not only has two ends but it also has two pairs of symmetrical sides. There are but two planes of symmetry in a biradial animal, one passing through the anteroposterior and sagittal axes and the other through the anteroposterior and transverse axes. Biradial symmetry occurs in the phylum Ctenophora (see COMB JELLY).



FROM L. H. HYMAN THE INVERTEBRATES: PROTOZOA THROUGH CTENOPHORA (MCGRAW-HILL)

TYPES OF ANIMAL SYMMETRY. A. SPHERICAL: B, RADIAL: C, BIRADIAL; D. BILATERAL

In bilateral symmetry, there are the same three axes as in biradial symmetry but only one pair of symmetrical sides. the lateral sides. since the other two sides, now known as the dorsal (back) and ventral (belly) surfaces. are unlike. Hence there is only one plane of symmetry that will divide a bilateral animal into symmetrical halves! the median longitudinal or sagittal plane, passing through the anteroposterior and sagittal axes. Bilateral symmetry is characteristic of the vast majority of animals. Types of symmetry are illustrated diagrammatically in fig. 1.

The forms of animals are clearly of adaptive significance. Thus the spherical and biradial forms are suitable only for a floating kind of life in a uniform medium; the radial type of symmetry is best adapted for an attached existence; and the bilateral type is necessary for efficient forward progression on a substratum. Bilateral symmetry is the most common type among animals because it is obviously more adaptable to a variety of circumstances than the other types and because through its suitability for forward progression it encourages the differentiation of head and brain. The forms of animals have little relation to internal anatomy since animals of very different anatomical construction may have the same type of symmetry. However, the spherical type of symmetry is possible only in minute animals of simple construction since in spheres the interior mass is large relative to the surface area and becomes too large for efficient functioning with increase in size and complexity.

Cephalization.—As already indicated a concomitant of bilateral symmetry is the progressive differentiation of the anterior end as an obvious head bearing conspicuous sense organs as eyes and tentacles and inclosing a concentration of nervous tissue. There is little or no differentiation of a head among spherical, radial or biradial animals. The differentiation of the head through the compacting of the anterior end. especially of anterior nervous and sensory structures, is termed cephalization. This process becomes more and more pronounced among bilateral animals as one ascends the scale of increasing complexity of structure and finally culminates in man and the apes with their overdevelopment of brain.

Segmentation. — A feature of animal form found in certain phyla is the repetition of body parts at regular intervals along the anteroposterior axis. These intervals are typically marked by a ringlike constriction so that the body of such an animal consists of a longitudinal series of joints or segments each of which typically contains a representative of all the body systems as a pair of kidneys, pair of nerve ganglia. etc. Such a type of animal construction is termed segmentation and occurs in the phyla Annelida. Xrthropoda and Chordata. Its occurrence does not necessarily indicate relationship. No generally accepted theory has been reached as to the origin of segmentation and its adaptive significance but the most plausible explanation is that segmentation began in the musculature in an elongated animal swimming by serpentine movements. Such movements would presumably be facilitated by the breaking up of the musculature into short segments. with accompanying segmental nervous control. But segmentation does not appear to be particularly advantageous since among segmented groups there is evident a tendency toward loss of segmentation through fusions of segments, dropping out of certain systems from some segments, etc. Among segmented animals cephalization involves the fusion of a number of the most anterior segments to form the head. with loss from these segments of most other systems except the nervous and sensory. As the vertebrates are a group of animals that show both segmentation and a high degree of cephalization. one of the great problems of vertebrate morphology in the past was that of the segmentation of the vertebrate head. especially the number of segments that had gone into its composition. From a long series of embryological researches the conclusion has been reached that the vertebrate head consists of three segments anterior to the ear capsule and a variable number. 2 or 3 to 10 or 12 or more in different vertebrates, behind the ear.

Variations of Form. — Numerous variants of the types of symmetry (except the spherical) are possible through relative growth;

i.e., greater growth during the animal's development along one axis than along others. Thus a given type of symmetry may express itself in long, thin forms, short, plump forms, etc., and, in the cases of biradial and bilateral symmetry, forms flattened along either the transverse or the sagittal axis. Kelative growth may also involve only one part of an animal, resulting in long-legged or long-necked forms, for instance! or types like the lobster and other crustaceans in which certain clams are enlarged out of proportion to other body parts. Again, relative growth may result in spiral types, a very common modification of bilateral symmetry seen in general body form in snails and other mollusks and in individual parts in innumerable cases. These variations of form also have adaptive significance. Thus very elongated types are frequently associated with burrowing habits, flattened forms are often bottom dwellers and the "streamlined" shape is the most suitable for rapid swimming.

One has only to think of birds and fishes to realize the numerous form variants possible to a single structural plan,

Convergence and Divergence.— As the forms of animals may be assumed in all cases to have adaptive significance for certain ways of life, it follows that animals of very different internal construction, and hence of no or very remote zoological relationship, may come to resemble each other superficially Such resemblance, of common occurrence among animals, is termed convergence. An excellent example of convergence is that of the whale, a mammal descended from land inhabitants, nhich has taken to the water and has come to have the iorm and appearance of a fish. On the other hand, animals closely related zoologically may through different habits of life come to differ greatly in superficial appearance. This phenomenon, also very common, is termed divergence. Thus the seal is closely related to the cat, although this would certainly not be evident from their external appearance.

Homology and Analogy.— The adaptive nature of form and the existence of such phenomena as convergence and divergence make it necessary to distinguish very clearly in zoology between genuine structural similarity and adaptive or functional resemblance. The recognition of this difference arose gradually and was only firmly established and defined by Richard Owen in 1843, who applied to structural resemblance the term homology and to functional or physiological resemblance the term analogy. This distinction between homologous and analogous structures is fundamental; it underlies all studies in comparative anatomy, embryology and classification. Homology is understandable only in terms of the principle of evolution. Homology is intrinsic anatomical similarity indicative of a common evolutionary origin. Homologous structures may seem unlike superficially but can be proved to be equivalent by any or all of the following criteria: similarity of anatomical structure; similarity of topographical position in the animal body; and similarity of embryological development. A familiar example of homology is the forelimb of the vertebrate, which may take the form of the wing of a bird. the flipper of a seal or the leg of a horse. Investigation of these shows that they have the same arrangement of bones. are operated by similar musculature and originate from the same embryonic rudiment. the limb bud, having the same topographic relation to the body. Analogous structures are those having a superficial and functional resemblance but which do not fulfill the above criteria. Analogy is seen in the wing of the bird and the wing of the bat. Whereas the bird wing is the entire modified forelimb, containing the whole of the limb skeleton, the bat wing is a fold of skin supported only by the hand bones. To discover what structures are homologous and to trace their evolutionary changes through a series of animals is the chief end and aim of a branch of zoology termed comparative anatomy (*q.v.*).

Form and Function.— The adaptive nature of form has been emphasized in the foregoing discussion. This should not be taken to mean, however. that changes of form are brought about directly by environmental action. Although the argument as to the causal relationship of form and function is an old one and cannot be said to have been conclusively settled. modern opinion is practically unanimous in negating any direct causation of adaptive structures by environmental factors. Adaptation is believed to originate through the preservation by natural selection of chance beneficial variations. Every species shows a certain amount of variation in all its characters, and those variations that happen to be most beneficial in given circumstances give their possessors a greater chance of survival. This process continued through ages eventually results in the production of highly adaptive structures related to the environmental conditions in question.

Experimental Morphology.——Animals come from an egg cell that bears no resemblance to themselves and achieve their final form and structure by a series of changes termed development or embryology. The question then arises whether the ultimate form and structure of an animal already pre-exist in some manner in the egg or whether they depend upon or can be altered by environmental factors, acting during development. To answer this question there arose about 1890 the science of experimental embryology, which continues to be one of the most flourishing and interesting branches of zoology. The problem has been attacked by two main methods: (1) subjecting the embryo to various agents and conditions, such as chemical solutions or alterations of temperature and (2) separating eggs and early embryos into pieces or grafting pieces to other embryos. The egg, of course, possesses an hereditary mechanism which causes it to develop into the same kind of animal as that which produced it, but the degree of fixation of adult characters in early developmental stages is variable with different eggs.

The first method of experimentation has shown that the proportions and arrangements of parts can be greatly altered by the application of chemical and physical agents. Such agents act chiefly by differential retardation of different embryonic regions or parts. Duplications of parts may be induced in this way or normally paired parts caused to fuse to one. Thus the production of cyclopia, or fusion of the two eyes into one, has become a commonplace in experiments on vertebrate embryos.

Through isolation and grafting of parts of eggs or very young embryos it has been found that all gradations exist from little to a very high degree of fixation of structure. At one extreme are the regulative types of eggs or young embryos of which a small part will produce an entire normal embryo, and at the other extreme is mosaic or self-differentiation in which a part will form only those structures that it would have formed when in its normal position in the whole. Experiment has shown, however, that the regulatory types become as development proceeds more and more self-differentiating so that eventually in every embryo a stage is reached in which the fate of each part is fixed and determined and not subject to alteration. The most interesting experiments are those perrormed on the regulative types of embryos, such as amphibians, during early stages before determination of parts has occurred. Such experiments reveal many cases of correlative development, *i.e.*, those in which the development of an embryonic area into the dehnite expected structure will occur only under the influence of some other embryonic part. Thus in vertebrates the lens of the eye comes from the skin over the eye whereas the nervous part of the eye (retina) comes from a brain bulge termed the optic vesicle. In the embryos of some animals the lens will not develop if the underlying optic vesicle is removed, and in such embryos any piece of skin graittd in contact with the optic vesicle will iorm a lens. The lens is therefore in such cases not preformed in any way but is called into existence by some influence emanating from the optic vesicle. The most remarkable case of correlative development is probably that discovered by Spemann in amphibian embryos in which at certain stages it nas found that the dorsal lip of the blastopore (containing material that will become notochord and mesoderm) induces the formation of the central nervous system. Consequently if this lip region is grafted onto another amphibian embryo in an area that would normally produce nothing much but skin and muscle. there can be induced another embryo compounded of cells of both graft and host.

Experimental embryology thus teaches that the form and structure of animals result in part from a pre-existing organization of the egg and in part from correlative factors operating during development. (L. H. H.)

MORPHY, PAUL CHARLES (1837–1884), U.S. chess player, was born in New Orleans, La., on June 22, 1837, the son of Alonzo Morphy (1798–1856) and his wife. whose maiden name was Le Carpentier. The father, the son of a well-to-do Spanish immigrant, was a prominent jurist and legislator and, like his brother Ernest, passionately fond of chess. Learning the moves from his father at the age of ten, Paul gave evidence of such extraordinary precocity that in less than two years he was able to defeat all the amateurs of his native city. While still at school he competed successfully with such strong players as Eugbne Rousseau and the Hungarian master J. Lowenthal. He attended the Jesuit college of St. Joseph at Spring Hill, Ala., and applied himself to the study of the law, being admitted to the bar of Louisiana in 1858.

During the autumn of 1857 Morphy took part in the first American chess congress at New York. winning the first prize from 16 competitors, including the well-known L. Paulsen. Morphy went to Europe in the spring of 1858 and entered upon a series of triumphs, both in regular matches and in blindfold play, that proved him to be one of the best players of the time. The winter of 1858–59 was passed in Paris, where he was destined to gain his greatest triumphs, practically winning the championship of the world by beating Adolf Anderssen, champion of Germany, by a score of 7–2, aith two games drawn. Another feat was his simultaneous blindfold match against eight strong French players, six of whom he defeated. At this time he was in his 22nd year Returning to the United States in 1859. he intended to establish himself in the practice of law at New Orleans, but the outbreak of the Civil War frustrated these plans. His devotion to chess had begun to affect his health. After a year in Paris, he returned to New Orleans in 1864, his health permanently impaired. He became insane, and at last died in New Orleans in 1884.

MORRILL, JUSTIN SMITH (1810–1898), U.S. congressional leader, was born at Strafford, Vt., April 14, 1810. At the age of 15, he became a clerk and later partner in a general store, retiring to a country estate in 1848. He devoted the latter half of his life to public affairs, serving in the national house of representatives from 1855 to 1867 and in the senate from 1867 to 1898. Morrill's long service was especially notable in three areas. As a conservative financier, he sponsored the tariff act of 1861 that inaugurated the policy of high protection. A consistent champion of "sound" currency, he opposed the resort to legal tender paper money during and following the American Civil War and also opposed the various proposals for the use of silver as a standard. For special needs, and to supplement tariff receipts, he favoured internal revenue taxes.

In Washington, D.C., Morrill made an influential contribution to the landscaping of the capitol grounds, the completion of the Washington monument, the construction of the Library of Congress building and to other projects. Most far-reaching of the measures he initiated in congress were the acts for federal aid to education. The Morrill act of 1862 provided grants of land to state colleges in which the "leading object" should be to teach subjects "related to agriculture and the mechanic arts," without excluding the general sciences and classical studies. It also provided for training in military science. This aid was supplemented in 1890 by a monetary grant. The enduring significance of these measures was in the incentive they gave to the states and in the precedent of national aid to education. Morrill died in Washington, D.C., Dec. 28, 1898.

See George W Atherton, *The Legislative Career of Justin S. Morrill* (1901) ; William B. Parker, *The Life and Public Services of Justin Smith Morrill* (1924). (E. D. Ro.)

MORRIS (MORRISON), **CLARA** (1848–1925), U.S. actress, whose most popular roles were Camille, Lady Macbeth and Cora in *L'Article* 47, was born in Toronto, Ont., March 17, 1848. She began her stage career in Cleveland, O., at the age of 14. In 1869 she joined a company in Cincinnati and a year later was engaged by Augustin Daly for his Fifth Avenue theatre in New York. Her first role there—Anne Sylvester in *Man and* Wife—brought her immediate popularity. In 1873 she began playing at A. M. Palmer's Union Square theatre.

Her health failed at the peak of her acting career and from 1900 Clara Morris wrote books and stories about the stage until her death at New Canaan, Conn., Nov. 20, 1925. During the last 20 years of her life she had appeared occasionally in vaudeville.

See Clara Morris, *Life on the Stage* (1901) and *Life of a Star (1906).* (S. W. H.)

MORRIS, EDWARD PATRICK MORRIS, 1ST BARON, (1858–1935), mas prime minister of Newfoundland from 1909 to 1918, Under him Newfoundland advanced from colonial status to membership in the British Commonwealth of Nations.

Morris was born in St. John's, Nfd., on May 8, 1858, and educated at St. Bonaventure's college, St. John's, Nfd., and the University of Ottawa, Ont. A Roman Catholic, Morris represented St John's West in the house of assembly from 1885 to 1918. Originally an Independent, he held office in Sir William Whiteway's Liberal administrations of 1889–94 and 1895–97. He was a member of another Liberal government, led by Sir Robert Bond, from 1900 to 1907, when he resigned because of the premier's overcautious social policies. Along with other rebel Liberals, he joined the Conservatives to become leader of a new People's party.

As prime minister after 1909 he made vigorous efforts to bring about social improvements, and, after 1914, to assist the British war effort. In 1916 he became a member of the Imperial War Cabinet. In 1917 Morris persuaded the Liberal party and the Fishermen's union to join him in a National government. He resigned as prime minister in Jan. 1918. and retired to England, where he was appointed to the house of lords for his "distinguished services to the Empire." He died in London on Oct. 24, 1935. (G. O. R.)

MORRIS, GOUVERNEUR (1752–1816), U.S. statesman and diplomat, was born in the old Morrisania manor house, in what is now the city of New York, on Jan. 31, 1752. He graduated from King's college (later Columbia university) in 1768, studied law and was admitted to the bar in 1771. An extreme conservative in his political views, he distrusted the democratic tendencies of the patriots, but a firm belief in the justice of the American cause led him to join their ranks. In 1776–77, Morris served in the New York provincial congress, which also functioned as a constitutional convention. In this body Morris distinguished himself by a successful fight to include a provision for religious toleration in the first state constitution, but failed in his efforts to obtain the abolition of slavery. He was a major advocate of a strong executive and a strong central government. He then served in the continental congress, 1777–79, where he was a chief supporter of George Washington. In 1778 he was selected chairman of the committee to treat with Lord North's conciliation commissioners, and as such presented the famous report, adopted by a unanimous vote of congress, which declared that the recognition of independence must precede any negotiations for peace.

Defeated for re-election to congress in 1779, Morris settled in Philadelphia as a lawyer. From Feb. to April 1780 he published in the *Pennsylvania Packet* a series of essays on finance, in which he criticized the issue of paper money, denounced laws passed for the benefit of the debtor class and urged the people to tax themselves for the common good. From 1781 to 1785 he was assistant to the superintendent of finance, Robert Morris (*q.v.*), to whom he was not related. In this office his most notable service was the preparation of a report on a decimal coinage suggesting the use of the terms dollar and cent. His plan, with some modifications by Jefferson, forms the basis of the present system of the United States. As a member of the Constitutional Convention of 1787 Morris was most active, speaking more frequently than any other delegate. He favoured a strong government in the hands of the rich and the well born and urged that the president be chosen for life with powers to appoint the senators for a similar term. Morris was instrumental in securing the executive veto and in defeating the proposal that the legislature should elect the president. He was a member of the committee of revision, where his literary skill was employed to give final form to the constitution.

In 1787 he returned to New York where he purchased the family manor from his brother. His well-known contempt for democracy, together with his multifarious commercial interests (many in as-

sociation with Robert Morris), prevented him from seeking office in the new government. In 1789 he went to France on private business and remained abroad for a decade. He was a witness to the French Revolution and left a vivid account of it in his diary, fully recording his personal antipathy toward the radical developments after 1792. Appointed minister to France in 1792, he openly disapproved of the radical course of the revolution and sought to aid Louis XVI to escape from France. His open hostility to the revolution led the French government to request his recall in 1794. Thereafter he remained in Europe for four more years and traveled extensively. He ended his active participation in politics after a brief term in the U.S. senate, 1800–03. Completely out of sympathy with the forces of republicanism, he allied himself with the extreme Federalists, who hoped to create a northern confederation during the War of 1812. His only venture into public life at this time was his service beginning in 1810 as chairman of the commission in charge of the construction of the Erie canal. Morris was witty, intelligent and cynical, and possessed enormous personal charm. Although a convinced believer in the importance of aristocratic birth and the privileges of class, he had a strong sense of public service. He died at Morrisania on Nov. 6, 1816.

See B. C. Davenport (ed.), *A Diary of the French Revolution,* 2 vol. (1939) ; Howard Swiggett, *The Extraordinary Mr. Morris* (1952). (H AM.)

MORRIS, SIR LEWIS (1833–1907), Welsh poet. was born in Carmarthen in 1833. His great-grandfather, Lewis Morris (1700–65), had been a well-known Welsh poet and antiquary. He was educated at Sherborne school and Jesus college, Oxford. He won the chancellor's prize for an English essay in 1858, was called to the bar in 1861 and elected honorary fellow of his old college in 1877. He practised for 20 years as a conveyancing counsel, retiring from active legal work in 1881. He was knighted in 1896. *Songs of Two Worlds* (1872, 1874 and 1875) showed a fluent gift of versification, and *The Epic of Hades* (1876–77) has passages of undeniable force and effect. Among his other books were *Gwen* (1880), *Songs Unsung* (1883), *Gycia* (1886), *A Vision of Saints* (1890), *Idylls and Lyrics* (1896) and *The New Rambler* (1906). He died at Carmarthen on Nov. 13. 1907.

MORRIS, ROBERT (1734–1806), American merchant and banker, a signer of the Declaration of Independence, was born in Liverpool. Eng., on Jan. 31, 1734. He joined his father in Maryland in 1747, entered a mercantile house in Philadelphia and at the age of 20 became a member of a prosperous firm in which he was later a partner. During the American Revolution Morris joined the patriots and associated himself with their more conservative wing in Pennsylvania. He was vice-president of the Pennsylvania committee of safety (1775–76) and was a member of the continental congress (1775–78). He was reluctant to sanction separation from Britain, and voted against it in the continental congress. Even after the Declaration of Independence was adopted, he continued to hope for reconciliation with the mother country and did not sign the document until seven weeks later. After retiring from the continental congress, he served in the Pennsylvania legislature (1778–79 and 1780–81).

Morris performed his greatest service as the financier of the revolution. As chairman or member of various committees of the continental congress, he practically controlled its financial operations from 1776 to 1778. After the war he served as superintendent of finance under the Articles of Confederation from 1781 to 1784, and was also agent of marine during the same period, being in effect head of the navy department. He is especially remembered as the man who secured the funds which made it possible for Washington to move his army from the environs of New York to Yorktown and to force the surrender of Lord Cornwallis (1781). Morris borrowed from the French, requisitioned from the states and also advanced money from his own pocket. While there can be no doubt that his services were very valuable, it is also true that he sought to improve his private fortune while he held public office, and that his official functions gave him advantage in his private transactions. He was, however, acquitted by congress when charged with dishonesty.

In 1781 Morris established in Philadelphia the Bank of North America, chartered at first by congress and later by the state of Pennsylvania. It is said, on insufficient evidence, that Washington offered him the post of secretary of the treasury in 1789 and that, after declining, Morris was instrumental in securing the appointment for Alexander Hamilton. Elected to the U.S. senate, he supported Federalist policies and assisted Hamilton in executing his financial plans (1789–95). Meanwhile, Morris had disposed of his mercantile and banking investments and had plunged heavily into land speculation. When his lands failed to bring him prompt profit. Morris fell into bankruptcy and was confined in a debtors' prison for more than three years (1798–1801). He died in Philadelphia on May 7, 1806.

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MORRIS, WILLIAM (1834–1896), English poet and artist, third child and eldest son of William Morris and Emma Shelton, was born at Elm house, Walthamstow, on March 24, 1834. His father came up to London in 1820, and entered the office of a firm of discount brokers in nhich he afterwards assumed a partnership. William was a delicate and studious child. When he was six the family moved to Woodford hall, where the boy's health improved. He was then sent to a school at Walthamstow, and, after his father's death, when the home at Woodford was broken up, to Marlborough. There he acquired a taste for architecture, fostered by the school library, and an attraction towards the Anglo-Catholic movement. In June 1852 he matriculated at Exeter college, Oxford, but he did not go into residence till Jan 1853 Among his Oxford friends were Edward Burne-Jones and a little Birmingham group at Pembroke. They were known among themselves as the "brotherhood"; they read together theology, ecclesiastical history, mediaeval poetry and, among moderns. Tennyson and Ruskin. They studied art, and fostered the study in the long vacations by tours among the English churches and the continental cathedrals. Morris began at this time to write poetry.

Morris was entered (1856) as a pupil at the office of George Edmund Street, the architect; and on New Year's day the first number of *The Oxford and Cambridge Magazine* appeared. The magazine existed for only a year. The chief immediate result was the friendship between Morris and Dante Gabriel Rossetti (*q.v.*), who became a contributor. In the summer of 1856 Street removed to London, and Morris accompanied him, working hard at architecture and painting. Rossetti persuaded him to devote himself exclusively to painting. Early in 1858 Morris published *The Defence of Guenevere,* which was almost unnoticed by contemporary criticism, but is now recognized as one of the pearls of Victorian poetry.

On April 26, 1859, Morris married Jane Burden, a beautiful Oxford girl, who had sat to him as a model, and settled temporarily at 41 Great Ormond street, London. Meanwhile he set about building for himself at Upton a house which was to be the embodiment of all his principles of decorative art. Its furnishing had suggested a fresh activity; Morris now decided to begin decoration as a career. A small company was formed, consisting of D. G. Rossetti, Philip Webb, Burne-Jones, Madox Brown, Faulkner and Marshall, and in Jan. 1862 started business under the title of Morris, Marshall, Faulkner and Co.. with offices at 8 Red Lion square. The firm undertook church decoration, carving, stained glass, metalwork, paper hangings, chintzes and carpets. The business, after inevitable vicissitudes, flourished, but the "house beautiful" at Upton proved to be unhealthily situated. Serious illness obliged the family to remove to town, and in Nov. 1865 they resettled at 26 Queen square, Bloomsbury. Morris was now unceasingly busy, but he found time to write. In June 1867 he published *The Life and Death of Jason,* which was at once successful; and in April 1868 the first two parts of *The Earthly Paradise.* The rest of this wonderful storehouse of poetic romance appeared in two volumes in 1869 and 1870. In 1871 he took Kelmscott manor house, in the Upper Thames valley, in joint tenancy with Rossetti,

for use principally as a holiday home. In 1872 appeared *Love is Enough,* structurally the most elaborate of his poems; and in the autumn he began to translate the shorter Icelandic sagas, to which his enthusiasm had been directed by two inspiring journeys to Iceland. Business worries, however, interrupted him; the company had grown out of proportion with the existing division of profit and labour, and reconstruction was necessary. Long negotiations ensued, and in March 1875 the old firm was dissolved. Morris now became sole manager and proprietor.

Meanwhile in addition to his work upon the sagas, Morris had actually finished and (in 1875) published a version of the *Aeneid.* In 1876 appeared *Sigurd the Volsung,* a version full of heroic vigour, movement and vitality, but somewhat too lengthy and incoherent in design to preserve the epic interest intact to the British taste. This splendid burst of poetic activity had raised him to a place among the first poets of his time; and in 1877 he was offered the professorship of poetry at Oxford, which he declined. A fresh outlet for his energy was furnished by his foundation in 1877 of the Society for the Protection of Ancient Buildings, which sprang into being as a practical protest against a scheme for restoring and reviving Tewkesbury abbey.

At first Morris inclined, in politics, to the Radical section of the Liberal party, but in Jan. 1883 he joined the Democratic Federation, soon afterwards becoming treasurer of the party. On Dec. 30, 1884, he and others seceded from the Federation and formed the Socialist League, largely on the grounds that parliamentary action on which the leaders of the Federation tended to concentrate, was premature. Morris was appointed treasurer and editor of the monthly organ of the new League, the *Commonweal,* to which he later contributed his *Dream of John Ball* and *News from Nowhere.* The League started by repudiating State Socialism, and later became definitely opposed to parliamentary action. Morris lectured and spoke at meetings, and was several times arrested for obstruction in open-air meetings. But he was beginning to see that the time was not ripe for revolution. In 1890 the Anarchist section of the Socialist League became dominant, and Morris had to relinquish the editorship of the *Commonweal.* He still kept up with the Hammersmith Branch, which became independent, and met at Kelmscott House until its dissolution in 1892. But from this time on he took up a negative position. His *News from Nowhere,* published in book form in 1891, is a delightful and inspiring book, and a classic of the English movement, describing an England in which the socialist commonwealth has been realized.

Long before that time, however, Morris had returned to art and literature. When his business was enlarged in 1881 by the establishment of a tapestry industry at Merton, in Surrey, Morris found yet another means for expressing the mediaevalism that inspired all his work, whether on paper or at the loom—or indeed in political thought. In 1887 he published his translation of the *Odyssey.* He then added another to his multitudinous activities; he assumed a direct interest in typography. *The House of the Wolfings,* which was printed in 1889 at the Chiswick Press, was the first essay in this direction; and in the same year, in *The Roots of the Mountains,* he carried his theory a step further. Some 15 months later he added a private printing-press to his multifarious occupations, and started upon the first volume issued from the Kelmscott Press, his own *Glittering Plain.* For the last few years of his life this new interest remained the absorbing one.

His last piece of work, decidedly the crowning glory of his printing-press, was the *Kelmscott Chaucer,* which had taken nearly two years to print, and fully five to plan and mature. It was finished in June 1896. His vigour had been slowly declining for some time, and he sank gradually during the autumn, dying on Oct. 3, 1896. He was buried in Relmscott churchyard.

Essentially the child of the Gothic revival, he had put an ineffaceable stamp on Victorian ornament and design, his place being that of a follower of Ruskin and Pugin, but with a greater practical influence than either. In house decoration of all kinds — furniture, wall-papers and hangings (which he preferred to paper), carpet-weaving, and the painting of glass and tiles, needlework, tapestry—he formed a school which was dominated by his protest against commercialism and his assertion of the necessity for natural decoration and pure colour, produced by hand work and inspired by a passion for beauty irrespective of cheapness or quickness of manufacture.

His friend Swinburne said that he was always more truly inspired by literature than by life. His socialism was tinged by a passionate enthusiasm for an inaccessible artistic ideal. Morris, indeed, was not primarily interested in men at all, but in objects. His poetry deals, it is true, with the human passions, but the emotion is always seen as in a picture; he is more concerned with the attitude of the group than with the realization of a character. But the spirit of beauty breathes in every line; a sense of music and of colour is everywhere abundant. Nor does the poet lack power and vigour when an adventurous story is told. Over all hangs the faint atmosphere of mediaevalism, of an England of green gardens and grey towers, of a London "small and white and clean," of chivalry and adventure in every brake. The critic has also to remember the historical value of Morris's literary influence, following upon the prim domesticities of early Victorian verse, and breaking in upon Tennyson's least happy phase of natural homeliness.

See the *Life and Letters, in* 2 vols., by J. W. Mackail; also H. Jackson, *William Morris* (1908); J. **B.** Glasier, *William Morris and the Early Days of the Socialist Movement* (1921); *H.* **H.** Sparling, *The Kelmscott Press and William Morris (1924);* G. Fritzsche, *William Morris' Sozialismus und anarchistischer Kommunismus* with bibliography (1927).

MORRIS-DANCE or **MORRICE-DANCE,** an old English dance, which is said by various authorities to have been introduced by John of Gaunt from Spain or borrowed from the French or Flemings. That it was a development of the moriscodance or Spanish fandango is not invalidated by the fact that the morisco was for one person only, for, although latterly the morrisdance was represented by various characters, uniformity in this respect was not always observed. There are few references to it earlier than the reign of Henry VII., but it would appear that in the reign of Henry VIII. it was an almost essential part of the principal village festivities. In earlier times it was usually danced by five men and a boy dressed in a girl's habit, who was called Maid Marian. There were also two musicians; and, at least sometimes, one of the dancers, more gaily and richly dressed than the others, acted as "foreman of the morris." The garments of the dancers were ornamented with bells tuned to different notes so as to sound in harmony. Robin Hood, Friar Tuck and Little John were characters extraneous to the original dance, and were introduced when it came to be associated with the May-games. The morris-dance was abolished along with the May-games and other festivities by the Puritans, and, although revived at the Restoration, the pageant gradually degenerated in character and declined in importance. Maid Marian latterly was personated by a clown, who was called Malkin or Marykin. The interest of the subject has revived in recent years in connection with the new movements associated with folk-music generally. *(See* also DANCE; FOLK-DANCE.)

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MORRISON, ARTHUR (1863–1945), English novelist, was born in Kent on Nov. 1, 1863. He was for a short time a clerk in the civil service, and in 1890 took to journalism. *Tales* of *Mean Streets* (1894) and *A Child* of *the Jago* (1896) contained admirable realistic descriptions of London life. He also wrote *The Painters* of *Japan* (1911) and plays. His collection of Chinese and Japanese paintings was acquired by the British museum in 1913. Morrison died at Chalfont St. Peter, Dec. 4, 1945.

MORRISON, GEORGE ERNEST (1862–1920), British journalist and traveller, mas born at Geelong, Australia, and educated at Melbourne University. From 1882 he travelled extensively in the South Sea Islands, where he studied the Kanaka labour question; in Australia, which he crossed on foot from the Gulf of Carpentaria to Melbourne; and in New Guinea. He took his M.D. degree in 1887 and after journeys to the United States and the West Indies he worked in his medical capacity in Spain, Morocco and Australia. In 1893 he abandoned medical work and

set off on extensive travels in the far east. He was special correspondent of *The Times* (London) in Siam (1895), and in Peking (1907–12). In 1912 he resigned his *Times* appointment and became political adviser to Yuan Shih-K'ai, president of the newly formed Chinese Republic. Morrison's published works include *An Australian in China* (1895). He died at Sidmouth, Devonshire, on May 30, 1920.

MORRISON, RICHARD JAMES (1795–1874), English astrologer, commonly knoun by his pseudonym "Zadkiel," was born on June 15, 1795. He served in the Royal Navy, but resigned with the rank of lieutenant in 1829. He then devoted himself to the study of astrology, and in 1831 issued *The Herald of Astrology,* subsequently known as *Zadkiel's Almanac.* In this annual pamphlet Morrison, over the signature "Zadkiel Tao-Sze," published predictions of the chief events of the coming year. He died on April 5. 1874.

MORRISON, ROBERT (1782–1834), the first Protestant missionary to China, was born of Scottish parents at Buller's Green, near Morpeth, on Jan. 5. 1782. After receiving an elementary education in Newcastle. he was apprenticed to a lastmaker, but his spare hours were given to theology, and in 1803 he was received into the Independent academy at Hoxton. The London Missionary society sent him out to Canton in 1807. He became translator to the East India company's factory there in 1809, and worked at a *Chinese Grammar* and *a* translation of the New Testament, both published in 1814. In 1817 he published *A View of China for Philological Purposes,* and his translation of the Old Testament (in which William Milne collaborated) mas completed in the following year. He established (1820) an Anglo-Chinese college at Malacca for "the reciprocal cultivation of Chinese and European literature," and for the training of native Chinese evangelists who could proceed to the mainland and carry on Christian work with comparative immunity. In 1821 Morrison's *Chinese Dictionary* (6 vol.), was published by the East India company. Leaving China at the close of 1823, Morrison spent two years in England, where he was elected a fello of the Royal society. Returning to China in 1826, he began to prepare a Chinese commentary on the Bible and other Christian literature. He died at Canton on Aug. 1, 1834. Morrison's establishment of a dispensary, manned by a native who had learned the main principles of European treatment, marks him out as the forerunner of modern medical missions.

His *Memoirs,* compiled by his widow, were published in 1839.

See also R. Lovett, *History of the London Missionary Society,* vol. ii, ch. xix; C. S. Horne, *The Story of the L. M. S.,* ch. v; Townsend, *Robert Morrison (1888).*

MORRISON OF LAMBETH, HERBERT STANLEY MORRISON, BARON (1888–), British Labour party leader, was born at Brixton. London, on Jan. 3. 1888, the son of a policeman. In 1912 he became deputy circulation manager of the Labour party newspaper, the *Daily Citizen,* and from 1915 to 1940 he was secretary of the London Labour party, which he helped to found. Mayor of Hackney in 1920–21. Morrison mas a member of the London County council from 1922 to 1945, serving as leader from 1934 to 1940. He served as Labour member of parliament for South Hackney (1923–24, 1929–31 and 1935–45), East Lenisham (1945–50) and South Lewisham (1950–59). Retiring from the house of commons in 1959, Morrison was created a life peer with the title Baron Morrison of Lambeth.

Morrison was chairman of the Labour party in 1928–29. He then became minister of transport (1929–31) in Ramsay MacDonald's second Labour government and in that post completed plans for the formation of the London Passenger Transport board. In May 1940 he became minister of supply in Winston Churchill's coalition government, and in October of that year he was made home secretary and minister for home security. As a member of the mar cabinet (1942–45). he mas chairman of the cabinet's civil defense committee and his name was given to the indoor air raid shelter used during World War II. At the war's end Morrison played a leading part in developing the Labour party's strategy in the elections of 1945, 1950 and 1951. In Clement Attlee's government of 1945 he became lord president of the council, deputy prime minister and leader of the house of commons. As the government official responsible for arrangements for the Festival of Britain (1951), Morrison was referred to in the commons as "Lord Festival." He succeeded Ernest Bevin as foreign secretary in March 1951 and, after his party's defeat at the 1951 parliamentary elections, was elected deputy leader by the parliamentary Labour party.

Morrison's published works include *Socialisation and Transport* (1933); *How Greater London Is Governed* (1935; rev. ed., 1949); *Looking Ahead* (1943); *The Peaceful Revolution* (1949); *Government and Parliament: a Survey From the Inside* (1954).

MORRISTOWN, a town of New Jersey, U.S., 30 mi. W. of New York city; the seat of Morris county and the retail-trade centre of an area that in the latter part of the 20th century was rapidly changing from one of large estates and farms to one of chemical industries, research laboratories and housing developments occupied by people who commute to New York city and to Newark. Established as West Hanover in 1710 uhen a forge was established to utilize the iron ore there, it was renamed in 1740 in honour of Lewis Morris, then governor of the colony. The Morristown National Historical park, established in 1933, includes Jockey hollow, where U.S. troops spent the winter of 1779–80; the Ford mansion, which served as George Washington's headquarters the same year; and the site of Ft. Nonsense, low earth works built by the troops quartered in the town in 1777, primarily, apparently, to keep them busy. Adjacent to the Ford mansion is the Historical museum with an outstanding collection of relics. books and manuscripts pertaining to Washington and the American Revolution.

Benedict Arnold was court-martialed in the Dickerson tavern and Alexander Hamilton courted his future wife Elizabeth ("Betsy") Schuyler at the Jabez Campfield mansion. still standing. Samuel F. B. Morse and Alfred Vail developed the telegraph at the Speedwell ironworks. Late in the 19th century the town was the home of millionaires and such well-known personages as Frank R. Stockton. Bret Harte, Rudyard Kipling and Thomas Nast.

Educational institutions in the Morristown area include Delbarton and the Morristown school, both preparatory schools for boys; Peck, a coeducational elementary school; and Villa Walsh, a Roman Catholic high school and junior college for women.

Morristown was incorporated in 1865. For comparative population figures *see* table in NEW JERSEY: *Population.* (E. R. D.)

MORROW, DWIGHT WHITNEY (1873–1931), **U.S.** lawyer, financier and statesman, was born in Huntington, W.Va., on Jan. 11, 1873. His father, James Elmore Morrow, served briefly as president of Marshall college, Huntington, W.Va. (1871–73), then resumed teaching in Pennsylvania. Dwight, one of five surviving children, was frail but precocious, gifted in mathematics and endowed with a strong personality. He graduated from Amherst, Amherst, Mass. (1895), and Columbia law school (1899), then entered the firm of Reed, Simpson, Thacher & Barnum. On June 16, 1903, he married Elizabeth Reeve Cutter, a graduate of Smith college, Northampton, Mass. They settled in Englewood, N.J., where their four children were born.

Morrow became a partner in the reorganized firm of Simpson, Thacher and Bartlett in 1905 and won an enviable reputation in corporation lan. He aided in drafting a workmen's compensation law in 1911 and in preparing a report in 1917 that led to prison reform in New Jersey. He accepted a partnership in J. P. Morgan & Co. in 1914. Among his notable achievements was the organization of the Kennecott Copper Corp.

After the U.S. entered World War I, Morrow went to Europe early in 1918 as adviser to the Allied Maritime Transport council. After the war Morrow helped Cuba solve its financial troubles. As chairman of the president's aircraft board in 1925 he aided in formulating a national military and civil aviation policy for the U.S.

President Coolidge appointed him ambassador to Mexico in Sept. 1927. He immediately established cordial relations with President Calles, temporarily settled the oil, debts and claims problems and partially restored harmony between church and state. Morrow's work was a strong precedent for the Good Neighbor pol-

icy. As a delegate to the London Naval conference in 1930 he played a vital conciliatory role. He uas elected senator from New Jersey in 1930, but attended only one session of congress before his death on Oct. 5, 1931. Morrow's unimpeachable integrity, judicious temperament and thorough scholarship largely explain his success in finding acceptable solutions to extremely complicated economic and political problems.

Anne Morrow, a daughter, married the famous aviator Charles A. Lindbergh (*q.v.*) on May 27, 1929. (H. G. WN.)

MORSE, SAMUEL FINLEY BREESE (1791–1872), U.S. artist and inventor, was one of the most respected American artists of his day and invented the most widely used telegraph. He was born at Charlestown, Mass., on April 27, 1791, the son of Jedidiah Morse. a distinguished clergyman and geographer. At Yale college where he was a fickle student, Morse developed a passion for painting miniature portraits. After a struggle with his parents, he was permitted to study historical painting in England nith Washington Allston from 1811 to 1815. On his return he found Americans cold to his historical canvases and reluctantly returned to portraiture to earn a living. He boldly portrayed the character of his subjects. Though often poor he was affable, at home in intellectual and wealthy circles, and possessed a gift for friendship. After settling in New York. he became the leading founder and first president (1826–45) of the National Academy of Design.

In 1832 he was returning by ship from art study in Europe, when, after a shipboard conversation on the newly discovered electromagnet, he conceived the idea of a single circuit electromagnetic telegraph. (See TELEGRAPH.) Although electric telegraphs had been proposed before 1800 and Joseph Henry had published a detailed description of an electromagnetic one in 1831. Morse believed for several years that his was the first electric telegraph proposed.

Until at least 1837, Morse devoted himself chiefly to painting, teaching art at the University of the City of New York (later New York university), and to politics (he ran on nativist tickets for mayor of New York in 1836 and 1841).

By 1835 he probably had made his first working telegraph. In 1837 a science colleague at the university, Leonard Gale, introduced him to the work of Henry; and Alfred Vail, through his family's iron works in Morristown, N.J., offered to provide materials and labour to build telegraph models. Gale and Vail became partners in Morse's telegraph rights. By 1838 he had developed the Morse code, an alphabet composed of dots and dashes in its first form; in altered forms it was to become known throughout the world. In 1838, while in the process of attempting unsuccessfully to persuade congress to build a telegraph line, Morse acquired another partner, Congressman F. O. J. Smith of Maine. After failing to organize the construction of a Morse line in Europe, Morse alone among the partners persevered in promoting his telegraph, until in 1843 congress voted to pay Morse to build the first telegraph line in the United States, from Baltimore to Washington. The next year he sent the first message on this line: "What Hath God Wrought!"

Thereafter Morse was caught in a swirl of legal claims among his telegraph partners and rival inventors. A natural controversialist like his father, he fought vigorously in this and such other controversies as that in art with John Trumbull, in religion with Unitarians and Roman Catholics, in politics with the Irish and with Abolitionists, and in daguerrotypy—of which he was one of the first practitioners in America—with François Gouraud.

He established his patent rights through a series of court battles which culminated in a decision by the supreme court in 1854. As telegraph lines spread he was rewarded by many governments of Europe for his invention. In old age he was a philanthropist. He died on April 2. 1872, in New York city.

See Carleton Mabee, *The American Leonardo, A Life of Samuel F. B. Morse* (1943). (C. ME)

MORSE CODE: see TELEGRAPH.

MORSHANSK, a town of the R.S.F.S.R., U.S.S.R. in the *oblast* of Tambov, in 53° 28′ N., 41° 45′ E., on the Tsna river. It is a grain collecting centre and has an elevator. There are manufactures of glass, cloth, makhorka tobacco and sauce. Pop. (1933) 31,000. The town was founded in the 17th century.

MORTALITY STATISTICS: see DEATH RATE; LIFE INSURASCE.

MORTAR: see BRICKWORK; MORTAR IN BUILDING.

MORTARA, EDGAR, an Italian Jew, of a Bologna family, whose abduction in early childhood (1858) by the Inquisition occupied for several years the attention of European diplomacy. When five years of age he fell ill. His nurse, a Catholic, arranged with her priest for his baptism in that faith. unknown to his parents, on June 24, 1858. She had tried to convert his elder brother in a similar way, but failed. This time everything was concerted in advance with the ecclesiastical authorities. and immediately after the baptism both child and nurse disappeared. The story became known, and protest was aroused in nearly every European country.

Pius IX maintained that the question at issue was a spiritual one, outside his temporal jurisdiction. and would not take any action, meanwhile indicating the direction of his sympathies by making Mortara his ward. In 1861 the Mortara family induced the Italian government to demand the prosecution of the nurse. who had meanwhile entered a nunnery, but subsequently, on the threat of intervention by Prussia. they withdrew their plaint. After the capture of Rome by the Italian troops in 1870 Edgar Mortara had the opportunity of reverting to Judaism, but he refused to do so. and became an Augustinian.

MORTAR IN BUILDING. Mortar is a mixture of inert siliceous material with cement which, after being prepared into a plastic state with water, has the property of hardening into a stonelike mass. Mortar is used in the construction industry to bond brick, building stone, tile, concrete block and other masonry units into a single unit or structure. Its fundamental purpose is to bed fully the masonry units so that the load of the structure is distributed uniformly over the entire bonding surface of the units; it provides, moreover, a weathertight joint. Mortars should be proportioned so that the mix possesses a good plastic quality in its wet state, thereby permitting it to flow readily under the weight of the masonry unit plus a tap of the mason's trowel. The cement content should be held to a minimum consistent with the desired properties of strength and watertightness, since it is the most costly constituent of the mix. (See also MASONRY.)

Cementing Materials.—The choice will be controlled by three factors: the availability of supply. the size of the structure and location—for example, the structure may be below ground level or under water. The types of cements include hydrated lime, hydraulic lime, pozzolan cement, natural cement, slag cement. masonry cement, and Portland cement. Since the size of the structure determines the magnitude of the dead weight of the material, massive structures demand the use of only those cements possessing good strength properties, such as Portland cement and masonry cement.

Some cements have the property of hardening in the presence of water. and are thus termed hydraulic cement. Only those with excellent hydraulic properties should be used in structures built in water and below ground level.

Most of the cementing materials may be manufactured in a ready-to-use state whereas others must be prepared for use on the job site. With a few exceptions, the former are used exclusively in the United States;-this is not the case, however, in many other parts of the world.

Hydrated *lime* is a nonhydraulic cement which must be prepared on the job site. When a limestone is calcined, the resulting product is quicklime. A quicklime that has been chemically satisfied with water is hydrated lime. The process of hydration is called slaking. Because the chemical composition of limestones vary. there are four classes of quicklimes: high-calcium, calcium. magnesian, and high-magnesian. The rate of hydration of the various classes of quicklime depends upon its (1) physical condition (fineness of grind), (2) chemical composition (calcium and magnesia content), and (3) calcining temperature. The procedures for slaking quicklimes are given below:

Quick-slaking Lime.––Always add lime to water. The water

should cover the lime; if escaping steam is observed, the material should be hoed and enough water added to stop the steaming

Medium-slaking Lime.—Add enough water to the lime to half submerge it. Hoe mixture and add a small amount of water if steaming occurs.

Slow-slaking Lime—Add enough nater to thoroughly moisten the lime As the hydration continues, sprinkle the lime nith small amounts of water to assure its complete hydration.

The slaked lime kept in a putty form, is usually allowed to stand at least 24 hours before using in mortar Some masons prefer putty which has aged for longer periods, perhaps from tno weeks to as long as several months. Aging is desirable nhen the putty is to be used for wall plaster; honever, 24 hours is satisfactory for mortars

The mixing of the putty with sand or similar inert material produces mortar. Table I indicates the characteristics of the several classes of lime putties.

TABLE I.—*Characteristics of Lime Putties*

Class	Plasticity	Sand-carrying capacity	Yield
Calcium	Fair	Excellent	Good
High-calcium	Fair	Excellent	Excellent
Magnesian	Good	Good	Good
High-magnesian	Excellent	Fair	Fair

Lime putty alone does not make a wholly satisfactory mortar because of the excessive shrinkage which develops when it sets and hardens. The inert siliceous material reduces shrinkage sufficiently to prevent cracking of the hardened lime. Also it reduces cost materially.

Because of its nonhydraulic quality. hydrated lime mortars should be used only above ground level. The hardening of lime mortars is the reconversion of the lime hydrate to the original calcium carbonate and the rate of hardening is slow. Lime mortar in the centre of wall joints may develop as little as 20% of its strength in five to ten years. Therefore its use should be limited to the less important structures. A characteristic of high-magnesian lime mortars is its excessive expansion. sufficient in amount to cause the cracking and bulging of brick masonry.

Hydrated lime is frequently reduced to a dry powder form for use with other cements to provide a fatty quality in the mortar. In the United States quicklime is the usual term applied to lime putty and hydrated lime is applied to the powder form.

Hydraulic lime is prepared by calcining siliceous or clay-bearing limestones. The resulting clinker contains sufficient lime silicate to be hydraulic and also contains free lime so that the calcined material will slake when water is added. The slaking of hydraulic lime breaks the calcined clinker into a fine powder. Only a light sprinkling of water is necessary in the slaking process.

Although the lime is hydraulic. it should not be used for subaqueous structures. In addition hydraulic lime sets slowly and has low strength. Its use should be limited to unimportant masonry structures or for such purposes as stucco and plaster.

Pozzolan or pozzuolana cement is produced from natural or artificial pozzolanic materials. The natural pozzolans include pumicite. obsidian. tuff, trass. santorin and scoria originating from volcanic rock and diatomaceous earth, opal and those clays, shales and cherts containing opaline silica. Artificial pozzolans include fly-ash and water-quenched boiler slag. Because of their low strength, pozzolan cements are usually blended with Portland cement at the ratio of 30% pozzolan to 70% Portland cement. These blended mixtures will produce strengths approaching that of Portland cement and provide plastic mixes. True pozzolanic cement has been knon-n since the early Christian era. It is made by grinding two to four parts of pozzolan with a powdered hydrated lime.

Slag cement is essentially a pozzolan cement. It is produced by finely pulverizing blast-furnace slag with hydrated lime. Slag cement is used as a masonry cement because of its nonstaining characteristic.

Natural cement is so named because it is manufactured from a clayey limestone that produces, uhen calcined and pulverized, a hydraulic cement. It should not be used in structures demanding high strengths, or exposed to severe weathering.

Masonry cement has been developed for the specific purpose of making mortars to bond together masonry units. The exact composition of the many trade name brands are considered trade secrets by the individual manufacturers. A study made in 1934 on masonry cements manufactured in the United States indicated compositions as follows: Portland cement and hydrated lime mixtures; Portland cement and plasticizing agents such as limestone dust, fly-ash, diatomaceous earth, and other siliceous materials; Portland and natural cement blends; Portland cement; natural cement; Portland and slag cement; hydrated lime; and hydraulic lime. Many of these brand cements contained water-repellent additives such as petroleum products or fatty acid derivatives. The water repellents increase the entrained air causing increased yields, increased watertightness and increased resistance to weathering action such as freezing and thawing. The study showed a wide range of properties for the masonry cements. indicating that caution should be exercised if shrinkage, good compressive strength and resistance to freezing and thawing mere important construction factors.

Portland cement will make the strongest and most durable mortars. However, because of its poor water-retention property, it is difficult to produce a workable (plastic) mortar. Since joints must be made watertight, it is necessary to add a plasticizer such as hydrated lime. diatomaceous earth. limestone dust and similar substances if the mortar is to work well and stick in the vertical joints. Portland cement is the product obtained by pulverizing the clinker formed when calcining properly proportioned mixtures of calcareous and argillaceous materials. Portland cement is of the same general character wherever it is manufactured. (For the history of Portland cement *see* CEMENT.)

Inert Aggregate Materials.— Many kinds of siliceous materials combined with cement produce satisfactory mortars. The most common inert aggregate fillers are sand. crushed stone, crushed brick or burned shale and slag. The purpose of the aggregate is to reduce costs and minimize the excessive shrinkage and expansion characteristics of cements when used alone. The inert materials should be durable to weathering action. clean. strong and well graded from the smallest to the largest particle sizes. In general the maximum size of inert particles in mortars is one-fourth inch.

The Proportioning of Mortar Mixtures.— Numerousexperiments have shown that the strength and degree of watertightness of mortar mixes having similar density and workability is directly related to the cement content. Similarly if the cement content and workability are alike, the strength and watertightness of the resulting mortar increases with density. Therefore a well designed ccment-aggregate mixture requires dense graded aggregates proportioned with an optimum cement content. Typical mortar proportions are shown in Table II.

TABLE 11.—Typical Cement-Aggregate *Mixes for Mortars*

Principal cement	Volume of principal cement	Volume of hydrated lime powder or putty	Volume (in damp loose condition) of aggregate
Portland	1	¼	3 to 3½
	1	½	3½ to 4½
	1	1	4½ to 6
	1	2	7 to 9
Masonry	1	none	2¼ to 3
Slag	1		2¼ to 3
Natural	1	none	2¼ to 3
Pozzolana	1	¼ to ½	2½ to 4½
Hydrated lime putty (Quicklime)	1		1 to 3

Additional Constituents.— It is not uncommon to use admixtures in mortar mixes (sometimes these are added in the manufacture of the cement used in mortars) to provide special properties. The use of nater repellents and air-entraining agents nas mentioned in the discussions on cements. Other additives (admixtures) might include salt, magnesia or sugar.

Salt has proved beneficial when its value does not exceed 5%. The salt is added in dissolved form to the mixing water. It tends to assist in the process of hydration by acting as an accelerator to the chemical reactions of the cement. Its chief value is in cold weather construction. Salt causes efflorescence on the face on masonry work and, therefore, should not be used where this would be undesirable.

Magnesia in excessive amounts will cause unsoundness (excessive expansion). Magnesia contents to 2% may prove desirable for construction work subject to the action of sea water.

Sugar in water solution (not to exceed 2%) may be beneficial in extremely warm climates. It will retard setting and also prevent rapid drying, thereby permitting a longer working time for the mason. The use of sugar is a continental custom not practised in the United States.

Special Considerations. — Reinforcing of mortar joints is a practice which rapidly gained favour, particularly in walls below ground level. The reinforcement is a wire mat bedded into horizontal and vertical joints to withstand the bending action, when earth is backfiiled against the wall.

Repairing mortared walls is done by "pointing" the mortar joints. Pointing is the term used to describe the filling of both vertical and horizontal joints which have weathered and the areas where mortar has crumbled out after freezing and thawing. Another practice is the resurfacing of weathered walls with a hand applied stucco finish, sometimes tooled to resemble laid stone. Still another practice is surfacing walls with a pneumatically applied mortar surface. This procedure produces a weathertight surface of high strength and durability. It also has been used with success to bond masonry units racked into wall sections without the customary horizontal and vertical mortar joints.

Efflorescence is the deposit. of crystallized salts on the surface of brick masonry caused by the leaching out of the soluble salts found in bricks or mortar. Efflorescence appears as a white discoloration on the brick surface. The use of selected brick and mortar of low porosity slows down the passage of moisture through walls and hence minimizes efflorescence.

See M. O. Withey and G. W. Washa, *Materials of Construction* (New York, 1954); A. P. Mills, H. W. Hayward and L. F. Rader, *Materials of Construction* (New York, 1955); G. R. Burnell, *Linzes, Cements, Mortars* (London, 18jo). (E. C. T.)

MORTGAGE, the securing "money or money's worth" by making it a charge upon property, real or personal, so that if the debt is not paid by a time agreed upon by the parties, the creditor may foreclose or sell the property and pay himself out of the proceeds. In English law this is done by an actual or executory conveyance of the property to the creditor, subject only to its being defeated if the debt should be paid at the time fixed. The Law of Property act, 1925, initiated an altered system under which mortgages were charged without conveyance of the property to the mortgagee. (*See* HYPOTHEC.)

The mortgage of English law is the result of two distinct influences. Its origin and form belong to the common law; the restrictions by which it is made to serve the purpose of a security only, and nothing more. belong to the courts of equity. In the eye of the common law the mortgagee was the owner of the estate conveyed in the mortgage; in equity the mortgagor remains the real owner. and the mortgagee is merely an encumbrancer. At law, after failure of payment. the land belonged absolutely to the mortgagee, while in the meantime, before payment, the legal estate mas considered to be vested in him, subject only to being defeated by payment at the proper time. The court of chancery first interfered in the reign of James I to decree a redemption after forfeiture. and a case in the reign of Charles I decided that payment after forfeiture had the same effect as payment before. The right of the mortgagor to redeem his estate after it has been forfeited, according to the terms of the deed, is called his equity of redemption. No agreement between the parties was suffered to oust the jurisdiction of the court, or to deprive the debtor of his equity of redemption. And this equity, at first regarded as a mere right of the debtor, became established in course of time as an estate in land which descended to the heirs of the mortgagor. In spite of the terms of the mortgage, the owner of the land is still the owner. It may be a question whether a given deed is a conveyance or a mortgage, and the court, in deciding, will look at all the circumstances of the case, and will treat it as a mortgage when it was the real intention of the parties that it should operate as a security only.

A mortgagee may, however, on default of payment file a bill of foreclosure requiring the mortgagor to pay the amount of the debt with interests or costs by an appointed day, or submit to be deprived of his equity of redemption. The effect of failure to pay by the time appointed would be to make the mortgagee absolute owner of the estate; but the court in any foreclosure suit may, at the request of either side, order a sale instead of a foreclosure. The mortgagee is entitled to retain out of the proceeds of the sale the amount of his principal, interest and costs, the surplus belonging to the mortgagor.

An equitable mortgage is constituted simply by the deposit of title-deeds in security for money advanced. Any subsequent legal mortgagee, having notice of the deposit, will be postponed to the equitable mortgagee, and when the legal mortgagee has not inquired as to the title-deeds the court will impute to him such knowledge as he would have acquired if he had made inquiry. A Welsh mortgage is one in which an estate is conveyed to a creditor, who takes the rents and profits in lieu of interest and without account, the estate being redeemable at any time on payment of the principal. Any form of property, with few exceptions, may be mortgaged.

United States. — In the United States the common law mortgage was adopted in many states with such incidents as the English law had attached to it. Equity courts intervened to prevent strict foreclosure or the forfeiture of the equity of redemption upon nonpayment of the debt, insisting that foreclosure should be only made by judicial sale. Many states, however. permit the mortgagee to reserve a power of sale in the deed, which he may exercise without the intervention of the court.

In a number of U.S. states the common law mortgage no longer exists, a mortgage having the effect of giving the mortgagee a legal lien upon the property, the mortgagor still retaining title. The practical differences between this and the common law mortgage are not great.

Chattel mortgages are also common in the United States. recording of such mortgages being required by most states in order that the mortgagee's rights shall prevail against innocent purchasers of the chattel from the mortgagor.

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MORTIER, EDOUARD ADOLPHE CASIMIR JOSEPH, DUKE OF TREVISO (1768–1835), marshal of France, was born at Cateau Cambrésis on Feb. 13. 1768, and entered the army as a sublieutenant in 1791. Serving from 1792 in the north, in Belgium and on the Rhine, he was a staff officer from 1793, general of brigade in 1799 and general of division at the battle of Ziirich.

Napoleon chose him, on Gen. Pierre Lefebvre's suggestion, for the command in Paris in the years 1800–03 and showed approval by giving him charge of the occupation of Hanover. He was created marshal in 1804. In the march from Ulm to Vienna he met the Russians in a fine action at Diirrenstein. In 1806–07 he occupied Hanover and Pomerania, but joined the *grande armée* for

the Friedland campaign. He was then governor of Silesia and was created duke of Treviso in 1808. In Dec. 1808 he brought a corps to Spain: he served at Saragossa and won victories at Ocaña in 1809 and at Badajoz in 1811. In 1812 and 1813 he commanded the Young Guard; and in the "defensive" campaign of 1814 he rendered brilliant services in command of rear guards and covering detachments. In 1815. after the flight of Louis XVIII, he rejoined Napoleon, but at the opening of the Waterloo campaign he fell ill. After the second restoration he was for a time in disgrace. but in 1819 he was readmitted to the chamber of peers.

Mortier was ambassador of France at St. Petersburg in 1830–31 and minister of war and president of the council of ministers in 1834–35.

In 1835. while accompanying Louis Philippe to a review, the marshal was among the persons killed by the bomb aimed at the king by G. M. Fieschi (July 28, 1835).

MORTIFICATION: see GANGRENE.

MORTIMER (Family). The Mortimers of Wigmore, earls of March and Ulster, were descended from a certain Roger, lord of Mortemer-sur-Eaulne in Normandy, who fought for his duke William in the battle there against the French in 1054. Roger's son Ralph followed Duke William to England and became an important landowner in the March of Wales after the rebellion of Roger, earl of Hereford, in 1075. Many of the latter's forfeited estates, extending into 12 counties, were granted to Ralph, among them the castle and town of Wigmore, which became the chief seat of the family; Domesday book shows Ralph to have been one of the richest tenants in chief in northern Herefordshire and southern Shropshire.

Successive members of the family were involved in the political disputes of the Norman and Angevin reigns, generally in support of the crown, and. as Marcher lords, were frequently involved in warfare against the native Welsh. Ralph, 1st lord of Wigmore, rose in 1088 with the other barons of the March but was reconciled to William II and was later a partisan of Henry I. Roger de Mortimer (I of Wigmore; d. 1214) and his son Hugh (II of Wigmore; d. 1227) were staunch supporters of King John in the later years of his reign. Hugh's nephew Roger (II of Wigmore; d. 1282), after supporting Simon de Montfort and the baronial opposition to Henry III, deserted Montfort in 1261 and thereafter became a vigorous royalist. assisting Prince Edward in the final overthrow of Montfort at Evesham in 1265.

In the second half of the 13th century the position of the Mortimers was transformed by a series of successful marriage alliances. Ralph de Mortimer (II of Wigmore; d. 1246), who himself had married a daughter of Llewelyn ap Iorwerth, prince of Wales, had secured for their son, Roger II, the marriage of Maud, daughter and coheiress of the Marcher family of Braose and, through her mother, heiress also of one-third of the possessions of Richard earl of Pembroke, earl marshal of England. Her vast inheritance brought Roger lands in Radnor and West Wales and extensive lordships in Ireland. His grandson Roger (1286 or 1287–1330; *see* MARCH, EARLS OF) further increased his landed wealth through his marriage with Joan de Geneville, whose rich Geneville and Lacy estates, also mainly in Wales and Ireland, included the castle and lordship of Ludlow, thereafter the principal seat of the family.

These accessions of strength served to place the Mortimers among the greatest magnates of the realm and helped the last-named Roger to play a leading part in the politics of Edward II's reign. His resentment at the favour shown by the king to his family's Marcher rivals, the Despensers, caused him to take sides against Edward, only to be captured and imprisoned before he made his escape to France (1324).

At the court of Charles IV the exile formed an intrigue with Isabella, queen of England, and he accompanied her when she returned to England in Sept. 1326, helping her to overthrow the unpopular Despenser regime. After the deposition of Edward II, Roger, as the queen's paramour, virtually ruled England. He used his position solely to further his own ends.

Enriched by the lands of the Despensers and by those of Edmund, earl of Arundel (beheaded at his instigation), Mortimer, who was created earl of March in 1328, built up for himself a commanding influence in Wales and the Marches. His greed and insolence and his indifference to the welfare of the country made him unpopular, and the young king Edward III, resenting his subjection to the arrogant Mortimer, worked secretly for his fall. On Oct. 18, 1330, he was set upon in his apartments in Nottingham castle, taken prisoner and shortly after condemned for treason and hanged at Tyburn.

His grandson and heir Roger (1328–60), who fought at Crécy and was a founder of the Order of the Garter, was restored to a great part of the forfeited inheritance He secured the reversal of the 1st earl's attainder and in 1354 was restored in parliament to the title of earl of March. The marriage of his only son Edmund (1351–81), 3rd earl of Blarch, with Philippa, daughter and heiress of Edward III's second son Lionel, duke of Clarence. brought his issue into the direct succession to the throne and added the earldom of Ulster to his style. Edmund's son Roger (1374–98), the 4th earl, married Eleanor Holland, niece of Richard II, to whom he was heir presumptive. Although he took no strong side in the political disturbances, his loyalty was suspected in Richard's later years. Much of his career was spent in Ireland as king's lieutenant, and he met his death in 1398 fighting against the men of Leinster.

Roger's son Edmund, 5th earl of March (1391–1425), was regarded by many as the legitimate heir to the throne after the usurpation of Henry IV; and in 1415, on the eve of the Xgincourt campaign, Richard, earl of Cambridge, sought to involve him in a conspiracy to make him king in place of Henry V. He saved himself by denouncing the plot to Henry V, whom he afterward served faithfully in the French wars. This last member of the male line of the house of Mortimer died childless in Ireland on Jan. 18, 1425. His lands, his titles and his potential claim to the throne passed to his nephew Richard, son of Richard of Cambridge by the 5th earl's sister, Anne Mortimer. This Richard, 6th earl of Blarch, became duke of York in 1426 and was the father of Edward IV of England.

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MORTISE or MORTICE, a term for a socket or cavity cut in a piece of wood. or other material, into which a corresponding projecting end, a "tenon," fits, the two when fitted together forming a "mortise joint." for fastening two beams or other pieces of timber together.

When locks are made to be imbedded in a socket cut in the thickness of a door they are termed mortise locks.

MORTMAIN, the state or condition of lands or tenements when held by a corporation in perpetual or inalienable tenure Alienation in morimain having the effect of depriving the lord of the incidents of seignory, many English statutes were passed directed against such alienation. Later statutes were based rather on economic and social grounds. The earliest is that of Henry III. 36; others being 7 Edward I. 13 (De Viris Religiosis); 13 Edward I. 32; 15 Richard II, 5; and 23 Henry VIII. 10. The present law is regulated by the Mortmain and Charitable Uses act 1888, as amended by the act of 1891. A few British possessions passed similar legislation.

In the United States mortmain acts have been passed in some jurisdictions restricting the right of corporations to hold land and also their power to make devises or conveyances or to receive land by devise.

MORTON, JAMES DOUGLAS, 4TH EARL OF (*c.* 1525–1581), Scottish statesman, was the son of Sir George Douglas of Pittendriech, and before 1543 married Elizabeth (d. 1574), daughter of the 3rd earl of Morton, to whose titles and estates he succeeded in 1553. Ten years later he became lord high

chancellor of Scotland. He headed the armed force which took possession of Holyrood palace in 1566 to effect the assassination of Rizzio, and it was to his house that the leading conspirators adjourned while a messenger was sent to obtain Mary's signature to the "bond of security." The queen, before complying with the request, escaped to Dunbar, and Morton and the others fled to England. Having been pardoned, Morton returned to Scotland early in 1567. He led the army which defeated the queen's forces at Langside in 1568, and was the most valued counsellor of the earl of Murray during his regency. In Oct. 1572, he himself was elected regent. He effected a pacification with Huntley, the Hamiltons, and the Catholic nobles who supported Mary, and took by arms the castle of Edinburgh.

There were, however, undercurrents which combined to procure Morton's fall. The Presbyterian clergy were alienated by his leaning to Episcopacy, and all parties in the divided Church by his seizure of its estates. When the powerful earl of Argyll and Atholl, a Stuart and Roman Catholic, united with Alexander Erskine, governor of Stirling, and others, Morton offered to resign. He surrendered the castle of Edinburgh, the palace of Holyrood, and the royal treasures, and retired to Lochleven. But his ambition could not deny itself another stroke for power. Aided by the young earl of Mar, he got possession of Stirling Castle and the person of the young king. A nominal reconciliation was effected, and a parliament at Stirling introduced a new government. Morton, who secured an indemnity, was president of the council, but Atholl remained a privy councillor in an enlarged council with the representatives of both parties. In 1580 Morton was condemned by an assize for having taken part in the murder of Darnley, and the verdict was justified by his confession that Bothwell had revealed to him the design, although he denied participation in its execution. He was executed on June 2, 1581.

MORTON, JOHN (c. 1420–1500), archbishop of Canterbury, cardinal and statesman, was born either at Bere Regis or Milborne St. Andrew. Educated at Balliol college, Oxford, he graduated in law, and followed that profession in the ecclesiastical courts in London. He is said (*Dict. Nat.* Biog.) to have been "at once admitted to the privy council"; but probably this is a mistake for the ordinary council, of which Morton might well have been made a member when he was appointed master in chancery and chancellor of the duchy of Cornwall. He received a good deal of ecclesiastical preferment from the Lancastrian party, was present, if he did not fight on the losing side, at the battle of Towton in 1461, and was subsequently attainted by the victorious Yorkists. He lived with the exiled court of Margaret of Anjou at Bar until 1470, and took an active part in the diplomacy which led to the coalition of Warwick and Clarence with the Lancastrians and Louis XI., and indirectly to Edward IV.'s expulsion from the throne. Morton landed with Warwick at Dartmouth in September 1470, but the battle of Tewkesbury shattered the Lancastrian hopes, and Morton made his peace with Edward IV.

In 1473 Morton was made master of the rolls; he was sent on a mission to Hungary in 1474, and was one of the negotiators of the Treaty of Picquigny in 1475. In 1479 he was elected bishop of Ely. He was one of the executors of Edward IV.'s will in 1483, but was arrested after the accession of Richard III. He escaped from Brecknock castle to Flanders, and worked in the interests of the earl of Richmond. When Richmond secured the crown as Henry VII., Morton became his principal adviser. He became archbishop of Canterbury in 1486 and lord chancellor in 1487. In the year 1493 Morton was created a cardinal, and in 1495 was elected chancellor of the university of Oxford. He encouraged learning to the extent of admitting Sir Thomas More into his household, and writing a Latin history of Richard III., which More translated into English. He died at Knole on Oct. 12, 1500, and was buried in Canterbury cathedral.

Besides the authorities cited in the *Dict. Nat. Biogr. see* the calendar of Patent Rolls, 1461–85, *passim;* W. Busch, *England under the Tudors* (1892); J. Gairdner, *Henry VII.* (1889) and *Lollardy and the Reformation* (1908), and *Political History of England,* vols. iv and v. (Longmans).

MORTON, JOHN MADDISON (1811–1891), English playwright, the son of Thomas Morton (1764?–1838), also a playwright, was born at Pangbourne, on Jan. 3, 1811. He was the author of the famous farce Box and Cox (1847) and other pieces. He became a Charterhouse pensioner, dying on Dec. 19, 1891.

MORTON, LEVI PARSONS (1824–1920), American banker and politician, was born in Shoreham, Vt., on May 16, 1824. He was in business at Hanover, N.H., in 1843–49 and in Boston in 1849–54. He then became a partner in a New York dry-goods house. He established in 1863 the banking house of L. P. Morton and Company (dissolved 1899), with a London branch which had Sir John Rose (1820–88) as its principal member. The American firm assisted in funding the national debt at the time of the resumption of specie payments, and the London house were fiscal agents of the United States Government in 1873–84, and as such received the $15,500,000 awarded by the Geneva Arbitration Court in settlement of the "Alabama Claims" against Great Britain. He was a Republican representative in Congress in 1879–81, United States minister to France in 1881–85, vice-president of the United States in 1889–93, and in 1895–96 was governor of New York. He died in Rhinebeck, N.Y., on May 16, 1920.

See R. M. McElroy, *Life of Levi Parsons Morton* (1929).

MORTON, OLIVER PERRY (1823–1877), American political leader, "war governor" of Indiana, was born in Salisbury, Ind., on August 4, 1823. After studying for two years (1843–45) at Miami university, he practised law at Centerville, Ind., and in 1852 became circuit judge. In Feb. 1856 he was a member of the Pittsburgh convention which led to the organization of the national Republican party, and in the same year he was a candidate for governor of Indiana but was defeated. He was elected lieutenant-governor in 1860, and when Henry S. Lane, the governor, resigned, on January 16, 1861, Morton became governor. In 1864 he was re-elected. In meeting all the extraordinary demands resulting from the Civil War he displayed great energy and resourcefulness, and was active in thwarting the schemes of the secessionists in the neighbouring State of Kentucky, and of the secret societies of Southern sympathizers and other opponents of the war in Indiana. In 1863 a hostile legislature sought to deprive him of all control over the militia, and, failing in this, adjourned without making the appropriations necessary for carrying on the State government. In this predicament Morton appealed for financial aid to private individuals, bankers, the counties, and even the Federal government. The response was so prompt that he was able to conduct affairs practically single-handed until 1865, when a legislature more favourable to his policies assembled. Morton resigned as governor in Jan. 1867 to accept a seat in the U.S. Senate, in which he served during the rest of his life. He was recognized as one of the leaders of the Radical wing of his party, voting in favour of Johnson's impeachment, and being especially active on behalf of negro suffrage. He was a prominent but unsuccessful candidate for the Republican nomination for the presidency in 1876. He died at Indianapolis on Nov. 1, 1877.

See William D. Foulke, *Life of Oliver P. Morton* (Indianapolis, 1899).

MORTON, THOMAS (*c.* 1590–1646), usually called Thomas Morton of Merrymount, English adventurer in America, was a lawyer of Clifford's Inn, London, and seems to have practised in the west of England. He spent three months in America in 1622; returned in 1625, and settled at Mount Wollaston, in what is now Quincy, Massachusetts; and in 1626, when most of the settlers removed to Virginia, he assumed command of the settlement, and renamed it Merrymount. He came into conflict with the Puritan settlers, by setting up a maypole and also, it should be added, selling rum and arms to the Indians. He was banished to England, but returned in 1629, when he was arrested on trivial charges by the Massachusetts authorities, and was confined in the stocks. Later his house was burned and he was sent to England where he spent a term in the Essex gaol. After his release he wrote his New *English Canaan* (1637), in which he heaps ridicule upon the New England colonists. In 1643 Morton returned to America. He was imprisoned in Boston in the following year, was brought to trial, remanded pending the gathering of further evi-

dence, and after a year's confinement was fined £100 and released. He retired to Agamenticus (now York), Me., and in 1646 died poverty stricken.

See the *New English Canaan,* ed. by Charles Francis Adams, Publications of the Prince Society, vol. ix (Boston, 1883); C. F. Adams, *Three Episodes of Massachusetts History* (Boston, 1896); and, for a more favourable view of Morton, *A Few Observations on the Prince Society's Edition of the New English Canaan,* revised and reprinted from the *Churchman* (New York, 1883). Morton's adventures have furnished material for Nathaniel Hawthorne's short story, *The Maypole of Merrymount,* and for John Lothrop Motley's novels, *Morton's Hope* (1839) and *Merry Mount* (1849).

MORTON, WILLIAM THOMAS GREEN (1819–1868), U.S. dental surgeon, was born at Charlton, Mass., on Aug. 9, 1819, and studied dentistry at the Baltimore College of Dental Surgery. In 1844 he opened an office in Boston, where he gave especial attention to the improvement of artificial teeth and their means of attachment. It was necessary in many cases to remove the roots of old teeth, and in order to lessen the pain of this operation he searched for some means of deadening sensation. Charles T. Jackson (*q.v.*), a Boston chemist who already had made laboratory experiments dealing with the inhalation of sulphuric ether, suggested the use of this gas and demonstrated for Morton the method of inhalation. Morton first used it with success in the extraction of a tooth on Sept. 30, 1846, and on Oct. 16, 1846, he publicly administered ether at the Massachusetts General hospital while J. C. Warren performed a painless operation. Though Crawford W. Long (*q.v.*) had performed the first operation in which the patient was under ether in 1842, as subsequently revealed in 1849, it was Morton's independent discovery and his demonstrations which first made the value of sulphuric ether known to the medical world. He never benefited financially from his discovery and died in poverty in New York city on July 15, 1868. Morton published *Remarks on the Proper Mode of Administering Sulphuric Ether* (1847) and several papers in scientific journals.

MORTUARY, of or belonging to the dead or in particular to the burial of the dead (Lat. *mortuarium,* from *mortuus,* "dead," past part. of *morior).* The term was specially applied to the customary oblation or offering due from the estate of a deceased person to the church of the parish to which he belonged, and usually paid in kind to the incumbent. The parliament of 1529 (21 Hen. VIII, c. 6) limited the value of mortuaries to a maximum of 10*s.* in estates exceeding £40. Mortuaries, where customary, can be enforced only in the ecclesiastical courts. The custom is now obsolete, though claims have been made from time to time.

The modern use of the word, denoting a building in which bodies awaiting burial are temporarily kept, is derived from the Latin term *domus mortuaria,* mortuary house. But it has also been applied to many subjects connected with death and burial. In monastic institutions it was the duty of the almoner to send round to other monastic houses notice of the death of a member, asking for prayers for the soul of the dead. This notice was often beautifully illuminated. On being returned with the endorsement of the monastery to which it had been sent, it would be copied into the roll. Both the notice and the roll were known as a *mortuarium,* or mortuary.

See Abbot F. H. Gasquet, *English Monastic Life* (1904).

MORVAN, an elevated region of gneiss and granite forming the northern continuation of the Massif Central, France, and extending over a large part of the department of Nièvre and over portions of those of Yonne, Côte-d'Or and Saône-et-Loire. Its area is a little more than 1,000 sq.mi. The average elevation is about 1,600 ft., the highest point, the Bois-du-Roi, attaining 2,959 ft. It is traversed by the Yonne, which has its source on Mt. Prénelay (2,789 ft.), by the Cure and by several affluents of the Arroux. It contains much good pasturage and is well wooded; the timber industry is important.

MORVI, a city and tehsil (subdivision) in Madhya Saurashtra district. Bombay state, India. Pop. (1951) 40,722. The town is on the Machhu river, about 40 mi. from the east end of the Gulf of Cutch and 37 mi. N. of Rajkot, with which it is connected by rail. Morvi Technical institute was founded in 1951 in connection with Gujarat university.

MORVI STATE (area 822 sq.mi.; pop., 1941, 141,671), of which the town was capital, was in the Eastern Kathiawar subagency of the Western India States agency (Baroda residency) under British paramountcy. The ruler or thakur was a Jadeja Rajput. The state became part of Saurashtra on Feb. 15, 1948, which in turn merged with Bombay state on Nov. 1, 1956.

MORYSON, FYNES (1566–1630), English traveller and writer, son of Thomas Moryson, M.P. for Grimsby, was a fellow of Peterhouse, Cambridge. He spent many years in travel on the continent of Europe, in Palestine and in Asia Minor. In 1600 he became secretary to Sir Charles Blount, lord deputy of Ireland, where his brother, Sir Richard Moryson, held an appointment. In 1617 Moryson published *An Itinerary,* an account of his travels abroad and of his experiences in Ireland (where he witnessed Hugh O'Neill's rebellion). He died on Feb. 12, 1630.

The *Itinerary* was intended to consist of five parts, but only three were at first printed, a fourth being preserved in manuscript in the library of Corpus Christi college, Oxford (partially printed in 1903 by Charles Hughes as *Shakespeare's Europe*); a new edition, 4 vol., appeared in Glasgow, 1907–08.

MOSAIC, the art and the product produced by the art of decorating a surface by means of the application of closely set small pieces, usually of an inorganic substance such as stone, mineral, glass and tile or shell. Inlay in wood (intarsia) and enamel are not ordinarily embraced by the term; it has been adopted as a technical term in photography and photogrammetry (*q.v.*) to denote aerial photographs pieced together from many separate exposures.

Mosaic seems to have developed not so much from the multiplication of separate pieces of inlay as from the differential treatment of surfaces by the application of other material for the purposes of increased magical potency, enrichment and decoration. The germ of the idea might have lain in such ornaments as Old Stone Age man first created by stringing bones, teeth and shells in parallel strands, more elaborate examples of which are found in Melanesian fighting chams and necklaces. From New Guinea come the most primitive examples of mosaic—trophy skulls and masks covered with rows of small shells.

Central American Indian Cultures.—With the rise of urban civilization, specialized craftsmanship brought mosaic to a high degree of proficiency and at times to a degree of monumentality. Nowhere before Graeco-Roman times was it marked by such a combination of great technical skill and widespread use as among the Indian cultures of Central America. The representation of a mosaic mask on a stele at Seibal, Guatemala, which S. G. Morley dated A.D. 590, established the early use of the technique in Maya territory, but it became best known by the few specimens surviving from the time of the Aztec empire (*c.* 1376–1521) and from descriptions of others left by the Spanish conquerors. The Mexican lapidaries worked with obsidian, garnet, quartz, beryl, malachite, jadeite, marcasite, gold, mother-of-pearl and shell, but turquoise above all constituted their favourite material; the excessive richness of the religious ceremonial gave wide range to its employment in ritual paraphernalia of all sorts. The incrustation was laid upon wood, stone, gold, shell, pottery and possibly leather and native paper and was held in place by a tenacious vegetal pitch or gum or a kind of cement.

Masks, shields, helmets, knife handles, staffs, collars, medallions, ear plugs, leggings, mirrors, animal figures and cult statues received a covering, in whole or part, of small and irregularly shaped pieces of highly polished turquoise, cut to fit tightly together so as to form a brilliant green surface, varied at times with cabochons of turquoise or other material. Museums in Berlin, Copenhagen, London, Rome and Vienna preserve most of the two dozen major specimens of the art, which alone survived the Spanish spoil; others were acquired by the National museum, Mexico City, the Peabody museum, Cambridge, Mass., and especially the Museum of the American Indian, New York city. Most striking and best preserved of their types are a mask in the British Museum and a shield in the Museum of the American Indian. On the former, minute pieces of turquoise, studded with cabochon turquoises, completely cover the cedar mask and are laid in symmetrical lines

around the eyes and mouth and on the nose; eyes and teeth are of shell inlay. Over the wood of the latter, one panelled and three circular borders of mosaic frame a scene which may relate to the worship of the planet Venus; it is estimated that nearly 14,000 pieces of turquoise make up the decoration. The Nahuatl story of a hall at the Toltec city of Tula the walls of which were covered with fine mosaic may belong to legend but a monumental use of the technique was achieved in the mosaiclike treatment of the exterior wall casing of certain buildings. Those at Mitla in the state of Oaxaca are outstanding; bands and panels of simple but striking geometric ornamentation were produced by fitting together small stones of different shapes and sizes, tenoned back into the rubble mass of the wall. Each stone was cut for the spot which it occupied and some were more deeply imbedded than others so that the designs stand out in sharp relief. The effective simplicity of design and precision of workmanship of Mitla are not matched on the elaborate Maya façades, at Uxrnal and Chichen-Itza in Yucatan, for example, where, along with geometrical designs, animal forms also occur.

Another type of mosaic work, feather mosaic, was practised in Central America. This most perishable art may have had its roots in man's earliest days, for some primitive Australians glue feathers to their bodies in patterns to form ceremonial costumes. In Aztec times it was highly developed and placed in the hands of a special guild which produced gorgeous mantles and other regalia indicative of grades of rank in religious, military or civil affairs. Hardly more than a few fragments of pre-Columbian feather mosaic are extant, but the craft survived into the early colonial period for religious pictures and vestments.

Ancient Near East.—In the near east only Mesopotamia developed mosaic to any extent. From its first prehistoric period come slender cones of baked clay, some with the blunt ends painted red or black, the use of which was revealed in the remains of a large courtyard and columned hall of the second period at Warka, in the second half of the 4th millennium B.C. Red, black and white painted cones imbedded in the mud brick covered all vertical surfaces to form a highly decorative protective coating. Varied geometrical patterns drawn from textiles or rush matting were worked out on the side wall and its attached half columns while the lozenges on the eight-foot thick columns of the hall attest their palm-log origin.

In the historical period baked brick displaced imbedded cones as mural sheathing but other forms of mosaic were given architectural use in the early 3rd millennium. In the elaborate little temple of A-anni-padda at al-Ubaid two palm columns flanking the entrance were incrusted with a mosaic of red and black stone and mother-of-pearl in bands of lozenges, and around the exterior walls were two friezes of mosaic inlay. The lower represented cattle and dairy scenes with each figure cut out of limestone in one piece, or out of shell in several pieces, and set in a background filled in with pieces of black stone; the upper frieze had limestone figures of birds set in a like background. This technique the early dynastic Sumerians used also in portable objects as a costlier alternative to the shell reliefs in which the background was merely coloured black or red; cutout silhouettes with carved or incised details were set in bitumen on a wooden frame against a background of small pieces of lapis lazuli. Such plaques were applied to the sound boxes of musical instruments and to other objects; an independent example is the famous "standard" excavated at Ur which represents on one side the king warring and on the other the king feasting; the three zones of each side are framed in borders of shell strips and red limestone lozenges.

There is no evidence that this brilliant and varied use of mosaic techniques was prolonged in significant manner after about 2500 B.C. Nor did other near eastern civilizations begin to rival it. In Egypt the only approach to mosaic lies in the use of blue tiles to simulate mat wall coverings and door rolls in some rooms of the Great Tomb and pyramid of Zoser at Sakkara. Inlay of semiprecious stones and glass in furniture and jewellery was highly developed and often gives a mosaiclike effect. The Indus valley civilization used only a simple intarsia, mostly of shell. The Aegean civilization made scant use even of inlay but in some mosaiclike fashion it combined individual faïence objects to fonn little scenes.

Greek and Roman.—A humbler technique of Aegean culture supplied the origin of all later floor mosaic. Even in the Neolithic period, floors of waterworn pebbles were laid in Crete, and in the late Bronze Age (1600–1000 B.C.) they occur on the Greek mainland as well. Doubtless it was this practice which the Hellenic Greeks elaborated and spread from the 6th to the 4th centuries B.C., when pebble mosaics with representational and nonrepresentational decoration were used at various sites in Greece (*e.g.*, Athens, Corinth, Delphi, Olympia, Olynthus), Asia Minor (Assus, Tarsus) and as far west as the Phoenician colony of Motya in Sicily. Pebble mosaic had little place in public and religious buildings where floors were usually of cut stone and the extent of its use was not suspected until excavations at Olynthus first laid bare large residential areas of a Hellenic town.

Of the more than 100 houses uncovered there, 11 had pebble mosaic floors which date within the century before the destruction of the city in 348 B.C. White designs and white figures with linear black details were set against a black background and already the usual subsequent rule was observed of centring a main scene between multiple borders, and such common later border designs as wave, meander and rinceau occur. The developed composition of these mosaics implies a strong influence or even a direct copying of figured rugs and their simple bichromy reflects the taste of the times. These pebble mosaics, with unmodelled white figures, sharply visible and instantly comprehensible against the dark background, are particularly effective as floor coverings. The use of pebbles other than white and black, found in some examples, adumbrates the pictorial effects soon to prevail; in the Dionysus mosaic in the Villa of Good Fortune the chariot front and reins are made of red pebbles and some yellow and green pebbles are scattered among the white and black.

The great advance in technical skill which characterized all arts in the Hellenistic period was felt early in mosaic. The first notable feature was the introduction of small cubes (tesserae or tessellae) cut from stone, or occasionally glass, to replace the pebbles. A smooth surface of closely set pieces which wore better and gave opportunity for finer work was obtained thereby. This change was accomplished before the end of the 3rd century, for Athenaeus quotes from an earlier writer the description of a ship built under Hieron II of Syracuse (270–216 B.C.), certain quarters of which had a flooring of tessellated mosaic made from a variety of stones and representing scenes from the Iliad. This record also serves to underline the second new feature of Hellenistic mosaic, its imitative bent; the desire to represent traditional scenes made inevitable the use of painted scenes already in existence as models.

Thus began a long servitude to the art of painting which brought the result that the best endeavour of the Graeco-Roman mosaicist was often misdirected toward the imitation of paintings; when his work was technically greatest he achieved a tour de force of craftsmanship but not creative art.

In the Hellenistic period the smaller of the fine figured panels (emblemata) were made in the workshop on tiles or stone trays and set into a space reserved for them in the floor; very small tesserae were used and they were laid in straight or curved rows as the needs of the representation demanded. It has not been determined whether large emblemata were also prepared in the workshop, but in sections, or assembled on the spot. Individual representative objects or even figured panels were also worked out in floors as they were laid but their coarser quality differentiates them from the specially prepared emblemata. The general state of mosaic in a prosperous business community of the 2nd century B.C. was disclosed by excavations on Delos. Four kinds of mosaic floors occur: (1) the earliest consists of fragments of tiles or pottery; (2) most common is a pavement made of irregular chips of marble or stone; (3) pebble mosaic persists but it is rare and undecorated although twice pebbles were used instead of cubes in the background of tessellated mosaics; (4) tessellated mosaic, which alone is decorated, is neither rare nor abundant. One infers that it was just making its way into public favour. Usually the tessellated area is surrounded by a wide border of chip mosaic, hence

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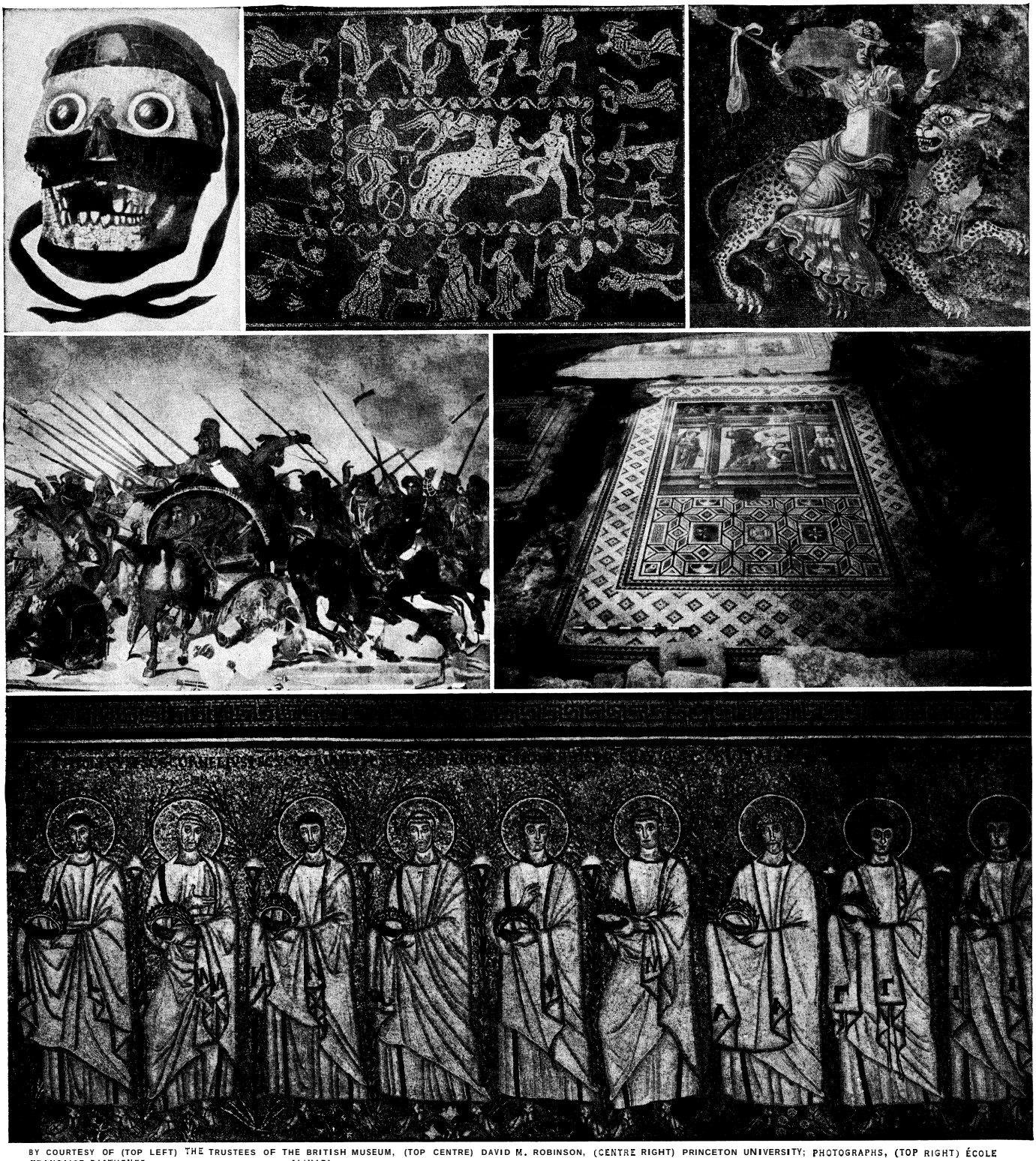
A MEDIAEVAL BYZANTINE MOSAIC

Detail showing the empress Irene from a larger wall mosaic, the so-called John panel, in the south gallery of St. Sophia. Istanbul. This mosaic dates from the 11th or 12th centuries, when Byzantine mosaic art reached the period of its finest expression

MOSAIC



BY COURTESY OF (TOP LEFT) THE TRUSTEES OF THE BRITISH MUSEUM, (TOP CENTRE) DAVID M. ROBINSON, (CENTRE RIGHT) PRINCETON UNIVERSITY; PHOTOGRAPHS, (TOP RIGHT) ÉCOLE FRANÇAISE D'ATHENES, (CENTRE LEFT, BOTTOM) ALINARI

ANCIENT AND MEDIAEVAL MOSAICS

Top left: Human skull covered with a mosaic of obsidian and turquoise. Aztec

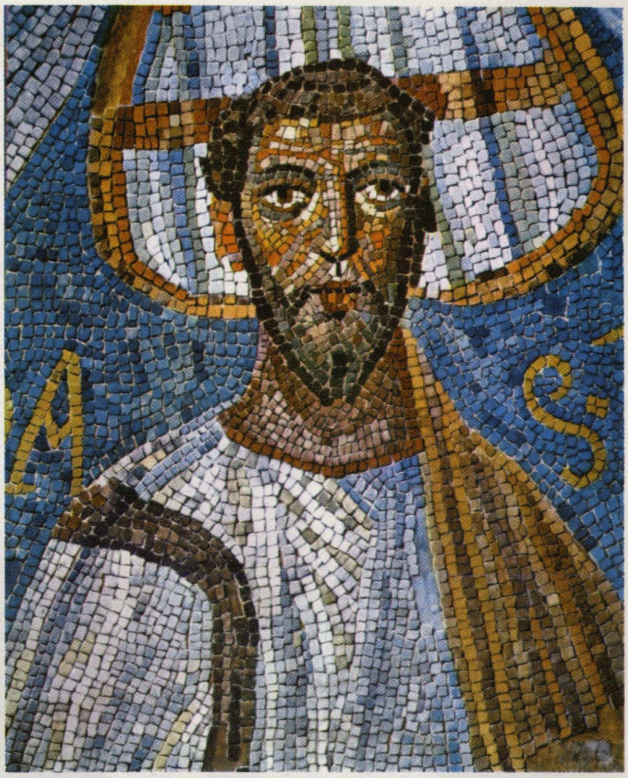
Top centre: White on black pebble mosaic of Dionysus from Olynthus, Greece. Before 348 B.C.

Top right: Polychrome tessellated (checkered) mosaic on black ground from the House of Masks, the island of Delos, Greece. Probably from the first half of the 2nd century B.C.

Centre left: Detail from the Alexander mosaic from Pompeii, probably a copy of the lost painting of the battle of Issus by Philoxenus. First half of the 1st century B.C.

Centre right: Typical mosaic floor of a Roman villa at Daphne, a suburb of Antioch on the Orontes. About A.D. 200

Bottom: Part of one of the rows of saints on the walls of the church of S. Apollinare Nuovo, Ravenna, Italy. 6th century



PHOTOGRAPHS, THREE LIONS, INC.

FIFTH AND SIXTH CENTURY MOSAICS OF RAVENNA

Top left: Christ appearing to the Apostles. Church of S. Apollinare Nuovo. Sixth century

Top right: St. Judas Zelotes. The baptistery of Neon. Fifth century

Centre left: Peacock chasing a dove, detail of a mosaic in the church of S. Vitale. Sixth century

Bottom left: Christ separating the sheep from the goats. S. Apollinare Nuovo

Bottom right: Detail showing a dignitary in the escort of Empress Theodora of Byzantium. S. Vitale

appearing like a rug spread out on a chip floor. Although decorative elements such as the commonly found dolphins are usually dark on a white ground, the figure scenes, few in number, preserve the black ground of Hellenic pebble mosaics. Best preserved is a square panel representing Dionysus (?) riding a panther. The scene is obviously pictorial in its modelling and rich polychromy; the wide range of coloured stones is supplemented by at least red and green glass.

The history of mosaic for the next two centuries in the Greek near east remains obscure, but Pompeii shows, first, the introduction of Hellenistic mosaic into Italy and, second, the first stage of its development under Rome. Polychrome emblemata of the late 2nd and early 1st centuries B.C. are among the earliest mosaics there; in them the black ground is discarded. The famous Alexander mosaic with its amazing craftsmanship represents the battle of Issus in so completely pictorial a fashion that it is no mere guess to identify its ultimate model as the lost painting of the scene which Pliny says was done by Philoxenus about 300 B.C. With scenes such as this, or the theatre scene signed by Dioscorides of Samos, subject matter and style pass outside the realm of the history of mosaic into that of the history of painting which they help greatly to supplement. These figured polychrome mosaics were never common at Pompeii and with the Roman occupation in 80 B.C. they almost disappeared in favour of other types. In sectile pavements thin pieces of marble and other stones were sawed into geometrical and later curvilinear and representational shapes, and were fitted together to form what is essentially stone marquetry, not mosaic.

The lithostroton floors, however, are mosaic, wherein larger or smaller cubes, oblong tesserae and irregular or shaped plaques of stone were variously combined to differentiate a central area from several borders. Apart from the emblemata, the tessellated floors at Pompeii were standardized into two main types, coloured and black and white, which lasted throughout the Roman empire. Most of the coloured floors are early but mark a decided development over those at Delos in the greater range of colours and of designs employed. The black and white floors, which hardly existed as an independent style at Delos, are the most characteristic of Roman Pompeii and show a considerable variety of decorative motifs which increased in numbers and complexity down to the destruction of the town in A.D. 79.

The and and earlier 3rd centuries A.D. witnessed tremendous activity in mosaic. Remains in considerable numbers, sometimes in great numbers, are found in all lands which formed part of the Roman empire. So vast a body of material cannot well be characterized briefly but these general observations may be made: the mosaics were assembled locally, for the local origin of most of the kinds of stone used in them has been proved in a number of cases; the distinction between the specially prepared emblemata and the coarser field was gradually lost; the tesserae increased in size and sometimes in irregularity of shape and were less closely set. Within a certain homogeneity of technique, planning, decorative repertory and subject matter, regional differences are evident but have only begun to receive study. Rome, for example, specialized in black and white mosaics and elaborated the rather simple black silhouettes of Pompeii into striking and effective mythological, marine and sporting scenes. At least three-quarters of the mosaics are black and white, either figured or purely decorative. Purely decorative polychrome mosaics remained rare until the second half of the 2nd century. Even polychrome figured mosaics were not common and the range of colours was usually rather limited. Several figured panels might be combined into one decorative scheme in a floor, or small insets, *e.g.*, of heads, might form part of an otherwise purely decorative pavement.

A contrast with mosaic practice at Rome is evident in the many mosaics from Antioch on the Orontes, which date from the late 1st into the 6th century A.D. Noteworthy is the absence of the black and white type and a predilection for polychrome figured mosaics, which is so pronounced in the suburban villas of the Antonine and Severan periods that the main rooms and corridors rarely lack one or more figured panels. They are composed with decorative panels and borders to accord with the use of the room, the dining rooms (*triclinia*), for example, having a figured panel in the centre and sometimes several along one side, while decorative panels form a "U" on the other three sides where the couches were placed. The earlier figured panels are the finer in workmanship but the technical disparity between the figured panels and the decorative panels and borders is usually not striking; small emblemata were found in only one house. The subjects were almost exclusively mythological. This wealth of figured panels makes the Antioch mosaics of the greatest importance in revealing the history of pictorial style in the Roman east. The figured scenes still occurred in the early Christian period (4th into 6th centuries), but they are much less frequent and differ in subject matter and treatment. Christian subjects were conspicuously absent; hunting scenes and personifications were popular and single objects, animal and vegetal, were often used as decorative motives in field and border. Composition by the accretion of rectangular panels gave way to a unitary treatment of the floor space in an allover figured scene or decorative pattern or in a radial arrangement of trapezoidal panels. The finest example of the latter type is one of the major surviving works of art of the period of Constantine the Great; personifications of the four seasons frame hunting scenes within figured and decorative borders. By the 6th century allover textile patterns showing strong Persian influence prevailed.

Mediaeval. — One returns to Italy to trace the next great stage of mosaic, the Christian wall mosaics. Already at Pompeii mosaic was applied to the walls of little fountain niches and to a few columns; the scant remains and rare literary references to wall mosaics of the 1st to 3rd centuries, give the probably mistaken impression of a very limited pagan use. With the 4th century, at any rate, wall mosaic became of first importance; floor mosaic took a subordinate role and was soon replaced by other forms of paving. The earliest surviving Christian wall mosaic is that covering the annular vault of the church of Santa Constanza in Rome, built about 350 as the tomb for Constantine's daughter; its 11 segments, carrying vine scrolls and geometrical designs which enclose figures drawn from the pagan repertory, closely resemble pagan floor mosaics in their white ground and use of stone, not glass, tesserae.

The art-historical significance of the mosaics which survive from the late 4th century on is that they best illustrate the development of early Christian art with its confusion of styles and varying iconography. The Moslem conquest obliterated Christian monuments in the east and except for remains in four churches in Salonika, Gr., the mosaics are concentrated in Rome and in Ravenna. Basilicas ordinarily had the walls of the central aisle, the triumphal arch and the apse covered with mosaic, as Santa Maria Maggiore at Rome, whose 5th-century mosaics are still of a rather illusionistic style, or Sant' Apollinare Nuovo at Ravenna, whose 6th-century rows of saints set against a gold background reveal the triumph of the other-worldly, hierarchical early Byzantine style. The early Christian period literally raised mosaic from its humble earthly position to the status of a major art, and by the development of a light but firm mortar and the exploitation of brilliantly coloured glass and gold cubes made it the chief vehicle of religious expression in the representational arts.

It remained for the Byzantines of the 11th and 12th centuries to realize the full possibilities of mosaic. There occurred that coincidence of perfection of technique, significance of subject matter, appropriateness of style to medium and wealth of patronage which brought the art to the peak of its inherent resources. Constantinople itself preserves nothing of the period except a few scenes uncovered after 1931 in St. Sophia, but some of the rich grandeur and magnificence of an all-enveloping mosaic decoration can be felt, despite serious damaging, in the provincial churches at Daphne, near Athens, and of St. Luke in Phocis, Gr. Even individual scenes, like the Pantokrator and Annunciation at Daphne or the Crucifixion at St. Luke, are of unparalleled impressiveness; the monumental figures on the gold background are sufficiently stylized in modelling, drapery and colour to be realized perfectly as divinity in human form. Byzantine mosaicists were called outside the empire to practise their art. Under the Norman kings of Sicily in the 12th century they produced work which sur-

vives as the greatest single body of Byzantine mosaic in existence, and which, at its best, as in the apse of the cathedral at Cefalh or in some of the scenes in the Martorana at Palermo, is comparable with that at Daphne and St. Luke in Greece. The extensive but somewhat inferior mosaic decoration in the cathedral at Monreale represents the work of Sicilian mosaicists; it is important as revealing the Byzantine iconographic scheme for the placing of the various series of scenes. The Venetians too brought Byzantine craftsmen to decorate their more sumptuous churches with mosaic. Among the earliest examples of the 11th or early 12th century is that in the cathedral of the neighbouring island of Torcello, the simple grandeur of whose apse mosaic remains unmatched. St. Mark's in Venice is a Byzantine church in all respects, and despite the restoration and replacement of much of the original mosaic of the 12th century by later work it best gives the effect of a large structure of its kind. The mosaics were begun in the second half of the 11th century and rather strict Byzantine style characterizes the work done into the 13th; in 1268 a decree provided for the setting up of a workshop of mosaic and the 14th century mosaics in the baptistery were probably done by Venetians. The Venetian workshop carried on the craft after the fall of the Byzantine empire into Renaissance and modem times, although its efforts were then spent in restoration and in the reproduction of paintings. It should be noted that almost all Christian mosaics have been subjected through the ages to more or less drastic restoration which imposes varying limits on the conclusions to be drawn from their present appearance. The Byzantines also made small, portable mosaic icons which represented individual Christian figures or scenes.

Through the 9th century mosaics in Rome retained certain individual characteristics in the use of colour despite strong Byzantine influence. Thereafter the art lapsed until the late 11th century; the revival was not marked by direct Byzantine work, as at Venice and in Sicily, but rather by a return to early Christian forms and composition within a generally Byzantinizing style. At the end of the 13th century artists' signatures began to occur, as those of Torriti and Rusuti in Santa Maria Maggiore. The mosaics by the famous painter Pietro Cavallini in the apse in Santa Maria in Trastevere are still sufficiently limited in pictorial quality to be effective as mosaic.

The extensive 13th-century mosaic decoration of the baptistery at Florence was begun by Venetian mosaicists working in rather pure Byzantine style and completed by local craftsmen whose work shows the influence of late 13th-century painting. At the end of the 12th century, from the example of the combination sectile and mosaic Byzantine pavements, there was developed in central Italy a stone intarsia which was widely used in pavements, to frame architecture openings and on church furniture; it was called Cosmati work after its originators.

There was no independent development of tessellated wall mosaic in Moslem hands. The elaborate 7th-century mosaics in the Dome of the Rock at Jerusalem and the Great Mosque at Damascus were carried out by Byzantine craftsmen, and in the 10th century the Spanish caliph had a Byzantine mosaicist brought to decorate the mosque at Cordova.

Apart from the elaboration and extension in use of ancient Egyptian intarsia, Islam's only significant contribution lay in a kind of sectile tile mosaic, wherein small pieces in geometrical shapes were cut from tiles glazed in different solid colours and combined to form elaborate decorative patterns on walls. From its origin in Persia' in the early 14th century, this craft spread west to Constantinople and south into India.

Modern. — The rise of illusionistic painting in the Renaissance successfully enslaved mosaic. Workshops existed at Venice and Rome, and their activity was almost limited to these cities. The revival of interest in mediaeval antiquities brought a renewed and widespread interest in the 19th century. Mosaic began to be employed occasionally in the major European countries under state or religious patronage and workshops were established for a time in Russia, France and England. The work was essentially imitative of earlier styles and of necessity largely carried out by Italian mosaicists, trained in reproducing paintings; frequently the mosaics were executed in Italy from cartoons and shipped to the place of erection.

The modem movement in the representational arts and architecture and the patronage of business firms in the 20th century occasionally brought mosaic back to a significant level of achievement. For utilitarian purposes its use ranges from the plain white-tile mosaic of bathrooms to the decorated floors of large buildings where stone tesserae form borders or allover patterns which may be drawn from Graeco-Roman models; a modem innovation is the insertion of widely spaced metal strips which decrease cracking of the floor and add to the decorative effect. Floor mosaic is usually assembled on a cloth or paper facing and pressed into the cement bed in strips or sections. This labour-saving practice when applied to wall mosaic of glass cubes reduces its effectiveness greatly by producing a smooth, tight surface whose hardness and lack of luminosity is then intensified by too bright lighting of the interior.

Only the wide spacing, gentle tilting and slight irregularity of hand-set cubes under subdued illumination, as in middle Byzantine work, exploit fully the resources of mural mosaic. The frank renunciation of this luminism in favour of a flat-pattern effect is more consonant with modem architectural decoration and is achieved by the use of relatively large cubes in simplified representations. A similar purpose has been attained through the adaptation of the Moslem tile mosaic technique to modern exterior and interior decoration in figured panels by cutting tesserae in a limited number of geometrical shapes from glazed tiles. The bright but opaque tiling of distinctive texture decorates the wall, yet preserves its solidity. Such efforts may serve to prolong the life of such an aristocratic handicraft as that of mural mosaic into an age of mechanized technique and high-priced labour.

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MOSBY, JOHN SINGLETON (1833–1916), U.S. soldier, was born in Edgemont, Va., on Dec. 6, 1833. He graduated at the University of Virginia in 1852, was admitted to the bar in 1855 and practised in Bristol, Washington county, Va., until the beginning of the Civil War. For a time he was adjutant of Gen. J. E. B. Stuart's 1st Virginia cavalry. In 1863 with Stuart's permission he undertook a quasi-independent command. In Fairfax, Fauquier and Loudoun counties within the federal lines, he raised and equipped a force of irregulars. On the night of March 8, 1863, with about 30 men, he penetrated the federal lines at Fairfax courthouse and took 33 prisoners, including Brig. Gen. Edwin H. Stoughton. He became famous for other such exploits. In the North he was regarded as a guerilla and in 1864, Sheridan, under orders from Grant, hanged seven of Mosby's men without trial; Mosby retaliated by hanging seven of Custer's cavalrymen. On April 21, 1865, 12 days after Lee's surrender, he disbanded his men. Through the influence of General Grant, he was paroled. He returned to his legal practice, joined the Republican party, canvassed Virginia in 1872 for Grant. In 1878–85 he was U.S. consul at Hong Kong, and was assistant attorney in the federal department of justice, 1904 to 1910. He wrote *Mosby's Reminiscences and Stuart's Cavalry Campaigns* (Boston, 1887) and

Stuart's Cavalry in the Gettysburg Campaign (New York, 1908). He died in Washington, D.C., on May 30, 1916.

See J. M. Crawford, *Mosby and his Men* (New York, 1867); A. Monteiro, *War Reminiscences by the Surgeon of Mosby's Command* (Richmond. Va., 1890); J. J. Willhamson, *Mosby's Rangers* (New York, 1909); J. W. Munson, *Reminiscences of a Mosby Guerrilla* (New York, 1906); J. H. Alexander, *Mosby's Men* (New York, 1907); J. Scott, *Partisan Life with Mosby* (New York, 1867).

MOSCHELES, IGNAZ (1794–1870), Bohemian pianist, was born at Prague on May 30, 1794, and studied music at the Conservatorium under Dionys Weber. He made his name in 1815 with his *Variationem über den Alexandermarsch.* He then toured the capitals of Europe as a pianist. During a visit to Berlin in 1824 he met Mendelssohn, then a boy of fifteen; and a friendship sprang up between them which was severed only by Mendelssohn's early death (see *Briefe von Mendelssohn-Bartholdy an Ignaz und Charlotte Moscheles,* 1888). In 1826 Moscheles married Charlotte Embden at Hamburg, and settled permanently in London. He was a brilliant executant, who interpreted the works of the great masters with conscientious fidelity. In 1846, at Mendelssohn's earnest solicitation, he removed to the Leipzig Conservatorium, then recently founded. Moscheles died on March 10, 1870. His numbered works extend to 142, apart from minor pieces; his most important compositions are his Pianoforte Concertos, Sonatas and Studies (*Études,* op. 70; and *Characteristische Studien,* op. 95); *Hommage à Händel;* and his three *Allegri di bravura.*

See *The Life of Moscheles* (1873), a translation by A. D. Coleridge of Mme. Moscheles' *Aus Moscheles Leben* (1872).

MOSCHEROSCH, JOHANN MICHAEL (1601–1669), German satirist, was born at Willstädt, near Strasbourg, on March 5, 1601. He was educated at Strasbourg, and after various appointments in different places, became privy councillor to the landgravine of Hesse-Cassel. He died at Worms on April 4, 1669. His most famous work is the *Wunderliche und wahrhafftige Gesichte Philanders von Sittewald* (anagram of Willstadt) (1641–1643), for which he took as his model the *Sueños* (visions) of the Spaniard Gomez de Quevedo y Villegas. Hardly inferior to the "visions" is the *Insomnis cura parenturn, Christliches Vermächtnis eines Vaters,* (Strasbourg 1643 and 1647). Noteworthy is also *Die Patientia,* discovered in 1897 in ms. in the municipal library at Hamburg.

Selections from Moscherosch's writings have been published by W. Dittmar (1830), F. Bohertag (in Kurschner's *Deutsche National-literatur,* xxxii., 1884), and K. Müller (in Reclam's *Universalbibliothek*). Reprints of the *Insomnis cura parentum* and *Patientia* have been published by L. Pariser (1893 and 1897), who is also the author of *Beiträge zu einer Biographie von Moscherosch* (1891). *See* also M. Nickels, *Moscherosch als Pädagog* (1883); J. Wirth, *Moscherosch's Geschichte* (1888); and bibliography by A. Bechtold. *Kritisches Verzeichnis der Schriften J. M. Moscherosch* (Munich, 1922).

MOSCHUS OF SYRACUSE (fl. *c.* 150 *B.C.*), Greek bucolic poet, of whose *Bucolica* three short extracts in hexameters are preserved by Stobaeus. A longer piece, again in hexameters, translated as *Love, the Runaway,* has also survived and an elegiac epigram on Love as a plowman, included in the *Anthologia Planudea.* The attractive short epic *Europa* is assigned to Moschus in some manuscripts. perhaps correctly. The *Megara,* a dialogue between Hercules' wife of that name and his mother Alcmena, is sometimes attributed to Moschus, but on the whole seems unworthy of him.

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MOSCOW (Russian MOSKVA), the most populated *oblast* of the Russian Soviet Federated Socialist Republic. Area 18.687 sq.mi.; pop. (1956 est.) 10,902,000; urban 8,377,000, rural 2,525,000. The region is of interest as the cradle of the Russian nation which rose after the decay of Kiev. It consists largely of the inter-riverine district between the upper Oka and the upper Volga, with the Moskva river flowing through its core to join the Oka. To the west of the region there was a convenient portage between the Moskva and the Lama, a tributary of the upper Volga, on which was situated the fiercely disputed Novgorod trading colony of Volokolamsk. The area has always been densely forested. The climate is continental; the rivers are frozen from about 150 to 160 days, and the average January temperature is 14° F. (July 66.5°). Snow lies thickly in the winter, and the average precipitation is 23.6 in. a year. The prevailing winds are southerly and southwesterly.

The area consists of undulating ground (500–850 ft.) with broad valleys carved out by the rivers. In the Tertiary period it was already continental, but was partly submerged by the Cretaceous sea. There are no Triassic or Permian deposits, and the Jurassic is represented by its upper formations only. Upper Carboniferous deposits of deep sea origin rest upon the Devonian, discovered in an artesian well at Moscow at a depth of 1,508 ft.

The district has been inhabited since the Stone Age, though bronze implements are rare. In some places stone, bone and iron implements have been found together. Burial mounds of the 10th and 12th centuries seem to be of Finnish origin. Finnish tribes certainly occupied the district at the time of its colonization by the Slavs, and some racial intermixture took place, thus somewhat emphasizing the difference between Russians and Ukrainians.

In early times the forest and coal of low calorific value provided fuel for the industries which sprang up around the market at Moscow, where the first fur-preparing and cloth factories were established. The making of textiles began first in the peasants' huts, and even in modern times peasant textile industries flourished in spite of the development of the factory textile industry. In 1876–80, the coal fields to the south of Moscow region provided 15.7% of the coal raised in Russia, but with the introduction of cheap transport on the Oka and Volga for the Don coal and Baku naphtha, the Moscow textile industry ceased to rely on local fuel. After the outbreak of World War I, an impetus was again given to the use of local coal which provided 700,000 tons in 1916–17. In 1940 the region produced 9,800,000 tons of coal (6% of the country's output).

Industrialization in general made considerable progress, especially after 1928. In 1913 heavy industry represented only 16% of the total industrial production (excluding the city of Moscow); in 1940 this proportion rose to 62%, although the output of light industry increased as well. By 1951 the production of heavy industry doubled in comparison with that of 1940. Many power stations were built after World War I. Peat is abundant and electric plants utilize that and lignite, also available locally.

Before World War I agriculture of the region was rather primitive and, because of poor soil conditions, by 1916 the area of cultivated land was 35.7% smaller than in 1887. It increased again in the late 1930s. In 1953 there were 1,418 collective farms (in 1950, before amalgamation, 6,069), 130 state farms and 115 machine and tractor stations. Forests occupied 38.9% of the region's area, arable land 30.8%, meadows 9.8%, pastures 4.9%, and marshes 3%.

In 1956 the following 19 cities in Moscow *oblast* in addition to Moscow had a population of more than 50,000: Perovo (132,000), Podolsk (113,000), Kuntsevo (111,000), Stalinogorsk (109,000), Orekhovo-Zuevo (109,000), Babushkin (103,000), Serpukhov (102,000), Noginsk (former Bogorodsk, 99,000), Kolomna (94,000), Mytishchi (91,000), Elektrostal (88,000), Lyublino (84,000), Lyubertsy (81,000), Tushino (74,000), Zagorsk (former Sergievo, 72,000), Egoryevsk (59,000), Uzlovaya (55,000), Balashikha (53,000) and Pavlovski Posad (52,000).

Communications are the best in the country; a network of waterways (including the Moskva canal opened in 1937), railway routes and roads lessened costs of transit from Siberia, the central Asian region and the Caucasus, and the productive regions of the south contributed to the development of industries.

MOSCOW (Russian MOSKVA), the capital of the Union of Soviet Socialist Republics and of the Russian Soviet Federated Socialist Republic, and the chief town of the *oblast* of the same name, stands on the navigable Moskva river, a tributary of the Oka, and is connected with the Volga by the Moscow canal. The city occupies an area of 127.4 sq.mi. and is divided into 25 administrative districts.

The estimated population (without suburbs) was 5,045,905 in 1959.

Moscow is situated at an average height of 394 ft. above sea level. The mean temperature of the coldest month (January) is 1j.j° F., but winter temperatures can drop as low as —38.8" F. The warmest month is July. with a mean temperature of 57.6° F. and a maximum temperature in the shade of 85.8" F. The mean rainfall is 7.5 in.; the heaviest rain falls during the end of July and the beginning of August.

Moscow presents a striking summary of the life of old and modern Russia: there are wooden houses in the suburbs. reminiscent of the peasant *izba* of the villages, large blocks of flats, built since World War II. and town residences, with pillared porticos. which belonged to the former aristocracy; there are factories producing motor vehicles and machine tools, medieval Orthodox churches with the oriental splendour of gilded and painted domes, and sport stadiums; there are narrow, irregular lanes of the Kitai Gorod and newly widened thoroughfares: and there is the Kremlin with its fantastic pink brick walls, towers and gates! and the modern skyscrapers.

Moscow is the largest political and administrative centre of the U.S.S.R., and it contains the offices of the presidium of the supreme soviet of the U.S.S.R., and of the central committee of the Communist party of the Soviet Union and of its presidium (the real political government of the union:). The city also houses the administrative government of the union, *i.e.,* the council of ministers with its ministries, the government of the R.S.F.S.R. and the central committees of both the All-Union Lenin Young Communist League and the All-Union Central Council of Trade Unions.

In prerevolutionary Moscow. up to 1917, the predominant industry was textiles and, in association with it, there were some chemical works. During the years of Soviet rule the size and structure of Moscovite industry changed radically, and in the 19jos the heavy industries occupied a leading place. In 1954 the metal-working industry accounted for 27% of the gross production, heavy metallurgy for 2.9%, chemicals 3.5%, textiles 15%, food processing 1; .4%, leather. footwear and furs 6.4%, others 27.8%. An important branch of Moscow's manufactures, machine-building. is represented by two automobile plants (the Likhachev factory and another for small cars), two ball-bearing factories, etc. Machine-tool factories such as the Sergo Ordzonikidze plant, the Red Proletariat plant. and the Frezer and Kalibr instrument-making factories are also important. Precision engineering occupies a considekable place. High-quality steel is produced in the Hammer and Sickle (Serp i Molot) plant, cast iron is molded in the Stankolit plant. The "Dynamo," the radiotechnical plant. the Vladimir Ilyich transformer factory and others are concerns in the electrotechnical industry. The chemical industry is represented by an aniline dye plant. There are also pharmaceutical, synthetic rubber, perfume, cosmetic, soapmaking and other enterprises. The most important light industries are concerned with footwear and textiles, such as silk and wool. synthetic fabrics and printed cottons.

Communal central heating has developed. From 1940 to 1955 the number of buildings so heated increased 21 times. In 1913 about 6,000 flats in Moscow had gas; in 1955 the number had increased to 482.314; in addition many industrial undertakings were supplied with gas.

The face of Moscow was completely changed by the quantity of building that took place in the first 40 years of the Soviet period, but, because of the great increase in population, there was still a housing problem in the late 1950s. Moscow became a well-ordered modern city with broad asphalt streets and squares, many-storied houses. granite embankments and new bridges over the Moskva river, both in the centre and in the outskirts. Modern buildings. green parkways and boulevards contrast with numerous ancient buildings. The basic radial-ring plan of the streets has been preserved. In the 1920s building began, first in the workers' districts. where planned living complexes. with a network of service establishments were erected. Workers' clubs and "palaces of culture" (community halls) were built, and the sharp distinction between the central and suburban districts began to disappear.

In 1933 a stone mausoleum for Lenin in Red square replaced the wooden one which had been erected in 1924. From 1953 to 1961 it also contained the body of Joseph Stalin. This severe monumental building. which also serves as a tribune, adds to the historical aspect of the city's chief square. In 1935 work that was being done on the rebuilding and general rearrangement of Moscow was given great scope by the approval of a general plan for the reconstruction of the capital. During the years 1933–35 the city centre was cleared of small buildings; in the Okhotny Ryad. a street of shops. the offices of the council of ministers of the U.S.S.R. and the Moskva hotel were constructed; and the principal streets and squares (Gorki. Kaluzhskaya and others) were rebuilt. Among the buildings of that time are the Lenin Library of the U.S.S.R., the M. V. Frunze Military academy, the Tschaikovski concert hall and the Dynamo stadium. In 1939 a group of permanent buildings for the All-Union Agricultural exhibition was erected.

The construction of dwellings, schools. hospitals and other buildings became more extensive after World War II. especially in the 1950s. During the years 1949–54 seven high buildings mere erected. including that housing Moscow university (39 stories), which is situated on the Lenin hills. In 1956 the sport complex of Luzhniki, including the Central Lenin stadium, was completed. The city of Moscow expanded in the late 1950s mainly toward the northn-est and southwest. In 1956, 52 schools. 1j hospitals, and houses with 2,193,000 sq.yd. of living space were built,

The number of Moscow's educational establishments is considerable. In 1956 there were 1,033 kindergartens with 99.794 children; 95 primary and 558 secondary schools with a total of 608,846 pupils; 188 young workers' schools with 60,659 pupils; many primary and secondary vocational schools (including one for circus performers). There were also 88 institutions of higher education, including the M. V. Lomonosov State university. the N. E. Bauman College of Engineering. the K. A. Timiryazev Agricultural academy. the D. I. Mendeleyev Chemico-Technological institute, the V. I. Lenin Pedagogical institute and also the Academy of Social Sciences and the Higher Party school, the two last named under direct supervision of the central committee of the Communist party of the Soviet Union. The Soviet Academy of Sciences. with its affiliated institutes and research centres, has its headquarters in Moscow and so have the specialized academies, and the party-controlled Institute of Marxism-Leninism.

Moscow has 116 museums, of which the Central Lenin museum, the Museum of the Revolution and the Soviet Army museum were created after the 1920s. It also has about 3,200 libraries, general and specialized. the All-Union Lenin library containing 19,000,-000 books and periodicals. Of Moscow's 34 theatres. the Bolshoi (opera and ballet) and the MKHAT (Moscow Arts theatre) are well known. Six film studios are working in Moscow and there are many motion-picture theatres. Among the city parks, the Central Park of Culture and Rest. the Izmailovski and the Sokolniki are the largest. There are also 35 sport stadiums. 17 establishments for aquatic sports and 38 boat stations.

Moscow is the most important centre of Soviet newspaper and book publishing. In 1956 there were 159 newspapers and 698 periodicals. In the same year more than 100 state publishing houses issued 26.574 titles accounting for 733,458.000 copies.

City transport was highly developed. There were bus. trolley car, streetcar and subway transport services. In 19j6 the over-all length of bus routes was 1,590 mi. The first part of the Moscow "Metro" or underground railway came into use in 1935; by 1956 it extended more than 37 mi. and had 41 stations in use. These stations are distinguished by their elegant and expensive decoration. Eleven trunk railway lines radiate from Moscow. There are 9 passenger and 11 freight stations, all linked by a circular railway. The passenger stations, listed clockwise. beginning with the one at the west, are as follows: Byelorussian (for trains to Minsk, Warsaw and Berlin), Riga, Leningrad. Savyolovo (to places north of the capital), Yaroslavl (to Vologda and Arkhangelsk), Kazan (to Siberia and central Asia). Paveletsk (to the Caucasus), Kursk (to Kharkov and the Crimea), Kiev (to

MOSCOW

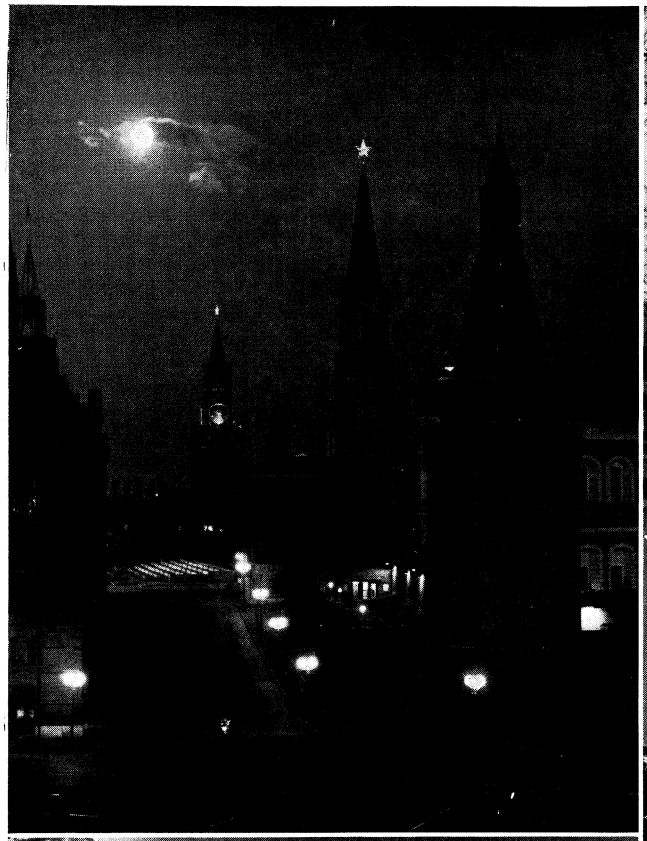
PHOTOGRAPHS, (1) DE COU FROM EWING GALLOWRY, (2) EWING GALLOWAY

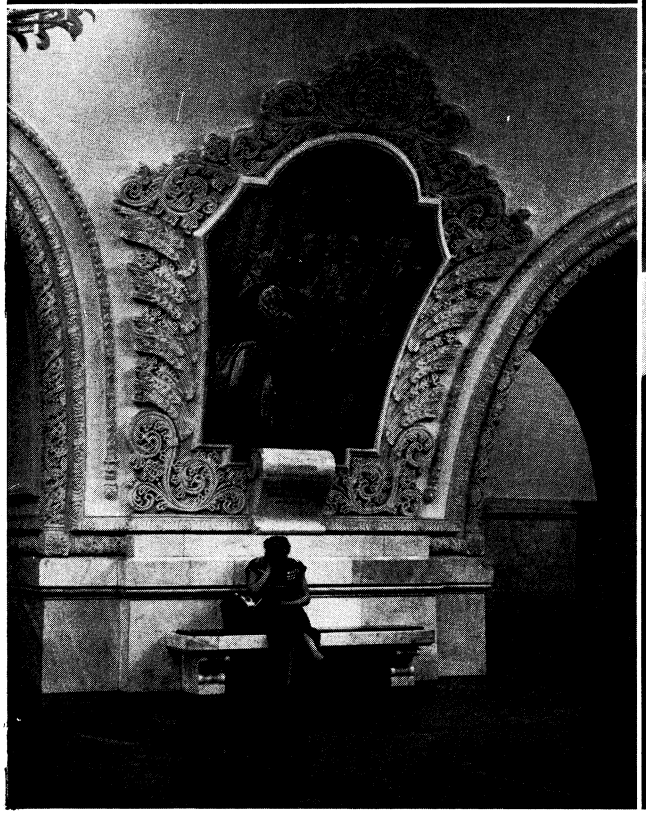
THE KREMLIN AND THE RED SQUARE IN MOSCOW

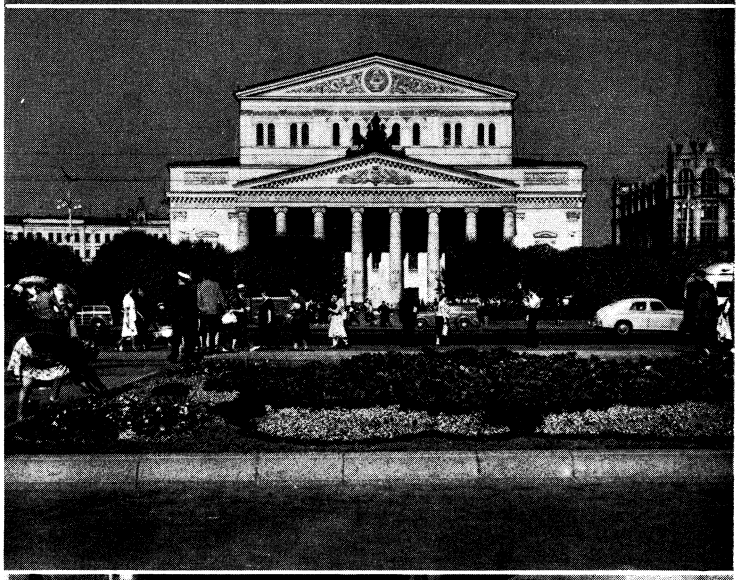
1. The Kremlin, an old fort which was for many centuries the centre of Russia's political and religious life. It contained within its wails the tsar's palace, great churches and palaces of the nobility

2. The Red square, adjoining the Kremlin walls (left background). The square is the site of mammoth parades, demonstrations and military reviews staged by the Communist rule

MOSCOW







BY COURTESY OF (TCP LEFT) SCANDINAVIAN AIRLINES SYSTEM. PHOTO BY GEORG ODDNER. PHOTOGRAPHS (TOP RIGHT, BOTTOM RIGHT) PETER SCHMID. PIX FROM PUBLIX, (CENTRE RIGHT, BOTTOM LEFT) VAN SPRANG FROM BLACK STAR

VIEWS OF THE CITY AND PEOPLE OF MOSCOW

Top *left:* The Kremlin at night
Top right: Sunday visitors at a cemetery in the city
Centre right: Bolshoi theatre, Sverlov Square
Bottom left: Elaborately decorated station of the Moscow subway
Bottom right: Shoppers at *GUM*, the city's largest department store

Bucharest and Budapest).

In 1937 navigation along the Moscow canal was begun and on the Moskva river there is transport by motorboats.

Moscow is linked by air with all the important cities of the Soviet Union, with Peking and all the eastern European capitals, but up to 1958 the only air links with aestern Europe and the Americas were through Helsinki, Prague and London though agreements with other countries had been discussed. The Moscow civil airport is at Vnukovo, 17 mi. southwest of the city centre.

History.—Moscow was first mentioned in Russian chronicles around 1147, although, according to archaeological excavations, an earlier settlement existed there already. In 1156 the wooden Kremlin (citadel) was built in Moscow by Yuri (George) Dolgoruki, prince of Suzdal. The Kremlin became the centre around which Moscow has grown. It is shaped like an isosceles triangle, the southern side being parallel with the Moskva river, the northwestern with the Neglinnaya river, a tributary of the Moskva (now running underground), and the northeastern running along an artificial moat. In the 12th and 13th centuries Moscow was an important town with a trading settlement to the northeast where artisans worked, and in the latter century it became the centre of the new Moscow principality. About 1237–38 the city was burned by the Tatars but soon recovered from its destruction. The Tatars burned it again in 1293. Three years later the Kremlin was encircled by a strong earthen wall and an oaken palisade. Under Ivan Kalita (1325–41) the principality of Vladimir was incorporated into that of Moscow. In 1326 the residence of the Russian metropolitan was transferred from Vladimir to Moscow. In the second half of the 14th century Moscow headed the struggle against the Mongol-Tatar yoke. The Moscow general levy formed the nucleus of the Russian forces which, under Demetrius (Dimitri) Donskoi, routed the Tatar army under Mamai at Kulikovo on the Don in 1380. In 1382, however, after a heroic defense, Moscow was captured and plundered by another Tatar leader, Toktamysh, but in 1408 it resisted a Tatar attack led by Edigei.

As Moscow increased in importance the area occupied by the city grew and its appearance changed. Ivan Kalita widened the Kremlin area by extending its earthen and oaken fortifications to the northeast and building there the first Uspenski cathedral made of stone (1326). In 1367, during the reign of Demetrius Donskoi, the first stone walls of the Kremlin were erected, and within the area it occupied were the palace of the grand duke, the palaces of the boyars (*q.v.*), monasteries and administrative buildings. There are six gates leading out of the Kremlin: one to the Moskva river, two to the Neglinnaya and three to the northeastern side of Krasnaya Ploshchad or Red square (this is a mistranslation and should be Beautiful square, its proper name since the 17th century). In 1404 Lazar, a Serbian monk from Athos, fitted the Kremlin bell tower with a clock striking the hours.

After the second half of the 15th century Moscow, having annexed most of the surrounding principalities, became a centre for the unification of a national Russian state, though it was not until the reign of Ivan III (1462–1505), who annexed Novgorod in 1478, that the prince of Moscow claimed to be "ruler of all Russia." Ivan IV (1533–84) subdued the khanates of Kazan and Astrakhan, but Moscow suffered many disasters at this time. In 1547 two great fires destroyed the greater part of the city; in 1571 the Tatar khan of the Crimea captured Moscow and burned it again, except for the Kremlin (the annals record that of its 200,000 inhabitants only 30,000 survived); in 1591 the Tatars of the Crimea again attacked the city outside the Kremlin, the stubborn defense of which was helped by the fire-resisting brick walls and towers built in 1489–95.

Moscow's population was composed of a secular and ecclesiastical aristocracy, of merchants, artisans, small traders and serfs. The differences among the inhabitants with regard to the property owned by each, and the social conflicts, sometimes turning into open rebellions (for example in 1382, 1445 and 1547), were typical of medieval Moscow. In the city were concentrated the state businesses and workshops in which cannon were cast, gunpowder was prepared and weapons forged. The leather trade, the production of clothes and provisions, and the working of silver were important. The craftsmanship practised in 16th-century Moscow excelled in its quality and variety. The industrial character of the city was clearly reflected in the names of its suburbs: Bronnaya (arms makers). Kuznetskaya (blacksmiths) or Kotelniki (boiler workers). The centre of commercial life in Moscow was the market, adjoining Red square, where each stall traded in a certain kind of goods. This market was the largest in the land and played a big part not only in internal but also in external trade in the 16th century. The Moscow merchants traded with western Europe, especially with England and Holland, with central Asia, Transcaucasia. Persia, and with such trading settlements on the Black sea as Kaffa (Theodosia) and Surozh (Sudak). Among home products furs, for which there was a great demand in western Europe, took first place.

Moscow was also the centre of state administration. It contained the tsar's court, and the boyars' *duma* (council), the assembly of the *zemstvo* (an advisory organ made up from elective representatives), the *soslovya* (states of the country squires and burghers) and the *prikazy* (central governmental institutions controlling the separate branches of the state administration). The Moscow patriarchate was founded in 1589 with the idea of strengthening the power of the Moscow sovereign and also the powers of the church. The great importance of Moscow in the life of the Russian realm made foreigners identify it with the Russian state itself, which, in foreign writings of that time, was often called "Muscovy."

In the second half of the 15th and the beginning of the 16th century the number of stone buildings within the Kremlin increased. The old Uspenski cathedral fell to ruins in 1472 and a new one was built in 1475–79 by Ridolfo di (Aristotle) Fioravante, a Bolognese architect. It is in the Lombardo-Byzantine style, with Indian cupolas; its Italian innovations were frequently copied in later Russian churches. From the 16th century it was the church where the tsars were crowned. The Cathedral of the Annunciation (Blagoveshchenski), with its nine cupolas, was erected in 1484–89 by architects from Pskov on the site of an old church first built in 1397; the sacred pictures by Andrei Rublev (1405), on the ikonostas of the high altar of the older church, were preserved in the newer one. The Archangel (Arkhangelski) cathedral was designed by an Italian architect and built in 1505–09 on the site of the original 14th-century cathedral. It contains the tombs of the tsars, from Ivan Kalita (d. 1341) to Ivan V (d. 1696), with the exception of Boris Godunov, whose body was removed in 1606 to the Troitse-Sergieva Lavra; of the later tsars only Peter II (d. 1730) is buried there.

Among the Kremlin's stone buildings of the 15th century is the Granovitaya (Granite) palace (1487–91); it is a single-vaulted state reception hall, and there Ivan the Terrible, in 1552, celebrated the conquest of Kazan. Opposite the Uspenski cathedral rises the lofty belfry of Ivan the Great (1505–08, completed in 1600 in the reign of Boris Godunov). Near the belfry stands the Tsar Kolokol, the largest bell in the world, which weighs 200 tons and was cast in 1731–35; during the fire of 1737 it fell from its scaffolding and a piece weighing 11 tons broke off. After 100 years it was raised up and placed on a granite base. To the east of it are two other belfries; one, erected by the Italian architect Petroche "the Little" in 1532–43, holds the chief church bell of Moscow, whose first stroke at midnight on Easter eve was later used as a signal to set the bells of the other 3jo churches of Moscow ringing.

Near the Spasskie Vorota (Redeemer gate) stands the former Voznessenski (Ascension) nunnery, restored in the 19th century; it is the burial place of the wives and sisters of the tsars. The Chudov (Miracles') monastery (14th century, rebuilt 1771) was formerly the residence of the metropolitan of Moscow and later a state prison; restorations undertaken in 1924, when the building was transformed into a museum for the objects of art from the famous Solovetski monastery on the White sea, evacuated after the civil war, revealed ancient corridors and rooms. Opposite the Chudov monastery stands the huge and ornamental Tsar Pushka (Tsar cannon), cast in 1586 and weighing 40 tons.

The Red square lies along the northeastern wall and moat. It

is linked with the Kremlin by three gates, of which the Spasskie Vorota is in the centre. Behind Red square was the principal part of the old settlement, the Kitai Gorod or Chinatown (a name supposedly derived from the Tatar word for fortress). While the Kremlin was the residence of the court and aristocracy, the Kitai Gorod was the residence of the merchants. It was enclosed by stone walls built by Petroche between 1535 and 1538. The Byely Gorod or White City—the settlement which had grown around both the Kremlin and the Kitai Gorod, north of the Moskva river—was enclosed in 1585–93 by stone walls built by Fedor Kon. The present boulevard ring occupies the site of these walls. Another settlement, known as Zemlyanoi Gorod or Earthen Town, grew up outside the White City and also on the south side of the Moskva river; it was surrounded by an earthen wall at the end of the 16th century. The site of this wall is now the green belt or Sadovoy ring. The main thoroughfares form radii of these concentric circles, cutting across the two rings and coming together at the Kremlin. Thus originated the radial-ring planning of Moscow. The city approaches were protected by a half-ring of monastery-fortresses (Simonov, Danilov. Andronikov).

In the 16th century the number of stone structures, religious and residential, in the settlement increased. In the years 1 jj5–60 the Pokrovski or St. Basil's cathedral, better known as the church of Vasily Blazhennoi (the Blessed)—named after the holy fool buried in the church vaults during the reign of Fedor Ivanovich (Theodore I. 1584–98)—was built in Red square to commemorate the subjugation of the khanate of Kazan. This cathedral is an outstanding monument of Russian national art.

Between the 14th and 16th centuries Moscow became the cultural centre of the Russian nation. The all-Russian archives as well as the archives of ecclesiastical literature were assembled there. Education made considerable advance in the 16th century, to which the growth of the book trade testifies. There existed a special book arcade and libraries which were large for the time. The first printing house was founded about 1 jj3. Architecture, painting and applied decorative arts (wood carving, needlework and jewelry making) reached a high level. The greatest artists of Moscow were Andrei Rublev (end of 14th—first third of the 1 jth century). and Dionisi with his sons (second half of the 15th—first third of the 16th century).

At the beginning of the 17th century, during the *smutnoye vremya* (time of troubles). Moscow was seized by a Polish protégé, Pseudo-Demetrius (Dimitri I) and in Sept. 1610 Hetman Stanislaw Zolkiewski entered the city. In May 1611 the Muscovites attacked the Polish garrison and forced the remnant of the Polish troops to take refuge in the Kremlin. where they surrendered in Nov. 1612. Kuzma Minin, a butcher. and Prince Dimitry Pozharski played a great part in the liberation campaign.

In the 17th century Moscow, the greatest commercial and industrial city in the country. took on a new significance as the centre of the developing all-Russian market. The city area at this time extended beyond the boundaries of the Zemlyanoi settlement. The basic element of the population, as before. was made up of artisans, day labourers and tradesmen who rose against exploitation in 1648 and 1662. At the time of the Peasants' War (1667–71), under the leadership of Stepan Razin, the unrest of the people of Moscow was recorded. The execution of Razin in 1671 was carried out in Moscow in order to terrorize the populace.

The architecture of 17th-century Moscow underwent striking changes, taking on more and more a trim and decorative character. In the 1620s the Kremlin lost its importance as a fortress. and ornamental tent-shaped additions were made to the Spasskie Vorota; in the 1680s similar decorations were added to other towers. In 162j an Englishman erected the famous peal of bells in the tower above the Spasskie Vorota (from which the "International" is now played at 12 o'clock and 6 o'clock each day). Large commercial houses and public buildings in stone occupied a still larger portion of the city. Toward the second half of the 17th century buildings sprang up which are complex, picturesque in composition and outline, and finished with ornamental brick masonry, coloured tiles, carved details in white stone, etc. Among the surviving buildings the following should be mentioned: the Holy Trinity (Svyatoi Troitsy) church in Nikitniki, in the Kitai Gorod (1628–34); the Nativity (Rozhdestva) church (mid-17th century) in Chekhov street; St. Grigory Neokessaryiski church in the Great Polyanka (1660s); the Holy Trinity church in Ostankino (1678–93); the buildings of the Pechatny Dvor or state printing house (1642–45) and of the Novodevichi and Simonov monasteries (1680s); and the Volkov house in the Great Kharitonyevski passage (second half of the 17th century).

During the 17th century Moscow continued to play a leading role in the cultural and artistic life of the nation. It was also a centre of educational development; in 1687 the ecclesiastical Slavonic-Graeco-Latin academy was founded. Russian literature and that translated from various languages was published and official chronicles were compiled.

At the same time, however, there was much disorder and internal strife. Revolts were crushed with the aid of the *streltsy,* a class of citizens and merchants rendering hereditary military service to the tsar. The spread of *raskol,* a nonconformist religious movement, led to further repressive measures. In 1698 the *streltsy* themselves revolted and were suppressed only after fearful slaughter by Peter the Great. In 1703 Peter, wearied of the opposition to his plans of reforms, of the conspiracies of the *boyars,* and of the distrust of the masses, founded St. Petersburg, to which, in 1712, the capital was transferred. Moscow's importance declined. The great fires of 1737, 1748 and 1752 caused much misery, but led to the enlarging of the streets and squares. Under Catherine II. in the 1790s, the population of Moscow mas about 175,000.

Eighteenth-century Moscow remained. however, the great centre of culture and enlightenment in Russia. A large number of educational institutions were founded: the school of mathematical and navigational sciences (1701), the medicosurgical college (1786) and others. In 1755, through the initiative of the great Russian man of learning, M. V. Lomonosov, the first university in Russia was founded in Moscow. Changes in the tenor of life of the city gave rise to new types of domestic, public, commercial and industrial buildings, as special attention began to be paid to the planning and suitability of the architecture. The arsenal in the Kremlin. begun in 1701, was completed in 1736. The Menshikov tower (properly the church of the Archangel Gabriel) was built by I. P. Zarudny in 1705–07.

After an interruption, caused by the transfer of the capital to St. Petersburg, construction became more intensive (*i.e.,* the storied belfries of the Donskoi and Novospassky monasteries, 1750s; the church of St. Kliment in Pyatnitskaya street. 1762–70) and flourished especially in the last third of the century when Russian classicism saw a brilliant development in the works of architects such as V. I. Bazhenov (1737–99) and M. F. Kazakov (1738–1812). Characteristics of the buildings of this period are monumentality of form. logical planning, and harmony of composition. Among the most remarkable buildings of these years are the house of Pashkov (now the old building of the Soviet Lenin library); the building of the former Moscow senate (1776–87) in the Kremlin (now a Soviet government building); the old university building, on the corner of Mokhovaya and Herzen streets; the Golitsyn hospital in the Great Kaluzhskaya street and many others. Typical of this time was a nobleman's town residence. usually consisting of a two- or three-storied house, standing in the courtyard or along the street front: with wings, servants' quarters and a garden. A number of smaller private detached residences were also built, together with thousands of little wooden houses. shops and workshops scattered throughout the city in a haphazard fashion.

Moscow played a significant part in the patriotic war of 1812 when the city was a large arsenal and provision depot for the Russian army. The seizure of Moscow was considered by Napoleon to be the deciding factor in winning the war and near the city the crucial battle of Borodino took place, after which Gen. Mikhail Kutuzov, commander in chief of the Russian army, decided to leave Moscow in order to conserve his army and be able to prepare a counteroffensive. Moscow was occupied by Napoleon from Sept. 14 to Oct. 19 (new style; Sept. 2 to Oct. 7, old style), 1812. This, however, did not save the French from rout.

On the first night following the entry of the French, the city was set on fire through the carelessness of its inhabitants, and the stores in the bazaar were destroyed. The citizens fled and the city was plundered by the troops of both armies. The burning of Moscow (more than three-quarters of the houses were destroyed), however, was the signal for a general rising of the peasants against the French. The want of supplies and the impossibility of wintering in a ruined city continually attacked by Cossacks and peasants compelled Napoleon to leave Moscow, after an unsuccessful attempt to blow up part of the Kremlin.

After the liberation a great program of building was begun under the direction of the Commission for the Construction of the City of Moscow, founded in 1813. The centre of the city mas partially replanned. With the building of the Bolshoi theatre in 1821–24 (rebuilt after the fire in 1856), the Teatralny square took on a new appearance. Changes made in the Red square included the filling-in of the moat, the building of the Torgovye arcades opposite the Spasskie Vorota in 1889–93 in the neoclassic style (the site of the present G.U.M. or State Universal store), and the erection of a monument in 1818 to Minin and Pozharski. The riding school or *Manezh* was built in 1817 and the university which had suffered from fire was reconstructed.

In the 19th century the industry of Moscow reached its highest development to that time and the *bourgeoisie* increased in importance. In 1837 the stock exchange was founded. After the abolition of serfdom in 1861. Moscow was rapidly transformed into the largest centre of manufacturing industry after St Petersburg and became the biggest railway centre in the country. In 1872 its population reached 602.000. In the period from the second half of the 19th century to the beginning of the 20th century intensive construction of banks. commercial houses, railway stations, blocks of flats and industrial plants gave it the appearance of a commercial and industrial city. Among the largest buildings are the Gorodskaya Duma or town hall (1890–92, now the Central Lenin museum). the Polytechnic museum (1877) and the historical museum (1875–81). The construction, however, was carried on piecemeal. and all attempts at a rational replanning of the city met with opposition from private landowners. In the outskirts there arose all types of huts. workers barracks and other dwellings of the poor. These districts formed a sharp contrast to the business centre and the residential districts of the well-to-do people.

In the architecture of Moscow of this period imitations of former styles and, at the beginning of the 20th century, the so-called modern style (for example, the Taroslavl railway station, 1904–14) predominated. In a few buildings there was a harmonious blending of various architectural styles of former times, for instance, in the Kazan railway station and the great Tarasov house.

In the second half of the 19th century a progressive patron of the arts, P. M. Tretyakov, collected in his gallery the best works of Russian national art. In 1892 he gave his collection to the city and, after 1918, this gallery was called Tretyakovskaya. In 1897 K. S. Stanislavski and V. I. Nemirovich-Danchenko founded the Moscow Arts theatre.

With the appearance of the industrial proletariat in the 1870s and 1880s, workers' movements in Moscow bkcame more extensive and many strikes took place. In the 1880s the first Marxist groups came into being. On the eve of Nov. 16 (N.S., 3, O.S.), 1917, shortly after the successful Communist revolution in Petrograd (previously St. Petersburg), Soviet rule was set up in Moscow as the result of an armed revolt of workers. On March 10–11, 1918, the Soviet government and the central committee of the Communist party headed by V. I. Ulyanov-Lenin moved from Petrograd to Moscow, which again became the capital of Russia, the first Socialist state in the world. Aiter the end of foreign and civil wars, during the years of the establishment and development of state economy, Moscow rapidly became an important industrial centre. Just before World War II the industrial production of the Moscow region was almost twice that of all pre-1914 Russia.

During World War I the population of Moscow grew to 1,983,700 (1915), but during the revolution it diminished to 1,027,300 (1920). It grew to 2,029,425 in 1926 and in 1939 it passed the 4,000,000 mark. During World War II (described in the U.S.S.R. as the Great Patriotic War 1941–45) its population diminished somewhat, especially toward the end of 1941 when the German invaders approached the capital. From Oct. 20 the city was declared to be in a state of siege. It was bombed from the air by German aircraft and fighting raged in the countryside around Moscow. The Soviet counterattack on Dec. 6 saved the city, and the Germans were forced to retreat. After World War II the capital changed almost beyond recognition, especially in its centre, and the population reached an estimated 5,032,000 (1959).

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MOSCOW ART THEATRE, founded in the spring of 1897 by Konstantin Sergeevich Stanislavski and Vladimir Nemirovich-Danchenko, two intellectuals who felt that Moscow needed a playhouse to do justice to the new realistic playwrights. The co-founders were prompted by the spirit of protest against the prevailing star system, the triteness of the repertory and the routine of staging and acting. Their decision to start a new theatre amounted to a declaration of war on all existing theatrical conventionalities.

On Oct. 14, 1898, the Moscow Art theatre was opened with Aleksei Tolstoi's *Tsar Fyodor Ivanovich,* staged by Stanislavski with Meiningen-inspired devotion to historical accuracy. The decisive battles, however, were waged and won when the director and cast attempted the plays of Anton Chekhov, *The Sea* Gull in 1898, *Uncle Vanya* in 1899, *The Three Sisters* in 1901, and *The Cherry Orchard* in 1904. Maksim Gorki's *The Lower Depths* in 1902 likewise was a test of strength for the young company that gropingly discovered a new acting style of psychological realism.

After the Russian Revolution of 1917 the Art Theatre was unsuccessful in attracting the new audiences. The company was sent abroad for an extensive tour to Berlin, Prague, Paris and the United States. Before visiting other American cities the troupe played in New York city for eight weeks (January and February 1923), a highly successful engagement that revealed to American audiences the virtues of concerted ensemble-acting. (A. M. N.j

MOSELEY, HENRY GWYN-JEFFREYS (1887–1915), British physicist whose name will always be associated with his work on the X-ray spectra of the elements, was born at Weymouth, Dorset, on Nov. 23, 1887. He was educated at Eton and at Trinity college, Oxford. Immediately after graduation he mas appointed lecturer in physics in Rutherford's laboratory in the University of Manchester, where he was later John Harley fellow and where he worked from 1910 until 1914, when he entered the army. His first researches were concerned with radioactivity; he then studied with remarkable success the X-ray spectra of the elements. In a series of brilliant investigations he showed that the frequencies of corresponding lines in these spectra were proportional to the sauares of whole numbers which increased regularly by unity as one passed from one element to the next when the elements were arranged in order of increasing atomic weights. The atomic numbers represented the electrical charges on the nuclei of the atoms of the various elements, and Moseley's fundamental discovery was a milestone in advancing knowledge of the constitution of the atom.

Moseley's death in action at Gallipoli on Aug. 10, 1915, at the age of 27, robbed physics of one of its most promising investigators. (D. McK.)

MOSELLE, a *département* of northeastern France, formed of the portion of Lorraine which was annexed by Germany as the result of the war of 1870. Area 2,405 sq mi. Pop. (1954) 769,388. It is bounded on the north and northeast by Luxembourg and Germany, including the Saar territory, on the east and southeast by the *département* of Bas-Rhin and on the south, southwest and west by the *département* of Meurthe-et-Moselle.

The *département* is largely floored by Triassic rocks, which form a surface. for the most part. between 600 and 1,000 ft. above sea level and are drained by the Moselle and its feeders; and it has a number of small lakes toward the east. Across the German border. southeast of the Moselle, stand the heights of the Hunsriick and the Palatinate. but the valley of the Moselle and the passes of Saverne and Haguenau across to the Rhine valley have made this area a double gateway between Germany and

France, and in spirit it has long been a frontier province of the latter.

Moselle is a region in which, partly because it has taken great effort to transform the soil, and partly because wars have retarded social change, the traditional system of concentrated villages and infinite subdivision of strips has persisted. The valley of the Moselle in the region of Metz is famous for its vineyards. There are very important mines of coal and iron in the de'partement, and famous salt deposits.

The chief industries are salt working, metal founding, lime burning and cement making, and the manufacture of glass, crystal, pottery and porcelain (Sarreguemines), machinery, chemical products, textiles, paper, wooden objects, preserved foods, brushes, boots and shoes, pipes and leather goods.

There are nine arrondissements (Metz-urbain, the capital, Metz-rural, Boulay, Château-Salins, Forbach, Sarrebourg, Sarreguemines, Thionville-east and Thionville-west), 36 cantons and 763 communes. The de'partement forms part of the 6th and 20th military regions, and Metz is the seat of a bishopric.

MOSELLE (Ger. MOSEL), a river of France and Germany, 342 mi. long, a left-bank tributary of the Rhine. It rises on the west flank of the Vosges near the Col de Bussang. It first flows northwest, crossing the Hercynian gneisses, turns north at Remiremont, passes off the gneisses at Épinal to cross the Trias and Jurassic rocks. From Toul past Nancy, Metz and to Diedenhofen it flows along a subsequent valley, after which it turns northeastward to cross the Trias and Devonian rocks and join the Rhine at Coblenz. It leaves France below Diedenhofen, for a short distance forms the frontier between Germany and Luxembourg, and then enters Germany. The chief tributaries are the Moselotte, Meurthe, Seille and Saar on the right, and the Madon, Orne and Sauer on the left. Navigation for small vessels extends downwards from Fronard, a little below Nancy. The river meanders about in its lower valley, where are the vineyards from which the well-known Moselle wines are produced. See RHINE.

MOSELLE WINES come from the German vineyards along the banks of the Moselle river and also of its tributaries, the Saar and the Ruwer. The distance from Trier to Coblenz is 62½ mi. and the average width of the vineyards along each side of the river is only 5 mi. Nevertheless the vineyards are closely packed along the winding bank; they are normally small in size as the sites are of considerable value.

The wines are green-golden in colour and possess a most distinctive racy flavour, which they acquire from the slate content in the soil. They possess the lowest alcoholic content of any white wine in the world—about 9% by volume—but the best of them give the impression of having body as well as lightness; in this they are unique. The wines should be drunk when young; they lose their natural freshness after perhaps five to eight years.

The best wines come from vineyards which face south. The vineyards are usually "manured" with slate chips, cut from the steep banks of the Moselle. These chips, spread upon the top soil, not only absorb the heat of the sun, but help to keep the soil moist during summer, and they impart to the wine its individual, almost effervescent or *spritzig* quality.

Except in the upper Moselle toward the Luxembourg frontier, where the soil is mainly shell-limestone, and the wines sour and second class, the Riesling grape is grown exclusively. The best vineyards are found in the middle Moselle from Trier as far as and including Reil, while the next best vineyards are on the lower Moselle between Punderich and Coblenz. Wines from Piesport are known for their fullness and from Dhron for their bouquet. Wines from the Saar or from the Ruwer can have exceptional flavour and quality, although they are successful less frequently than those from the parent river.

See S. F. Hallgarten, ***Rhineland-Wineland*** (1951); A. Langenbach, ***The Wines of Germany*** (1951). (C. C. H. F.)

MOSEN, JULIUS (1803–1867), German writer, best known for his stories (Georg ***Venlot,*** 1831; Bilder *im* Moose, 2 vol., 1846), his political-historical novel Der Kongress von Verona (1842) and his poems (1836 and 1843), some of which attained popularity (*e.g.,* "Andreas Hofer"). Many of his writings, although fundamentally romantic in approach, show the influence of contemporary events. Mosen was born at Marieney in the Saxon Vogtland on July 8, 1803, and studied law at Jena and Leipzig; he traveled in Italy and in 1844 accepted the post of dramaturgist to the court theatre in Oldenburg. Soon afterward he was stricken with paralysis and he died at Oldenburg after many years of ill-health on Oct. 10, 1867. His other works include the epics Das Lied vom Ritter Wahn (1831) and Ahasver (1838) and a number of plays (*e.g.,* Theater, 1842, and the tragedies Herzog Bernhard, 1855, and Der Sohn des *Fürsten,* 1858). His collected works appeared in eight volumes (1863).

See H Schuller, "Zu Mosens Georg Venlot," ***Euphorion,*** vol. 23 (1921); F. A. Zimmer, ***Julius Mosen*** (1938). (L. H. C. T.)

MÖSER, JUSTUS (1720–1794), German writer, a forerunner of the Sturm und Drang movement, was born at Osnabruck, Dec. 14, 1720. A barrister, he became virtual head of the government of Osnabruck, a Protestant prince-bishopric, displaying great statesmanship in this post. The fruit of his experience and of his love of the region was a collection of weekly papers, on the English model, Patriotischen Phantasien (1774–76). His Osnabrucks Geschichte (1768) was a pioneer wbrk, showing the influence of folk traditions on the customs and government of a community. His contributions to the rediscovery of the past strengthened that literary revolt against foreign influence and the Enlightenment of which Goethe, who admired Moser, was the greatest figure. He died in Osnabruck, Jan. 8, 1794.

Moser's collected works were edited by B. R. Abeken (1842–43; new ed., 1945 et seq.); a selection was edited by K. Brandi (1921). His letters were edited by E. Beins and W. Pleister (1939).

See F. Meinecke, ***Die Entstehung des Historismus,*** 2nd ed. (1946); P. Klassen, ***J. Moser*** (1936).

MOSES (Gr. Μωυσῆς, Μωσῆς), the great Jewish lawgiver, prophet and mediator, and leader of the Israelites from Egypt to the eastern borders of the promised land. The records of his life and work are noticed in the articles EXODUS, BOOK OF; NUMBERS; DEUTERONOMY, where the several sources of the narratives are described. He appears in Midian at the "Mount of God" (Horeb) dwelling with its priest Jethro (*q.v.*), one of whose seven daughters he married, thus becoming the father of Gershom and Eliezer. Of his earlier life it was said that he was born in Egypt of Levite parents, and when the Pharaoh commanded that every new-born male child of the Hebrews should be killed, he was put into a chest and cast upon the Nile. He was found by Pharaoh's daughter, and his (step-)sister Miriam contrived that he should be nursed by his mother; on growing up he killed an Egyptian who was oppressing an Israelite, and this becoming known, he sought refuge in flight.

At the holy mount, Moses received the divine revelation and was commissioned to bring the people a three-days' journey out of Egypt to sacrifice at this spot (Exod. iiii, 12, 18; v, 3, viii, 27). The deity revealed himself in a new name, Yahweh, and with signs and wonders fortified Moses for his task. On his return he experienced a remarkable incident which is obscurely associated with the rite of circumcision. The plagues with which the reluctant Pharaoh was coerced culminated in the destruction of all the first-born, and Israel escaped to the Red Sea. The pursuing Egyptians were drowned and the miraculous preservation of the chosen people at the critical moment marks the first stage in the national history (see EXODUS, THE).

The other events need not be detailed. Kadesh (holy) was the chief centre. This was the scene of the "strife" at Meribah (striving) where Yahweh "shewed himself holy" (Num. xx, 1–13); a parallel account joins the name with Massah (trial, proof) where Yahweh "proved" the people (Exod. xvii, 1–7). These two names (Deut. ix, 22, xxxii, 51) with their significant meanings recur with varying nuances (Ps. lxxxi, 7, xcv, 8 seq.). Here also in the wilderness of Shur, and possibly at En-mishpat (well of judgment, *i.e.,* Kadesh, Gen. xiv, 7), Yahweh made for Israel "statute and judgment" and "proved them." This is apparently viewed as the goal of the three-days' journey (Exod. xv, 22–25). In this district the defeat of the Amalekites is more naturally located (Exod. xvii; cf. I Sam. xxvii, 8) and here, finally, for some

cause, now obscured, Moses and his brother Aaron (*q.v.*) incurred Yahweh's displeasure (Num. xx. 12, xxvii. 14; Deut. xxxii. 51; Ps. cvi. 3). Pisgah or Mt. Nebo (the name suggests a foreign god), to the north-east of the Dead Sea became the scene of the death of Moses; his burial-place was never known (Deut. xxxiv.).

Close study of the Pentateuch, in connection with the political and religious history of Israel as presented to us in other parts of the Old Testament, makes it difficult if not impossible to accept the tradition which ascribed to Moses every detail of Israel's legal and cultural institutions. It was inevitable that these should be traced back to the great hero, and there is evidence which suggests that in some quarters other elements in Israelite life, repudiated by the orthodox Jew, were once attributed to him. The snake worship of Jerusalem was thus assigned to him, and it is at least possible that at one time he was held to be the author of the bull worship of Bethel and Dan (II Ki. xviii. 4).

Beyond question Moses must be regarded as the founder alike of Israel's nationality and of Israel's religion. His leadership in the Exodus and his prominence in the great covenant at Sinai (or Horeb) are hardly to be doubted. It was he who welded into one people the various kindred tribes under his leadership, and it was he who introduced Israel to Yahweh and Yahweh to Israel. But further details must be a matter of conjecture. Even the earliest code of laws in the Bible (Ex. xxi.–xxiii.) is simply a local and national form of the civil law common to Babylonia, Assyria and the Hittites, and (since it presupposes an agricultural community) was probably adopted by Israel after the settlement in Canaan. The familiar Decalogue (Ex. xx. 1–17) is sometimes attributed to Moses in its earliest form, but all we can say with certainty is that it probably represents the ethical principles he laid down. Yet, with all this doubt, the fact remains that Moses stands out as one of the greatest figures in history.

(S. A. C.; T. H. R.)

MOSES, ASSUMPTION OF, an extra-canonical apocalyptic work of the Old Testament. (*See* APOCALYPTIC LITERATURE.) It is a prophecy of the future relating to Israel, put into the mouth of Moses, and addressed to Joshua just before the great lawgiver died. Founded upon the book of Deuteronomy, it contains a brief history of Israel from Moses to the Messianic age. The most striking feature in this work is the writer's scathing condemnation of the priesthood before, during, and after the Maccabean period, and an unsparing depreciation of the Temple services.

The book has been assigned to most dates between the death of Herod the Great and that of Bar-Cochba; but the true date appears to lie between 4 B.C. and A.D. 30. Herod is already dead (vi. 6), hence it is after 4 B.C.; and Herod's sons are to rule for shorter periods than their father, hence it must have been composed before these princes had reigned thirty-four years—*i.e.*, before A.D. 30. But there are grounds for assuming that A.D. 7 is probably the earlier limit.

The author was not an Essene, for he recognizes animal sacrifices and cherishes the Messianic hope. He was not a Sadducee, for he looks forward to the establishment of the Messianic Kingdom (x.). Nor yet was he a Zealot, for the quietistic ideal is upheld (ix.), and the kingdom is established by God Himself (x.). He was clearly a Pharisaic Quietist, a Pharisee of a fast disappearing type, recalling in all respects the *Chasid* of the early Maccabean times, and upholding the old traditions of quietude and resignation. His object is to protest against the growing secularization of the Pharisaic party through its adoption of popular Messianic beliefs and political ideals. But his appeal was in vain, and so the secularization of the Pharisaic movement culminated in due course in the fall of Jerusalem.

See the edition by R. H. Charles (1897), and his article in *Apocrypha and Pseudepigrapha of the Old Testament* (ed. Charles, 1913, vol. ii., where full bibliographies are given. (R. H. CH.)

MOSES OF KHOREN (MOVSES KHORENATZI) is known as the "father of Armenian literature." Traditionally held to be a 5th-century author, he has been dated as late as the 9th century. Nothing is known of his life apart from alleged autobiographical details contained in the *History of Armenia* bearing his name. His claims to have been the disciple of St. Sahak and St. Mesrop, to have studied in Edessa and Alexandria after the council of Edessa (431) and to have been commissioned to write his *History* by the governor Sahak Bagratuni (481–484) have been rejected by most serious scholars, mainly in view of anachronisms in his text. He is the only early Armenian historian to treat of events in his country long before its conversion to Christianity, and his lively style, narrative skill and diversity of interests ensure his continued popularity. *A Rhetoric*, a *Geography* (now attributed to Anania Shirakatsi) and some homilies also bear his name. (C. J. F. D.)

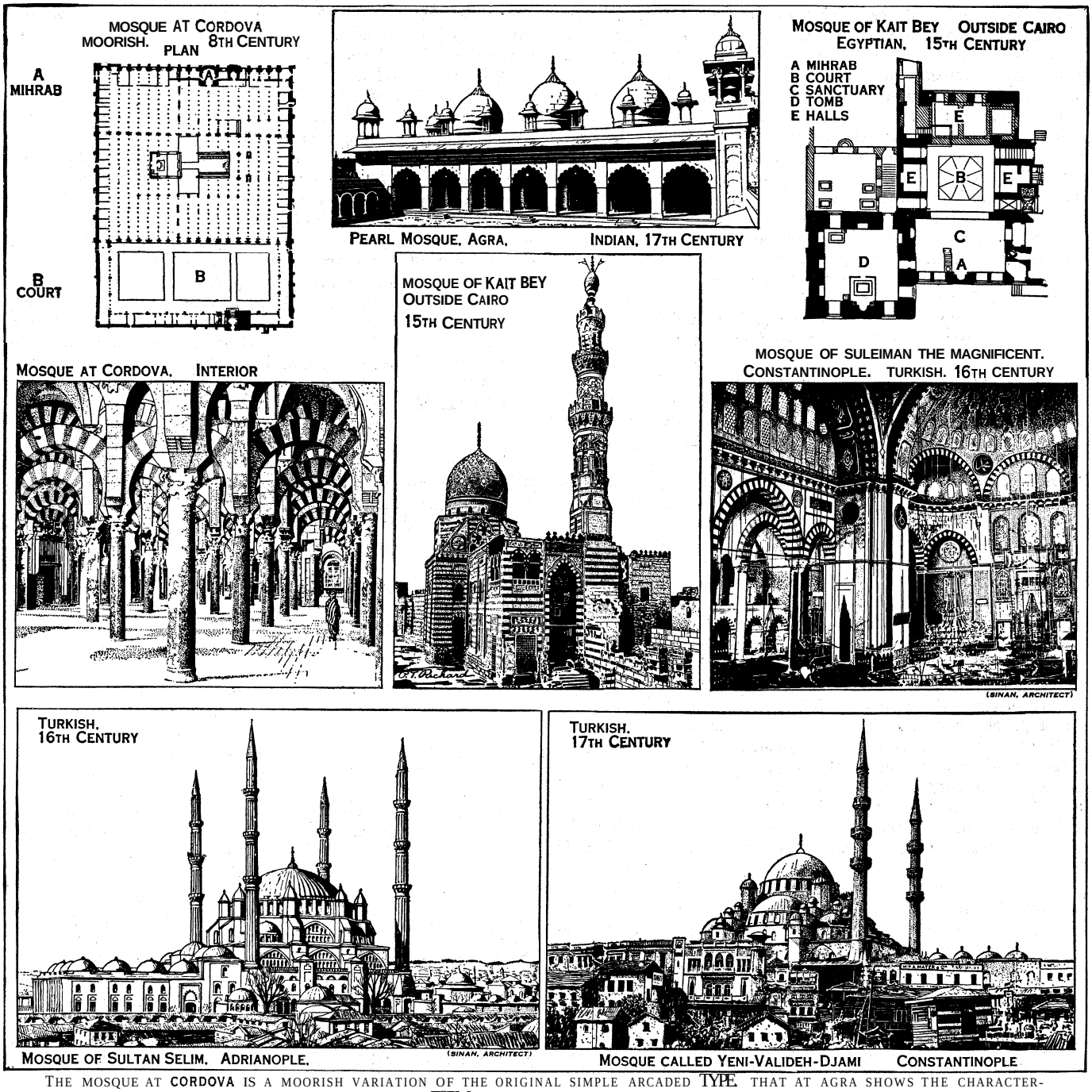
MOSETENAN, an independent linguistic stock of South American Indians, whose name is derived from the Mosetenes, one of its most important tribes. They live in northern Bolivia along the Beni river and east of it, approximately between 15° and 16° S. latitude. They are rather light in skin colour. They are a sedentary and largely agricultural folk, living in reed and thatch huts, and wear brilliantly coloured cotton sleeveless homemade tunics. They do not use canoes, but make rafts. The bow is their main weapon.

MOSHEIM, JOHANN LORENZ VON (1693–1755), German Lutheran divine and church historian, was born at Liibeck on Oct. 9, 1693. He studied at Kiel, and became professor at Helmstadt in 1723. His *Institutionum historiae ecclesiasticae libri IV* (1726) established his reputation. Mosheim was consulted by the authorities when the new university of Gottingen was being formed; and in 1747 was made chancellor of the university. He died at Gottingen on Sept. 9.

MOSLEY, SIR OSWALD ERNALD, 6TH BART. (1896–), British politician, leader of the British Union of Fascists from 1932 to 1940, was born in London on Nov. 16, 1896. Educated at Winchester, he entered parliament as a Conservative in 1918, became an Independent (1922) and in 1924 joined the Labour party, and was chancellor of the duchy of Lancaster, 1929–30. He resigned from the Labour party in 1931 to form a new socialist party, but lost his seat at the general election in October. In 1932 he founded the British Union of Fascists and, a powerful orator, roused some enthusiasm, being supported in 1934 by Lord Rothermere, who publicized the party as the only alternative to socialism. Interned in 1940, he was released in 1943, and after World War II unsuccessfully attempted to found a new union party. Sir Oswald married in 1920 Lady Cynthia Curzon (d. 1933), daughter of Lord Curzon of Kedleston, and in 1936, Diana Guinness, daughter of Lord Redesdale.

MOSQUE, a building erected for Mohammedan religious services. The early type of mosque is determined by the position of the Mihrab or prayer niche indicating the direction of Mecca and the ritual custom of having all the worshippers arranged in parallel lines facing in this direction. Thus the Mihrab is placed in the centre of a long wall and accommodations for the lines of worshippers furnished by a series of arcades parallel or perpendicular to the wall in which the Mihrab is placed. The covered portion thus formed is usually a rectangle, wider than it is deep, enclosed by walls at the back and two ends, but open through the final arcade at the front on to a court, frequently surrounded by colonnades, and containing, in its centre, a fountain for ritual ablutions. Beside the Mihrab was placed the Mimbar, or pulpit, which usually consisted of a tall, shrine-like platform against the wall, covered with a pyramidal roof, and approached by a long, straight flight of steps. In later mosques there was also frequently a large raised platform supported on arcades, known as a Dikka, from which portions of the service were read. At Mecca, the first mosque consisted of a series of arcades surrounding a rectangular court in which was the Ka'ba, or sacred rock; obviously no Mihrab was necessary, and the arcades themselves surrounding the court, formed the prayer hall.

This primitive type of arcaded or colonnaded mosque underwent many changes in various parts of the Mohammedan world. As the Mohammedan builders were peculiarly apt at learning the technique of the peoples whom they conquered, mosque design necessarily absorbed different influences in each country; the influence of Byzantine art was especially strong throughout western Asia. Five differing general schools may be recognized: First,



THE MOSQUE AT CORDOVA IS A MOORISH VARIATION OF THE ORIGINAL SIMPLE ARCADED TYPE. THAT AT AGRA SHOWS THE CHARACTERISTIC INDIAN MOGUL DEVELOPMENT OF THIS EARLY FORM. THE MOSQUE OF KAIT BEY OUTSIDE CAIRO SHOWS THE LATER TYPE OF EGYPTIAN MOSQUE WITH VAULTED HALLS AND A DOME. THE THREE TURKISH EXAMPLES SHOW THE SKILLFUL ADAPTATION AND DEVELOPMENT OF BYZANTINE DOME IDEAS WHICH MAKE THE BEST TURKISH MOSQUES MONUMENTAL AND LOGICALLY BEAUTIFUL

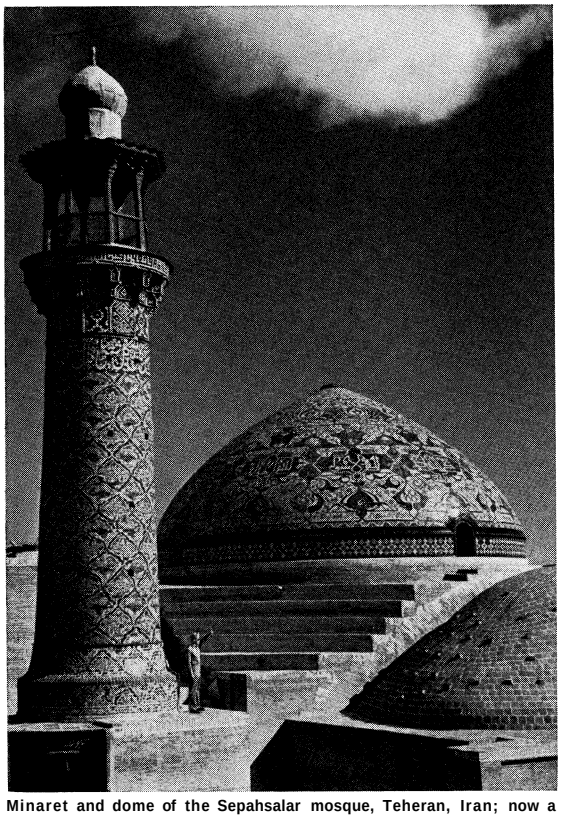
the school of Egypt and Syria; second, the school of north Africa and Spain; third, the school of Persia; fourth, the school of the Turkish empire; and last the school of India.

Early Mosques.—It is in the early mosques of the first school that the primitive form appears most completely. The mosque of Amru or Amr (begun 642) and that of Ibn Tulun (878), both in Cairo, and the Great Mosque at Aleppo (978) as well as that of Medina, in Arabia (707), are all remarkably complete examples; those of El-Aksa, at Jerusalem (685) and the great mosque at Damascus (707) are both built with materials taken from Christian churches. The result is necessarily different from the normal type, and the nave, transepts and aisle scheme of a Christian basilica may still be recognized, despite the additional ranges of colonnades and the changes in direction. In both of these, moreover, the Byzantine decorative influence is marked, and especially in El-Aksa, mosaics are used in an entirely Byzantine manner. In the famous Kubbet-es-Sakhra or mosque of Omar (a shrine rather than an ordinary mosque), a purely Byzantine plan, with a circular domed central nave and surrounding octagonal aisles is used. Only the slightly pointed arches differentiate it from a Christian building, and the whole bears witness to the power of Byzantine tradition on early Mohammedan mosques, and is also the earliest example of a dominant dome, which later became a characteristic feature of many mosques.

The mosque of Ibn Tulun, at Cairo, is one of the earliest in which no Byzantine or Roman materials are used; the pointed arch is used throughout and the decoration of the stucco which covers the rough construction already shows that preoccupation with flat surface ornament which is characteristic of later Mohammedan art.

By the time of the Mamelukes a love for more unencumbered interiors, and a growing skill in domical construction had worked

Dome of the Rock, or mosque of Omar, Jerusalem; 7th century. It exemplifies the Byzantine influence on early mosques



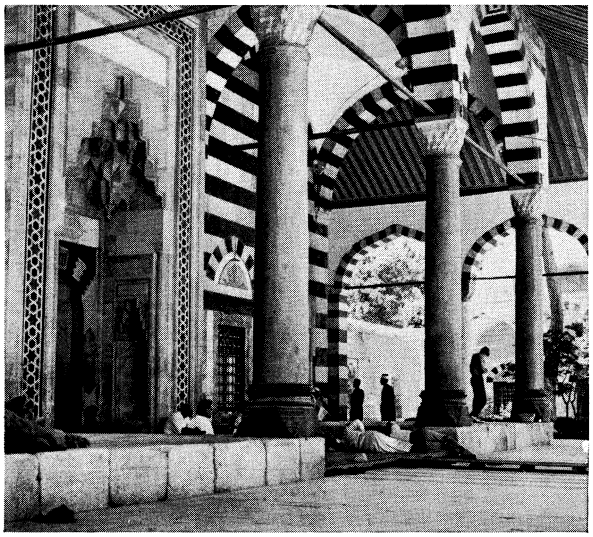
Minaret and dome of the Sepahsalar mosque, Teheran, Iran; now a theological college and library

Mosque of Sultan Selim II, Adrianople, Turkey; built by Sinan during the 16th century

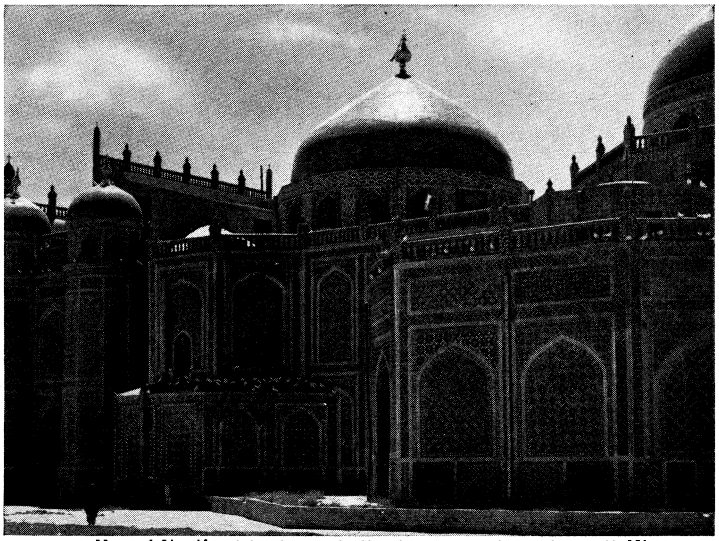
MOSQUES OF THE NEAR EAST AND MIDDLE EAST

BY COURTESY OF (BOTTOM RIGHT) TURKISH PRESS BROADCASTING AND TOURIST DEPT.; PHOTOGRAPHS, (TOP) PATELLAN:— PIX FROM PUBLIX, (BOTTOM LEFT) JOE COVELLO FROM BLACK STAR

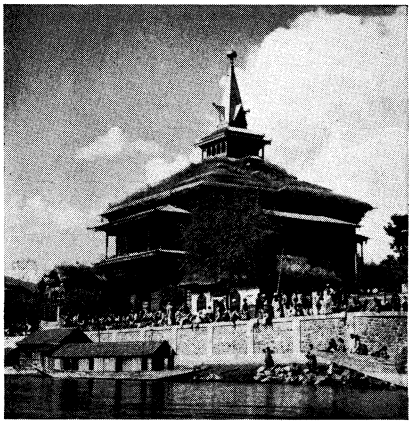
MOSQUE



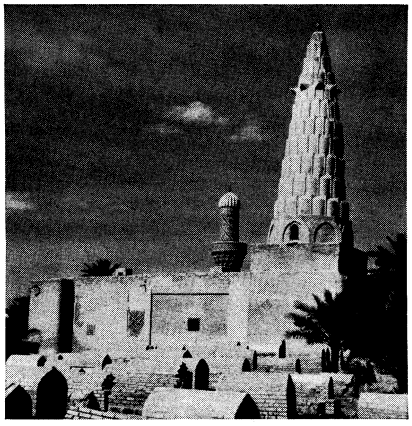
Entrance and arcades of the Sultan Suleiman mosque, Damascus, Syria



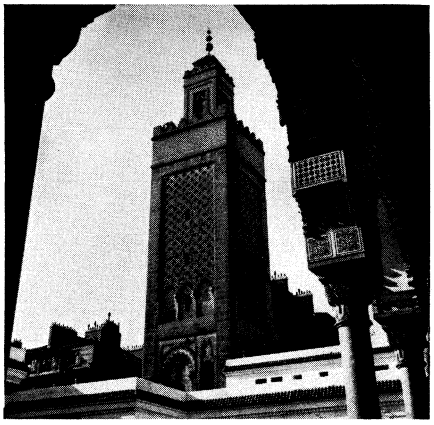
Mosque at **Mazar-i-Sharif,** Afghanistan; built about 1420 by Sultan Ali **Mirza**



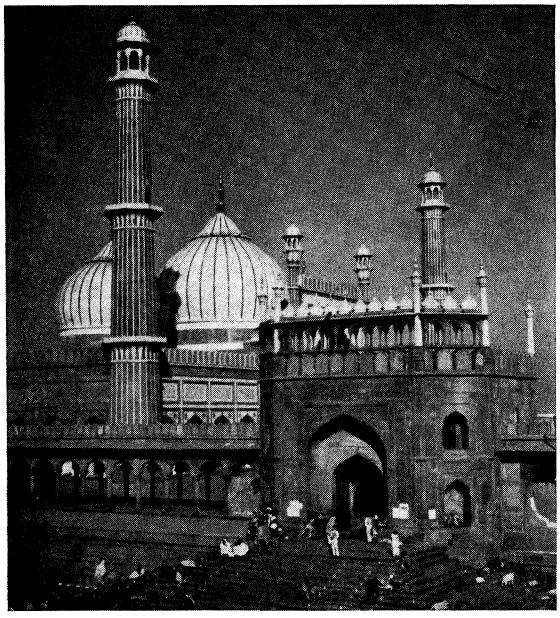
Wooden mosque of Shah **Hamadan,** on the Jhelum river, Srinagar, Kashmir



The old mosque of Sheikh **Omar,** Baghdad, Iraq; built during the reign of **Harun al-Rashid** (786–809)



Minaret of the mosque at Paris, 1922–24; a **20th-**century interpretation of 14th-century Moorish design



Jamma Musjid, or Great mosque, Delhi, India; built by Shah Jahan in the 17th century

Dolmabahce mosque, Istanbul, Turkey: built in 1853

MOSQUES DATING FROM THE 8TH TO THE 20TH CENTURIES

BY COURTESY OF (TOP RIGHT) AFGHAN INFORMATION BUREAU, LONDON, (BOTTOM RIGHT) TURKISH PRESS BROADCASTING AND TOURIST DEPT.; PHOTOGRAPHS, (TOP LEFT) OMNIA FROM THREE LIONS, (CENTRE LEFT AND RIGHT) © ENCYCLOPEDIA BRITANNICA, (CENTRE) ENRICO MARIANI, (BOTTOM LEFT) W. SUSCHITZKY

a profound change in Egyptian mosques, and led, as well, to a continually growing richness of exterior treatment and the use, both outside and in, of much rich stalactite ornament. Moreover, a type of plan. originally used for colleges or medressehs, consisting of four great vaulted halls around a central square court, became usual. The most beautiful example of this is the great mosque of Sultan Hassan at Cairo (1356); even more rich in its decoration and unusual in its plan is the mosque of Kait Bey Outside the Walls (1472).

These Egyptian and Syrian mosques furnish excellent examples for tracing the development of the minaret (*q.v.*)—the tower from which the call to prayer is given, an integral part of every developed mosque—from the primitive tower of Ibn Tulun, with its outside stair, like that of an Assyrian ziggurat or pyramid temple, to the slenderness and rich balconies of Kait Bey.

Moorish.—The Moorish school of North Africa and Spain, because of its distance irom Byzantine centres, preserved the primitive type of mosque plan even longer. The Great mosque of Qairwan (begun 675) bears many resemblances to those of Amru and Ibn Tulun. It is noteworthy. however, that in the mihrab, dating from 837, although the capitals are still of quasi-Roman type the surface decoration already approaches the Moorish type that flowered later in the Alhambra, and that, perhaps as a result of Roman influence, domes of considerable size appear at both ends of the central aisle leading to the mihrab. Equally primitive in its type is the great mosque at Tlemçen (1136); the same type is preserved in many other smaller mosques, such as those of Sfax (prior to the 11th century), and the Great mosque at Algiers (1018). By far the most important of the Moorish mosques is the Great mosque at Cordova, begun 780 and much extended in the 10th century, so that the prayer chamber occupied the enormous area of 148,000 sq.ft., with 16 rows of arcades. The whole is decorated with a lavishness unknown in other examples of the style and is noteworthy for the complicated interlacing arches, the doubling of the arcades, the intricate plaster ornament and the frequent use of cusped arches.

Persia.—In Persia the tradition of Sassanian vault building and of polychrome. glazed tiles led to mosques of a character entirely different. Thus. although the plan of the great mosque of Isfahan (begun 760, enlarged 1080. repaired in the 16th and 17th centuries) retains the many-columned prayer hall or maksoura and the great court of the primitive type, it has a structural grandeur, and a totally different architectural character as the centre of each side of the court is occupied by an enormous vaulted chamber opening on the court by a great arch, and instead of the intricate relief ornament there exist large simple surfaces to receive exquisite polychrome tiles. Throughout Persian mosque design domes have an importance not observable in Egypt or Moorish countries, and are frequently of bulbous outline. During the 1jth and 16th centuries the colonnaded prayer halls disappeared in favour of large. square, domed interiors, occasionally surrounded by lower vaulted side aisles, as in the Blue mosque at Tabriz (1437–68), famous for its faïence mosaic; the imperial mosque at Isfahan (1612) retains the original court with its four impressive porches, but all the covered portions are roofed with vaults. The main prayer hall, covered by a bulbous dome and preceded by the enormous pointed arched porch flanked by slim minarets, is perhaps the climax of Persian mosque design.

Turkish.—It is natural that the Ottoman school should be the closest to Byzantine tradition. The Great mosque at Konia (1220) shows a mixture of influences—Persian, Syrian, Byzantine, Armenian. The monumental doors are Persian, but the use of carved, relief ornament borrons much from early Armenian churches. In the Yechil-Medresseh or collegiate mosque at Nicaea (1420) the Byzantine influence is already dominant; dome forms, the use of alternate dark and light stones and the entire composition are wholly Byzantine. The green mosque at Brusa (begun 1424) is noteworthy in its attempt to combine with the purely Byzantine domed scheme details such as stalactite ornament, doors in niches, surface decoration and elaborated pendentives which are distinctly Mohammedan and developed from both Persian and Syrian sources.

The capture of Constantinople by the Turks in 1453 consolidated a tradition already strong—the attempt to build a mosque which should be structurally Byzantine but decorated with details Mohammedan and especially Persian. The development of the mosques of Constantinople and Adrianople, from the simple dome of the Mosque of the Conqueror at Constantinople (begun immediately after the conquest) by the Greek architect Christodoulos, and built with materials taken from the church of the Holy Apostles. to the piled masses of the Achmedieh mosque (1609), is continuous. In the piling up of dome over dome and half dome, the expression of buttressing masses and the consistency of exterior effect, as well as the creation of vast, unencumbered interior spaces, the Ottoman architects went far beyond the precedent set them in St. Sophia. Although Persian tiles and the rather garish interior painting never equalled the Byzantine marble and gold mosaic as interior decoration, the climax was reached in the mosque of Suleiman the Magnificent by Sinan (1557), the beautiful silhouette of which is almost matched by the simple dignity of its interior. In the 18th century daring lightness of construction was sought at the expense of every other quality, as in the little mosque called Nour-i-Osmanieh. "the lantern of Osman," with its dome. carried on four great arches. which seems almost to float. In detail. however. European influence was making itself felt, and the building of mosques rapidly declined.

Indian.—Indian mosques usually betray the Persian origin of the Moslem conquerors. Nevertheless, as mosque building continued more and more native influences made themselves felt. In the mosque of Ajmere (begun 1200) the plan is of characteristic early mosque type save that the arcades are covered by typical Jain octagonal domes, but the front to the court, with its high, central arch capped by twin minarets, is basically Persian. In the mosque of Kutub at Delhi. of approximately the same date, the plan is similar but the details entirely Indian, and the great minaret with its massed alternation of vertical and horizontal shadows is characteristically Indian In the 14th and 15th centuries. as in the mosques of Jaunpur (Redgate mosque and Jumma Musjid), the Indian delight in beam construction and the distrust of the arch give a character essentially non-Moslem. Under the Moguls there was a new influx of northern Moslem influences; the emperor Berber called to his service several pupils of Sinan from Constantinople. and the following hundred years saw the great mosques of Agra, Bijapur and Fatehpur Sikri, and the later work at Delhi, in which the Indian love for rich surface, the Mogul lavishness in the use of gleaming white marble. often inlaid with coloured stones. and a characteristic use of pointed, cusped arches combined with the Persian love of great size to produce results of vivid beauty. The most important examples are the great mosque at Agra (middle 16th century), the mosque of Fatehpur Sikri, nearly contemporary, especially remarkable for its magnificent gateway, and the Pearl mosque at Agra, of the middle 17th century, famous for its simple plan and delicate inlays.

Chinese.—Mosques are common in China, but in almost every respect follow Chinese temple precedent slavishly. Frequently the only thing which differentiates them from ordinary Chinese temples is the existence of a mihrab in the form of a pointed arch niche. as in the mosque at Hangchow, with decoration distantly based on Arabic sources.

Modern.—The most interesting of modern mosques is that at Paris. by Fournez. Mantout and Eustache (1922–24). This. built generally on the model of the Medresseh Bou Anania at Fez, is a beautifully planned, carefully detailed and lavishly executed modern interpretation of 14th-century Moorish design.

See H. Saladin, *Manuel d'Art Musulman,* v. i (1907). *See* also MOHAMMEDAN ARCHITECTURE. (T. F. H)

MOSQUERA, TOMÁS CIPRIANO DE (1798–1878), president of Colombia. was born in Popayán, Colombia, Sept. 20, 1798. While he was still a young man, the revolt against the Spanish rule began to gain ground in Colombia and he early joined the Colombian army, eventually rising to a high rank and becoming aide-de-camp to Simon Bolívar. He also held a number of governmental positions in these years, including those of intendant

to Guayaquil and to Popayán. He devoted the three years after Bolivar's death to travelling in Europe and the United States, but returned to Colombia in 1833 and in 184j was elected president, succeeding his son-in-law, General Pedro Herran. He failed of re-election at the expiration of his term, but in 1861 again was made head of the state with the title of dictator when he defeated the conservative army led by President Mariano Ospino, in a civil war over the issue of whether the government of Colombia should be a centralized or a decentralized one, Mosquera's faction favouring the latter position.

Under his leadership a congress was called which formulated a new constitution, changing the name of the country to the United States of Colombia and making the individual states almost independent of responsibility to each other and to the central government.

Mosquera was elected first president of Colombia in 1863, left the office in 1864 and was re-elected in 1866. Almost at once, however, he adopted measures which alienated both the conservatives and the radicals, the latter of whom particularly resented his attempts to assume responsibility for keeping peace between the individual states of the nation. In 1867, therefore, he was ousted and banished to Peru, and after his return from that country lived in political obscurity until his death in Coconuco, Oct. 7, 1878.

Mosquera is generally considered to be surpassed as a Colombian statesman only by Bolivar and Santander. During his first term of office especially, he was responsible for numerous reforms in education, transportation and particularly finance. He was the author of a biography of Bolivar and of *Memoria sobre geografía fisica y política de la Nueva Granada.*

MOSQUITO, the name applied to species of blood-sucking flies belonging to the family Culicidae, or gnats, of the order Diptera (*q.v.*). Prior to the year 1899 mosquitoes received very little attention from entomologists and only 400 species were known. At the end of the 19th century the researches of Sir Ronald Ross in India and Giovanni Grassi in Italy proved that mosquitoes are the agents concerned with the dissemination of malaria, and the establishment of this important fact has led to the collection and study of these insects in all parts of the world. More than 1,700 species of mosquitoes are now recognized, and it is probable that the number of kinds actually existing exceeds 2,500.

Mosquitoes bear a close general likeness to many harmless midges (Chironomidae) but may be distinguished by the following characters: (1) the lower lip or labium is prolonged into an elongate proboscis which forms a sheath enclosing the needlelike mouth parts; (2) the presence of scales on the body, wings and other appendages; (3) the costal vein runs completely round the wing; (4) the antennae are densely plumose in the males and less hairy in the females, while the palpi project forward and are not pendulous.

The family occurs in all parts of the world and although the tropics are much richer in genera and species than northern latitudes, mosquitoes are abundant even in arctic regions. Under the latter conditions they are found during the short summer and often occur far from the haunts of man and even in regions uninhabited by quadrupeds. In these regions they may go through several generations without blood, obtaining nourishment from the juice of plants, but the arctic species are vicious biters and are present in such huge numbers that mosquito head-nets and gloves are necessary for protection from them. There are many kinds of mosquitoes that never suck blood; but the majority do, and many of these cannot produce fertile eggs unless they have had a blood meal. One of the most vicious biters, *Aedes molestus,* which proved to be a serious pest in air-raid shelters and in the underground or subway of London during World War II, is able to reproduce without feeding, all the necessary energy being stored up during the larval stage. Its larvae live in polluted water. Some kinds of mosquitoes that never bite are predaceous in the larval stage on other kinds of mosquito larvae. Still others have a preference for certain types of animals and feed reluctantly on other kinds. Most kinds are attracted to light, some more readily than others, and light traps are used in order to obtain information concerning the kinds and abundance of each in an area.

Only the females suck blood, the mouth parts of the males being unsuited for this purpose. The males feed on pollen and nectar and probably upon the juices of plants, but it is likely that many of them are able to fertilize the female; without first taking food.

Classification. — Some students include with the mosquitoes the families Chaoboridae and Dixidae, but in these the mouth parts are not adapted for blood sucking and the larvae are conspicuously different in appearance.

The family Culicidae may be differentiated from all other flies by a very few characters taken together: (1) the antennae are composed of more than ten segments (usually 15); (2) the mouth parts are elongate; and (3) there are scales on the veins of the wings as well as on the front margin, and the fringe is composed of scales. The wing venation and other characters are typical but consideration of the three points outlined are all that is necessary to determine whether a fly is a mosquito or not. The antennae of the males generally have long rays of hair and are quite bushy; in the females the hairs are shorter and less numerous. This definition will exclude the Dixidae, which never have scales on the wings, and the Chaoboridae, which may have scales on the hind margin and rarely a few on the veins. These families also lack scales on the body whereas mosquitoes always have them. Other related families have different wing venation and their larvae do not at all resemble the wrigglers of mosquitoes.

The Culicidae are divided into several subfamilies and tribes, depending upon the groups included. The distinguishing features may be summarized as follows:

ADULTS

(1) Wings and body entirely without scales wing venation as in fig. 4 ..... Dixinae
Wings with scales at least on the hind margin; body with many, few, or no scales; wing venation as in fig. 2 2

(2) Wings with scales only on the posterior margin, the body rarely with a few scales, mouth parts short and not of piercing type ..... Chaoborinae
Wing veins clothed with scales body with numerous scales in addition to hairs and bristles; proboscis long and adapted for piercing. ..... Culicinae

The tribes of the Culicinae are as follows:

(1) Proboscis thinned toward the end and bent downward; palpi of female short; apex of scutellum evenly convex ..... Megarhinini
Proboscis of about even thickness, not curved downward; palpi and scutellum varied. 2

(2) Palpi of females about as long as the proboscis scutellum evenly convex behind; underside of the abdomen usually mostly without scales. ..... Anophelini
Palpi of females less than one-third the length of the proboscis; scutellum emarginate toward each side and therefore weakly trilobed. ..... Culicini

LARVAE

(1) Thorax not wider than the segments of the abdomen, and divided into three segments ..... Dixinae
Thorax conspicuously wider than the segments of the abdomen. 2

(2) Antennae moderately long, armed at the end with strong spines, used in capturing prey ..... Chaoborinae
Antennae short, not armed, and not adapted for catching prey. ..... Culicinae

The larvae of the tribes of Culicinae may be distinguished as follows:

(1) No siphon (breathing tube) at posterior end of the abdomen. ..... Anophelini
A long siphon at the end of the abdomen. 2

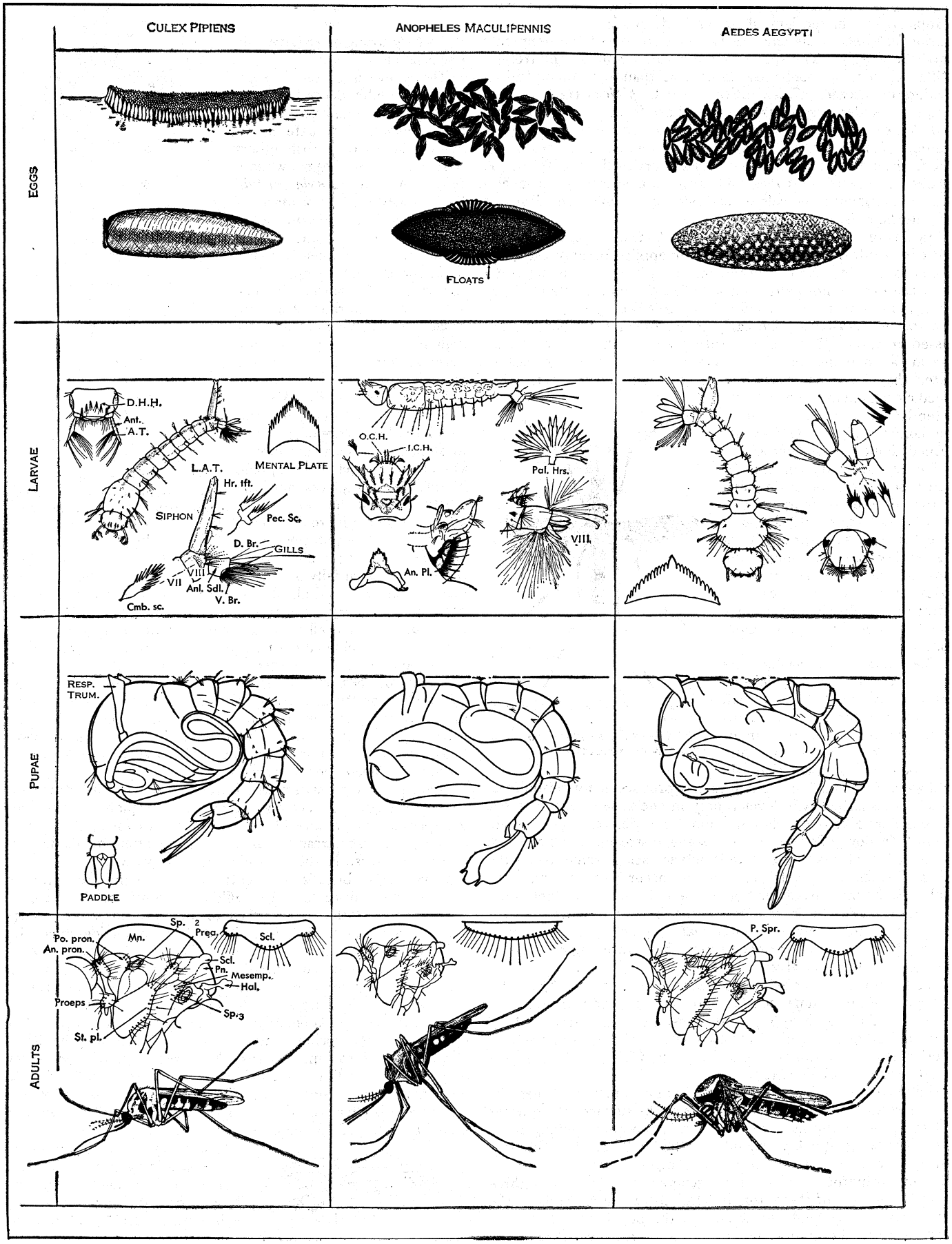
(2) Mouthbrnshes with about ten stout rakers, colour of larvae usually pink. Megarhinini
Mouth brushes with numerous hairs; colour pink in only one genus. ..... Culicini

The Dixinae are of little economic importance. The larvae are generally bent ∩-shaped and feed upon small organisms. They are poor swimmers and usually crawl out of the water when mature.

The Chaoborinae are of considerable importance since the larvae, which are known as phantoms because they are almost colourless, are predaceous and destroy mosquitoes as well as other small aquatic insects and other creatures.

The Megarhinini are essentially tropical, only a few occurring in the warm temperate regions and none occur in Europe. They are important because the larvae are predaceous and feed to a large extent on the larvae of other mosquitoes, chiefly of those breeding in tree holes and similarly sheltered places. They do not occur in large bodies of water. The adults are day fliers, are usually very beautiful, and do not suck blood. The approximately 60 species are almost equally divided between the Americas and the old world.

The Anophelini are the most important tribe. There are approximately 175 species of *Anopheles* of which almost one-third are carriers of human malaria. A few are known to transmit



FROM HERMS, "MEDICAL ENTOMOLOGI." BY PERMISSION OF THE MACMILLAN COMPANY, PUBLISHERS

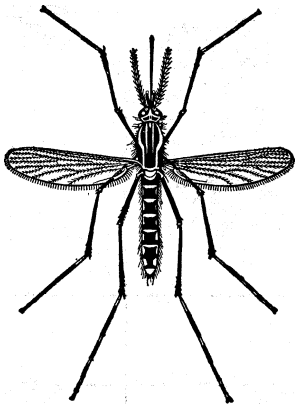
FIG. I.—DETAILS IN THE LIFE HISTORIES OF THREE GENERA OF MOSQUITOES, INCLUDING CHARACTERS USED IN CLASSIFICATION

encephalitis and filariasis, a nematode infection. The most dangerous species in the United States is *A. quadrimaculatus,* nhile *A maculipennis* is the chief carrier in Europe and the temperate portions of Asia. The species are most numerous in the tropics.

The Culicini are only less important than the Anophelini as carriers of disease. *Culex fatigans* and *C. pipiens* transmit bird malaria. *Aedes aegypti* transmits yellow fever in the Americas and Africa and is found in all tropical and warm temperate regions. It also (as well as *A. albopictus* and *A. obturbans* in the Pacific islands and the coast of Asia) carries dengue fever. A number of species of *Culex* and *Aedes* are vectors of bird and equine encephalitis, as well as filariasis which sometimes develops into elephantiasis.

Species of *Sabethes* and *Haemagogus* transmit "jungle" yellow fever in South America, the name being applied because the fever is contracted by people working in the jungle. as distinguished from the disease normally contracted in or about human habitations and knoun to be carried only by *Aedes aegypti.*

Breeding Habits.— The early stages of all the Culicidae are passed in water. The vast majority prefer fresh water but some live in salt marshes and brackish water, while others do best in water that has been contaminated with sewage. Species that breed close to houses, or that consistently enter houses, such as the common *Culex pipiens* are termed domestic mosquitoes.



BY COURTESY OF THE U S DEPARTMENT OF AGRICULTURE

FIG 2— AEDES AEGYPTI, THE YELLOW FEVER MOSQUITO

The eggs are laid on or near the water; sometimes on drying mud at the edges of temporary pools where they remain until the pools fill up the following spring. Most species lay the eggs singly and those of *Anopheles* have a pair of floats; *Culex* deposits eggs in rafts; the number laid by a single female varies from 40 to more than 300.

The larvae or wrigglers are very active and they may develop to maturity in an amazingly small amount of water, such as a hoofprint, coconut husk, tin can or even smaller receptacles. Any depression or container that will hold water for from five to ten days may produce many mosquitoes.

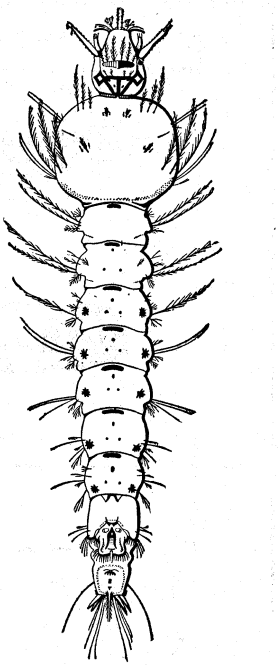
Most mosquitoes will develop only in one type of environment but some are able to develop in a number of different ones. Some live only in slowly flowing streams, some in streams in which there is vegetation, others where there is no vegetation; some live at the edges of lakes and ponds, while others occur only in temporary pools. Some must have sunlight. while other larvae cannot stand it. Many kinds live in tree holes and the axils of leaves which hold uater, and a fen live in the natery pulp of fallen tropical fruits. If the conditions under which they are living are altered the larvae cannot survive.

The food of the nonpredaceous larvae consists of small particles of vegetable and animal matter and very tiny animals that are swept into the mouth by a pair of dense brushes. Almost all of them, as well as their pupae, must come to the surface to breathe; a few kinds are known to obtain air by attaching their breathing tube to the stems of plants

The pupae are called bull heads and are also active. When the adult is ready to emerge the pupa rests at the surface of the nater and splits donn the back of the thorax. the adult pulling itself free. The wings quickly expand and the adult flies to a suitable resting place where its skeleton and wings can harden.

Some mosquitoes can produce a generation every two or three weeks. The eggs of these usually hatch in two or three days, the larvae mature in about one neek and the pupal stage lasts tno or three days The adult does not develop fertile eggs for at least two days All of the larvae do not develop at the same rate and mosquitoes from the same lot of eggs may give rise to adults over a period of two or three weeks. Mosquitoes that develop only in temporary spring pools have only one generation a year.

The winter is passed as eggs, larvae or adults, depending upon the species. The species of *Culex* and *Anopheles* hibernate in regions where there is frost; others pass the winter as eggs; while a few, such as *Wyeomyia smithii,* the pitcher-plant mosquito of North America. freezes in the ice in the leaf of the plant and resumes its growth when it thaws in the spring. In the tropics some species develop during the dry season, others in the wet season. Some of those living in tree holes high up in the jungle roof are very seldom found near the ground.



FROM "THE JOURNAL OF HYGIENE"

FIG 3 —LARVA OF AN ANOPHELES MOSQUITO WHICH FEEDS WHILE RESTING PARALLEL WITH THE SURFACE OF THE WATER

Control **Measures.**—Various methods for controlling mosquitoes have been developed. The ideal plan calls for a careful survey of the district. the mapping of all breeding places and the identification of the species; this is necessary in order to determine the kinds of mosquitoes present and their breeding habits. Control consists essentially of destroying the larvae and their breeding places. Tin cans and all objects that may hold nater are eliminated and necessary water receptacles, as rain barrels and cisterns are treated periodically. Drainage provides permanent control and is used to eliminate small pools, swamp and marsh areas; ditches and creeks are cleaned up so that the water flows evenly and does not back up. Areas of water that cannot be eliminated by draining or leveling are sprayed or dusted. Under military urgency when quick elimination is necessary, all possible breeding places are treated immediately by spray or dust; less obvious breeding places are then located and the breeding places of the species not affected are searched out.

Drainage may be undertaken in permanent establishments and stream beds cleared. The destruction of water plants to eliminate one species may produce ideal breeding places for another, especially in sluggish streams, while the elimination of shade may cause an increase in species which prefer open places.

Prevention of bites is an essential feature in the prevention of mosquito-born diseases. All buildings should be screened to prevent entry of the insects. Where there are no screens, sleeping nets should be used. Since *Anopheles* bite outside chiefly for about an hour at dusk and dawn, remaining indoors prevents bites. Certain repellents are available which repel mosquitoes for as much as five hours. Some repellents are effective against some kinds of mosquitoes but not others.

A mixture of Indalone, Rutgers 612 and dimethylphthalate is a good general repellent, but more effective ones may be developed from time to time. Aerosol bombs, containing pyrethrum, rotenone, or D.D.T. (dichloro-diphenyl-trichloroethane) are used to kill mosquitoes in small areas. D.D.T. is used to spray walls and screens and is effective over a long period, but it kills slowly and should be used with extreme care.

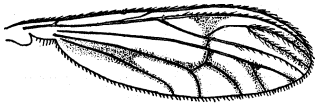


FIG. 4.—WING OF A SPECIES OF DIXA; COMPARE. VENATION WITH THAT OF FIG. 2

The so-called domestic *Aedes* and *Culex* may remain in dark portions of buildings or tents and bite during the day. Spraying will destroy them and prevent contraction of dengue and filariasis.

Mosquito surveys are made by

the use of light traps, animal traps, counting specimens in houses, and catching in the field. Man is sometimes used as bait for those species that prefer him. The trap is large and the entering mosquitoes are unable to escape; the man is protected by netting within the trap.

The larvae are controlled by the use of oil sprays and dusts. Dust containing 5% to 20% D.D.T. is applied from the ground and from the air. The amount used is determined by the area and depth of the water. It kills innumerable kinds of insect life and is probably to be considered merely as an emergency larvicide to be used only under special conditions. Several types of oil drippers have been developed for treating the surfaces of streams. Oil soaked sawdust in a sack tied to the bank is also employed. pyrethrum and rotenone are excellent larvicides, but, like D.D.T., they kill various insects and some other cold-blooded animals, including fish, if the concentration is too strong. They may be used to spray or dust to treat very small pools.

Several kinds of small fish, particularly *Fundulus* and *Gambusia,* are useful in controlling mosquitoes and are often introduced into ponds and other breeding places. They are very valuable for use in receptacles where water is stored, such as rain barrels, pails, water tanks, etc. They do not survive the winter in some places, so must be replaced each year.

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(A. D. I.; C. H. CN.)

MOSQUITO COAST (COSTA DE MOSQUITOS; MISKITO COAST), a section of the Atlantic coast of Central America comprising part of the republics of Honduras and Nicaragua, specifically a narrow strip, about 40 mi. wide, skirting the Caribbean sea for a length of about 225 mi. The name of the region comes from its ancient Indian inhabitants, the Miskito or Mosquito Indians. While the term Miskito can still be used to refer to an identifiable Indian population, a large percentage have long been mixed with Negroes.

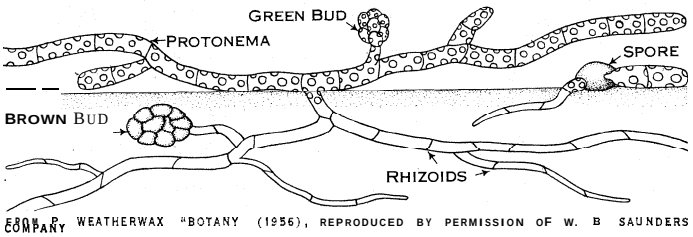
The Mosquito Coast was first discovered by Columbus in 1502, but there were only some tentative efforts at colonization by the Spanish and for practical purposes it did not come into contact with Europeans until the rise of the buccaneers in the 17th century. After that the English established a protectorate over the Mosquito Indians. Spain, Nicaragua and also the United States disputed this claim until the matter mas finally settled with the occupation of the Mosquito Coast by the Nicaraguan government and by the Clayton-Bulwer treaty (*q.v.;* 1850) between the United States and Great Britain, later revised under the Hay-Pauncefote treaty of 1901.

The Mosquito Coast of Nicaragua is divided among the departments of Rio San Juan, Zelaya and Cabo Gracias a Dios. Its principal city is Bluefields, the capital of the department of Zelaya, the principal city of the Atlantic region of Nicaragua and an important seaport (pop. [1950] 8,016). Other centres are Puerto Cabezas and San Juan del Norte (Greytown). See also NICARAGUA.

(M. F.-G.)

MOSS. The mosses. technically called Musci. constitute a subdivision of the Bryophyta (*q.v.*). The name is often misapplied to certain lichens (reindeer moss, beard moss). many fern relatives (club mosses) and certain flowering plants (Spanish moss, flowering moss).

Although usually small and often overlooked. some mosses are conspicuous by their size or abundance. The brook moss (*Fontinalis*) may form streamers one to three feet long in flowing water. The stair-step moss (Hylocomium splendens) forms a dense carpet very characteristic of the northern coniferous forest. Although the greatest number of species and the greatest quantities of mosses are found in areas of high humidity (*e.g.,* the Olympic and Great Smoky mountains in the United States and else here in the



FROM P. WEATHERWAX "BOTANY (1956), REPRODUCED BY PERMISSION OF W. B SAUNDERS COMPANY

FIG. I.— PROTONEMA AND RHIZOIDS OF A MOSS.
(Magnified about 200 times)

temperate rain forest of the tropics and the tundra), they are found also in almost all parts of the world, including the deserts.

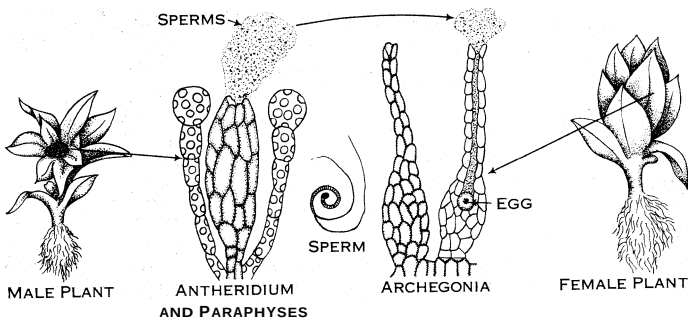
Some common species include the cord moss (*Funaria* hygrometric~ found on wood ashes, the silvery bryum (*Bryum argenteum*) and the horn-tooth moss (Ceratodon *purpureus*) occurring on various substrata; they are common in the United States and appear to be more or less cosmopolitan in distribution. However, most are restricted in range by substrata1 or climatic factors or past geological events, and exhibit much the same geographical range patterns as do the flowering plants.

The mosses multiply by branching and fragmentation. by regeneration from tiny pieces of leaves or stems or specialized bodies (propagula) and by the production of spores (minute single-celled and usually spherical structures) in the capsules (sporangia) of the sporophytes. The spore under favourable conditions germinates and grows into a branching, algalike green thread (protonema). Repeated branching may produce a mat of green felt which on exposed soil retards its erosion. (*See* fig. 1.)

Sooner or later, from these green filaments come branches (gametophytes) with leaflike scales (phylloids) arranged alternately in spirals or, less frequently, in two rows. In most cases there are eventually formed at the tips of the branches or in the axils of the phylloids the sex organs (see fig. 2): male (antheridium) and female (archegonium). The sexes may be represented by different plants or both types may appear in the same cluster of sex organs on one plant. The antheridium is usually shaped like a short sausage and is composed of a jacket of a single layer of cells enclosing a dense mass of tiny cells, each of which develops into a sperm (male gamete). At maturity the antheridium ruptures under moist conditions and the released sperms, equipped with two whiplike cilia, are capable of swimming.

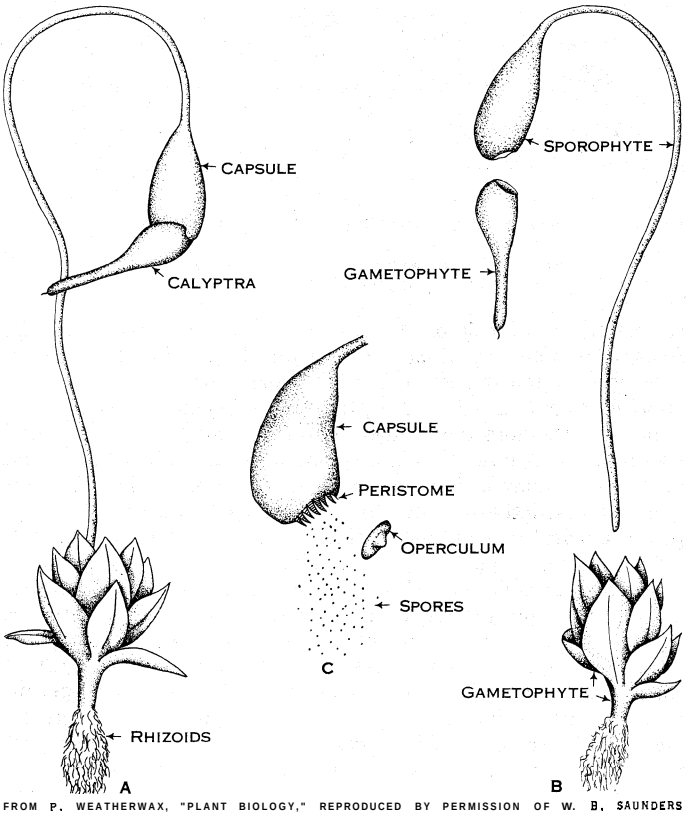
The archegonium is shaped like a flask with a long, narrow neck. The egg (female gamete) is borne in the centre of the enlarged base (venter). At maturity under moist conditions the top cell of the neck breaks away and the central column of cells in the neck disintegrate, forming a canal to the egg. Sperms within close proximity swim into the archegonium but only one penetrates (fertilizes) the egg to form a zygote.

The zygote divides, forming an embryo sporophyte which usually grows faster than the archegonium. As a result, the top part of the female sex organ is broken loose and borne aloft as a sort of pointed cap (calyptra) covering the top of the elongating sporophyte. The mature sporophyte usually consists of a foot em-



FROM P. WEATHERWAX, "BOTANY" (1956), REPRODUCED BY PERMISSION OF W. B. SAUNDERS COMPANY

FIG. 2.— SEXUAL REPRODUCTION IN A COMMON MOSS.
(Approximate magnifications: plants, 4 times; antheridium and archegonia, 50 times; sperm, 1,000 times)



FROM P. WEATHERWAX, "PLANT BIOLOGY," REPRODUCED BY PERMISSION OF W. B. SAUNDERS COMPANY

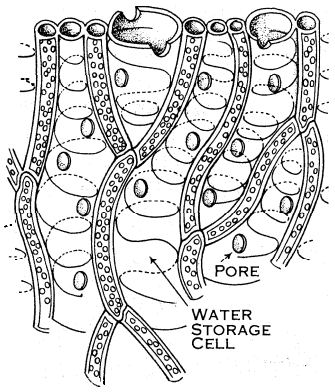
FIG. 3.—A MATURE MOSS PLANT (A) AND A DISSECTION OF THE SAME (B) TO SHOW THE TWO GENERATIONS; (C) MATURE SPORE CAPSULE

bedded in the base of the old archegonium, a stalk (seta) and an enlarged spore-bearing head (capsule or sporangium) under the calyptra. (See fig. 3.)

The capsule has a central column (columella) of sterile cells surrounded by the many minute spores mentioned above. They are enclosed by a thin inner jacket which is separated from the thicker, tougher exterior wall of the capsule by a spongy tissue (chlorenchyma) of green cells. The spaces in this tissue may connect to the exterior through pores (stomata) with regulatory guard cells.

The capsule usually has a definite lid (operculum) which neatly splits loose when the spores are ripe, and leaves a mouthlike opening. Under the operculum is a single or double row (peristome) of slender, triangular teeth which ring the mouth and are hygroscopic and move in response to changes in moisture. When the teeth are dry they curl back, exposing the interior of the capsule; when moist, they curve inward effectively blocking the mouth of the capsule, thus controlling to some extent the dissemination of spores.

A few mosses have capsules which lack the operculum and break open irregularly; others may have an operculum but lack the peristome.



FROM H. J. FULLER AND O. TIPPO, "COLLEGE BOTANY," REVISED (1954), REPRODUCED BY PERMISSION OF HENRY HOLT AND CO., INC.

FIG. 4.— SPHAGNUM.
Portion of "leaf" with narrow cells containing chloroplasts and wide, elongated cells with perforate walls, reinforced with internal rings and spirals

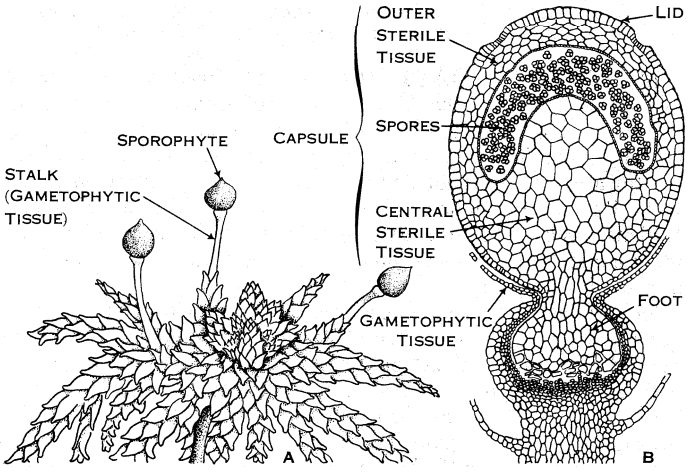
The mosses may be subdivided variously but are usually classified into three orders: Sphagnales, Andreaeales and Bryales.

Sphagnales.—This order, represented by a single genus Sphagnum, is often the chief component of peat bogs and is usually known as bog or peat mosses. Economically, they have the greatest importance of all of the Bryophyta. In addition to being the original source of peat and some charcoal, sphagnum has been used as packing for nursery stock and cut flowers, for surgical dressings, as an additive to soil and as litter for stables and chicken houses. Because so many of the cells in the leaves and stems are large, empty and have porous walls (see fig. 4), sphagnum can absorb tremendous quantities of liquids and odours. In addition, the plant contains a small amount of sphagnol, a phenolic compound with some antiseptic properties.

Sphagnum differs from the other mosses not only in the empty, porous cells mentioned above, but also in several other characters: a sporophyte (*see* fig. 5) without a stalk, which is raised at maturity on an elongated specialized branch (pseudopodium) of the gametophyte; a short domelike columella; spherical capsules with no peristome; long-stalked spherical antheridia; and the thalloid embryonic stages of the gametophyte.

Andreaeales.—Represented by a single genus Andreaea or the slit mosses, this order in North America has two characteristics in common with sphagnum : the pseudopodium and the initial thalloid stage of the gametophyte. Otherwise they appear different. Sphagnum may be over one foot long and is usually a pale colour; Andreaea is rarely over one-half inch high and is deep reddish-brown to black. The capsule opens by four slits in the lateral walls. It usually gro s on exposed noncalcareous rock.

Bryales.—Most of the mosses belong to the order Bryales, although they vary considerably in size, form and habitat. Among them are found the smallest, pygmy moss (*Ephemerum*) and the longest (*Fontinalis*). Their form often gives them interesting names: tree moss (*Climacium*); wind-blown moss (Dicranum);



FROM G. M. SMITH, E. M. GILBERT, ET AL.. "A TEXTBOOK OF GENERAL BOTANY," THE MACMILLAN COMPANY

FIG. 5.— (A) APICAL PORTION OF A LEAFY SHOOT OF SPHAGNUM BEARING SPOROPHYTES: (B) LENGTHWISE SECTION OF A NEARLY MATURED SPOROPHYTE. THE SPORES ARE IN GROUPS OF FOUR. EACH GROUP DERIVED FROM ONE SPORE MOTHER CELL

feather moss (Ptilium); extinguisher moss (Encalypta); turkish-slipper moss (Diphyscium); and the luminous elfin-gold (*Schistostega*), the protonema of which contain lens-shaped cells which reflect golden light from the dark depths of cellars or caves.

In the past, members of this order had more economic importance, fancied or real. than in modern times, although many are still used, particularly by peasants. The pigeon wheat or hair-cap moss (Polytrichum) and carpet moss (*Hypnum*) have been used in stuffing bedding; the carpet moss was thought to be capable of inducing sleep. Pigeon wheat, which often is over a foot in height, was and still is used in making brooms and dusters. The stems, stripped of their leaves and outer layers, were used in the plaiting of baskets and other articles, but as decorations on women's hats they have not proved very successful. They have been tried in landscaping, but some prove difficult to cultivate. They are also extensively used for Christmas decorations in Latin America, where bales of mosses are shipped annually from the mountains for this purpose. Some have a retarding effect on soil erosion, and newly cut banks along roads or trails in the Appalachian moun-

tains often are covered with green, feltlike mats of protonema of a moss (Pogonatum pensilvanicum) which greatly reduces erosion.

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MOSSADEGH (MOSADDEQ, MUSADDIQ), **MOHAMMED** (1880–). Iranian statesman mainly responsible for the Oil Nationalization act of 1951, was born in Teheran, the son of Mirza Hidayat, a former minister of finance. After serving for a period as treasurer of Khurasan province, Mossadegh went to Neuchâtel, Smitz. (*c.* 1908), where he studied law, obtaining the degree of Docteur en Droit for his thesis Le Testament en *droit musulman* (secte chyite) (Paris, 1914) On his return to Persia (1914) he was appointed governor general of the province of Fars; he showed both energy and tact in the performance of his duties. He refused to recognize the new regime established in Feb. 1921 by Sayyid Zia ad-Din and Reza Khan, but when Qavam as-Saltaneh became prime minister later in the year Mossadegh was appointed minister of finance. He introduced some much-needed reforms. In 1922 he became governor general of Azerbaijan, but soon resigned owing to differences with the military authorities. He was then appointed minister of foreign affairs (1923) but relinquished that post later in the year on being elected to the Majlis as a deputy for Teheran. He opposed the change of regime in 1925 and, being disliked by Reza Shah in consequence, retired into private life for a time.

In 1944 Mossadegh was again elected to the Majlis and played a leading part in opposing the U.S.S.R.'s demand for an oil concession covering northern Iran. He later occupied himself with the affairs of the Anglo-Iranian Oil company and was largely instrumental in the passing of the Oil Nationalization act in May 1951. He had become prime minister on April 30; his rigid enforcement of the act and his intractability in the resulting dispute with Great Britain led to the complete withdrawal of the Anglo-Iranian Oil company from Iran. Subsequently his failure to find markets for Iran's nationalized oil brought the country to the verge of ruin. At this time Mossadegh showed signs of what seemed to many to be emotional instability. His endeavours to obtain what amounted to dictatorial powers led to strained relations with the shah, Mohammed Reza Pahlavi. In Aug. 1953 a military coup d'état resulted in his overthrow, and he was later sentenced to three years' imprisonment for treason. After his release he led a life of complete retirement. See also PERSIA: History.

See N. Wilber, *Iran Past and Present,* 4th ed (1958); G Lenczowski, *The* Middle *East in* World *Affairs* (1952) (L Lo.)

MÖSSBAUER, RUDOLF LUDWIG (1929–), German physicist who received the Nobel prize in physics (1961) for his discovery and 1958 report of a phenomenon known as the Mossbauer effect (*q.v.*). Born in Munich. Ger., Jan. 31. 1929. he studied there at the Technische Hochschule (1949–55). After writing his doctoral thesis at the Max Planck institute (Heidelberg university) he was granted his doctorate in physics in 1958 from the Technische Hochschule and remained there through 1959 as a research fellow. In 1960 he was appointed senior research fellow at the California Institute of Technology (Pasadena), later becoming professor of physics. Mossbauer also received the Research corporation award (U.S., 1961), the Rontgenpreis from the University of Giessen (1961) and the Cresson medal of the Franklin institute (1961) (R. M SN)

MÖSSBAUER EFFECT, also known as recoil-free gamma-ray resonance absorption, was discovered in 1957 by Rudolf Mössbauer at the Max Planck institute, Heidelberg, Ger. His discovery was of great interest to physicists. who used the phenomenon to make by far the most precise "clocks" known. These "nuclear clocks" are not useful for ordinary timekeeping because they run at such a high frequency that there is no known way to relate them to conventional time scales. However, it is easy to compare the frequencies of two of these clocks, and a careful experiment can detect a difference of as little as one part in one hundred trillion (10^{14}) between two clock rates. Mossbauer experiments are done with two of these nuclear clocks. a source (generating) clock and an absorber (detecting) clock; the experiment consists in observing changes of the source or absorber clock rate under the influence of various disturbances.

The nuclei of atoms are used as the clocks in Mossbauer experiments. Atomic nuclei can exist only in certain configurations, or states. and can occupy only one of these states at a time. A nucleus in one of these states has a certain energy, and this energy is the same for all nuclei of that type in that state. The least energetic and most stable state is called the ground state; all others are called excited states. If a nucleus is in an excited state, it tries to move to an excited state having less energy or to the ground state. Since energy must be conserved, the nucleus must emit some energy in this process. If the nucleus moves from a state A to a state B of lower energy, the excess energy can be emitted as a gamma ray with an energy equal to the difference between the energies of states A and B. Since the energies of the states A and B are very stable and the same for all nuclei of a given type, the gamma rays will have a very uniform energy. It is this uniform energy that supplies the accurate frequencies used in Mossbauer experiments. (Energy and frequency are equivalent terms in describing the strength of a gamma ray and will henceforth be used interchangeably.) In iron-57, the isotope most commonly used for Mossbauer experiments, the gamma rays coming from all undisturbed iron-57 nuclei have the same frequency to within about one part in a trillion.

If the atomic nuclei that emit gamma rays are placed near a magnet, however, the gamma-ray frequency will change. The amount of the change is a measure of the strength of the magnet. Thus, by putting iron-57 atoms inside a solid, the magnetic fields generated by the other atoms in the solid can be measured. Experiments of this type. known as solid-state Mossbauer experiments, have revealed some failings of the classical theory of ferromagnetism (magnetism in steellike materials) that had not previously been suspected.

The best known experiments using the Mössbauer effect are those to measure the "gravitational red shift." Einstein's theory of relativity predicts that two identical clocks will run at different rates if they are in different gravitational fields (see RELATIVITY). Since the gravitational field of the earth varies with height, the rate of a clock should change with height. This change is so small that it is impossible to measure it by ordinary means, but the gamma rays from iron-57 have such a precise frequency (clock rate) that a change in height of only 50 ft. provides a frequency shift that can be accurately measured. This experiment was very carefully done by R. V. Pound and G. A. Rebka, Jr., at Harvard university. and the results were in excellent agreement with the predictions of the Einstein theory.

The method of detecting the frequency shifts of the gamma rays is closely related to the way in which the gamma rays are generated. If a nucleus is in the ground state (state B in the previous example), it can be moved into an excited state (A) if the proper amount of energy is added A gamma ray given off by a nucleus of the same type going from state A to state B has just the proper energy, since the energy difference between the A and B states is the same. A gamma ray that has exactly the right energy to raise the nucleus to the A state will be much more likely to be absorbed than one of any other energy; this is called resonance absorption. Gamma rays from the source go through a thin layer of absorbing material and then into a gamma-ray detector, such as a geiger counter. If the gamma rays are of the proper frequency to be resonantly absorbed, a large proportion will be absorbed and the counter will detect relatively few. If the gamma-ray frequency has been shifted (by a magnetic field, for example), fewer gamma rays will be absorbed and the counter will detect more. Thus. the percentage of gamma rays absorbed can be used to find the frequency shift.

In actual experiments the source is set in motion at a known velocity. This velocity introduces a known frequency shift through the phenomenon of Doppler effect (the same effect that makes the horn of an approaching automobile appear to have a higher

frequency than it actually does). The shift of gamma-ray frequency being produced by the disturbance under study is measured by finding the Doppler shift that is necessary to return the gamma-ray frequency to the proper value to be resonantly absorbed.

The preceding discussion must be qualified to the extent of considering the effect of the recoil of the nucleus. Just as a gun recoils when it is fired, a nucleus that emits a gamma ray recoils in the opposite direction to conserve momentum (Newton's third law). This motion of the nucleus takes up some of the energy difference between the A and B states, and thus the gamma ray has an energy slightly lower than would be expected from the oversimplified picture presented above. Similarly, the nucleus that absorbs the gamma ray recoils backward, and a gamma ray must have a slightly higher energy than the energy difference between the A and B states if it is to be resonantly absorbed. Although the recoil energy loss is only about a millionth of the gamma-ray energy, the resonance is so sharp that even this small loss will prevent the gamma rays from being resonantly absorbed.

Mossbauer discovered that under certain conditions the nuclei could be so firmly held in a crystal lattice (a regular array of atoms) that the loss of energy due to recoil was effectively eliminated, in a manner analogous to fastening a gun to the earth. (Hence the name "recoil-free gamma-ray resonance absorption.") Under these conditions, the gamma rays emitted by a radioactive source have essentially the full energy difference between the A and B states and thus can be resonantly absorbed if the absorbing nuclei have been similarly held in a crystal lattice. It was this discovery by Mossbauer that made it possible to use the extreme sharpness of the gamma-ray resonance.

The sharpness of the Mossbauer resonance is limited primarily by Heisenberg's uncertainty principle, which states that there will be an inherent uncertainty in the gamma-ray energy related to the half-life of the A level (the half-life is the time it takes for half of the nuclei in the A state to decay to the B state). By choosing nuclei which in the A state have a long half-life. the energy uncertainty can be made very small. For example, in iron-57. which in the A state has a half-life of a ten-millionth of a second, the uncertainty in the gamma-ray energy is about one part in a trillion. Other isotopes with still smaller uncertainties are available, but they are extremely difficult to use because the resonance is so critical that the slightest vibration or other disturbance will destroy it.

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MOSSI PEOPLES (also called MOSHI, MOLE or MORE), the inhabitants of a large area south of the river Niger, stretching roughly between the 11" 30' and 13° 30' N. parallels and from 2° to 5° W., and forming the core of the population of the Republic of Upper Volta. In 1960 they numbered approximately 1,500,000, and an additional 500,000 were estimated to live in other parts of west Africa. Their language, Mole, belongs to the Gur group and is akin to that spoken by the Mamprusi and Dagomba of northern Ghana. from whom the ruling estate trace their origin.

According to tradition, the first Mossi ruler was one Widraogo, the offspring of Yennenga, daughter of a Mamprusi chief from Gambaga, and a Busansi (Mande-speaking) hunter called Riale. Widraogo's sons, Diaba, Raoua and Zungurana. are said to have conquered the areas covered by the kingdoms of Fada N'Gourma, Yatenga (capital, Ouahigouya) and Tenkodogo respectively, and it is to them that the present rulers trace descent Zungurana's son, Oubri, was sent out to establish the fourth of these major kingdoms founded by the Mossi conquerors. that of Ouagadougou. In Fada N'Gourma, the rulers adopted the speech of the indigenes (Gurma), but in the other areas they imposed their own language upon the previous inhabitants.

The establishment of these states apparently precedes the 14th century, for a 17th-century chronicle, the *Tarikh es Soudan,* records that in 1333 Mossi troops sacked Tombouctou, a town of great importance as a terminal in the trans-Saharan trade. The whole area became subject to French administration with the entry of the latter into Ouagadougou in 1896 and received its independence as the Republic of Upper Volta (*q.v.*) in 1960.

The country is rolling savannah and, though it receives a low rainfall, supports a population of up to 70 a square mile. Although there are a number of part-time specialists, such as smiths, leather workers and weavers, the Mossi are essentially hoe agriculturalists, whose main food crops are pennisetum and sorghum. Some cattle, sheep and goats are kept.

The population is divided into royalty, nobles, commoners and, formerly, slaves; in addition, Muslim groups wield some influence. However, the religious system of the majority of the people places a strong emphasis on the cult of the ancestors and the cult of the Earth. The Earth priest plays a significant part in local affairs, filling a complementary role to the village chief. At the top of the hierarchy of each kingdom stands the paramount ruler, the senior of whom is the Moro Naba of Ouagadougou. This ruler is assisted by divisional chiefs who also act as electors, although it is usually his eldest son that succeeds.

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MOST (Ger. BRÜX), a town in Usti nad Labem *Kraj* (region), northwestern Bohemia, Czech.. lies on the north bank of the Bilina river, a tributary of the Labe (Elbe), and is about 150 km. (93 mi.) N.W. of Prague by rail. Pop. (1961) 45,417. It is mentioned by its German name in early 11th-century documents. Both forms of the name mean "bridge" and appear to derive from the structure built and maintained to cross the marshy ground near the old town. Traces of the town's older appearance remain in the Renaissance belfry in the town centre and in the late Gothic church of St. Mary. Most has long been the chief town of a region of active lignite mining and is the headquarters of the state lignite mining authority. Some lignite seams are nearly 100 ft. thick and are largely suitable for opencast mining. The annual yield is about 38,000,000 tons. The production of steel and ceramics is also important. Four miles to the north lies Zaluzi, with the largest chemical combine in Czechoslovakia; synthetic petrol is an important product. (H. G. S.)

MOSTAERT, JAN (c. 1475–1555/1556), Dutch painter, who is said to have spent 18 years in Brussels and Malines as painter to Margaret of Austria, regent of the Netherlands; other evidence, however, suggests that he worked chiefly in his native town, Haarlem. His chef-d'oeuvre is the "Deposition" triptych in the Brussels gallery; other notable works are an "Adoration of the Kings" (Amsterdam), a "Tree of Jesse" and a curious West Indian landscape (in private collections), and some portraits (Brussels, Copenhagen. Paris, Liverpool, Sarasota. Fla., etc.). Mostaert's style, though not unaffected by the more modern manner of Quentin Massys or Joachim de Patinir (*qq.v.*), is essentially that of a belated follower of Geertgen van Haarlem (*q.v.*); his pictures are assembled from much phlegmatically observed detail and have the smooth finish and crystalline brightness of an older generation of Netherlandish painters. (D. KG.; X.)

MOSTAGANEM, a town and seaport of Algeria, on the edge of the coastal plateau 80 km. (50 mi.) E.N.E. of Oran by road, is the headquarters of the Mostaganem *département* created in 1956. Pop. (1960) 64,000, of whom about 20,000 were Europeans. Divided by the ravine of the Ain Sefra river are a large modern quarter on the left bank and the compact Muslim quarter Tidgit (dominated by two *marabouts,* or shrines) on the right. The modern town has wide streets and tall buildings, and there is a large public garden. The port area is west of the town. Farther west are bathing beaches at La Salamandre and Les Sablettes. Mostaganem is linked with Oran by rail. The surrounding district is mainly cultivated; there are vineyards and the port exports wine, vegetables, citrus fruits and kieselguhr (diatomaceous earth). A gas pipe line from the Sahara to Mostaganem and to the Algerian coastal areas runs from Hassi Messaoud via Hassi R'mel.

Mostaganem was known in the 11th century as Murustuge. The *bordj* (bastion) al Mehal (the old citadel, now a prison) is attributed to the Almoravid amir Yusuf ibn Tashfin (reigned 1062–1106). Conquered in 1516 by the sea rover Arouj Barbarossa, the town passed to his brother Khair ud-Din and enjoyed great commercial prosperity. It was garrisoned by the French in 1833. (FR. D.)

MOSTAR, the capital of Hercegovina region of the Peoples Republic of Bosnia and Hercegovina, Yugos.. lies on the Neretva river just south of the famous Neretva defile, among gaunt and rugged mountains. Pop. (1961) 35,242. Immediately upon their conquest of Hercegovina, the Turks chose it as a military base. They built the Neretva bridge in 1566 in a stone arch, 90 ft. wide and 60 ft. high. Mostar (Serbo-Croatian "old bridge") is on the road and railway from Sarajevo to Dubrovnik. In 1875 the Hercegovinians started an uprising against the Turks which ended with the Austrian occupation. Under Austrian rule (1878–1918) Mostar was the centre of the Serbian patriotic movement. Some of the best-known poets in Serbian literature worked there. Mostar is the seat of the district court and of both a Roman Catholic and an Orthodox bishop and has a large Orthodox cathedral. There are a gymnasium, a theatre, state schools of viticulture and horticulture and a state stud farm. The principal industries are textiles, wine and tobacco. The district is well known for its tobacco which was formerly used at both the Istanbul and Vienna courts Good wines, *blatina* and *zilavka,* are produced in the neighbourhood, and fruit, vegetables and walnuts are grown. Within a few miles of the town are the sources of the Buna, a small affluent of the Neretva. which issues from a cavern amid scenery of wild grandeur. Anthracite is found in the district. (V. DE.)

MOST-FAVOURED-NATION TREATMENT is best defined as equality of trading opportunity. Attempts to guarantee such equality were incorporated into the provisions of commercial treaties and agreements at least as early as the beginning of the 17th century. The most-favoured-nation clauses in such treaties did not grant special favours but guaranteed treatment equal to that of the most-favoured nation. Since every state sought this guarantee. the effect was to establish equality of trading opportunity among states. The principle had been formulated in various ways for more than two centuries before its adoption in the Anglo-French treaty negotiated in 1860 by Richard Cobden and Michel Chevalier established it as standard practice.

Most-favoured-nation treatment is therefore both a principle of public international law and an instrument of economic policy. It establishes the sovereign equality of states in respect of trading policy, and it provides a treaty basis for competitive international transactions. Imposed unilaterally upon weaker powers, such equality of trading opportunity has been called the "open-door policy." Negotiated between independent states, it has generally consisted of a broad covering clause in commercial treaties, supplemented by specific clauses applying the principle in detail to a constantly increasing variety of subjects. It confers two main rights—a guarantee against discriminatory treatment, and equal participation in concessions made by either contracting party to the citizens of any other state.

The primary application of most-favoured-nation treatment has always been in respect of the duties charged on imports, but specific provisions have extended the principle to a wide variety of international economic contacts. These include the establishment of nationals of one country in the territory of the other; navigation in territorial waters; real and personal property rights; intangible property rights such as patents, industrial designs, trademarks, copyrights and literary property; import entry, duties and quotas; government purchases; foreign exchange allocations; and taxation. In all these fields the right to equality of treatment has been elaborated in considerable detail which varies from treaty to treaty.

Most-favoured-nation treatment often has been advocated and attacked as a device to extend free trade. Theoretically it can be used either by a protectionist or by a free-trade country since it merely guarantees treatment equal to that enjoyed by any third state. In practice it has operated to generalize the lowest rate of duty and the most favourable treatment enjoyed by any state to all other trading states having commercial treaties incorporating most-favoured-nation clauses. The Cobden-Chevalier treaty of 1860 was the model for many similar agreements in subsequent decades. These built up a set of interlocking tariff concessions, all of which, by most-favoured-nation treatment, were extended throughout the trading world. The United States in 1934, under the leadership of the secretary of state, Cordell Hull, modelled the Reciprocal Trade Agreements act upon this practice. The use of most-favoured-nation treatment in the executive agreements subsequently negotiated was strongly attacked by protectionists. Its application was somewhat limited by following the practice of granting concessions to the principal supplier country in an effort to get reciprocal concessions.

From its first commercial treaty with France in 1778 until the practice was formally abandoned in 1923, the United States insisted upon the conditional form of most-favoured-nation treatment. The argument was that the contracting parties did not guarantee to each other all concessions made to third parties, but only those made gratuitously or upon the same or equivalent conditions if the concessions had been bargained for. An attempt was made by the United States to obtain for each extension of most-favoured-nation treatment to a third party a concession equal to that obtained from the original contracting party. This conditional form was embodied in most of the commercial treaties entered into by the United States before 1922. A typical wording, in the 1911 treaty with Japan, was: ". . . in all that concerns commerce and navigation, any privilege, favour or immunity . . . to the citizens or subjects of any other State shall be extended to the citizens or subjects of the other Contracting Party gratuitously, if the concession in favour of that other State shall have been gratuitous, and on the same or equivalent conditions, if the concession shall have been conditional." By contrast, the unconditional form provided that "any privilege, favour or immunity . . . shall be extended immediately and unconditionally to the subjects or citizens of the other Contracting Party."

Even where the language of a treaty was in the broad unconditional form, successive administrations in the United States insisted upon a conditional interpretation. This was essentially a development from the law of contract. It was argued that for a contract to be binding there must be a consideration. A succession of judicial decisions in United States courts, of which the leading cases are *Bartram* v. *Robertson,* 122 U.S. 116, and *Whitney* v. *Robertson,* 124 U.S. 190, upheld this legal argument. Authoritative opinion among international jurists was divided. L. F. L. Oppenheim *(International Law,* 6th ed., rev., vol. i, p. 750 [1945–47]) and Sir Thomas Barclay *(Problems of International Practice and Diplomacy,* p. 383 [1907]) disputed the U.S. interpretation, but F. de Martens (*Traité de droit international,* vol. ii, p. 509 [1883–87]) and J. Westlake (*International* **Law,** part i, "Peace," p. 294, 2nd ed. [1910]) approved it.

Other governments from time to time attempted, under nationalist and protectionist pressure, to use the conditional form or to invent devices which might achieve the same effect. Thus in 1892 France enacted minimum and maximum tariffs in an attempt to secure a range of bargaining; but in practice other countries invoked their most-favoured-nation privileges to secure the minimum tariff. In 1919 France adopted the conditional form used by the United States, but was unable to implement its adoption. More successful efforts at evasion have been made by many countries primarily by reclassification and minute definition of items in the customs tariff so that a duty concession, while general in form, applied in practice only to one country. Thus, in the reciprocal trade agreement between the United States and the United Kingdom in 1938, the United States subdivided the item "building stone" and made a concession on "Cornwall building stone." The best-known illustration of a classification designed to confine a tariff concession to imports from one country without breaking the most-favoured-nation clauses in treaties with other countries occurred in the German tariff of 1902. Item 103 of this tariff admits at a special rate "large dappled mountain cattle or brown cattle, reared at a spot at least 300 metres above sea-level, and which have at least one month's grazing each year at a spot at least 800 metres above sea-

level."

After more than a century of effort to make effective use of the conditional form of most-favoured-nation treatment, the United States reverted to the unconditional form which had been common elsewhere. A thorough study conducted by the U.S. Tariff commission, published in 1918 as "Report on Reciprocity and Commercial Treaties," revealed the fact that additional concessions obtained from other countries by insisting upon a specific price for each extension of most-favoured-nation treatment had been negligible. The United States had been involved in incessant disputes contesting its interpretation of the principle. Great difficulties had arisen in defining what constituted an equivalent concession. Many countries had penalized U.S. imports. The legalistic attempt to enforce reciprocal concessions for each extension of most-favoured-nation treatment had backfired in discriminatory treatment of U.S. exports. Moreover, the composition of these exports had changed. During World War I it became clear that the United States was changing from an agricultural-exporting to a manufacturing-exporting country, and this weakened its bargaining position to secure equivalent concessions.

Pres. Woodrow Wilson included adoption of the unconditional form of most-favoured-nation treatment in the third of his 14 points offered to Germany as a basis for peace negotiations. The first application of the unconditional principle was in an exchange of notes with Brazil on Oct. 18, 1923. On Nov. 30, 1923, in an address at Philadelphia, Charles Evans Hughes, then secretary of state, stated that "in our commercial relations the United States is seeking unconditional most-favoured-nation treatment in customs matters." Thereafter, all commercial treaties and executive agreements under the Reciprocal Trade Agreements act, 1934, included the unconditional clause. In 1945 the United States published its "Proposals for the Expansion of World Trade and Employment" which were developed at conferences at London, Geneva and Havana into an international trade charter. In all these negotiations, the United States was the leading advocate of unconditional most-favoured-nation treatment. The charter was abortive, but the unconditional principle was included in the 1948 General Agreement on Tariffs and Trade (G.A.T.T.).

Exceptions are recognized in respect of frontier traffic, of fish caught in contiguous waters and of preferential arrangements between metropolitan countries and their colonies. The latter has been interpreted to include the preferential arrangements among the self-governing states of the British Commonwealth, as well as those between the United States and Cuba and the Philippines. Attempts to extend this exception to cover preferential arrangements between neighbouring countries were resisted in the period between World Wars I and II. Groups of European states wished to foster mutual trade but were unwilling to create a customs union by abandoning all tariffs on imports from each other. These attempts to form regional preferential groups failed when other states, including the United States and the United Kingdom, insisted upon their most-favoured-nation rights.

Following the World Economic conference, 1927, the Economic committee of the League of Nations developed (1929–31) an elaborate codification of most-favoured-nation treatment. The economic depression of these and succeeding years nullified this work. No government adopted the code. New devices of trade regulation, notably import quotas, exchange control and state trading, became greater obstacles to trade than tariffs. The League code and successive reciprocal trade agreements negotiated by the United States included clauses intended to apply most-favoured-nation treatment to these new devices, but the discretionary and often arbitrary administration inherent in their nature rendered impossible any specific guarantee of equality of trading opportunity. All that can be written into a treaty is an assurance in general terms that the governments will not discriminate against each other in administering these devices. Various formulas have been experimented with, such as quotas proportioned to imports in a previous period, but none established equality of trading opportunity in the former competitive sense. Quotas, exchange control and state trading were in fact devised to give governments means to control imports more directly and flexibly than by tariffs permitting price competition. Necessarily these devices involve discrimination, which is the antithesis of most-favoured-nation treatment. They often are advocated on this ground by nationalists and protectionists. Whenever international price discrepancies are exaggerated, as they were after 1931, by currency depreciations, the differences between the productivity and therefore the living levels of trading countries are emphasized. Then protectiqnist attacks are directed against most-favoured-nation treatment on the ground that it is a freer-trading device advantageous to the economically strongest country. Discrimination is defended as essential to the welfare of less competitive economies, and methods of trade regulation are adopted which circumvent the pledge of equality of trading opportunity.

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MOSUL (AL MAWSIL), a liwa (province) and the most northerly of the administrative units of Iraq. Area 20,118 sq.mi.; pop. (1957) 717,500. Formed after 1924 from the old vilayet of Mosul which also included the *liwas* of Irbil, Kirkuk and Sulaymaniyah, the liwa consists essentially of a section of the main valley of the Tigris river, which is defined to the east by a series of low ridges, the chief being the Jabal Qarah Chawq and Jabal Batiwa; west by an irregular upland forming part of Al Jazirah (see IRAQ, *Physical Features*). The southern boundary is arbitrarily taken at 35° N. lat. Mosul liwa thus has three distinct types of terrain: from west to east Al Jazirah culminates in the north at the Jabal Sinjar (about 3,000 ft.), and slopes down from an average altitude of 1,200–1,500 ft. in the north to 700 ft. in the south, where there are numerous shallow basins mostly filled by salt pans (sabkhat) that become marshy in spring; the riverine zone itself is narrow with the Tigris sometimes deeply incised into a narrow channel and sometimes flowing in more open, flatter country; eastward the land rises to form a series of northwest- southeast-aligned ridges which are the first outliers of the Zagros mountain system, and there the liwa boundary follows the watershed between the main Tigris valley and the Irbil lowlands.

There are no large settlements other than the city of Mosul, and economic life centres on trade and communication with the neighbouring regions, together with the exploitation of oil. In 1939 deposits were discovered at 'Ayn Zalah to the north of the city (though production did not begin until 1952), with a second centre at Butmah, each having four wells and together ranking as the third field in order of production within Iraq. Oil also exists in quantity at Qayyarah on the Tigris but high gravity and sulfur content have so far inhibited exploitation. A little cultivation occurs near the Tigris, but large numbers of the population are still nomadic herders, chiefly of sheep, goats and some cattle. Many of these people are of Kurdish origin, and there is extensive seasonal movement either over the Jazirah or to and from the hill country of the north and east. The liwa of Mosul is in a special way an intermediary for contact with adjacent lands and has more distinctiveness and individuality than many other areas of Iraq. (W. B. FR.)

History.—The area witnessed the birth of the Assyrian empire (see BABYLONIA AND ASSYRIA) and within Mosul liwa are the archaeological sites of the ancient capitals Ashur, Kineveh and Nimrud (*qq.v.*). The later history of the liwa is inseparably bound up with that of Mosul city. Refounded by the Muslims under the Omayyad caliphate on a site opposite Nineveh, long occupied by a Sasanian. and almost certainly by a far earlier, town, Mosul became, in and after the 8th century A.D., a spacious, rich, walled and fortified city with excellent markets, mosques, hostelries, baths, Christian convents and spreading gardens. It was an important Kurdish and Arab tribal centre and became under the Abbasids the capital of Al Jazirah province and the greatest city of northern Mesopotamia. This status generally persisted throughout Abbasid times (*i.e.*, until 1258), including those periods when the city and district fell under the temporal power of independent dynasties (uhich acknowledged, however, the spiritual overlord-

ship of the caliph of the time). These dynasties, which were far from contemptible in their wealth, power and high Islamic civilization, arose almost continuously from the mid-10th century onward to dominate Al Jazirah province and often much wider areas. Some were of Kurdish or Arab tribal origin (*e.g.*, the Hamdanids of Mosul and Aleppo, and the Ugailids of Mosul); some were from Persia (*e.g.*, the Buyids); others (in the 11th and 12th centuries) were established by the formidable incoming Seljuk Turks, or (in the 12th and 13th centuries) by their captains and successors, the atabegs. Some of the latter dynasties (the Zangids of Mosul, the Ortukids of Diyarbakir, the Begtiginids of Irbil-Mosul) occupied for years the seats of power in northern Mesopotamia. Particularly powerful was the atabeg Zangi, founder of the Zangid dynasty, whose influence extended far beyond the boundaries of the Mosul area (see CRUSADES). The famous Saladin (*q.v.*) was himself a native of the immediate vicinity of Mosul. Throughout this long and politically confused period, with changing temporal but an abiding religious overlord, Mosul with its thickly populated plain and its foothill and mountain dependencies passed through a protracted period of prosperity and relative internal stability.

This ended, there as throughout Mesopotamia, with the horrors of the Mongol conquest (1258) under Hulagu, the wholesale desolation of city and countryside alike and the feeble distracted rule of the subsequent short-lived Mongol, half-Persian and Turkmen states which succeeded to power, or at least to pretensions of power, in Al Jazirah (*see* MESOPOTAMIA). By the time of the brief occupation (1508) of Mesopotamia by the Persian Safawid conqueror Ismail I and its subsequent occupation by the Ottoman Turks (1534–1918), Mosul had fallen to a sad level of shabby and defenseless poverty from which nothing, until the 20th century, could rescue it. Under Turkish rule the city served as headquarters of an *il,* covering wide Kurdish as well as Arab districts; it was long (1726–1834) the seat of a line of Jalili pashas from a prominent local family. It was besieged by Nadir Shah of Persia (1743) and knew plague, flooding, drought, locust visitations and fierce civil and interfamily strife. Relations with the Kurdish chiefs were always close, and French influence among the local Christians, based on Syria, grew notably in the 19th century.

Under the British occupation (1918–20) and mandate, and during and after the period of the independent kingdom of Iraq, Mosul remained a provincial capital and the leading northern city. Its inclusion in Iraq, disputed by the Turkish republic during 1923–25, was, after a long diplomatic struggle and the visit of a League of Nations mission to Iraq, confirmed in 1926. Since then the city and surrounding area, with its rich oil wells, has been greatly developed and modernized.

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MOSUL (AL MAWSIL), the third city of Iraq and the administrative headquarters of the *liwa* (province) of the same name, lies on the right bank of the Tigris river, opposite the ruins of Nineveh, 225 mi. N. of Baghdad. In later Ottoman times Mosul was the headquarters of the Mosul region, which comprised the present *liwas* of Mosul, Irbil, Kirkuk and Sulaymaniyah. Pop. (1957) 179,646.

The population, comprising several communities, is composed mostly of Arabs with some Kurds and Turkomans. The majority are Sunni Moslems, but Mosul is also the seat of the Uniate Chaldean patriarch of Babylon, the church to which most of the 30,000 Christians of the city belong. The Monophysite (Jacobite) and the Uniate Syrian Catholic churches are represented by bishops. Smaller communities include Armenians (Orthodox and Catholic), Old Chaldeans (Nestorians) and Protestants.

The ancient walled city is about one square mile in area. The characteristic material used in the better class of construction is a gray alabastrine marble which lends itself to decorative carving. Many of the older Moslem buildings, both religious and secular, are associated with the Zangid atabegs of Mosul (A.D. 1127–1233) and with Badr ad-Din Lu'lu' who ruled, first as regent and then independently, from 1218 to 1259. Deserving of special mention are the Great mosque with its leaning minaret; the Red mosque or shrine of Khidhr on the site of an earlier mosque near the river; the mosques of Nabi Jarjis and, on the left bank of the Tigris, Nabi Yunus (Prophet Jonah); the shrines of the imams Yahya and Aun ad-Din; and the ruins of Badr ad-Din's palace, the Qara Saray. The mosque of Nabi Shith (Prophet Seth), a modern building, is remarkable for its cluster of fluted spires. The principal Christian churches also date in parts from the Zangid period; those of Mar Shimun as-Safa and Mar Gorgis (Chaldean), Mar Toma (Jacobite) and At-Tahira (Syrian Catholic) are of especial interest.

Several thoroughfares cut through the old city, and of these Nineveh street, running approximately from west to east, and Faruk and Nabi Jarjis streets, from south to north, are the most important. Suburban extensions since World War II include a municipal housing estate. Notable among modern buildings are the royal hospital, the educational centre (comprising the technical, agricultural and teachers' training colleges) and the museum which houses a small but important collection of objects from Nimrud and Hatra (al Hadr).

Mosul owed its ancient importance to its location on the main caravan route from Aleppo to Persia, in the middle of a fertile plain where numerous secondary roads converge, and on a river suitable for cheap raft traffic downstream. Developments in the 20th century seem likely to restore its position as a great commercial centre. The oil field of Ayn Zalah lies 60 mi. to the north. Most of the converging roads have been metaled (hard surfaced) for motor traffic. The last link of the railway connecting Baghdad with Mosul and the Syrian and Turkish systems was completed in 1940. The old bridge of boats was replaced in 1933 by a girder bridge, and the King Faisal II bridge of five spans (1,130 ft. in length), with dual carriageway and footpaths, was completed in 1958. There is an airport from which service is maintained with Baghdad.

The principal traditional exports are cereals, livestock, wool, hides and textiles. The old established light industries have been supplemented by a modern cotton-textile factory of 25,000 spindles and 640 looms, a sugar factory and, nearby, a cement plant and a bitumen refinery, all inaugurated in 1957 and 1958 by the governmental development board. The main imports are machinery of all kinds, building materials and the usual consumer goods.

See H. C. Luke, *Mosul and Its Minorities* (1925); *Annual Reports on the Operations of the Iraq Development Board.* (C. J. E.)

MOSZKOWSKI, MORITZ (1854–1925), German pianist and composer known for his Spanish dances, was born at Breslau, Aug. 23, 1854, of a Polish father. He studied the piano at Dresden and Berlin, where he gave his first concert in 1873. His two books of *Spanische Tänze,* opus 12, published in 1876 for piano duet and later in many different arrangements, were long popular as an example of national music in a light style. Other attempts with national idioms were less successful. His opera, *Boabdil* (1892), was known chiefly for its ballet. He also wrote concertos and chamber music. He lived in Paris from 1897 and died there, March 4, 1925.

MOTACILLIDAE, a family of perching birds comprising two subfamilies, the wagtails (Motacillinae) and pipits (Anthinal). *See* WAGTAIL; PIPIT.

MOTET, a musical art form of paramount importance in the 16th century. The word is of doubtful etymology and probably has more than one origin. Thus *motulus* suggests modulus or melody, and probably connects with *motetus* or motellus, which designates one of the middle parts in early vocal compositions. On the other hand, the Italian word mottetto (diminutive of motto) suggests the French mot (in the sense of bon mot) and is associated with a profane art form contemporary with the conductus and rondel of the 13th and 14th centuries.

The only mature art form denoted by the word motet is that of 16th-century pieces of liturgical polyphonic music in one or two (rarely more) continuous movements. The word is, however, used for any single Latin-text composition in continuous form,

not set sectionally verse by verse and not forming a permanent part of the mass. Thus Palestrina's *Stabat mater* is included among his motets; though the text is metrical and rhymed and the style is that of the homophonic litanies.

The title of motet is also loosely used for nonecclesiastical works, such as the dedicatory motet at the beginning of Palestrina's fifth book.

The most important kind of motet is that which is written for a particular holy day. Such motets are sung between the Credo and the Sanctus of the mass. They are often founded on the Gregorian tones of their texts, and the mass is founded on the same themes, thus giving the whole service a musical unity which has never since been approached in any church music even under Bach. When a motet was not founded on Gregorian tones it was still possible for the composer to design a mass on the same themes, and the titles of 16th-century masses, when they do not indicate a secular or diplomatic origin, indicate either the motet or the Gregorian tones on which they are founded. The illustration in the article MASS shows how Victoria uses the themes of a motet in his mass. When such a motet is associated with a mass it is a crime to perform the mass without it.

Sometimes one composer founded a mass on another composer's motet; thus Soriano's fine *Missa Nos autem gloriari* is based upon a motet by Palestrina, and Palestrina's *Missa Quem dicunt homines* is on a motet by Willaert. When a motet was in two movements the second movement always ended with the last clauses of the first, both in text and in music, producing a distinct impression of *da capo* form. In later times the term motet indicates any piece of church music of clearly single design, regardless of language or of place in a liturgy. (D. F. T.)

MOTH, in entomology, any lepidopterous insect in which the antennae or feelers taper to a point or, if clubbed, as in butterflies, the two wings of a side are held together by a bristle or frenulum; the latter device is never found in butterflies. *See* LEPIDOPTERA; ENTOMOLOGY.

MOTHER-OF-PEARL, a substance which lines the interior of many species of molluscs; it is similar in nature to the pearl itself. Its beautiful iridescence and lustre are due to that well-known optical phenomenon, the interference of light. It is extensively used in decoration for inlays, for the handles of knives and for cheap jewelry. See PEARL; LIGHT.

MOTHER'S DAY, a holiday celebrated on the second Sunday in May, in honour of all mothers, was instituted in the United States in 1907. The festival, recognized by the United States congress in 1914, is generally observed in the United States and to some extent elsewhere. (A. McQ.)

MOTHERWELL AND WISHAW, a large burgh of Lanark, Scot. Pop. (1961) 72,799. Area 7.3 sq.mi. It lies near the right bank of the Clyde, 12 mi. S.E. of Glasgow by road, in the centre of a coal-mining area. Motherwell (from a well dedicated to the Virgin) has been the seat of a Roman Catholic bishop since 1947.

The burgh has iron, steel and engineering works and manufactures clothing, confectionery and preserves. Motherwell and U'ishaw were united into one burgh in 1920.

MO TI (MO-TZU) (470?–391 B.C.?) was an important ancient Chinese philosopher and founder of a religion. His name was actually Mo Ti; Mo-tzu was the name that was popularly applied to him in a complimentary manner to mean "Master" or "Teacher" Mo. He is also sometimes referred to as Micius by western writers.

Mo-tzu was born a few years after Confucius' death, and lived as a contemporary of Socrates. By this time, the system of feudalistic hierarchy instituted at the beginning of the Chou dynasty had degenerated into a period of warring states, and the pressing problem confronting all thinkers was how to bring political and social order out of chaos. For approximately two centuries, Confucianism. and Moism were linked as the eminent schools of the day.

Mo-tzu was widely read and well versed in the common literary tradition of the age that has come to be known as the Chinese classics (*q.v.*). It is said that he was at first a follower of Confucianism but later became a renegade because of the burdensome code of rituals and its reticence on matters concerning positive religion. Except for a brief period as holder of a public office,Mo-tzu spent most of his life traveling from one feudal state to another in the hope of meeting a receptive prince to put his teachings in practice and the world in order. Since no such prince was at hand, he had to be contented with maintaining a school and recommending his disciples for administrative positions. He led a very simple life and his teachings even suggested ascetic practices.

Mo-tzu was a teacher who took his own teachings seriously. For example, in the *Mo-tzu*, the work that bears the philosopher's name and contains records of his sayings and doings, there is a chapter on "Condemnation of Offensive War." In the same volume there are also records of his journeying to distant states to prevent the outbreak of a war when he had heard of such a possibility. On one of these journeys, the record tells, he had to walk for ten days and ten nights and tear pieces of cloth from his garments to wrap round his feet. An ancient critic said of Mo-tzu, "Despite all personal hardships, he held fast to his ideas—a man of distinction indeed!"

One outstanding characteristic of Mo-tzu as a thinker is his insistence on methodology. In an age of a "hundred philosophers," it should be easy to see why he insisted that "some standard of judgment must be established." He himself came near to being a pragmatist, and his yardstick may be summarized as the threefold test and the fourfold standard. The threefold test concerning a proposition evaluates its basis, its verifiability and its applicability, while the fourfold standard is applied to the resulting benefits to the country and the people. These are measured in terms of enrichment of the poor, increase of the population, removal of danger and regulation of disorder. To Mo-tzu these tests and standards were indispensable: "To make a proposition without regard for the standard is similar to determining the directions of sunrise and sunset on a revolving potter's wheel." Six chapters in the *Mo-tzu* deal with such logical problems as definition, inference, etc., and they must have been the work of his disciples if not of Mo-tzu himself.

Universal love is the cornerstone of Mo-tzu's system. The world was in chaos, and, in the Moist analysis, this was due to selfishness and partiality. As to the cure, "Partiality should be replaced by universality." When everyone regards the states and cities of others as he regards his own, no one will attack the others' state or seize the others' cities. The same is true concerning the welfare of the family and the individual. The peace of the world and the happiness of man lie in the practice of universal love. Many objections were raised against this new doctrine—its impracticability, its neglect of the special claims of one's parents, etc—but Mo-tzu demonstrated that the principle of universal love had in it both utilitarian justification and divine sanction. He spoke of "universal love and mutual profit" without embarrassment or apology, and he was convinced that the principle was both the way of man and the way of God.

Mo-tzu's stand on religion makes him exceptional among Chinese philosophers. He might be said to be a revivalist, a champion of the anthropomorphic orthodoxy. To Mo-tzu there is Heaven, Heaven has a will, and this will of Heaven is to be obeyed by man and accepted as the unifying standard of human thought and action: "What is the will of Heaven that is to be obeyed? It is to love all the people in the world universally." Heaven not only "desires righteousness and abominates unrighteousness," but also metes out reward and punishment accordingly. To Mo-tzu it is a fact beyond doubt that Heaven loves all the people, teaches them all, claims all, just as it accepts sacrifices from all.

The system of Mo-tzu, with its gospel of universal love and the ascetic discipline as exemplified by his own life, soon after the master's death became embodied in an organized church with a succession of elder masters and a considerable body of devotees. At one time, it was said, as many as 170 followers were ready to die at the command of the master, but this religion was short-lived and is no more. In fact, Mo-tzu and Moism have been all

but completely eclipsed by the more popular doctrines of Confucianism and Taoism (*qq.v.*) in China for the last 2,000 years. One ancient writer made the observation, "Mo-tzu was blinded by utility and did not know refinement." It was not until the 20th century that Mo-tzu was rediscovered and his worth reappraised. *See* also CHINESE PHILOSOPHY.

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(Y. P. M.)

MOTION, an application to a court for a rule or order. Motions may be made either on notice or *ex parte,* and either orally or in writing. They may be based on facts of record in the action or as established by supplemental affidavits or oral testimony. *See* PRACTICE AND PROCEDURE. (C. E. CL.)

MOTION, PRINCIPLES AND LAWS OF. Mechanics is that branch of physics dealing with the motion of bodies. This article is concerned primarily with the meaning of motion in physics and the historical evolution of the principles and laws which describe it. Other aspects of the subject are treated in MECHANICS and DYNAMICS.

What is Motion?— It is first necessary to define motion from the standpoint of physics. As human beings we are immersed in a field of sensations—seeing, hearing, touching, tasting and smelling—which are forever changing. It is the function of science to describe these changes; they are of varying degrees of complexity. It has however been recognized for a very long time that certain changes can be compensated for much more readily than others by relatively simple adjustments in the body of the percipient. In the case of a motor car traveling down the street it is an easy matter to cancel the effect of its passage before one's eyes and to keep it in one's field of vision. Contrast this to the much more complicated case of the chemical reaction in a test tube in which an originally clear liquid suddenly becomes coloured; to bring back the original sensation requires a more or less elaborate series of laboratory operations. It is not surprising that the first type of change has made a vivid impression on the human mind and has engaged the attention of thoughtful people from the very earliest times. We call this motion.

So great indeed has been the preoccupation of physical scientists with motion as the most obvious and simplest of all changes in the flux of sensation that even in the case of phenomena in which no motion is directly observed a tendency has grown to interpret what goes on in terms of the motion of unobserved particles, *e.g.,* the molecules of the kinetic theory of gases. This explains the paramount place which mechanics holds in all physical science. For practical purposes motion may be defined as change of position of a particle or body with respect to some suitably chosen reference system, *e.g.,* the earth or the stars.

Ancient Views on Motion.— The views of the ancient Mediterranean peoples about motion were largely enshrined in the *Physica* of Aristotle (384–322 B.C.), a work which dominated western European physical science during the later middle ages and indeed until the 16th century. Aristotle contented himself with the common sense classification of all observed motions into natural motions and violent motions. Natural motions are those which take place without the obvious intervention of human beings, such as the circular motions of the incorruptible heavenly bodies and the rectilinear motions of freely falling or rising bodies on the surface of the earth. According to Aristotle the natural motion of the heavenly bodies is circular because this is the most perfect form of motion. The natural motion of a terrestrial object is rectilinear since this is the best way for it to reach its proper place or position of equilibrium. Heavy bodies (*e.g.,* solids and liquids) fall because they desire to get as close as possible to their proper position at the centre of the earth; light bodies (*e.g.,* flames and gases) rise since their proper sphere is above the earth.

In Aristotelian mechanics, motion produced by human agency is called violent motion; an example is the throwing of a ball. This motion may be neither entirely rectilinear nor entirely circular, but in any case must always be some combination of the two. This conclusion was of course wrong, since it was discovered later that the motion of a projectile on the surface of the earth, neglecting the effect of wind and air resistance, is parabolic.

Acting on the basis of his common sense classification, Aristotle was led to enumerate his "law" of motion: that in any motion, whether violent or natural, the velocity attained is the ratio of the applied force to the resistance which the medium offers to the motion. At first thought this seems sensible enough, and yet this law caused even Aristotle some moments of puzzlement; he was forced to conclude from it that there is no such thing as a vacuum since in a vacuum there would be no resistance to motion and hence even for the smallest force the velocity attained would become infinitely great, a thing never observed. Even more difficult to understand from Aristotle's law is the fact that a body set in violent motion by the hand, for example, continues to move when the hand no longer is in contact with it and is therefore exerting no further force on it. To meet this difficulty Aristotle was forced to assume that the air or other medium through which the motion takes place continues somehow to push on the object as well as to resist it. Finally Aristotle was led to the conclusion that in the same medium, heavy bodies fall faster than light ones, which common sense observation confirms in the case of a heavy stone and a feather but not at all in the case of two stones of the same size and shape but with different weights.

Galileo.—The modern theory of motion was largely the creation of the Italian scientist Galileo Galilei (1564–1642). Dissatisfied with the views of Aristotle, which in spite of their apparent commonsense approach were not successful in predicting accurately the results of even simple experiments, Galileo decided to examine with meticulous care the special case of freely falling bodies to see whether he could make an assumption about their fall which would lead by direct mathematical reasoning to a result he could verify by experimentation. He was finally able to do this and in so doing he not only provided the foundation for the science of mechanics which has endured since his time but also established the fundamental method for the description of experience which characterizes the whole of modern physics. Specifically, Galileo showed that by assuming that the acceleration (or rate of change of velocity) in free fall is constant he could deduce that the distance traveled by a body falling from rest is proportional to the square of the elapsed time. He verified this latter conclusion with sufficient accuracy by experiments on the motion of bodies rolling down inclined planes. It is appropriate to emphasize that this mathematical deduction of Galileo's was a genuine law of motion in the sense that it provided a precise and quantitative description of how freely falling bodies on the surface of the earth really move. As a description of a regularity or routine of physical experience it meets the test of what later came to be called a law of nature.

Galileo also introduced a radical change in Aristotle's views on violent motion. He developed a strong feeling that horizontal motion on the earth's surface (neglecting friction), unlike vertical motion, is not affected by the earth; hence, motion in this direction with any particular velocity should persist unchanged. He verified this ingeniously by performing experiments in which a ball was allowed, starting from rest, to roll down one inclined plane and on reaching the bottom was immediately permitted to roll up another. He showed that in every case, independently of the length of the horizontal projection of the second plane, the ball rose to practically the same height as that from which it originally started; hence, the horizontal velocity was retained unchanged in each case no matter how great the horizontal distance. Galileo therefore concluded that the velocity of a moving body not under the influence of a net, unbalanced force (*e.g.,* gravity) will not change. This was the discovery of the law of inertia, the real foundation of the modern theory of motion. Implicit in this is the idea of force as something which can change motion, *e.g.,* from rest into motion or from motion into rest.

Newton and the Principles of Motion.— The century following Galileo's death in 1642 saw the firm establishment of the principles of motion along the lines initiated by him. This was the work of several great minds, but the most definite system-

atization was performed by Sir Isaac Newton (1642–1727) whose *Philosophiae* Naturalis *Principia Mathematica* was published in 1687. Newton's famous three laws of motion (see MECHANICS) stated that: (1) every particle continues in a state of rest or motion with constant speed in a straight line unless compelled by a force to change that state; (2) the net unbalanced force producing a change of motion is equal to the product of the mass and the acceleration of the particle; (3) all forces arise from the mutual interaction of particles and in every such interaction the force exerted on the one particle by the second is equal and opposite to the force exerted by the second on the first, or as it is usually expressed: action and reaction are equal and opposite.

These "laws" are essentially hypotheses or principles of motion and not expressions of routines of experience like Galileo's law of falling bodies. All special cases of motion, however, are derivable from them, provided only that one makes a fortunate guess as to the nature of the relevant force. The first law is obviously Galileo's principle of inertia and the second law was also effectively applied by Galileo. The third law was Newton's own particular contribution to the theory of motion. It appears fairly reasonable in the case of two bodies in collision, like billiard balls, or two bodies joined by a spring. However, it required more imagination to apply it to two bodies separated by a relatively great distance like the earth and the moon between which there is no material connection. Here Newton saw the necessity of introducing some force of interaction and postulated his celebrated law of gravitation (*q.v.*), namely, that any two particles of matter in the universe attract each other with a force varying directly as the product of their masses and inversely as the square of the distance between them. By introducing this law of force into the second law of motion, and assuming that this was the proper equation of motion for the planets of the solar system, Newton was able to derive theoretically the laws which Kepler (1571–1630) had discovered about 1600 by direct observation of the heavenly bodies. According to these laws each planet moves in an elliptical orbit with the sun at one focus; moreover, in its path it sweeps out equal areas in the plane of its motion in equal times. Finally the square of the time for each revolution around the sun (one year in the case of the earth) is proportional to the cube of the major axis of the orbit, *i.e.*, the distance between the point of closest approach to the sun (perihelion) and the farthest point from the sun (aphelion). Newton verified his theory for the case of the motion of the moon.

Mathematical astronomers of the 18th century and after showed that his law of gravitation, taking into due account the perturbing influence of the attraction of the planets for each other as well as their attraction by the sun, accounts very accurately for the observed motions with one possible exception—the motion of the planet Mercury. This discrepancy was accounted for during the 20th century by Einstein's theory of general relativity.

The Newtonian formulation of the principles of motion was marred by certain logical difficulties. Newton was never able to give an adequate definition of mass, though it entered vitally into his idea that motion is always connected with the interaction of bodies. He was aware that it was intimately connected with inertia, but made little use of this in his applications of the laws of motion, being content to use weight (the force with which the earth attracts an object) as proportional to mass. Another difficulty Newton encountered was the fact that motion has no meaning except in relation to some chosen reference system. For rough practical purposes we do not worry about this, since we use the earth as a reference frame, but since the earth also moves (relative to the sun, which may itself move away among the stars) the problem arises as to whether there is any such thing as absolute motion.

Newton felt constrained to introduce an absolute space with respect to which all motion would be absolute. He also felt the necessity of introducing an absolute time, but this actually played a small part in his theory of motion, since in all derived equations the quantity representing time had to be replaced by numbers taken from clocks which were calibrated in terms of the earth's rotation on its axis or its revolution around the sun. Newton recognized that his laws of motion would keep precisely the same form for all frames of reference moving at constant velocity relative to each other, provided the forces employed were functions of the mutual separation of the bodies involved, as is true of course, for the force of gravitation. Frames of reference of this character are usually called Galilean or inertial frames. An important result of the form of Newton's laws is that by no mechanical experiment can one detect absolute motion of a Galilean frame. For example, when we play ball on the deck of a ship moving at constant velocity with respect to the shore, the motions of the ball and all aspects of the game proceed precisely as if the game were being played on shore. As far as any mechanical (*i.e.*, motional) effects are concerned it is just as correct to say that the ship is standing still and the shore is moving as it is to say the ship is moving and the shore is standing still. This result of the form of Newton's laws is usually called the Newtonian theory of relativity. It is interesting to note in this connection that the earth as a rotating body does not constitute a Galilean or inertial frame of reference. As a result when a particle moves on the earth's surface it is subject not merely to the ordinary acceleration of gravity but also to the well-known centripetal acceleration associated with motion in a circle, as well as the so-called Coriolis acceleration. For a freely falling particle the latter is an acceleration directed perpendicular to the meridian plane in which it starts to fall. It is always directed toward the east and is equal in magnitude to twice the product of the velocity of fall, the rotational velocity of the earth and the sine of the latitude. As a result of this acceleration, any freely falling body always lands a short distance east of the plumb line from the point from which the body was dropped. At latitude 45° N., for example, the deflection is about 0.1 ft. for a drop from a height of 500 ft. The Coriolis acceleration is responsible for the production of cyclonic wind movements on the earth's surface, since because of it, a wind starting in any direction is always deflected toward the right in the northern hemisphere and toward the left in the southern hemisphere.

The logical difficulty concerning mass inherent in the Newtonian theory was removed in the late 19th century by the Austrian physicist and philosopher Ernst Mach (1838–1916) and his contemporaries. Mach showed that one can readily define the ratio of the masses of any two interacting particles as the negative inverse ratio of their accelerations with respect to the same inertial frame. This makes it possible to choose a standard particle, label it as our unit of mass and determine (ideally, at any rate) the mass of every other particle in the universe by allowing it to interact with the standard mass. This permits a logical verification of the use of the balance as the practical method of comparing masses on the earth's surface. It also provides an easy way of grasping the significance of the readily deduced principle of the conservation of momentum which says that when any set of particles are interacting with each other the sum of all products of mass and velocity for each particle remains constant, even though the individual velocities may change with time. The illustration of a gun's recoil after discharge immediately comes to mind: the mass of the gun multiplied by the recoil speed equals the mass of the bullet multiplied by its speed. This principle is the basis of all jet propulsion and the launching of rockets and artificial satellites.

Relativity.—We have already commented on the inability of the Newtonian principles of motion to detect the absolute motion of an inertial system. In the late 19th century it was believed that this might be done by optical means, *i.e.*, by flashing light signals from one moving object to another. If light is a wave propagation in a medium and this medium (sometimes called the luminiferous ether) can act as a reference frame for light as the air does for sound, the detection of motion with respect to it (a kind of absolute motion) should be possible. All attempts in this direction failed however; finally, A. Einstein (1879–1955), H. Poincaré (1854–1912), H. A. Lorentz (1853–1928) and others set up in the early 1900s a more drastic theory of relativity than that of Newton; namely, that no physical effect whatever is competent to detect the absolute motion of an inertial frame. This theory

has had widespread consequences in the 20th century; one of its consequences is that the scale of time measurement must differ from one inertial system to another in contradiction to the Newtonian idea of absolute time. Moreover the mass of a particle is no longer constant but increases with its velocity to a degree which, while unnoticeable at the speeds of ordinary terrestrial objects, can become very perceptible with such atomic particles as electrons and protons. These effects of the theory of relativity must be taken into account in modern devices such as cyclotrons and betatrons (see ACCELERATORS, PARTICLE) for the production of very high-speed particles possessing energy sufficient to produce changes in the nuclei of atoms.

In 1915 Einstein extended the theory of relativity to derive a new theory of gravitation, essentially by treating gravitation as a kind of geometrical property of space and time (more strictly space-time structure). This theory was successful in removing the difficulty in accounting for the motion of the planet Mercury encountered by the Newtonian theory. The Einstein theory has been the starting point for elaborate 20th-century theories of cosmology. See COSMOGONY; COSMOLOGY; RELATIVITY; SPACE-TIME.

Quantum Mechanics.— The elementary particles which constitute the atoms of the 20th-century theory of the constitution of matter have motions obeying laws quite different from the classical uses of Newton. In fact, their behaviour inside the atom—if it can be described at all in terms of what we think of as motion in the large-scale world, a possibility which is becoming increasingly more doubtful—would appear to be more akin to wave motion in a continuous medium than to the motion of particles. This point of view was introduced by L. De Broglie (1892–) and E. Schrodinger (1887–1961) in the middle 1920s and was materially extended by W. Heisenberg (1901–), P. Dirac (1902–) and others. The original foundation was laid by N. Bohr (1885–) in 1913. The theory is now known as quantum mechanics since it employs the fundamental idea introduced in 1900 by M. Planck (1858–1947) of the essentially discrete character of all atomic processes, even radiation. See ATOM; QUANTUM MECHANICS.

Motion of Continuous Media and Wave Motion.—The foregoing discussion of the principles of motion has referred primarily to the motion of particles. Physics also is concerned with the motions of continuous media, *e.g.,* the flow of liquids and gases, as well as wave propagation in fluids and solids. It is important to note that the same fundamental principles of motion apply to these cases. See HYDROMECHANICS; AERODYNAMICS; WAVE MOTION; SOUND.

See also Index references under "Motion, Principles and Laws of" in the Index volume.

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MOTION PICTURES. The present article is divided into ten main sections, as follows:

I. History
II. Production Methods
III. Motion-Picture Direction
IV. The Screenplay
V. Motion-Picture Sets
VI. Motion-Picture Technology
VII. Exhibition and Distribution
VIII. Art of the Motion Picture
IX. Animated Cartoons
X. Educational Films

The motion picture is a modern machine tool in the service of expression. The endeavours to transmit emotional stimuli and experience hy recreating events have resulted in language, oral and written, the plastic and graphic arts, the stage, music and, eventually, the screen. Hitherto, motion had been consciously contrived for and successfully suggested in the fine arts; *e.g.,* the cavalcade in the frieze of the Parthenon. The motion-picture camera brings action into graphic art.

I. HISTORY

The motion picture first emerged from the laboratories of abstract science in 1894 as the Edison peep-show device known as the kinetoscope. By 1925 the motion picture seemed ready to begin clarification and refinements of its technique. Hardly had this apparent position been reached when the electrical and radio laboratories brought forth an array of improved photoelectric cells and methods of electrical amplifications which by 1928 resulted in the spectacular and revolutionary intrusion of the sound or "talking" picture. Contrary to popular belief, this development of the talking picture in 1927–28 was the first true junction of the motion picture with electrical science. The silent motion picture, being mechanical, optical and chemical, was in no way an electrical invention, nor, in any strict sense, dependent upon the service of electricity. The talking or sound picture is, however, electrical in that it is a device for the conversion of sound vibrations into electrical light variations photographically recorded, to be in turn electrically reconverted into sound.

After the introduction of sound, the next major development in motion pictures came from the mushroomlike increase in home television after World War II. In the beginning television made liberal use of old motion pictures for some programs and later presented some new programs on film. By the early 1950s television had made sufficient inroads on motion-picture audiences to stimulate the motion-picture industry to seek new means of capturing some of its lost audience. Various methods of photography and projection known as large or wide screen became popular. (See *Motion-Picture Technology* following.) In the United States the industry turned its facilities increasingly to the production of films for use on television.

The scientific study of the optical appearances of objects in motion had begun with the investigations of Peter Mark Roget in England, resulting in a paper presented by him, under the title of "The Persistence of Vision With Regard to Moving Objects," before the Royal society in 1824. Roget's paper inspired several scientists' to engage in various experimental investigations, among them Sir John Herschel and Michael Faraday. In Europe, Joseph Antoine Plateau of the University of Ghent and Simon Ritter von Stampfer in Vienna simultaneously discovered a method for viewing a series of pictures, representing phases of motion. The pictures were mounted in chronological sequence on the rim of a disk and were observed through slots in a similar disk mounted on the same rotating shaft. The pictures, antedating photography, were necessarily drawings of assumed phases of motion. Baron Franz von Uchatius, an Austrian artillery officer, in 1853 combined the disk device with the magic lantern and projected the pictures upon the screen. The capacity of the machine was obviously limited to a short cycle of movement. The Plateau-Stampfer labours gave rise subsequently to the invention of the zoetrope, or "wheel of life." which continues to be a familiar toy.

Photography.— As early as Leonardo da Vinci's experiments, photography (*q.v.*) had been in slow evolution. In 1860 Coleman Sellers, a mechanical engineer, in Philadelphia, made the first known endeavour to relate photography to the principle of the zoetrope. He posed his sons in a series of photographs showing them, in successive phases of a cycle of action, driving a nail into a box. The photographs were mounted on the blades of a paddle wheel, which nhen revolved from a given point of view produced a zoetropic effect. This machine was patented as the kinematoscope in the U.S. (Feb. 5, 1861). Photography then required exposures so long that a true record of motion was not possible. A complete anticipation of the motion picture was embodied in a patent application by Louis Arthur Ducos du Hauron, in France,

filed April 25, 1864. The Sellers method of photographing posed phases of motion was applied to a projecting zoetropic device by Henry Renno Heyl, an engineer and inventor, in Philadelphia, exhibited on Feb. 5, 1870. This was in effect the application of photography to the invention of Baron Cchatius. The Heyl device was christened the phasmatrope. It carried photographs of six poses of a waltzing couple, repeated three times, giving a capacity of 18 pictures. It is of interest to note that the wheel on which the pictures, glass plate transparencies, were mounted was actuated by a ratchet and pawl mechanism giving each image a period of rest on the screen, a method and principle which had to be rediscovered a quarter of a century later.

Two years later, in 1872. and without any intended relation to motion-picture development, Leland Stanford, a California railway magnate and sportsman. wished to investigate the gaits of the horse. Stanford assigned the photographic problem to John D. Isaacs, an engineer on the staff of the Central Pacific railway. Isaacs contrived a battery of cameras with electrical shutter controls. The shutter mechanisms were improved and the speed of photographic materials was increased, permitting at last the first real photographic records of objects in rapid motion. Exposures as brief as $\frac{1}{2,000}$ of a second were made. Eadweard Muybridge operated the Isaacs apparatus installed at Palo Alto on Stanford's stock farm. The pictures made were records in analysis of motion. Synthesis was still to come. (A description of these experiments was published in Stillman's *The Horse in Motion as Shown by Instantaneous Photography,* London, 1882.)

While visiting in Paris, Stanford displayed some of these pictures and word of them reached Jean Louis Meissonier, the painter, who was then in a heated controversy with French academicians over the postures of horses in his pictures. Meissonier sought Stanford and found vindication in the photographs from California. The artist prevailed on Stanford to send Muybridge to France. The differing academicians were confronted with the photographs, and as a final proof Meissonier synthesized the photographic analysis into motion pictures by projecting transparencies on a machine similar to the Heyl phasmatrope.

The method evolved by Isaacs and operated by Muybridge resulted in a changing point of view for the pictures as the action swept past the battery of cameras. The pictures obtained, synthesized on the screen, gave the illusion of the moving object in a single spot while the scenery ran past. Wallace Goold Levison of Brooklyn, N.Y., devised a camera which exposed successive plates in a single camera, obviating this difficulty. It was utilized only for scientific demonstration.

Edison's Inventions. — In 1887 Thomas **A.** Edison of New Jersey attacked the problem. He was aware of Muybridge's product. But Edison's efforts were dominated entirely by the phonograph idea. His first motion-picture machine recorded spirals of tiny pictures on a cylinder, in the pattern of a phonograph groove. The pictures were given an intermittent motion and viewed under a microscope. The results were inadequate and Edison determined upon larger images to be handled on a tape or belt. He built a device for this purpose and experimented with various materials, including films made of collodion varnish coated with photographic emulsion. The material was unsatisfactory. In Aug. 1889 George Eastman of Rochester. N.Y., began the manufacture of photographic film on a nitrocellulose base. a material evolved to meet the mechanical problems of "roller photography" for the Eastman Kodak. Edison heard of this material and purchased a sample strip 50 ft. in length for $2.50 and tried it with success in his picture machine. The demonstration of the Edison kinetoscope at West Orange. N.J., on Oct. 6, 1889, with a strip of Eastman film made the motion picture an accomplished fact.

The Kinetoscope. — The kinetoscope was a peep-show device in which the film ran with a continuous movement between a magnifying lens and a light source. The capacity of the machine was limited to 50 ft., the length of the tables on which the film was manufactured. which gave a motion record of 48 exposures a second, and lasted about 13 seconds. The size of the film, the image and the arrangement of the sprocket holes by which the film was driven in that first machine continue as the standard of the motion picture of today. The machine was patented by Edison in 1891 in the United States only. It stood idle in his laboratory until it came to the attention of Thomas R. Lombard of Cornelia. Ga., a promoter of the phonograph, who sought it as a novelty for display at the Columbian exhibition in Chicago. The machines, despite statements to the contrary, were not ready in time and made their first public appearance at a kinetoscope parlour at 1155 Broadway in New York city, April 14, 1894. Thus began the commercial history of the motion picture.

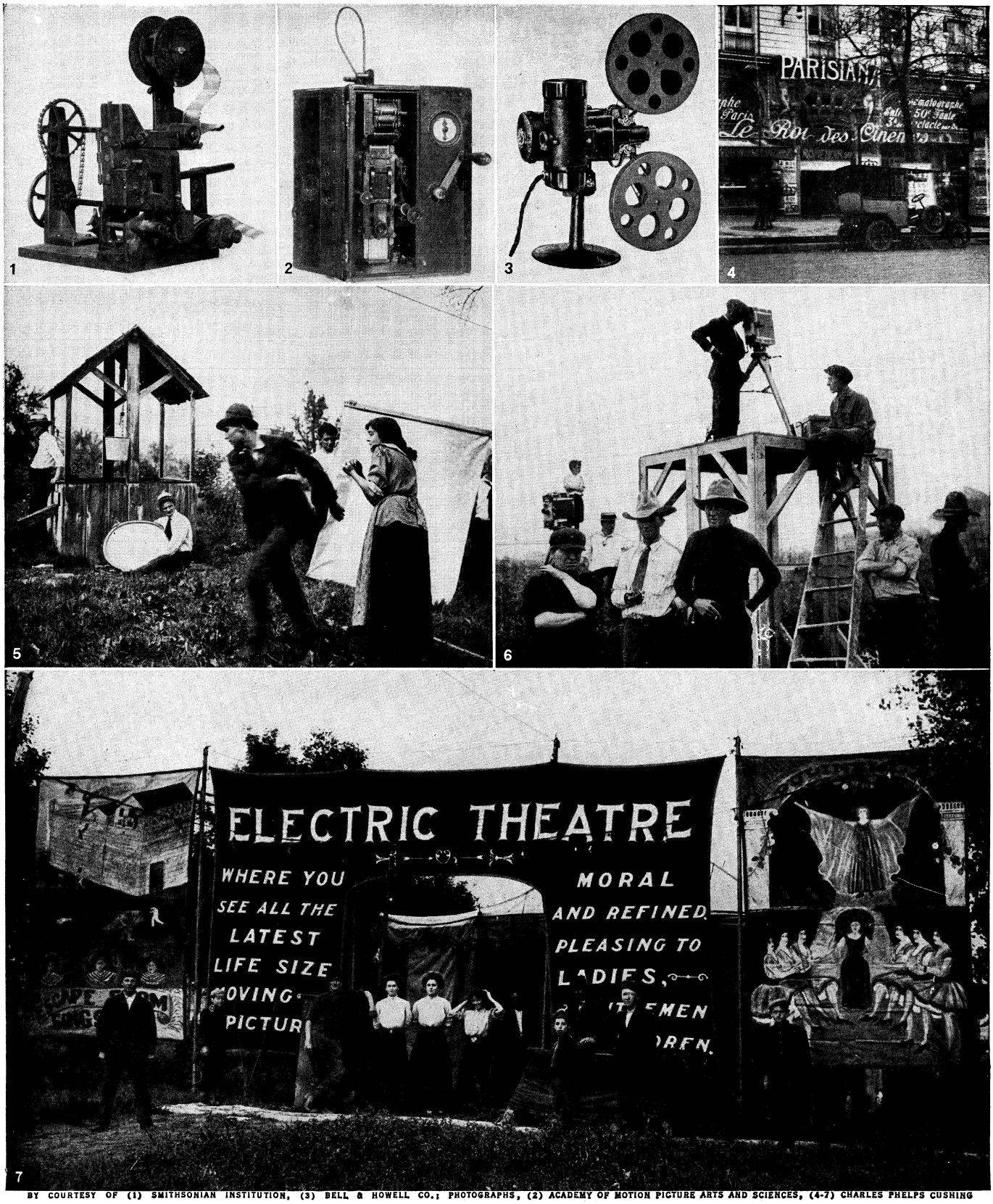
That autumn several machines were exported. From these machines the English and European development of the motion picture sprang. Edison's invention was not protected by patents abroad. The pictures for the kinetoscope were produced at West Orange in a tiny studio costing $637.67. The invention of the motion picture had now cost Edison $24,118.04. The tar paper studio, dubbed the "Black Maria," revolved to keep the stage in sunlight. The kinetograph, or camera, was almost a ton in weight and all events had to be brought to it. The subjects were necessarily those restricted in range of action: bits of vaudeville acts, snatches of prize fights and dances. By the winter of 1894 a demand arose for a machine which should combine the kinetoscope's film record with the magic lantern so the picture might be liberated from the peep-show and shown to a large audience for greater revenue. Edison had experimented in projection but discouraged the idea, stating that exhibitions to large audiences would too rapidly exhaust the novelty of the pictures. Several other experimenters attacked the problem of projection. On Feb. 22, 1895, Maj. Woodville Latham of Virginia, a Confederate officer in the Civil War (father of Otway and Grey Latham, kinetoscope exhibitors), gave a New York press exhibition of his pantoptikon. projecting a kinetoscopic film. On May 20 this machine was placed on public exhibition. It was highly imperfect. **A** second version of this device had a brief international career under the name of the eidoloscope. A more satisfactory machine known as the cinematograph was produced by Louis and Auguste Lumikre, photographic manufacturers at Lyons, Fr. They took out a French patent on Feb. 13, 1895, and demonstrated their machine March 22, 1895, in Paris, and June 10 in Lyons. Dec. 28 a public cinematograph show was opened in the basement of the Café de Paris and prospered.

The Vitascope. — In June 1895 Thomas Armat of Washington discovered the principle of the modern projector, differing from the Lumikre and other earlier devices by use of a film movement which gave each successive image a period of rest and illumination in excess of the period of movement from image to image. This machine uas first shown publicly at the Cotton States exhibition, Atlanta, Ga., Sept. 1895. It displayed Edison kinetoscope pictures. It was subsequently known as the vitascope. In Feb. 1896 Robert W. Paul of London, manufacturer of scientific instruments, gave a demonstration of a projection machine called the theatrograph. He had meanwhile manufactured duplicates of the kinetoscope, and had produced films for these machines with a camera of his oun devising.

The vast, world commercial career of the motion picture on the screen began with the presentation of the Armat machine as the vitascope at Koster and Bial's music hall, New York, April 23, 1896. A vaudeville career opened before the motion picture and the capacity of the machine was quickly increased to 1,000 ft. of film (sufficient to occupy the typical time of a stage turn), thus establishing the existing standard film unit of one reel.

The Lumikre influence on the art soon became important. The cinematograph was adjustable, making it a camera, a film-printing machine and a projector. It was mobile and could record the outdoor uorld. The Lumikres also reduced the rate of exposure from Edison's 48 images a second to 16 a second, the theoretical standard of the silent pictures of today. The Lumikre photographer-exhibitors were sent touring around the world carrying the films to far places and recording remote peoples for the screens of Europe and America.

The development of the art was, however, for some time under two important early handicaps. In Europe the screen suffered from the Charity Bazaar fire in Paris, May 4, 1897, in which 180



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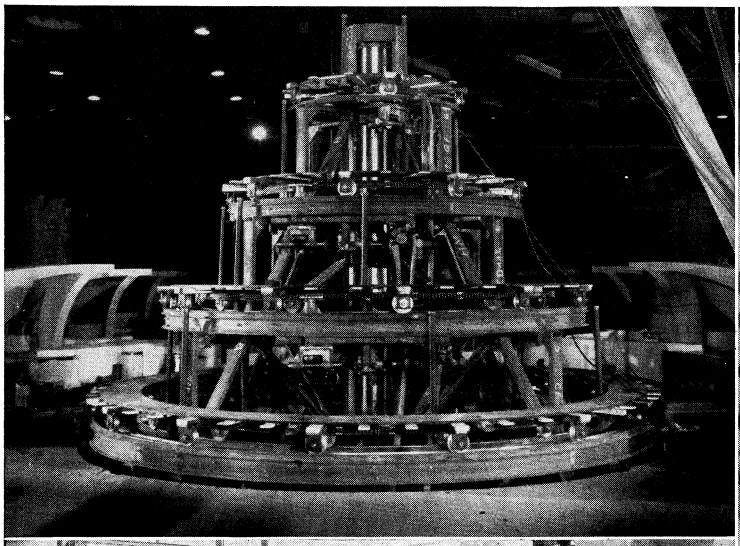
EARLY MOTION PICTURE TECHNIQUES AND THEATRES

1. The first modern projector, known as the vitascope, invented by Thomas Armat in 1895
2. Rear view of a Path6 camera of 1906. it was operated by hand crank (right) and film was fed in from a box (not shown here) with a wire pulley control placed atop the camera
3. One of the first 16-mm. projectors, built in 1923. It ran 400 ft. of film and was designed for a 200-watt lamp and hand rewind
4. "Parisiana, the King of the Cinemas," one of the first de luxe motion picture theatres In Paris, at it looked in 1911
5. Early lighting during filming was aided by means of reflected illumination from mirrors (beside the well) and reflecting sheets (behind the heroine). Thlt was a movie lot of the Fox Film corporation near Teaneok, N.J., 1916
6. Cameramen at work on a 1916 Vitagraph picture about automobile racing, made outdoors in the Sheepshead bay area of Brooklyn, N.Y.
7. A travelling "movie" show in Kansas, 1910. Known as "Black Tops" because the tent interiors were blackened to keep out light, these novelty shows toured small U.S. towns before the large-scale establishment of permanent motion picture theatres

MOTION PICTURES



BY COURTESY OF (TOP LEFT, BOTTOM RIGHT) WARNER BROTHERS PICTURES, INC , (TOP RIGHT) UNIVERSAL PICTURES CO INC , (CENTRE LEFT) CECIL B DE MILLE

DESIGN AND CONSTRUCTION OF SETTINGS

Top left: Frame of a foundation used in a waterfall scene

Top right: Set designer and two assistants at work on part of a stage setting

Centre left: Cecil B. de Mille mounted on boom for filming of moving crowd shot in "Cleopatra" **(1934).** The set represents the Forum at Rome

Bottom left: Settina designed by Wilfred Buckland for Douglas Fairbanks' production of "Robin Hood" **(1922).** The large simple architectural forms on which light is projected make an interestingly designed background. The framing by the arch produces depth and a sense of witnessing the action with the figure in the foreground

Bottom right: Studio art department where scale-model miniatures are made of sets used in a production

BY COURTESY OF (TOP LEFT, BOTTOM LEFT, BOTTOM RIGHT) WARNER BROTHERS PICTURES, INC., (TOP RIGHT) RKO RADIO PICTURES CORP., (CENTRE LEFT) 20TH CENTURY-FOX FILM CORP., (CENTRE RIGHT) UNIVERSAL PICTURES CO., INC.

PREPARATION FOR SHOOTING A SCENE

Top left: Director George Cukor explaining the action of a scene to James Mason prior to rehearsal

Top right: Marie Wilson rehearsing dialogue of a romantic comedy with director Frank Tashlin while a hairdresser readies her hair

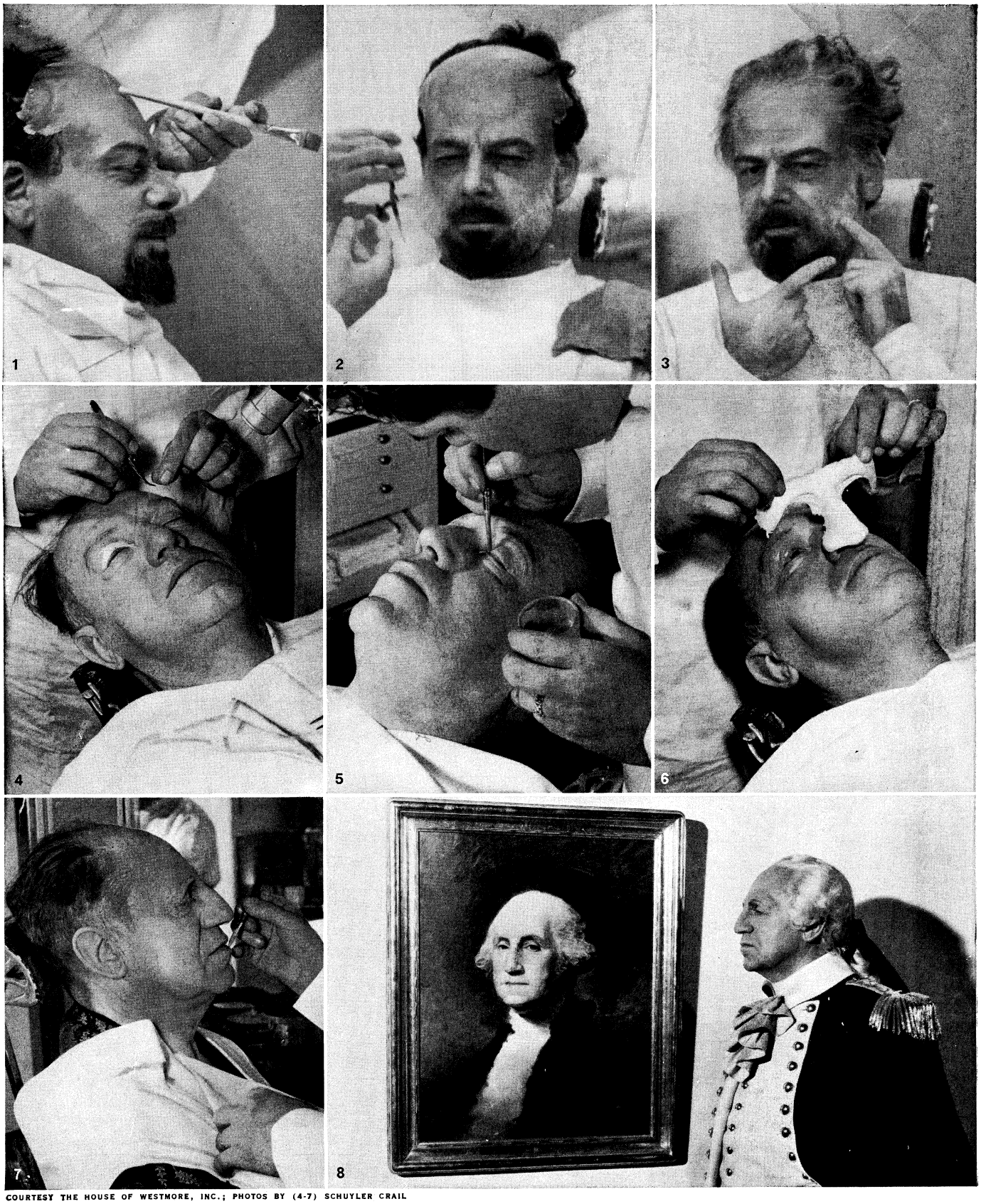
Centre left: Director Robert Webb explaining an underwater sequence being filmed off the Florida coast

Centre right: Camera angle platform for outdoor shooting

Bottom left: A "lightning box" for producing "dirty weather." Given 20 hours' notice, the operator can produce a London foggy drizzle, a hurricane, typhoons, cyclones and waterspouts

Bottom right: Camera setup for exterior filming. Sun reflectors for added light are supplemented by arc lights behind camera dolly which moves on special tracks to follow the action of the scene. Director Jack Donohue is seated high on stepladder (right) while assistant directors, Property men, script girl and other crew members stand by

MOTION PICTURES



COURTESY THE HOUSE OF WESTMORE, INC.; PHOTOS BY (4-7) SCHUYLER CRAIL

ART OF MAKE-UP IN MODERN MOTION PICTURES

1. Paul Muni, U.S. character actor, being made up for the role of Emile Zola in "The Life of Emile Zola." Gluing rubber cap on forehead is the first step. 2. Hair is applied to Muni's cheeks. 3. Hair is blended on cheeks. 4. First stage of making-up Montagu Love to resemble George Washington. Fishskin is applied to Love's eyelids to change the shape of his eyes. 5. Latex and fishskin are sealed together over his eyelids. 6. Latex nose and frontal piece are applied to his nose and forehead. 7. Finishing touches are applied to lips and eyebrows. 8. Make-up completed. Love poses in costume beside a portrait of Washington

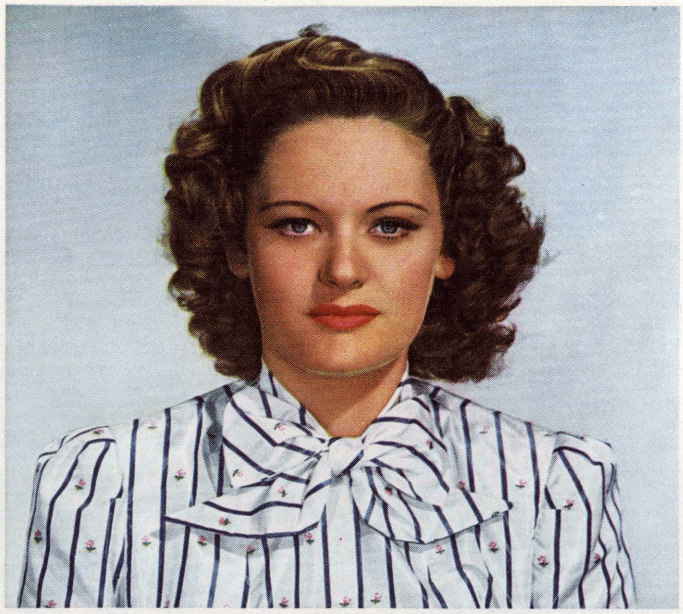
MOTION PICTURES

BY COURTESY OF (1, 2, 3) FREDRIC MARCH, (4, 5, 6) RUTH GORDON, (7, 8) PAT O'BRIEN; PHOTOS BY (2) MACK ELLIOTT, (4) DOROTHY WILDING, (9) INTERNATIONAL NEWS

THREE U.S. ACTORS MADE UP TO RESEMBLE ACTUAL PERSONS

1. Fredric March without make-up. 2. As the youthful Mark Twain in "The Adventures of Mark Twain." 3. March made up to resemble Mark Twain as an old man. The entire face is made of a latex appliance. 4. Ruth Gordon without make-up. 5. As Queen Victoria as a young woman. 6. As Queen Victoria as an old woman. 7. Pat O'Brien without make-up. 8. As the football coach Knute Rockne in "The Life of Knute Rockne." O'Brien wears latex nose, eyelids and forehead and a hairlace wig. 9. Knute Rockne himself

MOTION PICTURES



MAKE-UP TECHNIQUE BY THE HOUSE OF WESTMORE; PHOTOGRAPHS BY HENRY WAXMAN; POSED BY ALEXIS SMITH; COURTESY OF WARNER BROS.

VARIOUS TYPES OF MAKE-UP

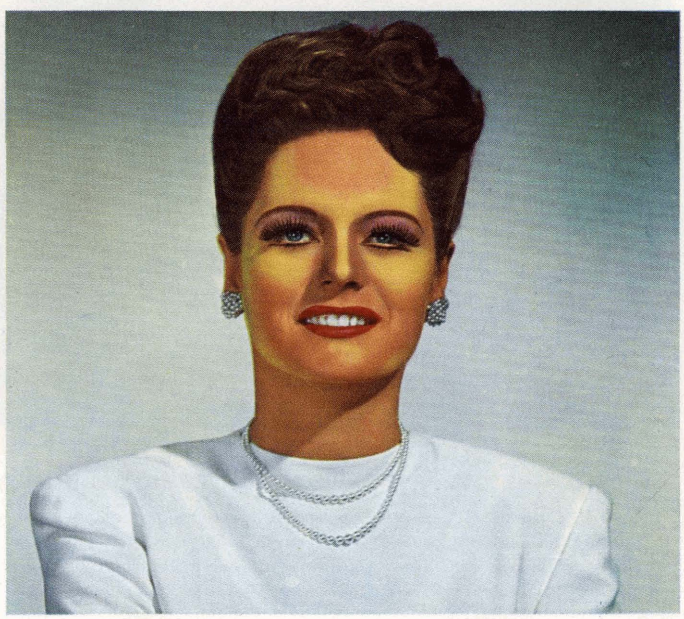
Upper left: Street and evening make-up. The procedure is basic far all other types of make-up

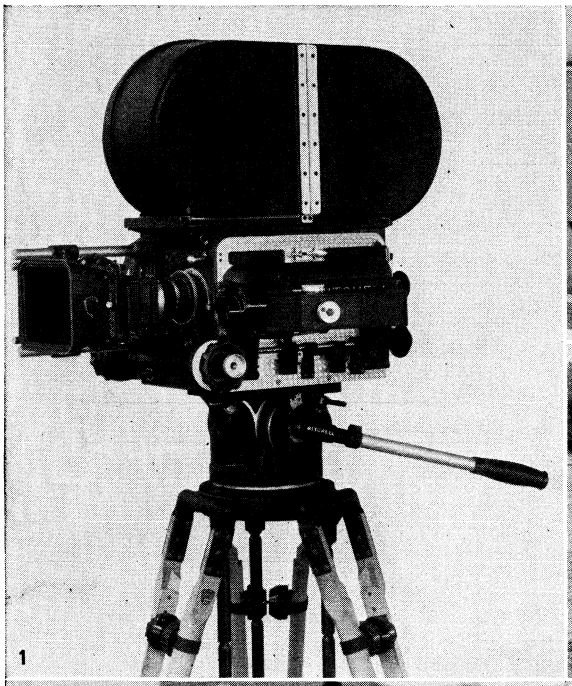
Upper right: For panchromatic screen. Tha foundation cream it tan; light powder is used on high lights first, and a medium powder over all. High lights, two shades lighter than the foundation, reflect light and give emphasis to certain features

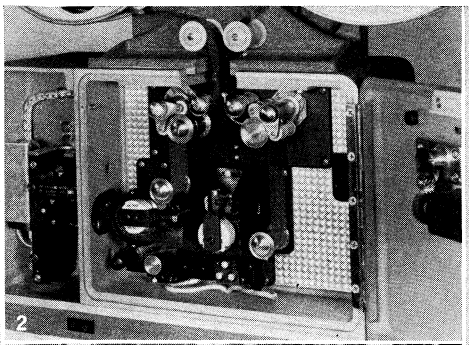
Above, left: For Technicolor. Make-up must be applied sparingly; otherwise the tendency of Technicolor to magnify and increase colour would give the actress a "masky" appearance. The foundation cream is gray. Black mascara or eyebrow pencil would appear as stage make-up and are therefore always avoided; soft browns are applied instead. A minimum of light cheek rouge is applied, on women only. Lip rouge is applied lightly and then taken off, allowing the owtline of the lip make-up to remain soft

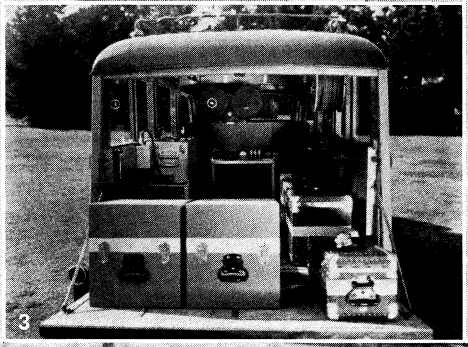
Above, right: For stage. This make-up stresses extreme accentuation of all features. The foundation cream and the powder are pink. High lights and shadows are accented strongly. Eyeshadow and cheek rouge are applied in densities about three times those of street make-up

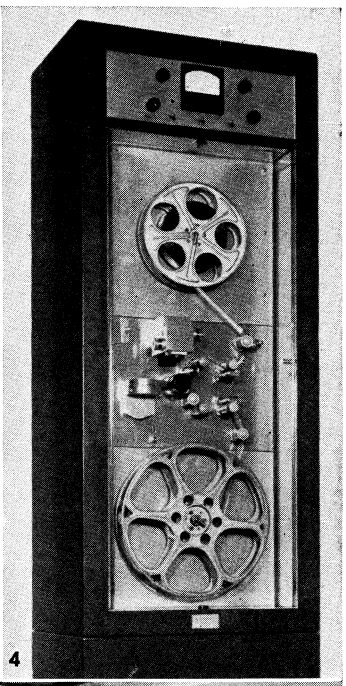
Right: For ielevision. Structural features must be strongly defined; otherwise the face is "washed out" in transmission. The shadows are four times darker than the orange-tone foundation cream, the high lights four times lighter

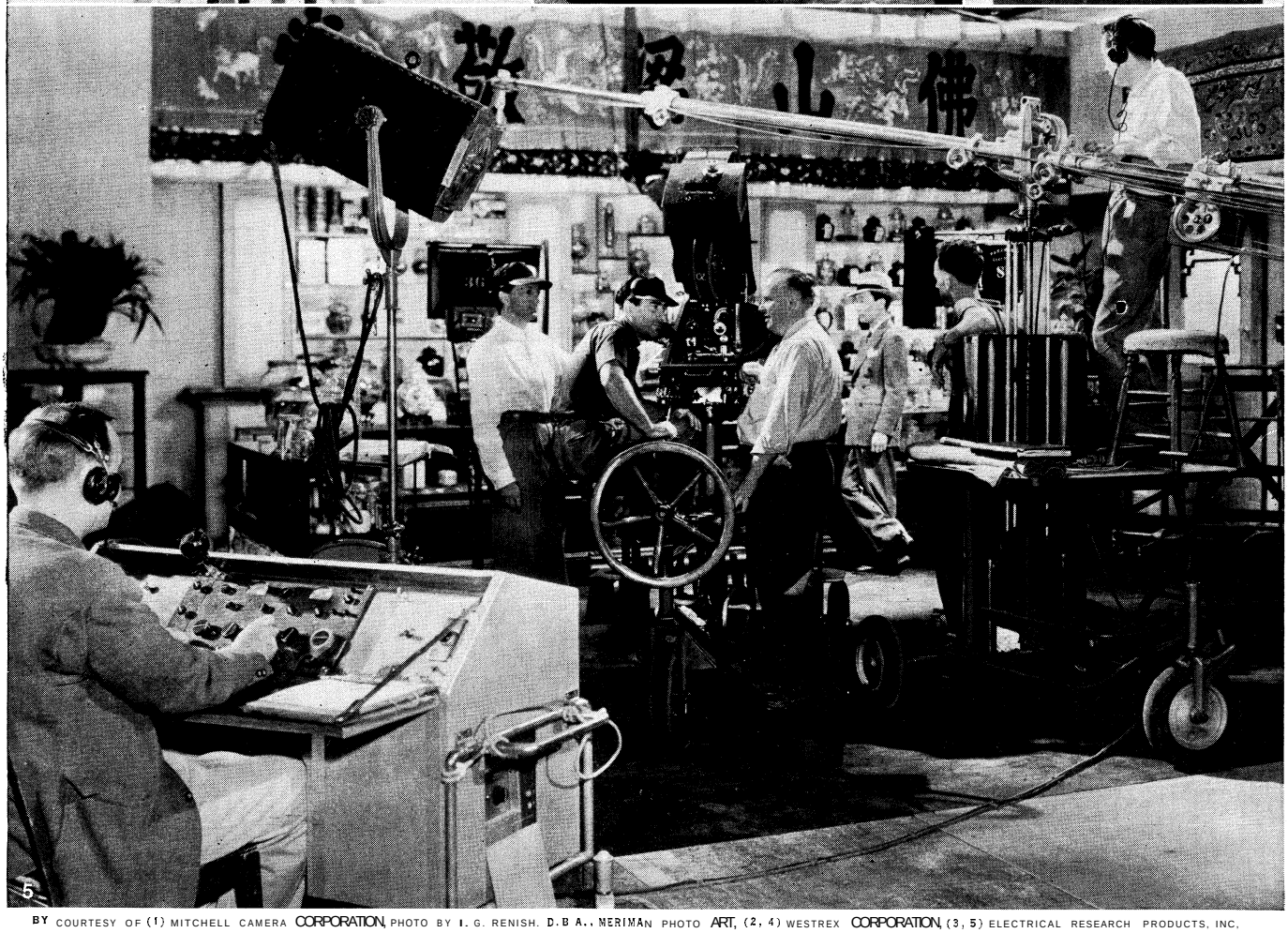










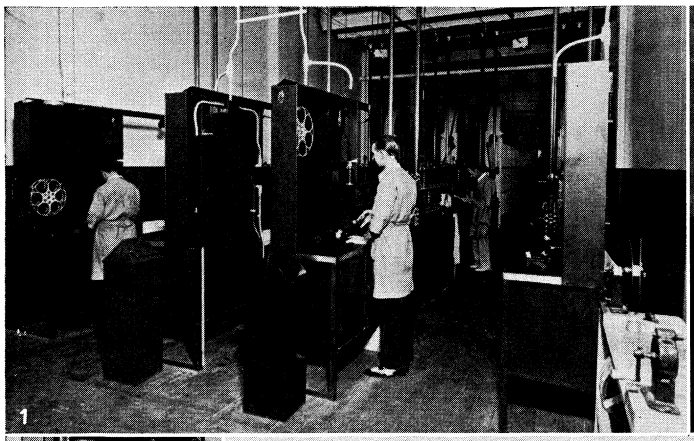


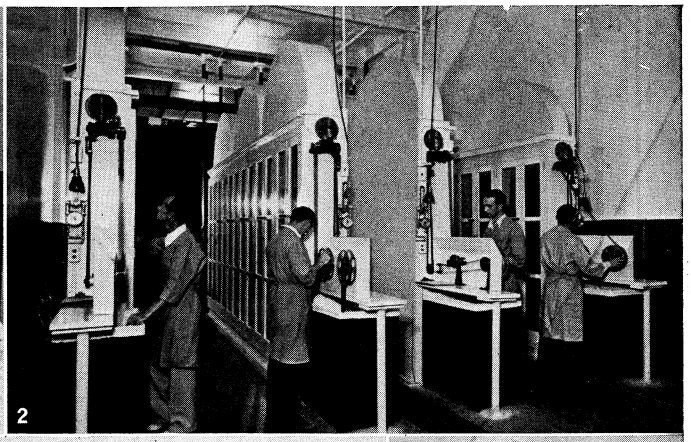
BY COURTESY OF (1) MITCHELL CAMERA CORPORATION, PHOTO BY I. G. RENISH. D.B.A., MERIMAN PHOTO ART, (2, 4) WESTREX CORPORATION, (3, 5) ELECTRICAL RESEARCH PRODUCTS, INC.

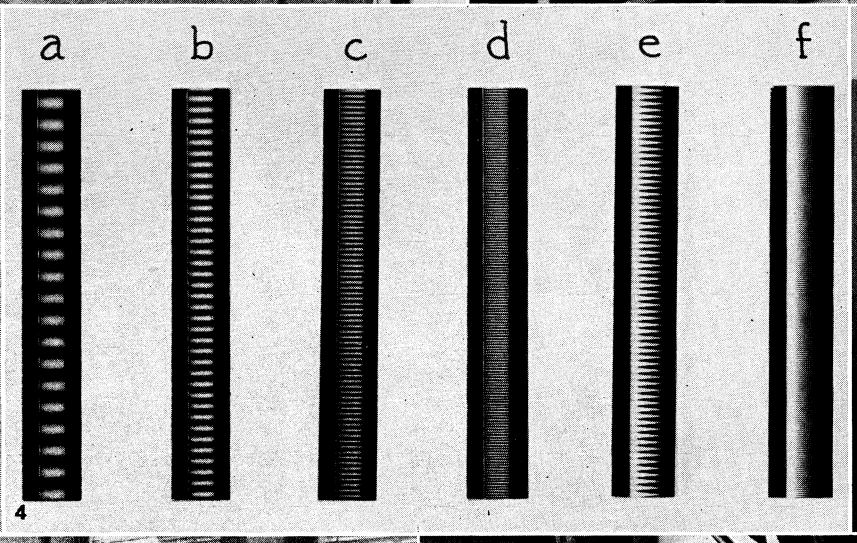
RECORDING MOTION PICTURES IN STUDIO AND ON LOCATION

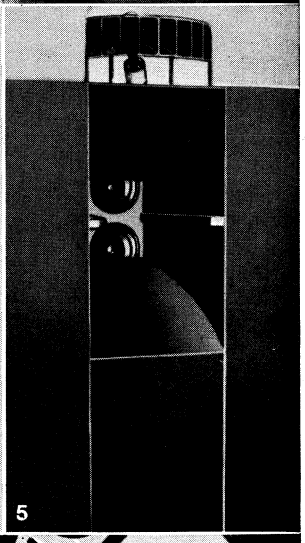
1. A 35-mm. camera for studio use. Sound insulation of the camera's moving parts enables cameramen to come within a few feet of the action without camera noises being picked up by the microphone
2. Interior of mechanism which records sound on motion picture film, either photographically or magnetically. If magnetically, the reels can be played back immediately without having to be developed
3. Mobile equipment for recording sound motion pictures on location
4. Re-recorder used in combining previously recorded sound film tracks including the ones for dialogue, sound effects and music. Two or more such re-recorders play simultaneously at a synchronized speed. Their sound tracks are fed into a re-recording and scoring console which receives and records them on a single track
5. Complete recording apparatus on a Hollywood set. In the left foreground is a mixer which adjusts the electrical output of the microphone (top, suspended above the actors from the end of a free-swinging, telescoping boom). The sound recorders are located in another part of the building. The "mike man" is shown in the upper right. In the centre is a sound-proofed camera mounted on a rubber-tired dolly

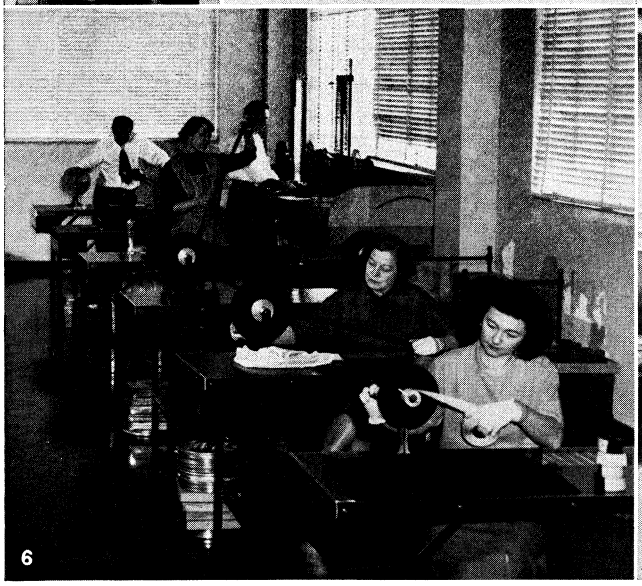
MOTION PICTURES

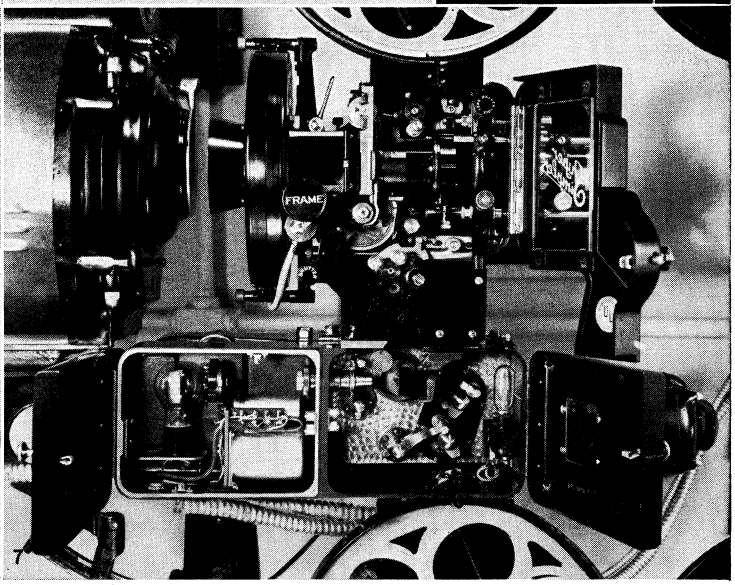












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PROCESSING AND PROJECTING MOTION PICTURES

1. Automatic developing machine for 35-mm. motion picture film, feed end of machine
2. Automatic developing machine for 35-mm. motion picture film, take-off end of machine
3. An example of motion picture film, showing pictures with corresponding round record along the edge. The track is about 1/10 of an inch wide and sound is recorded on it photographically by two methods which are illustrated in detail in figure 4
4. Photographic sound records. a, b, c, d: varible density type, representing pure sine waves having frequencies of 100, 200, 400 and 700 respectively. e, f: variable width type, representing pure sine waves with frequencies of 100 and 400 respectively
5. Loudspeaker system for large theatres, located immediately behind the screen
6. Negative cutting. When the picture is finished to the satisfaction of the producer, a master print is sent to the laboratory for negative cutting. From the cut negatives hundreds of prints are made to be sent out to the theatres
7. Interior of a sound motion picture projector. At the top is the projector which flashes the pictures on the screen. The sound reproduction equipment is contained in the two rectangular compartments below. A tubular incandescent lamp (extreme right) projects the image of the sound track through a lens (supported by the partition) into a photoelectric cell (extreme left)

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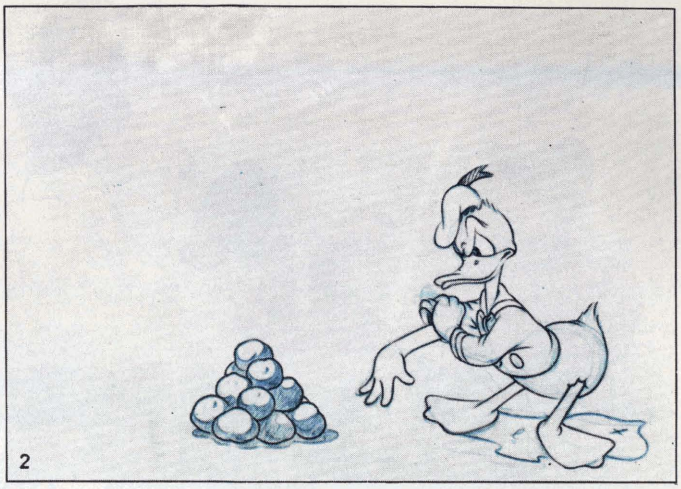
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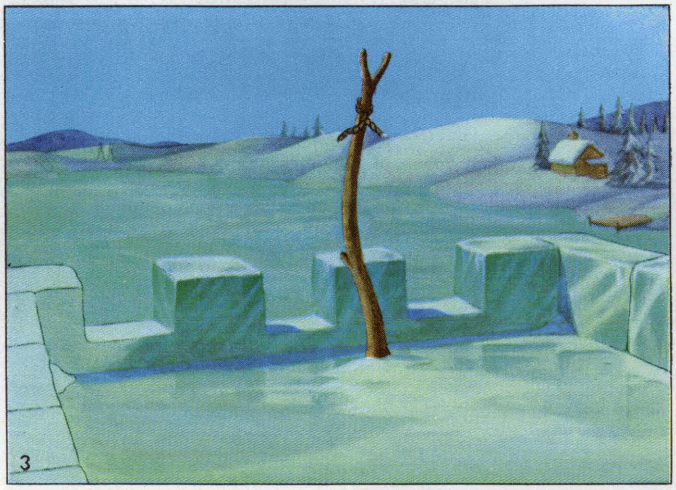
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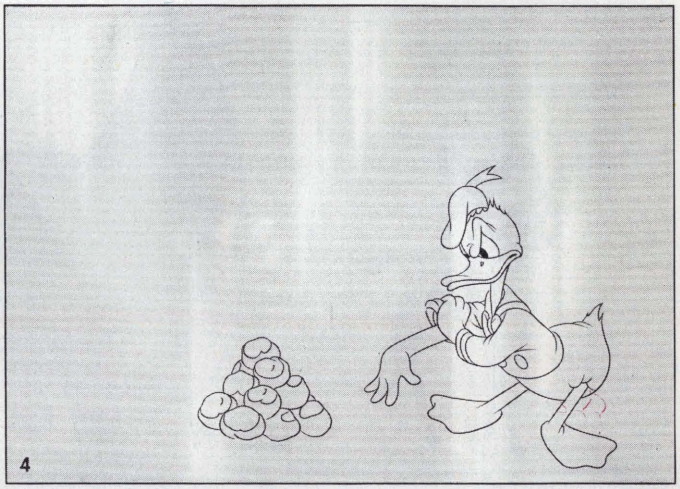
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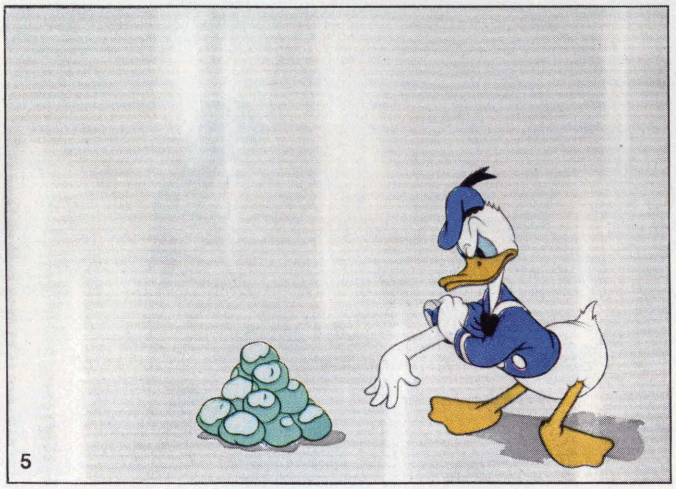
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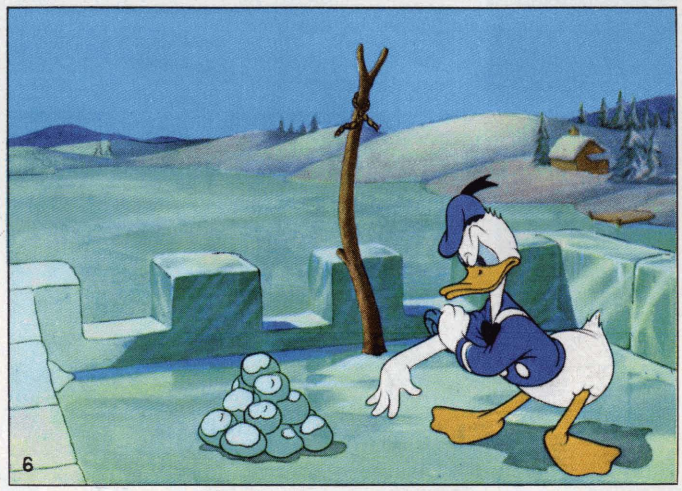
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STEPS IN THE MAKING OF AN ANIMATED CARTOON IN COLOUR

1. Rough pencil drawing for "Donald's Snow Fight," a short production by Walt Disney. The animators do not begin drawing a sequence of action until the background layouts are completed and the dialogue music and sound effects have been recorded
2. "Cleaned-up" pencil drawing. After the sound track is recorded, a chart is prepared to show the artists the length of each word spoken, the lip motions, accents, breathing, etc. The animators work on illuminated drawing boards so that when one drawing is finished another can be superimposed on it, with just enough change to make the action smooth
3. Completed background or setting for a sequence of action
4. Inked celluloid. When the drawings are finished and approved they are transferred to sheets of transparent celluloid, so that the background will show through. All details of the action drawing are carefully outlined in pen and black ink
5. Coloured paints are applied to the outlined character on the reverse side of the celluloid so that the inked outlines will not be covered
6. Character superimposed on background, ready for photographing on film. About two weeks' time is required to photograph the 11,200 frames of film in a 700-ft. short production. Each frame contains an average of four drawings

MOTION PICTURES

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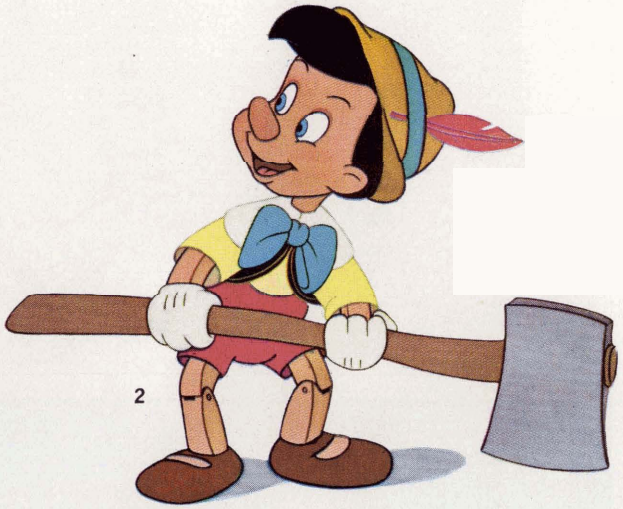

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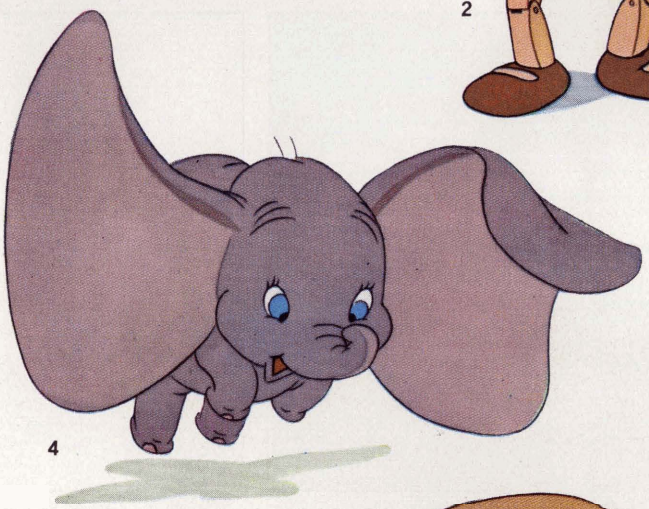

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CHARACTERS FROM ANIMATED CARTOONS

1. Snow White and two dwarfs, from the motion picture "Snow White and the Seven Dwarfs"
2. Pinocchio, from the motion picture "Pinocchio"
3. Bambi, from the motion picture "Bambi"
4. Dumbo, from the motion picture "Dumbo"
5. Mickey Mouse, as the sorcerer's apprentice, in "Fantasia"
6. José Carioca, Panchito and Donald Duck, from "The Three Caballeros"

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EARLY DAYS OF THE MOTION PICTURE

Top left: Sarah Bernhardt in "Queen Elizabeth," a four-reel drama which ushered in the "feature-picture" era (French, 1912)

Top right: "Barney Oldfield's Race for a Life," starring the pie-throwing comedienne Mabel Normand and produced by Mack Sennett (at extreme right) (U.S., c. 1913)

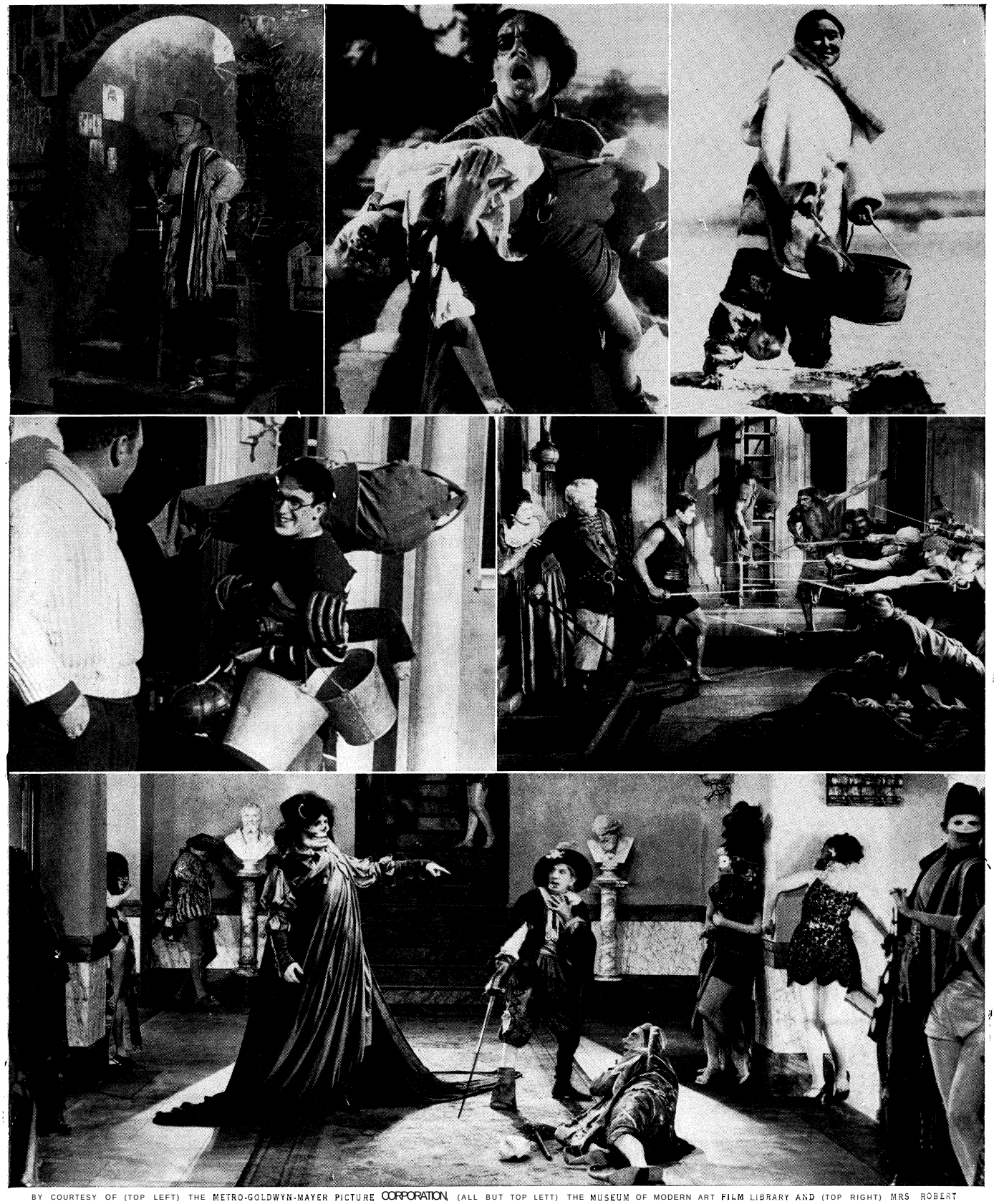
Centre left: Mary Pickford graduated from child roles to become "America's sweetheart" (U.S., c. 1913)

Centre right: Assassination of Lincoln, from D. W. Griffith's production of the Civil War film "The Birth of a Nation" (U.S., 1915)

Bottom left: Mack Sennett's bathing beauty brigade, Gloria Swanson at left (U.S., c. 1917)

Bottom right: "The Cabinet of Dr. Caligari," perhaps the first horror film, with Werner Krauss in the title role (German, 1919)

MOTION PICT RES



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FILMS OF THE EARLY 1920S

Top left: Rudolph Valentino in "The Four Horsemen of the Apocalypse" (U.S., 1921)
Top centre: Scene from "Potemkin," directed by Sergei Eisenstein (U.S.S.R., 1925)
Top right: Scene from "Nanook of the North," photographed by Robert J. Flaherty, outstanding as a producer of documentary films (U.S., 1922)
Centre left: Harold Lloyd as "The Freshman" (U.S., 1925)
Centre right: Douglas Fairbanks in "The Black Pirate" (U.S., 1926)
Bottom: Lon Chaney in a scene from "The Phantom of the Opera" (U.S., 1925)

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U.S. FILMS OF THE LATE 1920S

Top left: Scene from "Kid Boots" in which Eddie Cantor (right) made his screen debut. Clara Bow, the "It" girl of the 1920s, is at centre left (1926)

Top right: "What Price Glory" featured Edrnund Lowe and Victor McLaglen and began a cycle of war pictures after World War I (1926)

Centre left: Greta Garbo and John Gilbert in a scene from "Love," an early film version of Leo Tolstoy's novel "Anna Karenina" (1927)

Centre: Charlie Chaplin in "The Circus." This was no longer the pure slapstick of his earlier films, but one of the first to combine the comic and the pathetic (1928)

Centre right: The stars of "Seventh Heaven," Charles Farrell and Janet Gaynor (1927)

Bottom: Al Jolson in the title role of "The Jazz Singer," which marked the end of the silent film (1927)

MOTION PICTURES

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NOTABLE FILMS, 1928-31

Top left: Gloria Swanson in "Sadie Thompson," the motion picture version of "Rain" (U.S., **1928**)

Top right: George Arliss as "Disraeli" (U.S., **1929**)

Centre left: "All Quiet on the Western Front," a film dealing with the German side of World War I (U.S., **1930**)

Centre right: Marlene Dietrich in "The Blue Angel," directed by Josef von Sternberg (German, **1930**)

Bottom left: Raymond Cordy in "A Nous la liberté," airected by Rene Clair (French, **1931**)

Bottom right: Peter Lorre as the psychopath in "M," directed by Fritz Lang (German, **1931**)

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FILMS OF THE EARLY 1930S

Top left: Hertha Thiele (left) and Dorothea Wieck in "Maedchen in Uniform" (German, 1931)

Top *right:* W. C. Fields as Mr. Micawber in "David Copperfield," with Freddie Bartholomew in the title role (U.S., 1935)

Centre left: Claudette Colbert and Clark Gable in "It Happened One Night" (U.S., 1934)

Centre *right:* Jean Harlow, film siren of the 1930s, in a scene from "Riffraff" (U.S., 1935)

Bottom left: Victor McLaglen (right) in "The Informer," directed by John Ford (U.S., 1935)

Bottom right: Bette Davis and Leslie Howard in the film adaptation of W. Somerset Maugham's "Of Human Bondage" (U.S., 1934)

MOTION PICTURES

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FILMS OF THE LATE 1930S

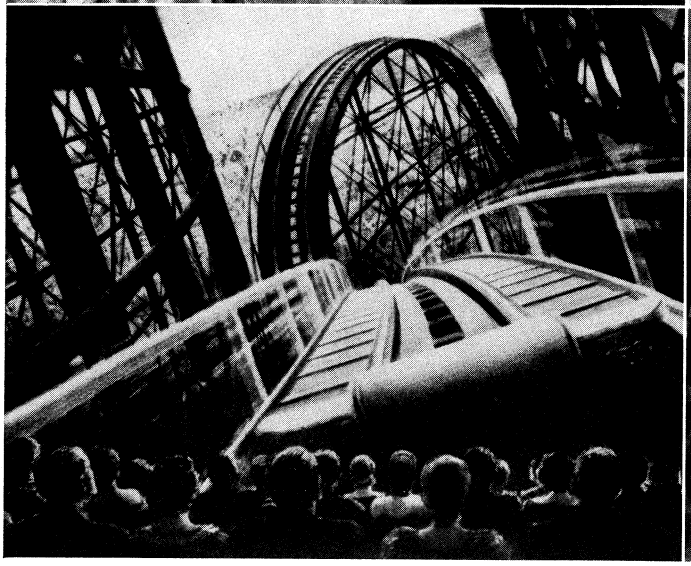
Top left: Shirley Temple in "Captain January" (U.S., 1936)
Top right: Gary Cooper (right) in "Mr. Deeds Goes to Town" (U.S., 1936)
Centre left: Dame May Whitty (left), Robert Montgomery and Rosalind Russell in Emlyn Williams' mystery "Night Must Fall" (U.S., 1937)
Centre right: Carole Lombard (centre) in "Nothing Sacred" (U.S., 1937)
Bottom left: Pierre Fresnay (left) and Erich von Stroheim in "La Grande Illusion," directed by Jean Renoir (French, 1937)
Bottom right: Leslie Howard and Wendy Hiller in "Pygmalion" (U.S., 1938)

BY COURTESY OF (TOP LEFT) DAVID O. SELZNICK, METRO-GOLDWYN-MAYER RELEASE (TOP RIGHT) SIRITZKY INTERNATIONAL PICTURES CORP., (CENTRE LEFT) METRO-GOLDWYN-MAYER, (CENTRE RIGHT) RKO RADIO PICTURES, INC., (BOTTOM LEFT) ARTHUR MAYER & JOSEPH BURSTYN, INC., (BOTTOM RIGHT) TRICOLORE FILMS, INC.

THE FILM DURING WORLD WAR II

Top left: Clark Gable and Vivien Leigh in "Gone With the Wind" (U.S., 1939)
Top right: Raimu (centre) in "The Baker's Wife" (French, 1940)
Centre left: Katharine Hepburn and James Stewart in "The Philadelphia Story" (U.S., 1940)
Centre right: Scene from "The Best Years of Our Lives," a sympathetic treatment of the problems of G.I.'s re-entering civilian life after World War II (U.S., 1946)
Bottom left: "Open City," produced by Roberto Rossellini, one of the first of the Italian films produced after World War II which were notable for their realism (1946)
Bottom *right:* Jean Louis Barrault as the pantomimist in "Children of Paradise" (French, 1946)

MOTION PICTURES



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THE MOTION PICTURE AT MID-20TH CENTURY

Top left: Scene from "The Bicycle Thief," produced by De Sica (Italian, 1949)

Top right: Alec Guinness (centre) who played multiple roles in the comic "Kind Hearts and Coronets" (English, 1950)

Centre left: Vivien Leigh and Marlon Brando in the film version of Tennessee Williams' "A Streetcar Named Desire" (U.S., 1951)

Centre right: Scene from "The Strange Ones," screenplay by J. P. Melville and Jean Cocteau, a film adaptation of Cocteau's "Les Enfants Terribies" (French, 1952)

Bottom left: Opening scene from "Cinerama," projected on an extra-wide curved screen from three projectors to give a three-dimensional effect, and featuring stereophonic sound (U.S., 1952)

Bottom right: Louis Calhern (left) in the title role of "Julius Caesar," with John Gielgud as Cassius (second left) and James Mason (right) as Brutus (U.S., 1953)

people perished. The fire was traced to the motion-picture machine. That autumn Edison launched a legal campaign for the protection of his invention and a violent and involved patent war hampered the industry for more than a decade. In that year. 1897, R. G. Hollaman of the Eden Musée on the roof of a New York building produced the Passion play in three reels, with a cast and dramatically arranged settings. thus instituting production for the camera. Meanwhile, in March of that year. Enoch J. Rector, earlier associated with the Lathams, had pictured the Corbett-Fitzsimmons fight at Carson City, Nev., in about 11,000 ft. of film.

The motion picture still continued as an incident of vaudeville. In 1896 George Méliès of the Théâtre Robert Houdin in Paris, a magician, applied the camera to feats of magic and gave the motion picture new life, incidentally adding fade-outs, dissolves and double exposures, now commonplaces. In 1903 Edwin S. Porter, an Edison cameraman, alarmed at the decline of the industry, sought to give it new impetus by novelty. He compressed all the known thrills of the screen into a single picture, *The Life of an American Fzreman.* This succeeded so well that he tried again with a cheap novel story entitled *The Great Train Robbery.* This picture, occupying a whole reel in length, established the "story picture" and founded the art of narration for the motion pictures, and placed them on an independent basis. With this production for its program the first motion-picture theatre. a "nickelodeon," was opened in Pittsburgh, Pa., in Nov. 1905, and started the screen on a new career. **(T. RA.)**

II. PRODUCTION METHODS

The professional production of motion pictures is designed primarily for theatrical, television: educational or industrial uses. The principal manufacturing countries, quantitatively, are the U.S., U.S.S.R., India, Great Britain, Italy, Germany, France and Japan, but thriving cinema industries exist elsewhere. Exhibition of these films varies from single scientific showings of nonfictional documentaries to world-wide showings of the more pretentious entertainments to audiences that sometimes total hundreds of millions. Synchronized translations are substituted for the original dialogue in the major foreign markets; for lesser foreign markets, frequent captions containing translations of the key lines of dialogue are superimposed over the visual image. A regular flow of product from large studios has been a dominant characteristic of American production methods from the early days. The growth of these studios, their facilities and the number of their personnel paralleled the increasing length of the films themselves, the development and growth of world markets and the steady increase in admission prices. Simultaneously, similar "major studios" developed in Germany before the outbreak of World War I and again between that war and World War II; and emulation of this assembly-line method of making films occurred intermittently, with varying degrees of success, in England, France, Italy. Japan and elsewhere. Production for other than theatrical purposes, as well as that of a relatively large percentage of the more successiul theatrical films, has been by independent units.

Each film is made under the supervision and final authority of the producer. In the large studios producers in turn work under the executive control of a studio head. The producer is responsible for budgeting and cost controls; and he is also in charge of the creative aspects, including selection of story, preparation of screenplay, selection of director (sometimes the producer is also the director), selection of cast and supervision of production and editing. He must also select! approve and co-ordinate the work of the set and costume designers. the cameramen and all other contributors to the translation of the screenplay into the completed motion picture.

The Wide Screen. — In the early 1950s there gradually evolved certain large-screen effects which had long been available. The prior use of these had been avoided because they would necessitate costly re-equipping of studios, laboratories and theatres: the resistance to them was overcome when it became apparent that pictures designed for theatrical use would require novelties of technique to overcome the increasing competition of free television. So-called three-dimensional films failed to have more than transient attraction value. largely because of the inconvenience of viewers having to wear specially prepared spectacles A greater degree of "audience participation" was achieved and introduced by the Cinerama process, initially used for training U.S. armed forces during World War II. The commercial use of Cinerama was limited by the requirements of three synchronized cameras and three synchronized projectors, each of the latter casting an image on a separate screen, with all three images joined to give the illusion of a single panoramic effect on a curved screen. Other developments in this field included anamorphic lenses to permit "squeezing" in photography and "unsqueezing" in projection of a wider image; the insertion of film in cameras horizontally to achieve panoramic effects; and the invention of a "bug-eye" lens, expanding the camera range to 130°, and of other lenses designed to widen the camera range and increase the illusion of audience participation by exhibition on large, curved screens, utilizing 65-mm. width film.

Accompanying these visual novelties, technicians and laboratories expanded the original use of single sound track to multiple-track systems permitting greater refinements of sound and truer reproduction values, notably for music. Attempts at directional sound for dialogue quickly proved of only limited value, because of confusion as to origin and consequent audience distraction and loss of illusion.

Colour.—Attempts at reproducing natural colour have been increasingly successful since the early days when each individual frame of each print was coloured by hand, as is still approximated for animated cartoons. Basic two-colour processes were followed by three-colour methods; and systems initially utilizing three negatives, one for each of the three primary colours, were followed by a monopack method, in which the photography of all the primary colours was made possible on a single strip of coated film. Greatest advances in this nork were achieved through the unremitting research of the Technicolor group and the Eastman Kodak company, although notable strides were also made by other technicians, laboratories and film manufacturing companies in the United States and elsewhere.

Screen Stories. — Most films designed for exhibition in theatres are based upon produced plays, published works, television plays or upon original stories by well-known novelists, playwrights or scenarists. These "originals" are sometimes initially submitted in extremely brief form, and only rarely is an original written and submitted at the writer's own risk produced. Occasionally the story basis comes from other sources; but the danger of plagiarism claims: the rarity of anything usable being found in the mountains of material submitted to studios and the impracticability of reading so vast a number of submissions have caused practically all established producers to reject such submissions unopened. Material from more recognized sources is read initially by readers who prepare synopses, and by story editors, although a large percentage of stories that achieve production have their inception in the enthusiasm of a director or a producer, or in the success of the material in its original theatrical or published form.

Transition of the original material to final screenplay usually begins with an outline or treatment. either written or verbal, devised by a scenarist, usually in collaboration with a producer or a director or both. The same craftsmen develop the screenplay, sometimes through many stages; until it seems suitable to the requirements of the market, the usually preconceived production cost limitation and the planned principal casting and satisfies the producer and usually the director. Scenarists have sometimes had their early training in other departments of film making. but a large number have had prior experience as authors or playwrights. More than one writer may be employed on a screenplay. and often these" writers are replaced at varying stages of the treatment or screenplay evolvement. By custom, only those scenarists are credited who are responsible for the major portion of what appears in the finally edited film.

Shooting. — It is most desirable to photograph the respective scenes of the screenplay consecutively in the order of the scenes of the script. but for reasons of economy the usual practice is to shoot all scenes within an individual set or group of sets. thus per-

mitting demolition of sets to clear stage space for the construction of other sets and completion of the services of an individual actor within the shortest possible time. Each scene normally is photographed from several different camera positions. occasionally simultaneously. This practice gives the producer. the director and the editors (cutters) flexibility in editing the photographed film, and permits emphasis on individual characters through the use of larger images (close-ups); utilization of more distant camera angles to show two or more characters and larger portions of the set; dramatic punctuation and rhythms; choice of renditions (takes) and even of sections of renditions.

Sound.--Sound tracks are recorded on a separate film negative, or on film coated with magnetic material, and are synchronized to the visual images. When the visual film and the sound track have been finally edited, prints are struck off from a composite negative, or from separate picture and sound negatives, for world-wide release (rental to theatres) and exhibition. The number of prints vary from 50 to 300 of films made outside the United States, and from 400 to 1,000, and occasionally many 'more, of films of U.S. origin.

Musical backgrounds almost invariably are based upon compositions especially written for each film. The technique of such composition has been mastered by a surprisingly small number of men, because of the difficulties occasioned by the need for exact timing to abet the varying moods both of individual scenes and of the film as a whole without disturbing them. Usually individual themes are composed and utilized to underscore the respective story threads or character relationships. Sometimes established classical or popular works are utilized in part for this underscoring, in their pristine form or freely adapted. The music is recorded, in sessions ranging from several hours to several days, on specially equipped sound stages. by large orchestras that customarily are conducted by the composer. The music is played in front of a tremendous projection of each scene to be scored, visible to the musicians, in order to accomplish exact timing.

The final recording of the sound portions of the film takes place in a large chamber equipped with projector, screen and several high-fidelity speaker systems, through which are played the edited dialogue as recorded at the time the film was photographed; any lines of dialogue that have been recorded separately, either for purposes of improving the original recording or rendition or because sound conditions (particularly on exterior scenes) were not such as to permit perfectly clear recording; the finally edited selections from the several recordings of the underscoring music; and varying "effects tracks." containing recordings separately made or selected from existing studio libraries of sound effects desired to complete the illusion. A composite track (recording) is thus achieved, and selections are made from the several recordings made of this merged audio reproduction, which in turn are spliced to achieve the final sound track. A new negative is then made. of which the sound track. which visually appears to be a series of waves, occupies a very small segment (ranging from a minimum of 1.93 mm. to a maximum of 2.54 mm. on a 35-mm. film). When the prints are made from the composite negative (or the separate sound and picture negatives) this track is printed, paralleling the visual image. The projection machines in theatres are equipped with masks to make this track invisible to the audience, but the sound is reproduced by apparatus synchronized with the visual projectors.

So-called musical films, containing songs or choruses. are usually prerecorded. The artists first record the numbers, and are then photographed as they sing to the accompaniment of. and in synchronization with. their own prior recordings. This practice permits selection from the prior recordings, and thus more perfect renditions, to the greater satisfaction of both artists and audiences, as well as allowing the artists to concentrate separately on their audible recording and on their photographed appearance.

Special Effects.—Among the less publicized of the motion-picture creators who have contributed to making motion pictures a world-wide source of entertainment have been the skilled devisers of illusion known as the special-effects men. Special lenses and screens have made possible expert rephotographing of filmed backgrounds of distant settings before which scenes are played within studio walls. Multiple photography and printing. miniatures, paintings designed to simulate extensions of relatively small settings; animated cartoons (in themselves an important development of the motion picture) and a myriad of other methods are used by these studio magicians to remove the limitations of the theatre's traditional proscenium arch and those of studio boundaries, and to make possible the photographing of almost anything that can be conceived by their fellow creators.

Design.—Production designers and art directors are an especially trained corps who must be able to design and to supervise expert studio construction crews in the building of outdoor and indoor settings precisely, accurately and with extraordinary speed, sometimes literally overnight, so that the settings are suitable not only to the story and script requirements but also to the complicated uses of lights and cameras. Costume designing is similar to that of the theatre, except for greater requirements of speed, research and quantity. The gigantic audiences of motion pictures, and their readiness to pick up technical or historical errors, require meticulous research in costumes, settings and other matters, and it 'is perhaps not surprising that in the pressure of quantity production errors are not unknown.

Technical Production.— The technical production of motion pictures involves many other departments, notably the camera crew. working under the direction of a chief cinematographer (cameraman), who decides solely or in collaboration with the director and sometimes the producer how the sets should be lighted and how otherwise the desired photographic effects are to be achieved. His staff includes. in addition to assistants charged with executing technical requirements. the camera operator and the chief "gaffer." who has responsibility for the proper setting and operation of the lights. The electricians must be skilled not only in electrical matters. but also in judicious artistic use of equipment. Laboratory technicians, charged with the printing and developing of the film. must also have special training. lest insensitive or improperly timed handling of exposed negatives result in damage to costly film that has involved the work of large numbers of artists and technicians.

In the Cnited States and England, especially, members of the various branches of motion-picture production, including producers and directors, have become unionized (in the creative and acting branches these are known in the U.S. as "guilds"). As a result the work has become highly specialized, with the function of most studio crafts being strictly limited by agreement between unions and studios. By contrast with films that are made by amateurs or by semiprofessional groups, especially outside the U.S., the number of people employed in the making of a professional motion picture has become greater with each passing year. Thus. no film made by any of the established producers can properly be said to be the work of any one individual, except perhaps as to concept and overall supervision. The making of a motion picture has become. in the larger sense: unique among art forms in that it is necessarily the work of a team rather than an individual. (D. O. S.)

III. MOTION-PICTURE DIRECTION

The function of the director is creative. In transferring the story from the scenario onto film. he brings the motion picture to life. Directing a film consists of bringing into play many different elements and blending them, with the proper timing and proportion, into a flowing, forward-moving expression. Of the many ingredients at the disposal of the director, the main ones are: (1) story and scenario; (2) staging of action; (3) camera-work; (4) editing or cutting; and (5) sound and music.

Each one of these elements can be used creatively. not merely as a device to record the action; but to enhance it in a way impossible in any other medium. Thus, the director can give the finished film a feeling of personal style and individual imaginative expression and comment. It is, of course. quite rare for any one director to possess equal facility in the use of all of the various elements. Hence. there is a great and interesting variety of styles among creative directors. Depending on his previous training—whether as cameraman. actor, cutter or writer—each director tends

to exercise his imagination along the channels most iamiliar to him. Direct personal experience with the camera. with acting or with cutting usually permits the director to be fully aware of the possibilities and limitations of these means of expression. Directors who come from the theatre, such as Elia Razan. often obtain from the actors they work with performances of an intensity and excitement hitherto unsuspected. Directors who were former cutters, such as Lewis Milestone, often excel in giving their films a smooth flow and an exciting sense of pace. Writer-directors, such as Joseph Mankiewicz, usually get their most telling effects from the spoken word combined with fine performances. Directors who were at one time cameramen, such as George Stevens, King Vidor and Victor Fleming. often conceive their approach in exciting visual terms. Among the many exceptions to this rule are John Ford and John Huston. who were never cameramen, yet are among the topmost visual directors, and William Wyler, who excels in obtaining great performances without having worked in the theatre.

The Scenario. — The blueprint which the director uses to transfer the story onto the screen is the scenario. Because time is a most expensive commodity under production conditions. the scenario is usually extremely detailed. It provides a complete and clear indication of all physical elements necessary — the cast, sets, costumes, props, special effects! etc. By breaking down the scenario, each department can prepare in detail for the pending production. In the creative sense, the director uses it for rehearsals with the cast. and for visualizing the style and manner in which he wants to tell the story. The unavoidable but evidently necessary drawback to this minute and detailed preparation. all geared to save the utmost possible amount of time on the set, is that it tends to make shooting conditions exceedingly rigid. The director is apt to find himself in a position in which it is impossible to improvise or to make changes and improvements. While this method provides fine technical polish in every aspect of the picture, it often tends toward an overly studied quality at the expense of spontaneity.

After the advent of sound, scenarios relied heavily on the use of dialogue, not necessarily the most imaginative way of telling a film story. There is usually an insistence on an elaborate plot and much action at the expense of a truthful and unsentimental study of human character! a less conventional approach to which modern audiences seem more and more in a mood to respond.

Staging of Action. — This consists primarily in obtaining performances from actors in terms of dramatic scenes. In a broader sense, it includes the organizing and setting up of any action involving moving or static objects which are to be part of the film. Since the advent of sound, there has been a tendency to identify screen acting with stage acting. These two branches, however, follow rather different laws. Screen acting tends to require intimacy, whereas stage acting, of necessity, involves a good deal of projection across the footlights. Through the means of the camera, the audience finds itself on exceedingly close terms with the performer. Therefore, projection has to be restrained and the intensity of the performance must be controlled: turned inward, so to speak.

The camera is capable of photographing peoples' thoughts and feelings. Therefore: in contrast with the theatre, what is between the lines of dialogue — the wordless reactions — can often be a great deal more telling than the dialogue itself. Some actors have, more than others, the ability to make these wordless feelings and thoughts transparent. A classic example of a true screen actress is, of course. Greta Garbo.

The individual directors' methods of working with actors vary in the extreme. Some try successfully for a great degree of spontaneity. with little rehearsing and a minimum number of takes. Others put their cast through exhaustive rehearsals, followed by a great number of takes. Still others compound this latter approach by photographing the same scene from a great variety of angles and from many different distances. They then obtain the final impact of their scene by editing the abundance of material in the cutting room.

Some directors dominate their actors and superimpose their own concept of the characterization completely upon them. This control may include not only the finest details of wardrobe and make-up but also the slightest inflections of the readings of each line and fine shades of timing. Other directors prefer to let the actor exercise his own initiative, while the director works to achieve proper proportion and perspective.

A stage actor. accustomed as he is to a live audience, and above all. to the delivery of a continuous performance in the course of a theatrical evening, a performance without any need for repetitions, may find the transition to screen acting uncomfortable. On the screen, this same performance may stretch over weeks and months. It is done for the sole benefit of the camera and of the director. There is no other live audience concerned with his performance, as such; the staff is concerned only with technical aspects. In this sense, the director is the spearhead of the future audience. He must sense — as the audience later will — whether the performance is impressive, moving, vital and intense enough and whether it has the proper pace. If it is too fast, important points may be slurred; if too slow, it may become dull. He must sense where and to what extent the performance can be improved and where it must be toned down.

Camerawork. — By imaginative treatment on the part of director and cameraman. the impact of a scene upon the audience can be infinitely enhanced and intensified. For the most telling presentation of a scene, the following means are at the director's disposal:

1 *Screen size of object.* Depending upon the desired effect, the object can be photographed at a variety of distances: very intimately (close-up); somewhat farther away (medium shot); or distantly (long shot or full shot).

2. *Composition.* In staging the action. the director will tend to arrange the dramatically important elements in a way pictorially effective and satisfying to himself and his cameraman. Composition is conditioned by camera angle, lighting and choice of lens.

3. *Camera Angle.* The lens may be photographing on a level or it can be pointing upward or downward. The proper choice of angle can enhance the action considerably. (Upward angles, for example, tend to make people and objects appear dominating and monumental.) The variety and contrast of sizes and angles is of great importance in the final editing, in order to achieve the proper rhythm and flow in telling the story.

4. *Movement.* The camera can move in different ways and thereby achieve a variety of effects. It can move toward or away from an immobile object. It can move in front of, or behind, or alongside of moving objects, such as two people walking. It can move at the same speed as the objects. or it can move faster and gain on them, or move more slowly and have the objects recede. This type of camera movement is called trucking. If a change in height is required during the movement in a truck shot, a boom is used, and the shot is called a boom shot. The camera can also remain in the same place but be moved horizontally on its axis to follow horizontal movement, a technique called panning. If the camera movement is vertical, it is called tilting. Excessive camera movement can easily become distracting, especially if it is employed for no valid dramatic reason. Many directors use it only sparingly. Dramatic movement can also be obtained by having the object move toward. across or away from a stationary camera.

j. *Lens.* The quality of composition, movement and perspective can be subtly changed by the use of different lenses. A wide-angle lens tends to force perspective and to exaggerate the speed of motion toward or away from camera. A long-focus lens eliminates the sense of distance — as, for instance, in newsreel shots of horse races. with horses galloping interminably toward the camera without seeming to come appreciably closer. In general, wide-angle lenses are used for long shots, longer-focus lenses for close-ups and nen sreel work.

6. *Lighting.* Lighting is of enormous importance in setting the mood for the storytelling. In keeping with the character of the story it can be gay and bright or stark and gloomy. It can be soft and flat or it can bring objects into sharply moulded contrast.

7. *Speed.* Interesting effects can be obtained by speeding up or slowing down the natural speed of an action. Achieving this effect by camera is called overcranking or undercranking.

Editing. — This process of selection involves the choice of spe-

cific fragments of photographed scenes and the joining together of these selected pieces into the most effective presentation of the material. Editing is fully as much a creative process as the other elements. concerning itself with pace, economy of expression, flow, variety and timing.

Place.—It is theoretically possible to tell a story—provided the story itself is interesting—in such a nay that the audience is breathless, leaning forward in their seats and hanging on every word: and also to tell the same story so that the audience leans back comfortably enjoying the picture, but not receiving so powerful an impact. Finally. the same story can be told so that the audience's understanding is a long way ahead of the happenings on the screen. Audience reactions depend largely on economy of expression. The audience should receive only the absolutely necessary amount of expository information, thus providing an opportunity for viewers to bring their own imaginations into play. to reach their own conclusions and to interpret as much as possible for themselves.

Pace is brought about to a great extent by variety. For example. a constant succession of fast-playing scenes would become monotonous and tiring. and the sense of pace would drop. At times the omission of a few feet of film can bolster the pace to an extraordinary degree. The pace and smooth flow of a picture can also be aided in editing by variety of cuts: well-considered changes in screen sizes and camera angles, in keeping with dramatic points which have to be made. A good sense of balance and proportion is necessary in editing. If there are too many rapid shifts of angles and sizes, the general effect is choppy and the film appears to be overcut. At times of course a choppy effect may be dramatically desirable, and instead of a smooth flow, shock cutting may be required. The best means of obtaining visual shock is by joining together the most contrasting sizes and angles—for instance, by cutting from an extreme close-up to an extreme long shot. By selecting the dramatically wrong angles, a picture can be hurt very badly. By retaining extraneous or unnecessary scenes, no matter how good they may be in themselves, a picture may lose pace and impact.

Timing.—Similar to an actor's timing on the stage—speaking his lines or making an important pause or gesture at a certain split instant—the art of timing in editing is of extreme importance, especially in comedy. The effect of a scene can be greatly weakened if the timing is off by even a few moments. This is especially true of laughs, and often it is necessary to verify and correct the timing after a preview.

Passage of time or a drastic change of place are often indicated by a gradual blending of one scene into another. This is called a lap dissolve The beginning and end of a major section of the film is often indicated by a fade-in and fade-out. These last two have a function similar to the curtain at the start and finish of each act of a stage play.

Sound.—Of all the sounds available to dramatize a film story, dialogue is by far the most important. Conceivably a film story could be told more imaginatively at times by giving more room to sounds other than words. Music can of course convey and interpret a great range of emotion. (F. Z.)

IV. THE SCREENPLAY

The screenplay serves the same purpose in motion-picture production as the stage play in the traditional theatre. There are two cardinal differences, both inherent in the two kinds of theatre. On the stage the accent is on utterance and the drama is largely unfolded by the actors' speeches. The motion picture is more concerned with action and the drama is disclosed as much by what the actors do as by what they say; whole sequences of a screenplay may contain no word of dialogue. There is an inner logic, of course, which unites these two methods, for one may construe deeds to be words in action and perceive words as symbolic deeds.

Nevertheless the disparity of method is considerable and must be taken into account. The early silent films strove to tell their stories entirely through action. Even with the addition of sound, the motion picture. true to its name, derives its primary force from images in movement and from the expressiveness of the human face when closely inspected; this latter is only possible in the more intimate medium of the screen. nhich can move the audience, so to speak, within a few inches of an actor's eyes.

The second important dissimilarity of the screenplay from the traditional stage play lies in the motion picture's absolute control of what the audience shall see at any moment. Successive details are pointed out and everything else is eliminated. Selected. detailed images are finally assembled or orchestrated, somewhat as sounds are organized in harmony and melodic line to create the effects of music, into a single strip of film a mile or two in length. It is the arrangement, or montage, of the piecemeal strips of film which achieves the final effect when the entire film is projected on a screen before an audience.

Unless these basic principles are grasped, the nature and method of the screenplay cannot be understood. In practice, stage and screen techniques are not always so disparate as they seem to be; for each has affected the other, both by imitation and by experimentation, thereby frequently enriching both forms.

The addition of sound and the spoken word to the silent screen in the 1920s, just when motion pictures had begun to realize the artistic potentialities of the medium, apparently placed the motion picture on a footing with the traditional stage; but only to the imperceptive. Undoubtedly the presence of living actors before an audience holds an immediacy which cannot be matched by their speaking images on a screen. But the motion picture makes up for this by the artful use of nhat would seem to be its worst limitation: the fact that the audience must view everything through the single eye of the camera. Against this seeming limitation. the stage audience is at all times free to observe w-hat it pleases of the ensemble. selecting this detail or excluding that at will, and perceiving it all from one unchanging point of view.

Yet the camera eye is master as well as slave. The genius of the motion picture lies in its mastery of what the audience, no longer autonomous individuals, shall be given to see. Not only does it dictate what each member of the audience shall see and how it shall be interpreted, but it tyrannically determines his point of view. deciding from what angle and from how near or far he shall natch and hear the action, no matter where he may be seated in a theatre.

It is this absolute control over the audience which makes the motion picture. and accordingly its screenplays, essentially unlike the traditional theatre and its stage plays. It is the source of the art of the film. The member of a stage audience sits in one place and observes what he will. By his liberty of attention he makes his own montage or individual accumulation of perceptions. The member of a film audience, sit where he may. can see only through the eye of the roving camera and perceive what it commands him to perceive. He must continually shift his position and point of view psychologically at the caprice of the mobile camera. Paradoxically, it is not so much the actors on the screen who are in motion in the motion picture as the audience which, comfortably seated and unaware of riding this witch's broom, is incessantly and artfully being shifted forward to peer into an actor's face or at some object or person at whom the actor looks; dropping instantly back to view the ensemble from afar in a vast natural setting; racing along in aeroplane or car to watch the actions and reactions of the actors while sharing their peril or excitement; and always changing its angle or point of view so as to be forced to observe what is dramatically important or of fresh visual interest. Being a machine of motion, the camera is a machine of time, like a dream clock ticking out the endless dance of life as accurately as it ticks off seconds, and with equal determinism.

At the mid-point of the century motion-picture producers, having perfected various systems of colour photography, began to innovate enlarged projection screens of new proportions. but while these gave the effect of novelty they could work no change in the basic techniques of film writing and film making; for these techniques, slowly evolved and perfected, are inherent in the mechanism. The large screens. along with complex sonic improvements, perhaps stimulated the motion picture's tendency to present spectacle. which was alnays intrinsic because the camera inevitably escaped from the four walls of a theatre as the traditional stage,

dependent on structural sets, could not. Only the motion picture goes directly to actual and natural environments for the enactment of its drama. This fact, combined with its ease of changing scene, is taken advantage of by the screenwriter.

A film must go through three stages of work before it can be said to exist: it must be imagined and written as a screenplay; it must be enacted and photographed under supervision of the director; it must be assembled or edited in its multifarious parts into one continuous negative, from which positive prints may be made for distribution and projection in the theatres of the world. There are many other technical contributions, *e.g.*, the addition of recorded music to the sound track, but these are the three principal stages of creation.

The idea of the screenplay and its function was rudimentary in the early days of the motion picture. Even after the turn of the century it was barely more than the director's notes after reading or conceiving a story which he planned to photograph. As films evolved in length and ambition, a writer-assistant was employed, a sort of director's clerk who expanded the notes and ideas into what was called the continuity. Simultaneously writers began to compose stories expressly for the new medium. The writers most valued in silent-motion picture days. however, were those who wrote what were called the "titles," fragments of dialogue or explanatory or humorous comments sporadically inserted into the film, thus interrupting the flow of images. The use of these titles from the very beginning indicated that the need for sound. for the added dimension of the word. was always felt, even though its interjection appeared to be an artistic defect.

When discovery and invention in the field of electronics made it possible to print on a single strip of film not only the picture images but a thread of fluctuating light which would reproduce speech and all the sounds of nature. the title writer vanished and the continuity writer came into his own; or rather, both functions were taken over by what sound film demanded — the screenwriter. From that time on, playwrights and novelists and story writers who could grasp the principles of the film medium and adapt themselves to the new form were recognized as the initial contributors to the production of motion pictures. The screenplay is the first essential. The infinitely complex and costly work of preparation, of gathering technicians and production crews, of casting, of finding outdoor locations and designing sets cannot commence until the screenplay has been written. The writing of screenplays has become an established profession in every country of the world where films are made. In the United States screenwriters organized their own guild and similar organizations were formed in England and those countries of Europe in which motion-picture production became an industry. Rarely. the gifted director may write his own screenplay. More often he mill work in close collaboration with the screenwriter. But the usual practice is to view the screenplay as a separate, primary stage of work, and the director and writer confer only on a final revision in which technical details can be worked out in harmony with the director's individual style and feeling.

Physically, the screenplay is a volume of 100 or more mimeographed pages designed to be read only by the director. producer, actors, cameraman, sound men, editor and all the production executives and their assistants. It presents a story told through a number of characters, their utterances, attitudes, moods and manner of speaking, their actions in all significant detail and descriptions of the environment of successive scenes and events.

Competent screenwriting requires knowledge of the medium of film and of its potentialities and how to go about achieving them; but this does not mean that there need be any mystery to the craft. Technical terms are hardly required. Such directions as fade-in, fade-out, cut. dissolve. close-up and close, medium or long shot are self-explanatory, and they are hardly requisite in any case, since director and editor will make the final decisions on such matters. What is required is the ability to tell an effective story in successive scenes in a highly visual way with dialogue when it is useful or necessary and to write everything with a trained instinct for film. It is the director's job to realize in film what the writer can only verbally express. Anything that can be imagined can be realized on film, so ingenious are the technical means of illusion and recreation. Basically, anything vividly recounted is a sequence of film and a skilled director could photograph it. The poets with their creative flow of imagery unwittingly wrote superbly worded screenplays long before the motion picture mas dreamed of. In fact, all our dreams are dramatized and poetized films. so to speak. spun out of the unconscious, which accounts for the power of the motion picture at its best over an audience, for there is direct communication with the secret centre of'the mind.

Screenplays have been published, but they hardly make attractive reading for the general public unless they are rearranged or rewritten for publication. It could not be otherwise, since they are written for the comprehension of specialized film craftsmen and are not in themselves the completed thing which is aimed at; they are not the end result, which is film—a motion picture.

(D. Ns.)

V. MOTION-PICTURE SETS

The first U.S. motion-picture sets were built on outdoor stages for the strong natural light then thought necessary. Later, glass stages hung with white and black diffusing cloths which could be pulled over the top were used to control the ever-changing daylight. Set construction was extremely simple, consisting mainly of flats very similar to those of the stage. All architectural details, including fireplaces, furniture and pictures were painted on these flats. The screen up to that time had developed no definite ideas about set design. Anyone from the property boy up took a hand in composition. Eventually, men with some degree of technical knowledge were engaged. Draftsmen were employed to draw plans. Architectural details were executed, and sets began to approximate reality.

Wilfred Buckland, who in 1914 became the first man of recognized ability to forsake the theatre for motion pictures, made the first consistently well-designed sets. He brought to the screen a knowledge of mood and a dramatic quality which until then had been completely lacking. After Buckland came Hugo Ballin, a noted mural and portrait painter, whose approach to the problem was that of a painter with architectural knowledge. His settings had a stimulating architectural simplicity. By eliminating unnecessary detail. he left the eye free to concentrate upon the actors and the action of the scene.

Modern sets almost without exception are realistic and architectural. In plan they follow much the same idea as real buildings with the exception that rooms are not necessarily connected. A hallway and living room, for instance, may be set up as a joint unit on one stage, while the dining room, as a single unit. may be placed on another. The designer. now known as the art director, depends upon the film cutter to establish the interrelation of rooms. One-room interiors, usually consisting of three sides, are built on indoor stages surrounded by light platforms to carry the lighting equipment. Interior sets appear much the same as real interiors except that mouldings and other breaks are exaggerated in depth to overcome the flattening effect of diffused lighting. The more frequently the wall is broken. either with jogs or recesses, the more interesting it becomes photographically as it gives opportunity for light and shadow.

The primary function of a set is to form a background for the actor. Except in cases where it is absolutely necessary to characterize a mood. any set which becomes more than a background is bad. In designing for motion pictures, the problem of geography frequently arises since one motion picture may require action in several different countries. There are several methods of optically establishing these changes of scene. One method is the use of famous structures, such as the Statue of Liberty. Eiffel tower or Trafalgar square. This is not a problem of design. but of mere reproduction. Frequently, however, the art director faces a tremendous problem in instances apparently calling only for pure reproduction. For instance, the Hall of Mirrors in the palace of Versailles is one of the most magnificent apartments in Europe, but its dimensions are 320 by 3j ft. Photographed by a motion-picture camera it would seem to be merely a long tunnel with no points of interest and leading nowhere. Obviously reality must be

circumvented in this case and a hall designed and built of proportions n-hich belie the truth yet permit those who have seen Versailles to believe they are viewing reality. The irony of this difficult type of set design is that in exactly that degree in which these problems are solved. in just that degree does the work pass unnoticed.

The problem of architectural design is far from being the only one that confronts the art director. Within the space of a fen. days he may be called upon to lay out and make sketches of Napoleon's coach. the interior of a ship's boiler room. an aircraft of 1975 and artificial flower buds which blossom mechanically. These problems require careful and extensive research.

A set is always designed with a particular type of lighting in mind. Proper lighting is almost equal in importance to design and the finest set may be ruined by improper lighting, just as a mediocre one may be immeasurably improved by good lighting.

Formerly, the mobile value of the camera was little appreciated, but gradually the camera was moved about more and more. This mobile quality of the camera is invaluable in making certain effects convincing. Hence. the motion-picture set must be designed to fit an ever-shifting camera and the result should be, and is, of advantage because this very movement gives a certain sense of plan and stereoscopic quality. The movement of the camera is so sustained that it is practically impossible to design a whole set so that in each setup the composition is good, and the art director learns to know intuitively where the grouping of actors will be most effective photographically.

An art director should be a combination of three things — painter: architect and dramatist. The screen set calls for the application of certain architectural principles to a given subject. This application must be done more with the eye of the painter than with the eye of the architect. For example, a practising architect knows that the airier and brighter a nursery is, the better it is. However, if the story calls for the child to be neglected by his parents, the set should be cold in appearance with no narmth or sunlight — a playrooin in which he cannot play — which is quite a different problem from that confronting the practising architect. And so with other interiors. In real life the most fashionable night club might not be particularly rich or ornate. On the screen. however. when Lord Blank takes his theatre party to a club. its appointments must necessarily be exceedingly smart and modern. The rapidly unfolding screen story has no time to explain that the drab. unattractive night club is popular and fashionable solely because of its excellent music and cuisine.

After the set has been designed and constructed it must be dressed. By dressing is meant the placing of furniture. hanging of draperies. accessories and appointments. In the larger studios this is done by the property department under the general supervision of the art director. In the smaller studios, the art director takes part in the actual dressing of his sets to a much greater degree. On the stage. an open foreground is considered an advantage. It has little or no effect upon the appearance of the set and gives the actors a chance to move about more freely. On the screen, the opposite holds true. The foreground should be rather well dressed with two or three pieces of furniture silhouetted against it to give roundness of composition and the feeling of a fourth wall. On the screen actors, in a sense. form part of the dressing since a set is seldom photographed without them. Therefore, the tendency in pictures must be to underdress the interior. (C. GI.)

VI. MOTION-PICTURE TECHNOLOGY

Motion-picture technology embraces all the applications of the physical sciences to film making. These sciences are principally mechanical, optical. chemical and electronic. This section treats of technology particular either to the motion picture or as applied in the film industry. For general information refer to such articles as: PHOTOGRAPHY: SOUND; LIGHT; COLOUR; TELEVISION; etc.

The production, distribution and exhibition of motion pictures — in theatres or via television — is a composite undertaking which relies more on creative talents, inspiration, hunch. luck, obstinancy and follow-the-leader-itis than it does on technology of any kind. This condition makes always difficult and often frustrating the lot of the motion-picture technician. However, the industry eventually takes full advantage of technical developments. The explanation for the relative indifference to technology and research is that in films things scientific are only handmaids of progress. They do not of themselves—as in many other fields — represent advancement and a guarantee of a better product. The finest film, technologically speaking. can be a financial failure. Pictures poorly made can be box-office hits. The film matter is always more important than the form. Yet excellent technology can add substantially to the entertainment value of a good picture.

The motion-picture industry and its millions of spectators throughout the world have benefited immeasurably from the fact that the raw material — film — has been subject to continuous research and improvement. All branches of the film industry profit from every improvement made in the basic materials by the large manufacturing firms such as Eastman Kodak. Colour also has come principally through the research of film manufacturers such as Technicolor. Inc., and other firms.

Sound is perhaps the most notable contribution which came principally from outside the motion-picture industry. It was developed by the American Telephone and Telegraph company, General Electric, the Radio Corporation of America and other companies prominent in electronics.

Interest in technology and special techniques within the motion-picture industry has fluctuated wildly. For long periods no basic changes in industry practices are introduced. Then for a period of several years there is a chaotic scramble for innovations. What are hailed as new inventions usually are throwbacks to methods tried in an earlier year and discarded for lack of interest, economic reasons or other factors.

Some of the film standards set by Thomas A. Edison and his contemporaries before 1900 endured for half a century. These were the guideposts for motion-picture technology. When sound became a commercial reality in the late 1920s the original standards were modified to include provision for sound tracks and a fixed projection rate. There was at that time no change in the basic 3j-mm. film or in the proportions of the projected picture. This standardization in film sizes and shapes, projection speed, screen proportion and the like facilitated production, distribution and exhibition throughout the world.

Both standards for pictures and sound were revolutionized in the period following World War II with the advent of wide screens and magnetic sound. Some believe that late in the 20th century film as such may be eliminated for certain uses by the recording of visual images as well as sound by electronic means. However, cost and complexity, as well as duplicating and editing problems, prevented such methods from seriously challenging general film usage up to the mid-19jos. So far as some television purposes are concerned. electronic recording devices have a certain advantage over photographic means and were introduced experimentally in the mid-1950s. The television camera produces an image that is already broken down electronically into tiny components. That is the way the image is transmitted and received. There are potential advantages in keeping the system electronic all the way through and forming an image only at the point of reception. On the other hand, in motion-picture work a film camera can "see" a whole scene all at once. making for relative economy in the use of material as compared with electronic memory tapes.

Two factors were chiefly responsible for the advent of wide screens in the middle 1950s. One was the growing popularity of television. The second was the success of Cinerama. a classic example of an innovation thrust on an indifferent industry. (*See* below.) One way to compete with television was to offer theatre patrons what was not practical in the home; *i.e.,* a huge screen. The motion-picture theatre enjoys the psychological advantages of having a picture of heroic proportions. The basic purpose of most wide-screen systems is to enhance the spectator's sense of presence at the scene and to achieve an attendant increase in the dramatic power of the medium.

Virtually all motion-picture technology is a study in compromise. Improvements in one area often result in deterioration elsewhere. Methods must be devised that will work not just under laboratory controls but in thousands of theatres and other places where mo-

tion pictures are exhibited. Motion-picture technology first of all is bound by the capabilities of human receptiveness. Human vision and hearing are senses with definite characteristics. Unless motion pictures are attuned to these characteristics they cannot create vivid illusions.

Motion pictures are made with and projected by means of light. Fortunately light is—for these purposes—of infinite velocity. Though light has the remarkable quality of virtually instantaneous transmission without changing the medium through which it passes, it too has its attributes. Film technology must study, adapt and be limited by the characteristics of light itself.

Only a film base was lacking to make motion pictures a reality decades before the end of the 19th century. The required knowledge of visual functions dated back a century and more, as did the development of workable projection apparatus.

Since much of colour reception is subjective. the problems of making motion pictures in colour involve complex technological factors.

The sound reproducing system must be a compromise between the ideal and the practical. giving regard to the physical characteristics of theatres and to theatre owners' financial resources.

Motion pictures are photographed and projected as a series of still pictures. Through the use of shutters and intermittent drives, exposure is made in the camera and projection onto the screen only when the film is at rest. Each second, 24 images are photographed or projected in standard 35-mm. practice.

The foundation of the motion-picture industry is a gift of nature—what is often erroneously called the persistence of vision. Unless the term is properly understood, it leads only to confusion. Physically speaking there is no such thing as persistence of vision. The motion-picture images, rapidly flashed before the eye. do not "persist" on the retina of the eye as if they were made by a rubber stamp. The rods and cones of the eyes "see" what is physically presented by the iris lens system. That is a picture, upside down, of course, of all that goes on before the eye—including the period of darkness on the screen and the two (or three) flashes of each picture caused by the rotating shutter of the projector.

The sense of vision. fortunately. "sees" something quite different. There is a time lag in the psychological perception. This time lag takes place in the brain areas associated with the sense of vision. How it all happens is not precisely known. One theory is that the perception of all motion by the sense of vision is the perception of a series of still pictures. In other words when we say that we see such and such moving, what really may have happened is that we merely have seen in swift succession a series of still images of the object in different spatial relationships. That difference in location is what we call "movement." In this way the motion picture recreates nature in an amazing and wonderful way. Whether this theory is true or not, the fact is that motion pictures are perceived not as disjointed pictures at rest but as an amazing reproduction of living reality.

Film.—The flexible support or base that makes possible motion pictures is called film. The same term is also used for the composite material including the emulsion and other related coatings. The best earlier types of bases—such as glass—could provide room for only a single brief scene. Moving pictures require a base that is tough enough to withstand rapid starting and stopping and flexible enough to be rolled on spools. From an optical and photographic point of view film base must have other qualities. It must not change the tone or colour values of the pictures, it must be uniform and it must be a base to which the photographic emulsions can readily adhere

John Wesley Hyatt of New York, while seeking a substitute for ivory for billiard balls. invented Celluloid in 1870. In 1887 Hannibal Williston Goodnin, an Episcopalian minister, received a C.S. patent on a "photographic pellicle," which he described as transparent, sensitive and like Celluloid. The following year John Carbutt in Philadelphia achieved some success in his efforts. started several years earlier, to treat with photographic chemicals long strips of Celluloid obtained from the Hyatt company plant in Newark, N.J. Late that same year. 1888, or early in 1889. Edison experimented with Celluloid coated by Carbutt in his effort to achieve a practical motion-picture device, after having firsi used a cylinder recording device analogous to his phonograph. Around 1870 William Henry Fox Talbot. photographic pioneer in England, had tried a similar system. Edison finally found a suitable material in film made by George Eastman.

Eastman Base.—Early in 1889 Eastman found a solution in a flexible photographic base—a plastic—and film was born. Meanwhile with the Carbutt material Edison had already started to notch or perforate his film. Edison established the first standard image proportions and the use of four perforations for each side of a picture or frame.

Commercial 35-mm. motion-picture film generally was made of cellulose nitrate until about 1950. After that cellulose acetate, or more correctly cellulose triacetate (42.5% to 44% acetyl content). has been used. Nitrate film is chemically related to guncotton and dangerous to handle because it burns rapidly, releasing dangerous gases. Cellulose triacetate stock is 5.5 mils thick and is slow burning. Unlike nitrate film, it does not explode or decompose in a dangerous manner.

Polyester Base.—In 1956 the first commercial sales of a polyester base produced by E. I. du Pont de Nemours & Co. and sold under the name of Cronar were made. Cronar motion-picture film base for certain uses is thinner than triacetate. Other properties that make it and other polyester bases attractive for some motion-picture applications are optical clarity, resistance to wear and tear, low sensitivity to moisture and relative stitiness. Chemical stability is high to permit these qualities.

Cronar is made from dimethyl terephthalate and ethylene glycol. In the manufacturing process, a molten polymer is extruded into a thick sheet. The mixture is cooled and then drawn out or stretched. For photographic applications an anchoring layer is applied to secure the photographic emulsions to the base. One of the problems in connection with the introduction of a polyester base has been that of splicing. While cellulose acetate film is readily spliced, Cronar requires different and more precise methods. The advantages of polyester bases such as Cronar are that more film can be stored on standard reels and breakage is virtually eliminated. Any new film base, however, must prove itself under varying conditions before it can win a substantial part of the market from acetate film. In 195j the Eastman Kodak company obtained a nonexclusive licence to manufacture polyester film base under du Pont patents and continued its own research on film base materials. In 1956 the Imperial Chemical Industries, Ltd., in Britain was also continuing experiments with a polyester film.

Monochrome.—For black-and-white photography the principal problem is to make a reasonable compromise between film grain and film speed. Ordinarily the faster the exposure speed the greater the grain and vice versa. The motion-picture cinematographer is usually restricted by the fact that movie films are run at 90 ft. a minute. which fixes his exposure time. He may adjust the diaphragm or stop opening to admit more or less light but he is restricted by unfavourable light conditions.

To satisfy the needs of motion-picture producers Eastman, du Pont and other film makers have devised black-and-white films of reasonable speed and fine grain. Fine grain is needed to permit the great magnification (as much as 300.000 times) of the 35-mm. image on a gigantic theatre screen. Reasonable speed is needed so that the requirement for lighting of the sets may not be excessive and to provide flexibility in outdoor photography. Special films are made for such purposes as sound recording.

Films in the latter 1950s were made in various sizes (fig. 1) for different uses, including nide-screen systems.

Colour Motion Pictures.—Colour motion-picture film is one of the wonders of the 20th century. The quest for colour motion pictures even antedates the motion-picture era. A complete motion-picture system was patented in France in 1864 by Louis Ducos du Hauron. A few years later he described a colour monopack film. Materials of his day. however, were inadequate to the task of putting those ideas into practice.

Colour films involve particular problems—psychological and physiological as well as technological—because so much of colour perception is subjective. Tastes in colour vary as do tastes in

food. No one can prove that he and only he sees a particular shade of a colour and that anyone else's perception is wrong if it differs.

Colour motion pictures fall into two main categories: the additive versus subtractive and simultaneous versus sequential pictures. The additive pictures are made by the addition of coloured illuminations and derive their colour effects from the nature of the eye, the brain and the perceptual process. Subtractive pictures derive their colour from the intermixture or superimposition of coloured layers or films; *i.e.*, the colour is physically present and is thus presented to the eye. In the simultaneous colour pictures, the colour impressions are all presented simultaneously to the eye. In the sequential process. the colour impressions rapidly follow each other and are perceptually combined. There are thus possible additive simultaneous pictures. additive sequential pictures and subtractive simultaneous pictures.

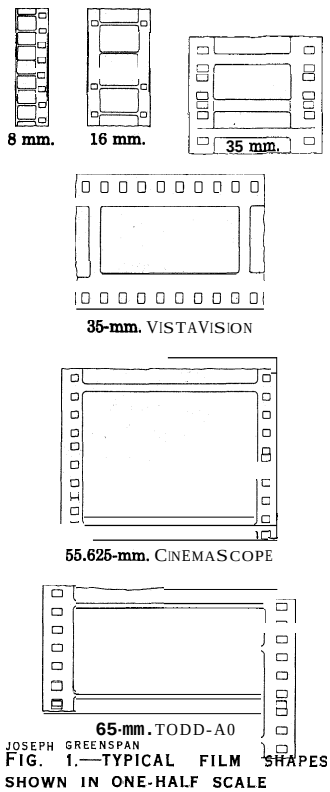


FIG. 1.—TYPICAL FILM SHAPES SHOWN IN ONE-HALF SCALE

The prevailing practice of the mid-1950s for colour motion pictures was of the subtractive simultaneous type, except in the case of lenticulated film which is of the additive simultaneous type. The subtractive primary colours are yellow, cyan (blue-green) and magenta. A sufficiently wide gamut of colour (and grays) for colour motion-picture purposes can be reproduced by the mixture or overlaying of these three subtractive primary colours or dyes in appropriate proportions. The corresponding additive primary colours are the complementary colours to the subtractive primary colours, namely! red. green and blue. While the colour filter wheels used in additive colour processes might appear to have some advantages on account of simplicity. they never became popular because exact synchronization was difficult to achieve and they were wasteful of projection light.

In the mid-1950s several different colour motion-picture systems were in use under various brand names. The most widely used colour film for production in the mid-1950s was Eastman Color negative, a single-strip film with three separate layers of emulsions. each sensitive to a primary colour. Ansco, Agfacolor. Gevacolor and Ferraniacolor are similar colour negative-positive systems. In each film three layers of emulsion are affixed to a single base and are photographed or printed together. From 1946 to 1956 the use of colour motion-picture film increased markedly. While the speed of colour film was improved in the mid-1950s. it is likely always to be considerably slower than black-and-white emulsions. It will also remain relatively costly and complex to process. except for the lenticular type which depends on black-and-white images and is therefore relatively simple to process.

Technicolor.—Motion pictures in colour became a commercial reality principally through the efforts of the Technicolor Motion Picture corporation. founded by Herbert T. Ralmus. The first three-colour feature in Technicolor was Becky *Sharp* (1935). *Snow White and the Seven Dwarfs,* Walt Disney's first feature cartoon. released in 1938. was another milestone in Technicolor progress. The methods of the Technicolor company have been refined and improved consistently through experimentation and research. Technicolor, a leader in colour film work since 1915, did much to increase attendance at theatres throughout the world. Patrons' preference for films in colour rather than monochrome was repeatedly demonstrated.

Technicolor uses a number of methods to produce colour prints, depending on the system used in photography and the current state of the colour film art and science. One Technicolor method of major importance involved the use of a camera equipped with three strips of negative film. One of the strips was in the normal position, directly behind the camera lens. The other two were located one on top of the other at right angles to the first strip. A prism directed the blue and red images to their proper strips at a 90° angle. The green image passed directly through the prism to the first film strip. Animated cartoons are made with a successive-frame camera in which three exposures are made of each image, one through a blue. another a green and a third a red filter. (See *Animated Cartoons* below.)

No matter what system is used to make the negative—a coiour negative, three-colour separation negatives or a successive-frame negative—the Technicolor company can make dye-transfer or imbibition prints. These prints are made from matrices. A matrix—one for each of three colours—has a relief image. The gradations of relief on the matrix correspond to the amount of exposure it has received of the colour aspect of the scene originally photographed. If the picture is to have a photographic (optical) sound track it is printed on a blank film at this stage in the process. If magnetic tracks are to be used they are applied after the colour printing is finished.

The blank film is printed in the imbibition process in the following way: the matrix film which has in gelatin relief the blue aspect of the scene is run through a yellow dye. The matrix is then brought into contact with the blank film and the yellow dye is transferred. The blank is next brought in contact with the second matrix which has in relief the red aspect of the scene. This second matrix has been dipped in a cyan dye solution. The blank now has had transferred to it the yellow and the cyan images. The third matrix has in relief the green aspect of the scene. It is dipped in a magenta dye. The one blank film is now capable of reproducing on a screen the original scene in full colour.

Projection of white light through a dye transfer imbibition print accomplishes the following: the yellow dye on the film subtracts the blue; cyan. the red; and magenta, the greed. Naturally, absence of all dyes from a part of the image results in white light on the screen and presence of all the dyes in sufficient density absorbs all light and gives black on the screen. Projection of white light through films made in all the subtractive colour systems achieves colour on the screen in the same manner.

Technicolor also has a process for making dye-transfer prints from 16-mm. Kodachrome originals. Technicolor first makes three silver separation negatives from the Kodachrome print and then proceeds with the making of the matrices and dye-transfer process as outlined above. Prints, of course, also may be made on colour-positive film by contact printing. Prints made in the dye-transfer or imbibition method in the mid-1950s were less expensive than prints made on colour-positive stock when a large number of prints were required.

The Camera.--In fundamentals the motion-picture camera has evolved but little since the time of Edison. It still is a device for passing film (perforated much as Edison established) behind a lens system by means of an intermittent cam. The introduction of sound made it necessary to design cameras that would operate in relative silence. Some cameras have been made to handle simultaneous sound recording; others have been specially built for two- or three-colour film systems; others for the two images necessary in 3-D pictures. Wide-screen systems presented many problems to camera makers.

While there are many makers of good cameras. the standard 35-mm. camera in most general use is made by the Mitchell Camera corporation in Glendale. Calif. A good professional motion-picture camera is a carefully made precision instrument. However, it does the same job—only better and with wider film—as is done with the $-mm. or 16-mm. amateur camera.

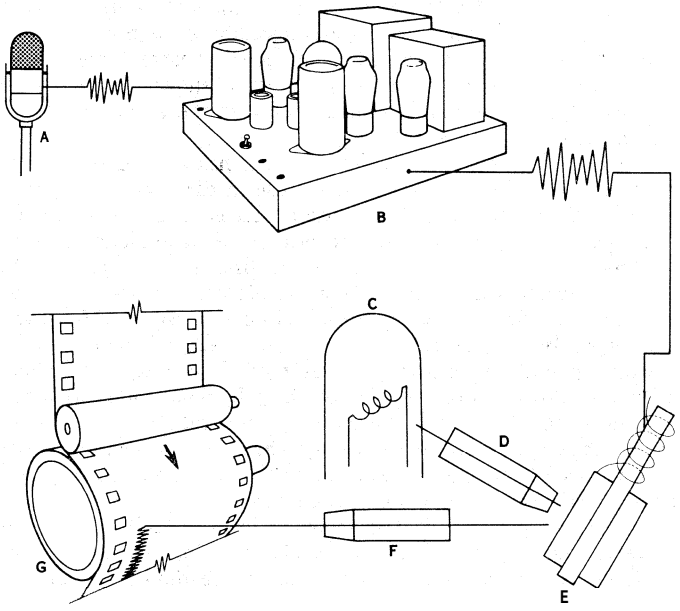
Sound.—From the beginning it was known that the ultimate in screen pictures would be those in realistic motion. in full natural colour and with sound. In 1877 Alfred Hopkins, editor of the *Scientific American*, commenting on several sketches of Edison's

projected phonograph, wrote: "It is already possible to throw stereoscopic photographs (stills) of people on screens in full view of an audience. Add the talking phonograph to counterfeit their voices and it would be difficult to carry the illusion of real presence further." When the Hopkins article was quoted in *Nature,* a British publication, Wordsworth Donisthorpe suggested the combination of the phonograph with motion pictures rather than with still stereoscopic pictures. Donisthorpe's device. the Kinesigraph, was intended to show motion pictures with sound.

It is not known whether Edison read Donisthorpe's description of his idea. However. ten years later: in 1887, Edison tried to combine the phonograph, by then a commercial success, with a motion-picture projector. The earliest Edison films were sound films. Synchronization was a difficult problem. The public was sufficiently challenged by and satisfied with silent pictures. Interest in sound remained dormant for decades.

The sound era began in New York on Aug. 6, 1926. with Don *Juan,* featuring synchronized music, and on Oct. 6. 1927, with *The Jazz Singer,* starring Al Jolson. with music and dialogue. Both were presented in the Vitaphone system, in which the sound was on disks. developed by the Western Electric company, and brought to the public through the enterprise of the Warner brothers—Harry, Sam, Albert and Jack—and the technical skills of Lee De Forest, Theodore Case, Charles A. Hoxie and others. At that time efforts were already well under way to record the sound on film instead of on separate disks, a system which presented problems in maintaining synchronization as well as in handling.

Optical (Photographic) Recording.— The two basic systems of recording sound optically. *i.e.,* photographically. differ little from each other in fundamentals. The methods are called variable



FROM A DRAWING BY C. S. PERKINS AND D. DEMAREST FOR ALTEC SERVICE CORP.

FIG. 2.—SCHEMATIC DRAWING OF OPTICAL RECORDING BY VARIABLE-AREA SYSTEM

The sound waves picked up from the microphone (A) on the recording stage or set are converted to electrical energy. At the amplifier (B) the signal is subject to various controls and equalizers to provide the best quality and level for recording. A fixed light source (C) is focused through an optical system (D) onto a galvanometer mirror (E). The output of the amplifier causes the galvanometer to swing back and forth, and the refiected light beam to be passed through an optical system (F) and photographed on the film. The film speed is kept ccnstant by a scanning drum (G)

area and variable density. In the former the sound. picked up from a microphone, activates a galvanometer. A fixed light source directed through the galvanometer is photographed on film. The fluctuations in the sound are filmed as variations in the area of light and dark (fig. 2). In the variable-density system a light valve admits more or less of the light focused on it, depending on the intensity and nature of the sound picked up by the microphone. The photograph of the variable-density track shows gradations from black through various shades of gray to white. In both systems the photographed sound track is changed to sound for reproduction by passing a steady light through the track onto a photoelectric cell (fig. 3). This action changes the gradations of light to sound waves. which are then amplified and fed to the loudspeakers located behind the screen. From 1926 to 1950 many variations of both variable-area and variable-density recording were developed. The ear is witness of the progress made in sound. Through systems of double recording and push-pull it was possible to suppress most of the distortion. Studio sound recording was better than most theatre equipment could reproduce. Theatres generally could reproduce sound only from 125 to 7,000 cycles. However, the development of FM radio, adoption of that type of transmission for the audio part of television and the wave of public interest in high-fidelity phonographs with new record speeds of 45 r.p.m. and $33\frac{1}{3}$ r.p.m. all made the film technicians realize that sound for motion pictures must be improved.

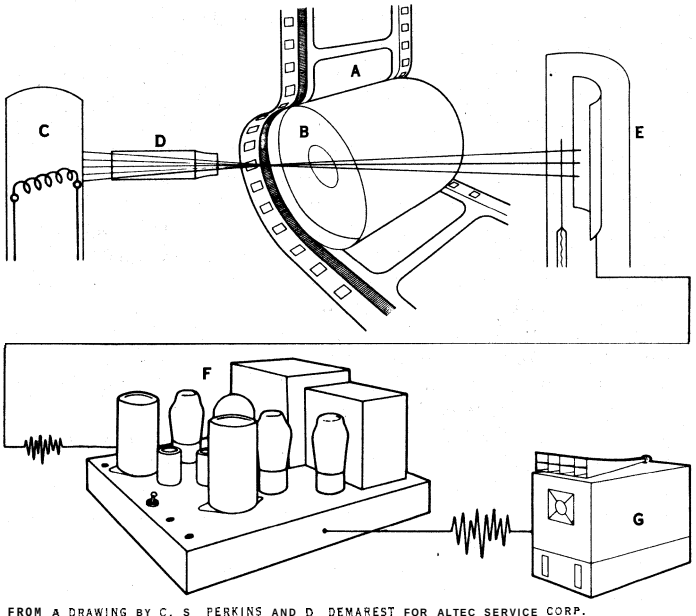
Magnetic Sound.--The solution to the problem came after World War II in magnetic recording. which was not new. It had been tested before the war with recording on fine wires but it was not found satisfactory for commercial purposes. During the war the Germans experimented with and developed magnetic recording on tape to a high degree. Taken over as one of the prizes of war, magnetic recording was then greatly improved by engineers in the U.S. The principles of magnetic recording and reproduction are wonderfully simple (fig. 4). In a magnetic system the base—tape or film—is coated with iron oxide, and the tape or film is passed at high, uniform speed through a magnetic field. The microphone output is fed to the magnet and the sound is recorded by changes in the magnetic flux. Reproduction, which can be done immediately, is exactly the reverse. No processing of any kind is required. The tape itself can be "wiped clear" and reused by running it through certain types of fields. In addition to being simple, magnetic recording provides sound of excellent quality. The signal-to-noise level is much greater than in optical recording. Also the potential frequency range is higher, running up to 20,000 cycles—well beyond the limits of human hearing. Magnetic recording was so excellent that by the mid-1950s it had replaced disks as well as optical sound for original recordings in many parts of the world. Magnetic striping to put the sound on the same film with the picture was introduced by Reeves Soundcraft in conjunction with an RCA projector in 1951. CinemaScope in 1953 made the first theatrical application of prints with magnetic striping. Magnetic sound first won favour in the larger studios fo economic reasons. It was originally used for location work because recording is so much simpler and the results can be checked instantaneously.

Stereophonic Sound.—In 1933 the Bell Telephone laboratories staged the first stereophonic or directional sound demonstration in Washington, reproducing sound originating on a stage in Philadelphia. The nature of stereophonic sound necessitates multiple channels to give sound lifelike qualities and proper spatial relationships. This first demonstration was "live." At Carnegie hall in New York city in the spring of 1940 the Bell Telephone system again demonstrated stereophonic sound, this time with sound on film. There was no picture but the sound was faithfully reproduced all across the stage. The first use of stereophonic sound by the entertainment industry was in Walt Disney's *Fantasia,* released late in 1940 and shown in about a dozen special theatres with a four-track optical stereophonic sound system designed by RCA. Results were impressive but costly for the exhibitor. The great width of the wide screens introduced in Cinerama in 1952 and a year later in CinemaScope suggested a directional sound system. Both systems use magnetic reproduction.

Under the sponsorship of Arthur M. Loew, president of Loew's, Inc., an optical three-channel sound system called Perspect-A-Sound was developed in 1954. It was quickly adopted by many major U.S. film studios. The system uses a single standard-size optical sound track but in the final recording stage three low-frequency (below the audible range) cueing signals are included, which switch the sound to three sets of speakers. In addition to the three sets of amplifiers and the three stage speakers, as used

for magnetic CinemaScope, the Perspect-A-Sound installations require an integrator, a relatively low-cost electrical device which picks up the cueing signals and effects the switching operation.

In the mid-1950s many qualified experts believed that optical



FROM A DRAWING BY C. S. PERKINS AND D. DEMAREST FOR ALTEC SERVICE CORP.

FIG. 3.— OPTICAL REPRODUCING SYSTEM

The film (A) with an optically recorded sound track passes over a scanning drum (B) which is mounted on a free turning shaft, coupled to a flywheel, to smooth out any irregularities in the movement of the film past the scanning beam of light. The light from an exciter lamp (C) is focused throuah an optical system (D) through a narrow slit on the film sound track. The light, fluctuating in intensity on account of the gradations of the recorded sound track, is converted to electrical energy by a photoelectric cell (E). The signal passes through the amplifiers (F) which usually include means of regulating volume and is carried to the stage speaker system (G) located behind the picture screen and usually consisting of a multicellular high-frequency horn and a direct radiator low-frequency horn

sound reproduction would prevail indefinitely in thousands of theatres and that only the more important theatres would use magnetic stereophonic sound prints. Magnetic sound is more costly to the distributor because each release print has to be striped with the magnetic tracks and recorded from the master tracks, whereas optical sound. being recorded as a photographic image, is readily printed. Magnetic sound is also somewhat more costly to the theatre. In 1956 some distributors adopted a combination four-track magnetic and Perspecta (Perspect-A-Sound) or standard optical print.

Wide Screens.—Basically "wide screen" means any departure from the screen proportions fixed by Edison and his contemporaries at 4 to 3 (or 1.33 to 1); *i.e.,* three units high for every four wide. The selection of a 4 to 3 proportion of "aspect ratio" was arbitrary, but it could not have endured if it had not given reasonably good results. It is said that Edison, who always had an eye for the practical, picked the 1.33 to 1 aspect ratio as the one closest to square and still pleasing to view. The square shape (1 to 1 ratio) would be the most efficient in its use of available light. The absence of noteworthy paintings in a square shape is proof enough that a square is not a pleasing proportion for a picture. The change in aspect ratios of motion-picture screens came in the early 1950s as a result of two movements. The first was the desire on the part of technicians to present a larger field of vision. The second was the stimulus provided by entrepreneurs who saw in the success of Cinerama—a very wide screen process—a key to financial success and a magical way to reverse a then current downward trend in box-office receipts.

If the aspect ratio were to be changed there was only one practical way—screens would have to be wider. Even apart from aesthetic considerations, screens of any reasonable size higher than wide would be impossible to construct in all but open-air theatres and drive-ins. Many theatres could not materially increase screen sizes much in the old 4 to 3 proportion because most of the available height was already used.

The human field of vision, either with one eye or both eyes. is substantially wider than high (fig. 5). When both eyes are used the field is extremely wide. The 1 33 to 1 aspect ratio motion-picture screen does not fill that eye field of vision, no matter where the spectator is seated in a theatre. The extent to which the field is filled depends, of course, not only on the dimensions of the picture but also on the location of the viewer. Champions of very wide screens feel that what they term peripheral vision—vision at the edges of the field—contributes much to a spectator's sense of presence at the scene. While not stereoscopic, some wide-screen films give an enhanced impression of depth. Our perception of depth is based on other factors than stereoscopy. Some very wide screens emphasize these factors, such perspective, contour, colour and relative motion. The problem of making a wide screen engulf a spectator for full saturation of the sense of vision and resulting maximum impact depends on circumstances within the theatre in addition to the width of the screen and its curvature. The wider the screen and the more deeply it is curved, the fewer the number of seats in a conventional theatre that are ideal in location. Distortion from side seats naturally increases with the size of the screen relative to the viewing position.

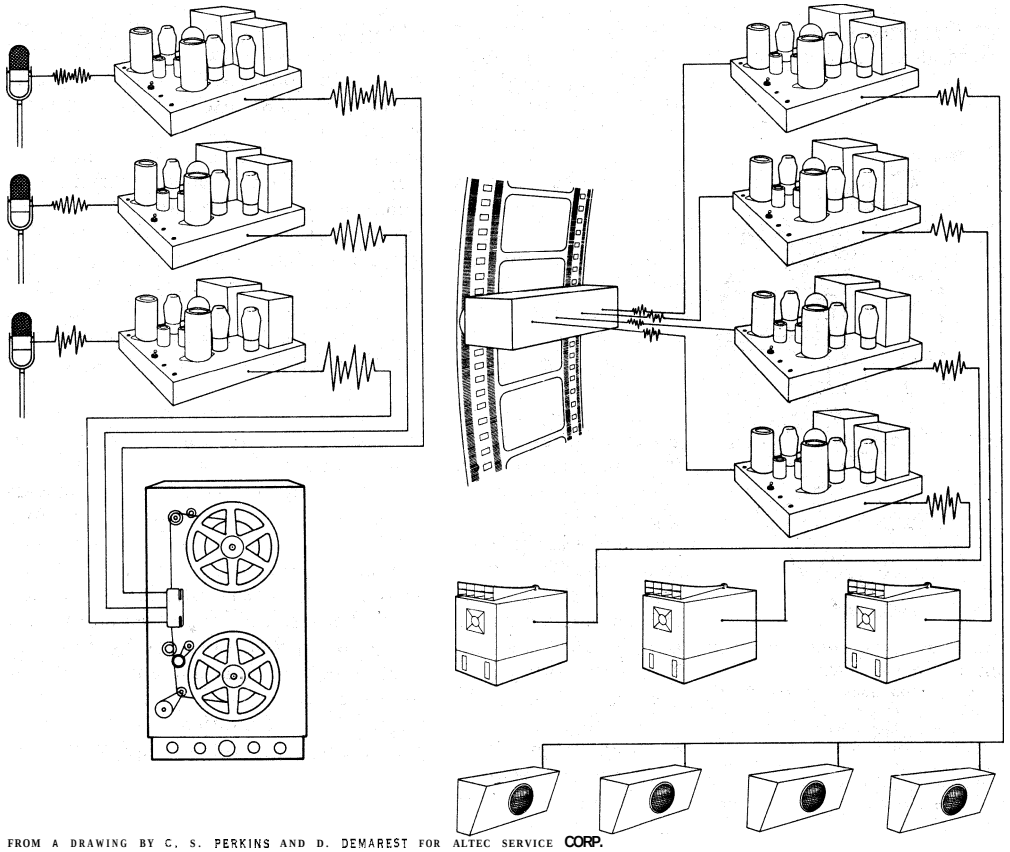
Many theatre installations represent substantial compromises apart from instances where theatres have been rebuilt for a road-show engagement, as from 1952 to 1956 by Cinerama or for Oklahoma, in the Todd-A0 wide-screen system. The first compromise is on width. Existing theatres, excluding the very large first-run theatres in metropolitan locations, usually do not have structural forms readily adaptable for a picture in the aspect ratio of less than about 2 to 1 without curtailing height. Many exhibitors do not wish to rebuild the front sections of auditoriums or to bring screens outside the proscenium area for architectural, economic or building code reasons. Even assuming an ideal theatre there is disagreement on whether all pictures should be shown on very wide screens. Many feel that for many subjects the audience should watch and not participate.

The type of wide screen of each system has an understandable influence on the subject prepared for use in that system and vice versa. Cinerama with the greatest screen curvature—largest aspect ratio and conveying the keenest sense of audience participation—was essentially confined in its first several features to travel subjects. CinemaScope, a single-projector wide-screen system, from its first production emphasized the use of colour and spectacle. When 3-D stereoscopic pictures reached the crest of a wave of popularity in 1953, stories tended toward those where tricks could be utilized. One reason the 3-D boom ended was that audiences grew tired of ducking arrows and stones—as well as of having their eyes strained from unsynchronized projection of the two images. Other factors were incorrect use of the camera and poor selection of material for 3-D features.

The motion-picture scientist and technician often have been required to do their best with the tools available. frequently improvising under the pressure of a release deadline. Often, for merchandising reasons, to provide what the trade calls a "gimmick," films made for one standard have been projected on various unrelated wide screens. In 1954, when cropping pictures was at its height and before the studios had changed camera framing lines, actors and actresses parading without legs and sometimes with heads chopped off were common occurrences in theatres that wanted a wide screen at any cost.

The key to success for any type of wide screen is light. The increase of screen area overtaxed the capabilities of the old 35-mm. film for sharp, bright images on screens approximately 50 ft. in uidth and wider. The possibilities of getting a larger clear picture depend on using film wider than 35 mm., using an anamorphic lens system (compression and expansion of the images). a combination of the two, or obtaining more light and less heat for projection.

Cinerama.—The most important milestone in screen history, technologically speaking, after the advent of sound in 1926 was the opening of Cinerama in New York city, Sept. 30, 1952. Its



FROM A DRAWING BY C. S. PERKINS AND D. DEMAREST FOR ALTEC SERVICE CORP.

FIG. 4.— MAGNETIC MULTIPLE TRACK OR STEREOPHONIC SOUND

Magnetic recording (left) picks up the output of three or more microphones and records the electrical energy by making changes in the magnetic flux of a band of iron oxide coated on a tape or film strip. There are separate amplifiers, gain controls and equalizers for each sound track. A number of sound tracks can be located on the same tape or film. For reproduction (right)— in this case from a CinemaScope composite print and four magnetically recorded sound tracks— the sound is picked up by a magnetic head, usually mounted in an attachment on the motion-picture projector, and amplified. For multichannel reproduction speakers are located at left, centre and right behind the screen. The sound of the fourth track may he fed to speakers spaced throughout the auditorium. The number of such speakers is determined by the shape and size of the theatre

success there and in various other U.S. cities and abroad touched off a pursuit, indeed a scramble, in Hollywood—and to a lesser extent in London and other film centres—for wide-screen systems.

The basic idea which eventually resulted in Cinerama came from a project of Ralph Walker, an architect commissioned to design an exhibit at the New York World's fair of 1939. Louis A. Bonn, vice-president of J. E. Brulatour, Inc. (after 1952 W. J. German, Inc.), suggested using multiple motion-picture projectors and recommended Fred Waller! an expert in photographic and special cinema effects, to engineer and develop such a process. Limited time prevented its development for the World's fair. but Walker, Waller, Bonn and others formed a company called the Vitarama corporation. Early experiments used a battery of eleven 16-mm. cameras and projectors. Waller believed that perception of depth depends on what he called "peripheral vision." He decided that the screen must be deeply curved to approximate the field of vision. Initial experiments were with a screen made from a spherical section, but Waller soon found that a curved screen caused objectionable reflections—side areas reflecting upon each other—resulting in a deterioration of the picture. To prevent this effect of reflected light, he developed a louver type of screen. During World War II the firm developed the Waller flexible gunnery trainer. a five-camera-projector model. Waller worked with Adm. Henry Martyn Baker, an expert in ballistics, and Robert Dresser: a consulting engineer, who helped with the sound and electronic requirements. Gen. Henry H. Arnold credited the 76 gunnery trainers delivered to the military services with saving the lives of thousands of Allied airmen.

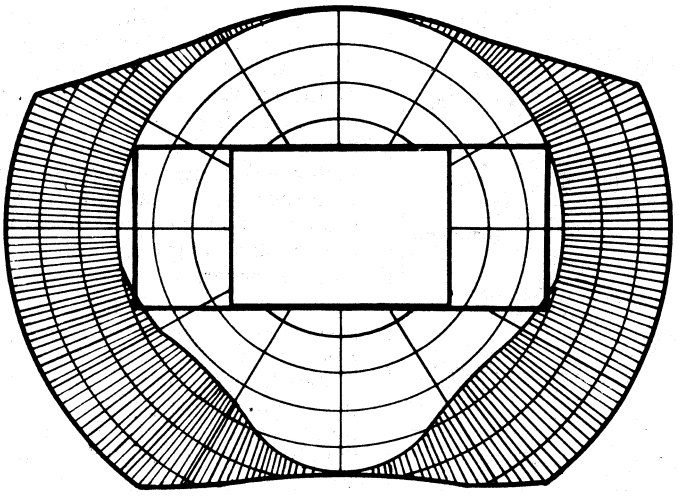
After the war, work was resumed on developing the multiple-camera-projector system for theatrical use. The original Cinerama company was formed with Laurance S. Rockefeller and Time. Inc., as the largest stockholders. Hazard E. Reeves, president of Reeves Sound studios, became associated in the project and was asked to develop the sound system. He suggested a multiple sound track system so that sound reproduction would be more realistic and thus in keeping with the realism of the picture. Work was carried on in one of the old Rockefeller stables on West 55th street. New York city; at the Reeves studios and on a converted indoor tennis court on an estate near Oyster Bay, L.I. Demonstration films were completed by the spring of 1949. Efforts to interest members of the theatrical motion-picture industry in the process were unsuccessful. In July 1950 the majority of the directors proposed liquidation of the company, and Reeves, who felt the process had a great future. acquired the physical assets of the development company for $1,500. He established a new Cinerama, Inc., and persuaded some friends and associates to invest in the project. Michael Todd. Lowell Thomas and a small group were licensed to make the first Cinerama show, *This* Is Cinerama.

Cinerama uses a camera equipped with three carefully matched lenses covering a field of about 146° as do the three projectors, as a group, thus maintaining perspective. Each of the three films is standard 35 mm. The Camera and projectors operate at 26 frames per second. 146 ft. per minute, instead of 24. Moreover, the height of each frame is increased by 50% as there are six perforations to the image instead of four. The camera aperture for each of the three film strips is 1.116 in. (28.35 mm.) high by 0.997 in. (25.32 mm.) wide. Each of the three projectors has an aperture 1.088 in. (27.64 mm.) high by 0.985 in. (25.02 mm.) wide. In the typical installation the screen has more than 1,000 vertical strips of perforated material and is curved to a maximum depth of about $17\frac{1}{2}$ ft. (fig. 6).

The public found Cinerama impressive not only to the sense of vision but also to the hearing. Cinerama was presented with the most highly developed sound system introduced up to its time. Magnetic stereophonic sound recording in motion pictures was presented for the first time. Reeves believed that theoretically there should be an infinite number of speakers behind the screen so that sound movement could coincide with picture movement. For practical purposes, five separate sound channels were established behind the screen. In addition. two channels were used to distribute sound to any part of the auditorium for special effects. Cinerama exhibitions from 1952 to 1956 were controlled by a special operator who regulated the sound level and adjusted picture brightness and focus at each performance.

Existing theatres had to be altered substantially to install Cinerama. In addition to the special sound installation, there were three special projection booths set up at a level which was no more than 5° out of alignment with the screen. These booths could be located at any distance from the screen provided correct alignment was made with the section of the screen covered by each projector. In some theatres these booths were installed on the main floor; in others in the mezzanine. The ideal Cinerama theatre was a one-floor unit in which the three booths were built into the rear and side walls of the theatre. The first Cinerama theatre was erected in Osaka, Jap. The best seats for a Cinerama show

were those near the crossover point of the three screens. Theoretically the peripheral vision effect was at a maximum at this point (fig. 6). Various attempts have been made to simplify the



JOSEPH GREENSPAN
FIG. 5.— THE FIELD OF VISION. WITH THE SHADED AREAS REPRESENTING THE PORTIONS SEEN BY THE LEFT AND RIGHT EYE RESPECTIVELY
Rectangles illustrate the traditional 1.33/1 screen proportions and the 2.5/1 wide screen introduced with CinemaScope in 1953. Arcs are drawn marking each 10° area of the field. Screens occupy a greater or lesser part of the field of vision depending on the location of the viewer. Screens outlined in the drawing are for the average favourite theatre seat—in the centre about two-thirds of the way back in the auditorium. Sitting up close to any screen may saturate the sense of vision. However, from the same viewing position the wide screen makes more use of peripheral vision

Cinerama system to make it suitable for more theatre installations. Cinerama, Inc., carried on developmental work although up to 1956 no substitute for its method of projection had been found. In 1955 National Theatres, Inc., announced a plan to develop a system called Cinemiracle, a wide-screen process similar to Cinerama. Three projectors in one centre booth instead of three separate booths were planned.

In 1956 the Radio Corporation of America contracted to develop for Cinemiracle a seven-track sound system using transistors instead of audio tubes.

Cinemascope.— The principle of anamorphic lenses and their proposed application to motion pictures dates back many decades before CinemaScope. Ernst Abbe of the Zeiss optical works in Germany described how a cylindrical anamorphoser should work. Detailed proposals were made in a British patent issued to P. Rudolph in 1898. Other patents were issued in the United States, Britain and elsewhere from that time on.

Henri Chrétien, a French optical scientist, described his anamorphic system at a meeting of the French Academy of Sciences. presided over by Louis Lumière, motion-picture pioneer. in Paris on May 30. 1927. In 1928 H. Sidney Newcomer, an American doctor in Paris for optical studies. became associated with Chrétien and tried to interest U.S. film companies in anamorphosers. Chrétien's lenses were demonstrated in New York in the early 1930s but interest in all wide-screen systems faded, principally on account of the current economic depression. Chretien's system was again shown at the Paris exposition of 1937.

Finally Spyros P. Skouras, president of 20th Century-Fox Film corporation, seeking a wide-screen system like Cinerama but practical for thousands of theatres—and also to recover audiences lost to home television—was introduced to Chrétien in Paris in 1952. A demonstration was given using one of the 20-year-old sets of lenses, and Skouras became enthusiastic.

The anamorphic lens system was acquired in 1953 by the 20th Century-Fox Film corporation and called CinemaScope. The Robe, the first feature in CinemaScope, was released in Sept. 1953. Before long the company decided to make all its pictures in the process. Other companies were invited to make pictures in CinemaScope by paying a royalty of $25,000 per picture or $75,000 per year for any number of films and also agreeing not to use the process on loiv-budget or black-and-white films. By 1956 theatres equipped to show CinemaScope films totalled 16.328 in the United States and Canada and 13.481 elsewhere in the world and included almost all first-run theatres.

CinemaScope is a system involving the use of anamorphic lenses at the camera and projector. The effect of an anamorphic lens system is to squeeze the picture in the horizontal plane at the camera and expand it to normal proportions in projection. Pictures made in such a system are similar to those seen in a "thin man" distorting mirror at a carnival—everything on the print looks excessively tall and very thin. CinemaScope pictures must always be projected through a cylindrical lens or a prism attached in front of the projector which expands the picture to a natural appearance.

An anamorphic lens system is particularly well adapted to wide-screen pictures because the expansion-compression process makes it possible for the camera to cover a wide angle without using a wide-angle lens, which is difficult to make and subject to various types of distortion. For CinemaScope a compression ratio of 2 to 1 was adopted, which means that. allowing space for the stereophonic sound tracks. a CinemaScope picture on the screen may have the aspect ratio of 2.55 to 1 (fig. 5). (The aspect ratio is greater than the compression-expansion ratio because the frame area on the film is wider than high in the 1.33 to 1 proportions set by Edison.) This is the widest ratio, exclusive of Cinerama, in commercial motion-picture use in the mid-1950s.

Assuming equal lens apertures, better definition can be achieved on large screens through the anamorphic process than without it when standard 35-mm. film is used. It is claimed that the anamorphoser increases depth of focus and thereby the sharpness of images, a claim subject to scientific debate. Although the increased sharpness exists only in one plane (because the compression is only one way), the sense of vision tends to get the impression of increased sharpness in the vertical as well as horizontal plane. An advantage of 35-mm. film such as CinemaScope in comparison with wide films (fig. 1) is that except for the anamorphic lenses at the camera and projector. most equipment is standard. Wide-gauge films require special manufacturing, camera, processing, editing and projecting equipment.

In France, the United States and elsewhere other optical systems

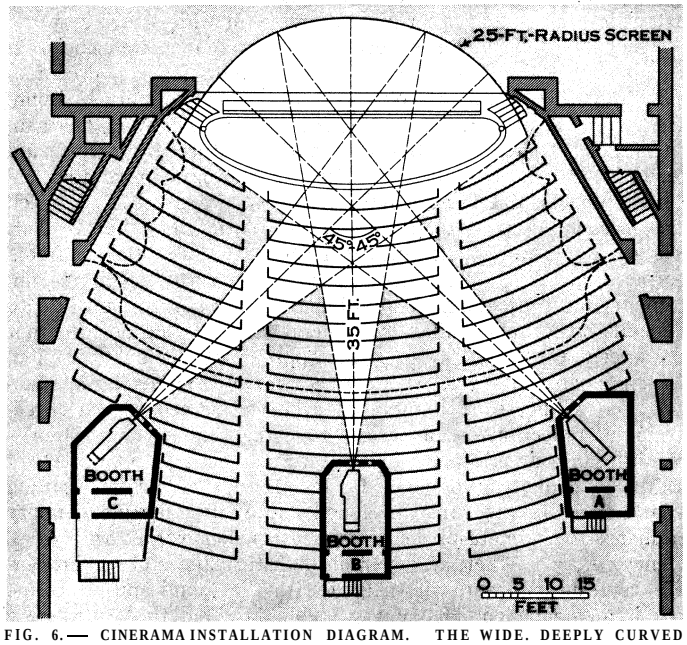


FIG. 6.— CINERAMA INSTALLATION DIAGRAM. THE WIDE. DEEPLY CURVED SCREEN IS COVERED BY THREE SEPARATE PROJECTORS. EACH PROJECTING A RELATIVELY NARROW PICTURE ON A SLIGHTLY CURVED SCREEN SECTION

compatible with CinemaScope were developed in 1954 and 1955. In 1954 one called Superscope, developed by Joseph S. and Irving Tushinsky. was introduced. In Superscope the squeezing is

done in the processing laboratory instead of at the camera. Projection is through CinemaScope lenses or prisms.

The wide screen of CinemaScope. especially in large theatres, requires a directional sound system. Earl Sponable, the technical director, and Lorin D. Grignon, a sound engineer of 20th Century-Fox, and others developed for CinemaScope a four-track magnetic sound system. In order to introduce the system theatres were not only required to install special magnetic sound pickup units on the projectors and the necessary amplifiers and speakers but also new sprockets in the projector mechanism. In order to make sufficient room on the 3j-mm. film for four sound tracks (three 0.063 in. [1.60 mm.] wide and one 0.041 in. [1.04 mm.] wide), it was necessary to specify smaller perforations. The standard optical track is 0.100 in. (2.54 mm.) wide. The smaller sprocket teeth can project satisfactorily films which have the regular perforations. Manufacturers discontinued making the larger sprocket teeth and eventually it is expected that the so-called "foxholes" will be standardized for all 3j-mm. films.

In the CinemaScope magnetic sound system the three main tracks supply sound to speakers located behind the left. centre and right sections of the screen. The fourth track is used for auditorium speakers or for special effects such as controlling volume or switching sound. For first engagements of *The Robe* the full stereophonic magnetic sound installation was required. Later the film and all subsequent CinemaScope productions were made available with an optical sound track. In the mid-1950s more than 3,600 theatres in the United States and Canada and 4.000 elsewhere had installed the CinemaScope magnetic three- or four-track system.

CinemaScope's great success came from the novelty of the wide-screen process. the excellent magnetic sound, the spectacular type of story material filmed in the process and the promotional campaign. The studios quickly learned how to compose scenes for the wide aspect ratio. Lenses were rapidly improved. Within two years after the first CinemaScope pictures it was difficult for any spectator to detect whether a film had originally been filmed in an anamorphic process or not, for distortion was entirely absent.

To introduce further refinements through the use of a large original negative, Fox in 1953 photographed *Carousel* with 55.625 film instead of 35 mm. (*see* fig. 1 for relative sizes). The camera aperture for the 55 62j film is 1.814 in. mide by 1.421 in. high. (The camera aperture for CinemaScope is somewhat larger than for regular 3j-mm. films—0.937 in. [23.80 mm.] by 0.735 in, [18 67 mm.].) Release of *Carousel* in 1956 was in 35 mm. CinemaScope prints made by a reduction process from the 55.625 negative. Other films in the process were to be shown in a few engagements with special projectors equipped to handle the 55 625 size. The 55.625 CinemaScope is recorded with six magnetic sound tracks plus a control track. The regular release is with four tracks. In 1956 about four films were to be made in the 55.625 mm. size. While regular CinemaScope requires only the anamorphic lens attachment on a 3j-mm. camera, the 55 62j mm, of course. requires a camera specially built to handle the wide film.

VistaVision.—One of the photographic facts of life is that defects in a negative become more pronounced as the size of any enlargement is increased. The same situation prevails with the projection of a motion-picture film on large screens. On the other hand a print made from a relatively large negative should be superior to a print from a small negative, all other things being equal.

VistaVision is the name of the motion-picture system developed by Paramount Pictures corporation which uses the larger negative method. In VistaVision standard 35-mm. film is passed horizontally—instead of vertically—through specially modified cameras. Each frame occupies the space of eight perforations instead of the four in conventional 3j-mm. practice (fig. 1). The result is to approximately double the negative area. For regular release VistaVision images are optically reduced, turned go° and printed in the standard fashion on 35-mm. film. By printing from a double-frame negative the VistaVision 3j-mm. image print is sharper than that obtained by direct contact from a standard 35-mm. negative. This increased definition is especially beneficial in theatres equipped with screens of moderate nidth. VistaVision advanced the film art by reducing the grain magnification factor.

Special horizontally running projectors were built by Century Projector corporation for Paramount and by the mid-1950s had been used in about a dozen theatres in the United States, one each in London. Paris and Toronto. The first exhibition with the double-frame projector using a direct contact print of the large size VistaVision negative was at the Radio City Music hall in New York city in Oct. 1954.

Loren L. Ryder, director of engineering of Paramount, developed the VistaVision method. The first use of a horizontally running 35-mm. camera system using 3j-mm. film was by Edison in his first camera. VistaVision. coming six decades later. was the first successful commercial application of this method.

One of the advantages of the VistaVision method of photography and processing is that for most theatres no change in equipment is required to show such pictures. After being reduced from the large negative. VistaVision films are handled on standard editing and processing equipment. While no special equipment is needed to manufacture or develop VistaVision negatives, both studio and portable cameras have to be specially made. Also, background projectors for special effects have been built to handle the horizontally running double-frame prints.

In 1953 Paramount decided to film all its pictures in VistaVision. A similar decision was made by the J. Arthur Rank organization in Britain in 19jj. VistaVision cameras were also in use by 1956 in Italy and elsewhere. The VistaVision camera aperture is 1.485 in. (37.72 mm.) by 0.0991 in. (25.17 mm). The standard frame projector aperture is 1.418 in. (36.01 mm.) by 0.722j in. (18.35 mm.); double-frame projector aperture—1.3665 in. (34.71 mm.) by 0 7225 in. (18.3j mm.). In the horizontal double-frame projection the speed is twice normal—180 ft. per minute. VistaVision films, both standard and horizontal double frame, use an optical sound track (Perspect-.\-Sound). When suitable equipment is available this single optical sound track may be spread through three sets of speakers located behind the screen to give directional effects. The quality of the sound reproduced on the double-frame system is superior to standard optical sound because the doubled speed gives a better sound track.

Other Wide-Film Systems.—In 1953, after Michael Todd parted company with his associates in Cinerama, he set about finding a one-camera wide-angle system that would approach the effects achieved by Cinerama's three-camera setup. At the U.S. navy Special Devices centre at Sands Point, L.I., he was shown a one-projector flexible gunnery trainer which was completed too late to be of use during World War II and had been declassified and was supposed to be generally available under U.S. government patents because the advent of the jet age had rendered obsolete most applications of manual gunnery. Todd sought out Brian O'Brien, optical scientist. who had worked on the navy project and subsequently had become vice-president in charge of research and development with the American Optical company. Todd-AO corporation was formed to develop a wide-screen single-camera single-projector system. The first film in the process. Richard Rodgers and Oscar Hammerstein's famed stage musical *Oklahoma!* opened at the Rivoli theatre, New York city, in Oct. 1955.

The specifications for Todd-AO film are: 6j-mm. film (fig. 1); aspect screen ratio 2 to 1; camera aperture 0.906 in. (23.01 mm.) high by 2.072 in. (52.6 mm.) wide; the speed is 30 frames per second in contrast with the usual standard of 24; composite release prints including the seven sound tracks are on 70-mm. film. The camera for Todd-A0 pictures has a three-blade shutter with a maximum opening of 170°. Exposure time at the 30 frames per second speed at 170° is 1/60 sec. Projectors capable of handling the 6j- and 70-mm. film and also 3j-mm. were built by Philips industries in Eindhoven, Neth. The sound system for *Oklahoma!* like that of Cinerama has seven magnetic tracks. In 1956 the second film in the Todd-AO process, *Around the World in 80 Days*, produced independently by Todd. was completed.

Another 6j-mm. film system with somewhat different characteristics is MGM Panavision, a combination wide-film and anamor-

phic system. The squeeze is applied partially at the camera and partially in the laboratory in a specially designed optical printer. The system was developed by Robert Gottschalk, president of Panavision, Inc., and Douglas Shearer, director of sound recording at Metro-Goldwyn-Mayer studios, and their staffs.

Double-frame VistaVision, 55.62j-mm. CinemaScope, 65-mm. Todd-A0 and 65-mm. Panavision are all systems which may be exhibited in road show or special engagements in a relatively limited number of theatres. Each of them, however, has provision for making 35-mm. prints, which most theatres require. Within certain limits negatives made in any of the special processes can be printed in dimensions compatible with those made in the other special systems, so that, if one or the other of these special big-negative methods prevails, motion pictures made in the others will not lose value but can be released in the system ultimately favoured by exhibitors and the public.

Exhibition. — The end to which all motion-picture technology is directed is exhibition. Motion pictures of whatever kind— amateur, industrial, commercial or entertainment — are intended to be viewed by numbers of spectators in various locations or at various times in one location. Exhibition may be in a home, with a picture projected in 8 mm. or 16 mm. or received over a television set, or the exhibition may be in a theatre or other auditorium equipped to handle standard 35-mm. or wider film. The type of exhibition location fixes the upper limits of quality attainable. Both economics and available viewing distances dictate that motion pictures directly viewed in the home or received via television must be seen on relatively small screens. Popular screen sizes for home movies are 20 in. by 30 in. or 30 in. by 40 in. While the size of television screens increased from 9 in. in the mid-1940s to 24 in. (measured as a diagonal) in the mid-1950s, it was not known when many homes would have television screens comparable in size to those of home moving pictures.

Moving pictures shown in the home may be silent or sound. Sound movies are presented with sound of fair quality in the home. Television from the beginning enjoyed the advantages of the high quality of FM (frequency modulation) sound. However, a full range of sound possible in a theatre, as well as stereophonic directional sound, is generally not practical in the home.

The heart of the exhibition system is the projector, a mechanical device for intermittently passing a motion-picture print before a strong light source and focusing the images on a screen. While projector design has been subject to many minor improvements, fundamentals of projectors in current use differ little from those in the days of Edison. Paul and Lumière. Various types of continuous-action projectors have been suggested, but they have been found practical only for special purposes including some television film projector models.

In regular theatre or home practice projectors operate with an intermittent movement. The usual intermittent is the so-called Geneva or Maltese cross movement. A rotating cam engages, successively, the arms of a four-pointed cross. Every motion-picture projector includes a shutter device to cut off the light from the screen during the time of film movement. In order to eliminate flicker, the period of light on the screen is also interrupted once or twice, depending on whether the shutter is of the two- or three-blade type.

One of the great problems in exhibition, aggravated by the increase in the size of screens, is that of light. The carbon arc, a powerful light source, has long been the standard. Carbon arcs are costly to operate at high amperages. Also carbon arcs, like other light sources, not only produce light but heat. The latter is an enemy of good projection. If the heat is too great the film will buckle or even burn. By the mid-1950s various devices had been introduced to cut down the amount of heat reaching the film from a carbon arc. In 1955 xenon projection lamps first were manufactured on a commercial basis in Germany and offered some promise for smaller theatres as a light source instead of the traditional carbon arc.

Although in pioneer days the screen was any handy white sheet or even a blank wall, large-screen systems required many refinements and improvements in screens. Until the interest in wide screens and in 3-D, dating from 1953, the diffusive screen provided good light distribution. Screen manufacturers were stimulated by the necessity of providing screens for 3-D pictures that did not change the polarization of light and that also would reflect the maximum light to the spectators. Drive-in theatres, using screens as large as 50 by 120 ft., required improvements in screen surfaces as well as more powerful, cooler light sources.

Technology's role is to give the exhibitor of motion pictures—. the theatre or television station or other user of film—the best instrument possible for the purpose in view. Progress through the years in this connection has been substantial.

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VII. EXHIBITION AND DISTRIBUTION

Early History. — On April 14, 1894, Thomas Edison's newest invention was first shown to the public at a phonograph parlor located at 115j Broadway in New York city. A spectator dropped a coin in a slot and glued his eye to a small peephole. He could see such animated objects as two men boxing, a girl dancing or a baby being bathed. Despite the primitive nature and quality of these earliest subjects they created a sensation and the kinetoscope almost immediately became the major attraction in the penny arcades of the larger American cities. The front doors and windows of storerooms were removed so as to afford greater visibility and easier access. Blaring music boxes, garish posters and leather-lunged barkers called the attention of passers-by to the extraordinary attractions on display. Thus at the outset of its career the picture industry identified itself with the circus tradition of superlative and sensational advertising to. which it has since consistently adhered.

Since only one person could look at a peep show at a time, ambitious arcade proprietors realized that profits would be substantially increased if the kinetoscope could be combined with a magic lantern so that pictures might be projected on a large screen. Thomas Armat discovered the basic principle of the modern'projector with its intermittent movement. and Edison consented to sell it under the name of the Edison Vitascope. Its world *première* on April *23,* 1896, at Koster and Bial's music hall in New York city constitutes a landmark in the history of motion-picture exhibition. When the waves of Dover were first seen dashing against the British coast, patrons in the front rows instinctively ducked, exactly as they reacted 56 years later to the first showing by Cinerama of the Coney Island roller coaster. The pictures exhibited, according to the *New York Times,* "were wonderfully real and singularly exhilarating" and the Edison organization and a few imitators were promptly inundated with orders from vaudeville theatres from all parts of the United States.

The use of movies as an adjunct to vaudeville was greatly accelerated by the actors' strike of 1900. In order to keep their theatres open, many vaudeville managers presented programs consisting solely of vitascope subjects. To their surprise these shows were well attended. In this fashion the early "living pictures" became known to theatre audiences in all important American cities long before they became equally well established in England or on the European continent.

The heads of vaudeville, however, lacked the imagination to grasp the vast potentialities inherent in the new device. As soon as the strike was over they relegated the vitascope to the humble position of a "chaser" designed to empty the theatre for the next performance. The active exploitation of the medium fell to the penny arcade proprietors, many of them drifters from carnivals, county fairs and medicine shows with the sole interest in making a "quick buck" out of what they. like Edison, regarded as a passing fad. A few enterprising young men, largely from New York's lower east side, rather than leaders in the world of

commerce, arts or entertainment, first recognized the possible impact of moving pictures on the American scene, and had the courage to stake their future on that vision. Such men as Adolph Zukor, Marcus Loew and William Fox relinquished hard-won footholds in the fur and garment business and through their energy, business acumen and instinctive showmanship became the leaders of the new industry in its unprecedentedly rapid expansion.

They and their competitors purchased projection machines discarded by vaudeville theatres, partitioned off the rear of their arcades, equipped them with 50 to 200 chairs (frequently borrowed from a neighbouring undertaker), hung a rudimentary screen on the wall and pasted enough film together to provide a show running anywhere from 1j minutes to a half hour. The low admission price of ten cents threatened at first to prove a boomerang. The public: conditioned by Barnum and other circus proprietors to exaggerated ballyhoo, was skeptical as to what, if anything, it would see for a dime in a dark rear room. To set their minds at rest, Thomas Tally, a former cowboy who had promptly sold his horse when he saw his first motion picture. cut a hole through the partition in his Los Angeles arcade which permitted prospective customers to catch a brief but intriguing glimpse of animated figures on an illuminated screen. This practice was widely copied by other exhibitors and in a short time public comment was so favourable that the manufacturers of film and equipment could not keep pace with the demand for their products.

The New Audience.— Up to the advent of motion pictures only 10% to 20% of the U.S. public, at best, had any first-hand acquaintance with theatrical entertainment. The price of admission for the spoken drama or musical comedies, even for burlesque, vaudeville and minstrel shows, put them beyond the reach of the working classes. Many in the middle income brackets who could have occasionally attended were restrained by the disapproval of some religious denominations, the scarcity of road attractions and the unwillingness of producers to cater to what they regarded as the low taste of the masses. The ten-cent theatre, located in the congested city areas, tapped a vast new audience, itself only dimly aware of its hunger for dramatic entertainment. The low admission price and the even lower demand on literacy made these first motion pictures particularly appropriate for children and for the immigrants who were pouring into the United States in the early 1900s. The captions, as subtitles were then called, proved an ideal way of learning English. Respectable citizens and sophisticates looked down their noses at the "movies," as motion pictures came to be called in the United States, but the common people loved and patronized them from the outset.

The subjects most appealing to this audience were humble people like themselves—workingmen. housewives, farmers, the poor and the inconsequential. The primitive action scenes of the peep shows were replaced by short skits, with themes indicating the proletarian sympathies and the theatrical naïveté of the onlookers. What could be better entertainment than comic cops unsuccessfully chasing a tramp or the unexpected arrival of a wife in her philandering husband's office just as he is about to kiss his secretary?

Moreover with the rapid improvement in picture making and exhibiting techniques it was soon possible to promptly display current news events such as President McKinley's inauguration and the Spanish-American War. The early pictures, in spite of their crudities, reflected the interests and activities of their patrons and helped to mould their opinions and their way of life.

So great mas their appeal that in 1902 Thomas Tally once again led the procession by discarding all other forms of amusement in his arcade and transforming the entire store into a theatre auditorium. Other exhibitors followed his example, but the transition on a national scale to exclusive movie houses did not occur until 190j when John P. Harris and Harry Davis remodelled a storeroom in McKeesport, Pa., recessed the front, purchased a Lumière cinematograph and equipped the auditorium with 92 seats and a piano so that musical accompaniments to the screen attractions could be played. They opened with Edwin S. Porter's *The Great Train Robbery* which, although it was not. as frequently claimed, the first American narrative picture, was certainly the first to clearly establish the storytelling capacity of the cinema. A continuous show ran from 8 A.M. until midnight and to publicize the fact that the price was only five cents the theatre was called a "nickelodeon."

The catchy name, the low admission price and the popularity of the opening feature proved so compelling that nithin four years there were at least 8,000 nickelodeons stretching from one end of the U.S. to the other. Eager entrepreneurs from all walks of life, with little or no experience or capital, remodelled empty stores with sidewalk box offices. small lobbies and flamboyant advertising displays. Very often the nickelodeons were family businesses with fathers running and repairing the projector, mothers and daughters taking tickets and sons ushering the patrons and trying to maintain a reasonable degree of order. Popcorn, peanuts and candy were hawked up and down the aisles and music publishers furnished song pluggers to sing popular tunes in which the audience was urged to join. There were illuminated slides reading "You Would Sot Spit On The Floor At Home. Do Not Do It Here," or "Ladies, We Like Your Hats. But Please Remove Them." There were as yet no carpeted floors, upholstered chairs, crystal chandeliers, sanitary rest rooms, symphonic orchestras or uniformed ushers. but the prototype of the modern motion-picture theatre was now established.

Difficult Days.—Further development was impeded, although never brought to a standstill, by forces both without and within the industry. Such opposites as saloons and churches found their attendance affected by the competition of the nickelodeons and sought to discredit them in the public esteem. The *Chzcago* Tribune declared "there is no voice to defend the five cent theatre . . . its influence is wholly vicious." Jane Addams, the famous social worker, however, raised her voice to reply that motion pictures "rightly conducted are a benefit and not a menace to the poorer classes," while the People's institute maintained that the much maligned "poor man's show" might well prove his university.

Meantime the Motion Picture Patents company, consisting of the ten producing companies authorized to use the original Edison patents and fortified by additional patents of their own, sought to establish a movie monopoly. All theatres were classified and assessed a fixed rental for film service. In addition they were charged a $2 weekly licence fee and restricted to the use of film and projection equipment manufactured by members of the trust. Seeking to establish "regularity and stability" in the business. the combine, which sold film by the foot rather than on the basis of quality, fought to prevent the development of the star system. At first the businessmen, lawyers and engineers who headed it insisted that one-reel subjects, and subsequently that two reelers, were all that the low mentality of movie-goers could comprehend. Like many of their successors, these early production heads underestimated the intelligence of their audiences. They also underestimated their willingness to pay for improved entertainment. At first a nickel, later raised to a dime, was ruled the maximum admission that could be charged.

In Europe, however, where Edison for reasons of economy had neglected to patent his invention, producers. unhampered by such shortsighted restrictions. were already turning out pictures running five to ten reels. Their appeal was directed to a smaller but more adult and theatrewise audience and admission prices approximated those prevailing in variety houses and music halls. Quo *Vadis,* a spectacular Italian feature. nine reels in length, was imported by George Kleine and opened at the Astor theatre, April 21, 1913, at a $1 admission. The engagement proved so profitable that by the middle of the summer 22 road shows were exhibiting the picture throughout the U.S. and Canada. Adolph Zukor, nho had the previous year defied the trust by importing the four-reel *Queen Elizabeth,* starring Sarah Bernhardt, decided that the time was ripe for equally ambitious American projects. We organized his own company. Famous Players, designed to bring to the screen distinguished plays or books, acted by well-known Broadway performers in features running an hour or even longer.

As the quality of pictures improved and their length increased, above all as the public adulation for such stars as Mary Pickford, John Bunny and Tom Mix swept the nation, the nickelodeon, with

its limited seating capacity and low admission price, rapidly became obsolete. By 1910 there were probably at least 10,000,000 movie "fans" in the U.S. First-run houses began to charge 1j to 20 cents and altered their daily change policy to one which held pictures over for two or three days. Pipe organs replaced pianos and theatres became cleaner as well as more comfortable. In April 1914 Mitchell Mark opened the Strand in New Pork city with 3,300 seats and an orchestra of 30 pieces. His *première* attraction. *The Spoilers,* played to almost 40,000 people in one week, creating another milestone in the history of motion-picture exhibition. Simultaneously *The Birth* of *a Nation* was sweeping the country, Many theatres charged as much as $2 admission to the D. W. Griffith 1-7-reel epic which was estimated to have earned, between 1915 and 1929, $18,000,000. It aroused in many quarters denunciation for its favourable portrayal of the Ku Klux Klan and almost universal praise for its artistic and technical excellence.

The 1920s and 1930s.—Obviously the days when the movies catered primarily to working men and women had come to an end. The younger generation of the middle and well-to-do classes became the mainstay of motion-picture attendance, dictating profound changes both in the operation of theatres and in the nature and ideology of the films which they presented. This younger generation in the years following World War I was generating vast changes in the social and economic tempo of American life. Arined with hip flasks, short skirts and a lack of reverence for the established mores. so-called "flaming youth" revolted against what they regarded as the inhibited, unexciting lives of their parents. They demanded greater freedom of speech and sex relations. Pictures reflected and, in the process, intensified their preoccupation with cars, petting parties and new dances like the Charleston. The public, old as well as young. wanted to see how the wealthy lived, dressed and misbehaved and skilful directors such as Cecil B. de Mille helped to educate an entire nation in boudoirs. lingerie and riotous living. The worship of the stars reached delirious proportions. Theda Bara was succeeded by a bevy of seductive ladies—Pola Negri, Gloria Swanson, Clara Bow, Mae Murray and many more. The males who, to the delight of feminine audiences, eventually mastered such charmers included Douglas Fairbanks, John Gilbert and, most irresistible of all, Rudolph Valentino. Some of these public idols survived the coming of sound in 1927, and some were replaced by younger performers with better diction or larynges. The movies themselves. however, although temporarily threatened by the rise of radio in the early 1920s, swept on to ever-increasing popularity. Even the depression of 1929 failed to affect the box office until 1932. As long as the average American family had any available spending money it regarded picture going as a necessity rather than a luxury.

So vast and luxury-loving a public required theatres as elaborate and pretentious as the pictures it patronized. "Cathedrals of the cinema," as they were called, were erected downtown in all important U.S. cities and subsequently in the neighbourhoods and suburbs. Never before had the average patron encountered anything to rival the opulence of their lobbies and auditoriums or the comfort of their cooling plants. rest rooms and meticulous service. The Roxy theatre, for instance; which opened in 1927 in New York city, with a 6.250 seating capacity, cost $8,000,000 and grossed in one week $144.267.

The entertainment in these motion-picture palaces was not confined to a feature picture. newsreel and short subjects. In addition there were elaborate "presentations" consisting of dancing, singing and vaudeville acts, and utilizing many of the country's best-known performers and name bands. Smaller theatres—any with fewer than 1,500 seats soon became regarded as small—made up for the absence of presentations by offering double features. If quality was lacking, exhibitors were determined to compensate for it with quantity. This unfortunate practice became prevalent and remains so in at least 70% of the movie theatres of the U.S. Where double features proved inadequate to attract business recourse was had to dish nights, bingo parties: lotteries and contests of every variety.

Major companies such as Paramount, Fox and Warner sought to control playing time by acquiring the ownership of large theatre circuits; pictures were sold in groups rather than individually (block booking): films were rented prior to their being screened for exhibitors (blind bu ing); and excessive clearance between the first and subsequent showing of films (protection) was required. After twelve years of litigation these and other trade practices were in 1950 declared in restraint of trade and ordered discontinued and the producers were instructed to divest themselves of their theatre properties.

Effect of Television.—In the meantime, however, the rise of television was creating havoc with motion-picture patronage. Weekly attendance in U.S. theatres declined from a probably overestimated 90,000,000 in 1947 to a possibly underestimated 35,000,000 in 1956. Gross receipts fell in the same years from an all-time record high of $1,565,000,000 to $1,185,100,000 in 1955. In 1945 there had been 20,355 movie houses. By 195j they had dwindled to 14.613. Actual seating capacity, however, had probably increased through the construction of 4,587 drive-in theatres, which, through their automatic elimination of the baby-sitter and parking problems, rose so rapidly in popularity that they accounted for close to 25% of movie attendance.

The world-ride investment in motion-picture theatres in the mid-1950s was believed to be at least $7,000,000,000, of which $2,555,000,000 was in the United States. A large share of the receipts of most U.S. theatres, rising to considerably more than 40% in drive-ins, came from the sales of concessions such as candy. popcorn and soft drinks. Estimated concession sales in U.S. theatres in 1954 amounted to $510,000,000.

To meet the threat of television's free home entertainment, movie producers in the 1950s introduced a large variety of wide-screen, third-dimensional processes, such as Cinerama. CinemaScope. VistaVision and Todd-AO. Among these. CinemaScope expanded with far the greatest rapidity. By the mid-1950s it had been installed in about 30.000 theatres throughout the world.

All of the new processes were best adapted to elaborate spectacular productions. Some, such as *The* Robe, *White Christmas* and *This Is Cinerama,* achieved fabulous box-office grosses. With a few exceptions, such as *Marty,* however, admissions on B pictures and even average A's steadily shrank. By the mid-1950s the previously prevalent habit of almost automatic, nonselective weekly movie attendance had disappeared. As *Variety,* the industry trade journal. phrased it. pictures were either "boffo or busto." More cultured commentators maintained that a steady diet of formula films and stereotyped productions rather than television had alienated all except the most adolescent. and undiscriminating public. Hollywood, however, continued to place its major reliance on strictly escapist, supercolossal attractions calculated to appeal to a large mass audience, not only in the U.S. but in other countries. from which 49% of its revenue was derived. The number of pictures produced annually was drastically reduced by almost half to approximately 325, but so large a proportion of these were mammoth westerns, historical and biblical pageants and elaborate musicals with negatives costing anywhere from $2,000,000 to $5,000,000 that budget outlays exceeded all previous records. These increased costs were reflected in higher film rentals. longer runs and the necessity for theatres large enough and high scaled enough to profitably show such so-called "epic" attractions.

This tendency ran counter to the development of smaller and more intimate theatres which had occurred in the early 1950s. About 500 of these less imposing but frequently better designed houses specialized in the showing of English, foreign language and unusual American pictures. They mere located in the 70 larger cities and in college communities and catered primarily to audiences seeking more adult fare than was usually furnished in the strictly commercial theatres. Although in the mid-1950s they contained less than 3% of the total number of theatre seats in the U.S., they served as a disproportionately effective catalytic agent on public taste and the aspirations of Hollywood's more creative artists and technicians. (A. L. MR.)

VIII. ART OF THE MOTION PICTURE

The motion picture, said Terry Ramsaye, recreates events more faithfully than other mediums. In fact, it reproduces their visual

and aural manifestations. All previously known mediums of expression, whether literary or graphic, had to rely in great part on devices such as suggestion, exaggeration, omission—on an increasingly conscious and deliberate exploitation of the apparent disadvantages of any given medium. Thus it came about, through long aesthetic custom, that a medium is defined and even judged as much in terms of its limitations as of its assets. For such reasons as these) the first aesthetic view of the motion picture was that it was a reproductive machine the utility of which to art was principally to be that of recording artistic performances in one or another of the older mediums. Its chief disadvantage at the beginning, silence. was looked upon as a mechanical defect of reproduction rather than a "limitation" which might be exploited for artistic purposes.

In practice, it soon proved otherwise. The pioneer film makers, notably D W. Griffith, early discovered that to record a stage drama on film in silence was not in any sense to reproduce its artistic qualities. Some substitute for the lacking voice had to be found. Trying to express all dramatic and narrative values visually: the pioneers began to anatomize each scene into all its visual components and, in photographing each visual segment, to place the camera at exactly that distance from the action which would be, optically and psychologically, most satisfying to the spectator. The unit of construction of the film thus became the "shot" rather than the scene, as in the theatre, and editing became the master act of composition.

By 1916 it had become evident to such various early observers as Vachel Lindsay, Guillaume Apollinaire, Iris Barry, Gilbert Seldes and Hugo Münsterberg that this method of approach to visual material had resulted in what was apparently a new aesthetic, rather than reproductive, medium. The dynamic relationship between three kinds of movement—movement of material on the screen. movement of the camera toward or away from the action and the movement created by the passage of successive shots across the screen—produced an aesthetic pleasure distinct from and often independent of what the narrative might be saying. In the Soviet Union during the 1920s such film makers as S. M. Eisenstein found in the editorial methods of the "American school" the basis of an aesthetic theory of the motion picture. Their contention was that two or more shots, representing distinct ideas and not necessarily related in space and time, when placed side by side "would explode into" a new, third concept. Eisenstein resorted to the analogy of Chinese ideographs; he cited particularly the ideograph for "to weep," which is composed of the ideographs for "eye" and "water." This "montage" theory of screen expression was modelled, after a fashion, on the epistemology of Marxism. Film construction was to consist of confronting a thesis with its antithesis, out of which a new synthesis would automatically arise. This theoretical pattern, which had the virtue of simplicity, was considerably blurred by the addition of sound to the screen. The Soviet theorists contended that sound of all kinds constituted a fourth "movement factor" which should be used in counterpoint to the earlier three, movement of material, camera movement and editorial movement. Attempts to use it thus freely resulted more often than not in narrati e confusion, and the theory of "contrapuntal sound," still officially held by the mid-1950s, was more honoured in the breach than in the observance.

All these American and Soviet theories and experiments were based on the postulate that the motion picture. while inherently independent of the older mediums. was still a species of narrative or dramatic art. An entirely different school of thinking about the motion picture, begun in 1913 by the painter Léopold Survage, tended to consider the film as belonging to the province of graphic arts. This tendency on the one hand produced the animated cartoon and on the other successive waves of avant-garde films in France. Germany and the U.S in particular. These latter, mostly made by poets or painters working in isolation from one another and from the commercial market, have tended to repeat themselves. Many were animated abstractions. Others utilized scenes from nature and to a degree based their editing patterns on the American and Soviet discoveries about film construction. Even in so doing, they often suggested paintings in motion. Their debt to Surrealist painting was underscored in their recurrent use of the symbology of psychoanalysis. Debate has been intense as to whether this use of the motion picture constitutes its most original employment or whether in fact such a use again reduces the camera to the status of a reproductive engine.

Such debate calls in question the nature of photography itself. This basic tool of the motion picture has received scant attention in film theory. Robert Flaherty, "father of the documentary film," relied principally upon this tool in his portraits of the life and culture of the Eskimos, Polynesians and other primitive societies. Instead of staging action for the camera, he used the camera as an exploratory observer, a preternatural eye which fixes and gives meaning to much that the human eye passes over or fails to notice. His production method was to shoot a rough version of his film, examine the results and then largely reshoot, basing the final version on what the first had shown him of his subject. The success of his method in penetrating to the essential facts of primitive cultures inspired John Grierson and others to try the same method in bringing to life on the screen the "drama of the doorstep," that of industrial society. It cannot be said that these makers of documentary films about civilized society have to date entirely succeeded in their purpose. In part this may be due to the complexity and shapelessness of contemporary society, as opposed to the simple, closely integrated cultures with which Flaherty was preoccupied. In part it may derive from the difficulty of placing nonactors in situations which require of them, if not professional acting, at least a kind of directed behaviour not really comparable to Flaherty's primitives, who were asked to do for the camera only what they did every day of their lives. The difficulty is well illustrated in the work of the latest heirs of the Flaherty tradition, the Italian neorealist film makers, who though they try to observe from life have resorted to the compromise of postsynchronizing dialogue spoken by professional actors over the lip movements of the nonprofessional players seen on the screen. In spite of all these problems, the "film of life" still seems likely to provide the most fruitful field of exploration, if the object of exploration is some knowledge of the nature of this photographic medium.

Such knowledge is now almost entirely lacking. No theory of the sound film so far advanced covers the known facts as satisfactorily as preceding theories of silent film composition. The place of dialogue has never been accurately defined. The perceptual and kinaesthetic effects of motion pictures have received little or no scientific attention. Most films, of all types, are as hybrid as opera.

The film is the most expensive of all the mediums, and research has seldom been entered upon for its own sake. Experiment has been made to meet specific isolated conditions, as instanced by the introduction of the wide-screen techniques, which raised for the first time in unequivocal terms the question whether the spectator is to feel he is an observer of or a participant in the action (see *Motion-Picture Technology* above). As much as the makers of entertainment films have been Influenced by the demands of the commercial market, so much have the makers of documentary films had to serve propagandist or instructional ends which forced upon them many premature formal solutions. Most film makers would agree that the resources and powers of the medium. considered independently of subject, market or purpose, have yet to be systematically explored, and that the specialized effects obtainable on the small screens of television and the giant screens of today's theatres are not immediately central to the problem.

Having said all this, everyone knons that the motion picture provides a unique human experience. Whatever the psychological and perceptual reasons. the intensity with which it drans the spectator into a created norld leaves him, at its end, suspended betaeen two worlds. The sensation is that of a sleeper wakened. The screen shows human life as Henry James, in *The Sense of the Past*, suggested that it might be seen, as a river, not viewed from a single vantage point on the bank, but surveyed from above in all its endlessness All that is shonn on the screen belongs to the past; it was photographed weeks or months or years ago. But it is presented alive before us. None of the tenses fit screen action. Through it, man first recaptured the past, not as remembered or

as recreated in print or on canvas, but some segment of it as it actually looked and sounded. Descendant of the magic carpet, the motion picture is also perhaps ancestor of the time machine.

(R. GH.)

IX. ANIMATED CARTOONS

The history of the animated cartoon dates back beyond that of the motion picture itself. In 1831 the first efforts were made to show motion pictorially with a device called the phenakistoscope, invented by Joseph Antoine Plateau. The device consisted of two disks mounted on a shaft. One disk carried the drawings, which were viewed through slits around the outer edge of the other. This device was followed by the daedaleum or "wheel of life," invented in 1834 by William George Horner in England and introduced into the United States in 1867.

The first U.S. animated cartoon actually drawn for motion-picture film was made in 1906 by J. Stuart Blackton for the Vitagraph company and was titled *Humorous Phases of Funny Faces.* The next, *Little Nemo,* which appeared in 1909, was one of a series produced by Winsor McCay for Vitagraph. It began a practice which became widespread of adapting newspaper comic strips for films. McCay conducted tours over vaudeville circuits using his cartoons. Certain animation processes were patented by J. R. Bray in 1913. Another cartoon series came into being that year. *Old Doc Yak,* created by Sidney Smith. Also in 1913, Bray started his *Col. Heeza Liar* series, the first to be commercially released through movie theatres. Earl Hurd. producer of the *Bobby Bump* series, and Bray combined their patents in 1914. Their chief competitors were Wallace Carlson with his *Dreamy Dubb* series; Paul Terry, who was making *Farmer Al Falfa;* and the Bud Fisher Films corporation, which produced *Mutt and Jeff,* released by the Fox Film corporation. Considerable improvement was made by the International Feature syndicate in 1917 and 1918. It issued such cartoons as *Jerry on the Job, Katzenjammer Kids, Bringing Up Fatlzer, Happy Hooligan, Krazy Kat* and *Silk Hut Harry.* Other animated cartoons of this period were *Terry Cartoon Burlesque,* released by the Kay company, and the *Zippy* cartoons of Sterling Pictures. In 1917 Max Fleischer introduced the first picture combining actual photography with a cartoon character, in his *Out of the Inkwell* series.

Walt **Disney.**—Walt Disney first began making animated cartoons in Hollywood in 1923, one series based on *Alice In Wonderland* and another on *Oswald the Rabbit.* Disney produced the first animated sound cartoon, *Steamboat Willie,* in 1928, starring his world-famous character Mickey Mouse. Disney's first colour cartoon! *Flowers and Trees,* was released in 1932. To him goes the credit for the first feature-length animated cartoon, *Snow White and the Seven Dwarfs* (1938). This cartoon, four years in the making, consisted of approximately 477,000 photographed drawings, and was translated into 13 foreign languages.

After World War II the animated cartoon extended its scope in such diverse ways as the abstract work of Norman McLaren in *The Loon's Necklace* and of Mary Ellen Bute in *Color Rhapsodie* and *Polka Graph;* and the popular *Gerald McBoing-Boing* and *Mr. Magoo* cartoons of Stephen Bosustow's United Productions of America. With the advent of the wide screen, Disney produced the first CinemaScope cartoon. *Toot, Whistle, Plunk and Boom,* in 1953. He also produced the first feature-length CinemaScope cartoon, *Lady and the Tramp,* released in 19jj.

Cartoon production costs spiralled over the years. The early cartoons seldom cost more than $2,000, sometimes less than $1,000. Disney's *Lady and the Tramp* had a multimillion dollar budget, as did his *Sleeping Beauty.*

Technique **of** Production **of** Animated Sound Cartoons. —Animation is a cartoon in motion. The illusion of movement in the cartoon is achieved by photographing a cartoon character or characters against a mobile background.

The entire process begins with a brief story plot laid out in a series of coloured-pencil action sketches pinned in sequence on a huge board. When the story is worked out satisfactorily, the board is moved from the rooms of the story crew to those of the director assigned to the cartoon. He in turn calls in the musician, layout man, background artists and animators and briefs them on their various tasks.

The animator does not begin to draw a sequence of action until the background layouts are finished, and the dialogue. sound effects and music have been recorded. The animator must watch the scene layouts carefully so that he will not have his characters walking through such objects as furniture. buildings or trees. After the dialogue track is recorded it is turned over to the cutting department where it is analyzed and a chart prepared which shows, in terms of single frames of film, the length of each word, the intervals between words, the vowel and consonant sounds, accents, inhalations and exhalations. The dialogue track governs the pattern, to which the animator must work, for timing and action. If the character says "hello." for instance, and the cutting department reports that this word, recorded, occupies eight frames of film. the animator must produce eight drawings in sequence in which the lips of the character move to form the word, plus whatever bodily accent may have been decided upon.

The animators have assistants who help develop the action. While an animator draws the most difficult and important points of action. his assistant follows through along the course indicated by the animator. The animators work on a drawing board illuminated from below so that after one drawing has been completed. a second can be placed on top of it, and the new drawing varied just enough to make the movement smooth. A completed series of drawings is photographed and returned to the animator who runs the film on a small projection machine, called a movieola. The director views the film and approves—or disapproves—the drawings.

When the drawings are approved, they are sent to the inking and painting department. There the drawings are transferred to sheets of transparent Celluloid by department employees. who outline the characters with pen and ink carefully so that they lose none of the charm of the original drawings. Other employees apply the chosen colours of paint to the reverse side of the Celluloids so that the inked outlines are accented. After the Celluloids are finished, they are sent to the camera department. Each Celluloid is placed over the correct background and photographed. Celluloids are photographed at the rate of approximately 8 ft. of film per hour. It requires about two weeks to photograph the average 700-ft. cartoon. It takes roughly 45,000 Celluloid setups which, when photographed, constitute one reel of film approximately 1,000 ft. long. There are 16 frames of film to a foot, which runs through the projector at the rate of 90 it, per minute or 24 frames per second.

After a production is filmed, the processes leading up to the finished product are similar to those used for a live-action motion picture. The sequences are placed together and previewed for audience reaction. The picture is then released as it stands or is returned for further editing at the studio.

The animation technique for a feature-length cartoon is essentially the same as for a short cartoon, since the short cartoon is basically comparable to one sequence of a full-length production. A feature-length cartoon may have as many as six directors, although three is usual, with each directional unit responsible for the making of several sequences of the picture.

Some changes in the production technique are required in the case of a CinemaScope cartoon. Animators' drawings must conform to the 2.jj to 1 ratio of CinemaScope. The movieolas, too, must have a wide-screen lens, to enable the animators to view their rough tests in the proper CinemaScope dimensions.

The backgrounds for CinemaScope cartoons are twice as long, and layout men have to redesign and restage all their action to meet this changed format. In addition, the Celluloids used in the inking and painting process call for minimum dimensions of 30 x 13 in. to maximum dimensions of 90 x 13 in., instead of the regular 16 x 13 in.

(X.)

X. EDUCATIONAL FILMS

Films designed to inform and instruct. although less spectacular and less lucrative than entertainment films, have an impressive history in the U.S., particularly in the years following World War II. The term educational films includes the how-to-do-it instruc-

tional film, the classroom study film, social documentary film, scientific film, discussion film, newsreel and "magazine." as well as many films produced for public relations, promotion and even advertising purposes — almost the entire output of nonfiction films for nontheatrical use. For motion pictures in educational practice, *see* AUDIO-VISUAL EDUCATION.

As early as 1910 a 336-pp. *Catalogue of Educational Motion Picture Films* was published by George Kleine; in his words the films give "the work of text-books without their dryness, and yet impart a knowledge which cannot be gained by mere reading." The films were selected from the collections of leading producers in the United States and abroad, and released (at 13 cents a foot) for educational use. "The word 'educational.' " wrote Kleine, "is here used in a wide sense, and does not indicate that these films are intended for school or college use exclusively." The catalogue included a short letter from Thomas A. Edison, who pointed out that "motion pictures are and mill be a great factor in the education of the public."

In the next decade a number of companies were organized to produce and distribute educational films exclusively for schools, churches, clubs, public institutions and industrial organizations. Overproduction, high costs and the vastness and chaotic nature of the educational field caused their failure.

The introduction of the portable 16-mm. projector in 1923 brought new interest in silent educational films. Most notable were the Yale Cniversity Press's *Chronicles of America Photoplays,* dramatic costume re-enactments of important episodes in American history. The Eastman Kodak company, which helped produce the first 16-mm. projectors! also pioneered in making films for school use.

In 1929 Electrical Research Products, Inc., a subsidiary of Western Electric, produced an educational film with sound on disk; but it was not until 1933 that the 16-inm. sound-on-film projector was introduced. In the 1930s Erpi Classroom Films released about 24 films a year, at first silent and later with sound. The company was acquired by The University of Chicago in 1943 in connection with its undertaking to publish the *Encyclopædia Britannica,* and became known as Encyclopædia Britannica Films Inc. After World War II Encyclopaedia Britannica Films became an independent company and released as many as 80 films annually, most of them about ten minutes long (one reel), in colour as well as in black-and-white. Other leading postwar producers of classroom films were Coronet, Young America and the Text-Film division of McGraw-Hill Book company.

Sixteen-millimetre film, which uses acetate safety stock in contrast with 35-mm. inflammable nitrate stock, has been established as the standard size for educational uses. Improvements in the efficiency and variety of projectors and in the quality of the films brought steady but slow gains in school film use before World War II. The Koon and Noble report for the American Council on Education in 1936 indicated that schools owned about 7,000 16-mm. projectors, only about 500 of which were equipped for sound.

An informal estimate by the Department of Audio-Visual Instruction of the National Education association is that about 150,000 sound projectors were owned by schools and colleges in the mid-19jos. It is generally estimated that a total of about 500,000 16-mm. sound projectors were in use throughout the U.S., in churches, clubs, iactories. libraries and other adult centres as well as schools. The rise in the number of educational films was also considerable. there being about 14,000 titles listed and described in the 1953 *Educational Film Guide* and its 1954 and 1955 supplements. Almost every imaginable subject was covered by the films. They were sponsored, produced or distributed by a variety of organizations. including nearly every branch of the federal government. many industrial and labour groups. universities. civic and welfare agencies, foreign governments and religious groups as well as commercial companies.

The sudden spurt in growth after World War II was apparently due to several interdependent factors: improvements in the quality of 16-mm. films and projectors; steady acceptance by educators specializing in the new audio-visual materials; and the rapid developments brought about by the huge wartime training programs of the armed services. In the course of such swift change a certain amount of chaos and confusion resulted. a not surprising condition in view of the pioneering that had to be done by producers, distributors and users of educational film, the popular appeal of the mass media in general, the appreciable resistance to change on the part of some older teachers and the varied and at times conflicting needs and interests which the educational film was asked to serve. Within this scene a number of national organizations have grown, each promoting some aspects of the educational film. Among them are the NEA's department of Audio-Visual Instruction. the American Library association's Audio-Visual board, the National Audio-Visual association, Educational Film Library association, Film Council of America, Industrial Audio-Visual association. University Film Producers association and Mental Health Film board. An earlier organization. the American Film Center, went out of existence at the end of World War II.

Educational motion pictures constitute a major activity in such diverse special-interest groups as the American Cancer society, hmerican Legion. .American Medical association, Anti-Defamation league. Boy Scouts of America, National Audubon society, National Board of Fire Cnderwriters, Twentieth Century fund and many more. Major denominations sponsor, produce and distribute their own educational films on religious and ethical subjects.

Of special interest is Teaching Film Custodians. Inc., a nonprofit organization established by the major Hollywood distributors of entertainment films. whereby suitable short subjects after 1938 and excerpts from ieature photoplays after 194j were selected by panels of educators and made available for use in classrooms at minimal charges. Showings were restricted to regular classroom hours. The first Hollywood company to become directly involved in the release of its films for unrestricted noncommercial use was Walt Disney Productions. In the early 1950s through its special 16-mm. division. the company began the annual release of selected short cartoons, feature animation films such as "Dumbo," and its nature series ("Seal Island." "Beaver Valley," *et al.*). Further developments in the availability of Hollywood films for unrestricted 16-mm. use occurred in the mid-1950s when large numbers of feature films were sold to television syndicates which in turn sold complete nontheatrical and nontelevision rights to educational film distributors. First major announcement of this kind came in 1956 with the release of a large number of RKO feature films through Films. Incorporated. a major 16-mm. feature film distribution company which became affiliated with Encyclopædia Britannica Films several years before. Foreign features. particularly British and French. have been made available for 16-mm. rental in increasing numbers.

A 1953 directory published by the U.S. office of education gave information about 2,660 16-mm. libraries around the country from which filins may be rented, purchased or in some cases borrowed. Schools, universities and commercial organizations account for the largest number: but rapid growth can he noted in public libraries circulating 16-mm. films—in 1947 there were 12, in 1953 there were about 165 (the latter figure includes about 50 libraries active in co-operative film circuits). A survey published by the Association of National Advertisers in 1954 indicated that 89% of the business sponsors of films listed schools and colleges as their prime audience target. To help sponsors produce more effective teaching aids. the association in 195j published a booklet entitled "Criteria for Business-Sponsored Educational Films," listing 22 basic points for consideration. A number of industrial films have won wide acceptance in education.

Government agencies were among the earliest producers and users of educational films, heginning with the department of agriculture's filming of the Wright brothers' flight in 1908. By the mid-1950s the department had about aoo filins in active distribution, and in the years between had produced many hundreds more. Educational films were a major part of the training and indoctrination programs of all the armed services during World War II; it was this association with nonfiction films that led many people to study film making or to use films in their postwar work. The Office of War Information, and later the department of state and the U.S.

Information agency, produced many films to explain the American way of life to audiences overseas. Other government sponsors of motion pictures are the Veterans administration, bureau of mines, fish and wildlife service. public health service and a multitude of state and local government agencies. A 1940 *Directory* of *U.S. Government Films* listed 379 titles available for public use; a similar 1951 publication included about 3,000 titles. Educational films, as well as 3j-mm. filmstrips and entertainment films, began to be annotated on Library of Congress cards in 1952.

By the mid-19 jos courses for the training of teaehers and other specialists in the use of educational films were offered in most colleges and universities, 50 of which reported graduate-level work in the field. Educational motion pictures were being produced by nearly 100 colleges and universities, among them the state universities of Minnesota. Iowa, Wisconsin, California, Indiana, Pennsylvania, the University of Southern California and Columbia and Yale universities.

Along with regular showings of filins about art and artists, a number of public museums show little-known "art" films and older classics which the younger generation have not seen. The Museum of Modern Art in New York city began circulating such films in the mid-1930s (many of them loaned by leading Hollywood producers and "stars"), and in the two succeeding decades it was the source from which about 2,000 educational institutions rented films of historical significance. The San Francisco Museum of Art, which won postwar recognition for its programs of experimental films, became west coast rental office for the Museum of Modern Art's film collection in 19j3.

Developments in the history of the educational film have been pyramidal and the future is not easily surmised. Commercial television increased the audience for educational films without interfering with the growth of the 16-mm. audience. Educational television stations in the mid-1950s had not developed sufficiently to indicate whether they would affect the use of 16-mm. projectors and films. Wider use of magnetic striping of tape on film and of the wide-screen and three-dimensional effects seemed probable. Experiments in magnetic and electronic picture images indicated the possibility of major changes in the techniques of making, editing and showing motion pictures. But ever since the first academic research studies in 191j, educators have demonstrated that the immediacy and impact of the motion picture are useful assets to good teaching techniques, whether for on-the-spot instruction or for thoughtful consideration. In one form or another the conveniently available motion picture seemed likely to play an increasingly active role in democratic education.

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British Educational Films.—Following the early news and travel films,, and the noteworthy efforts of the American Charles Urban in London, consecutive production of educational films began about 1919 when H. Bruce Woolfe established British Instructional Films. In the 1920s Percy Smith and Mary Field joined his staff, turning out several hundred short nature and science films in the series called *Secrets* of *Nature,* and later *Secrets* of *Life.* An amalgamation in 1933 saw the formation of Gaumont-British Instructional, Ltd., which until 1939 was the only professional company devoted to films lor classroom teaching. As in the U.S., World War II brought great changes in the output of films, for the training of armed forces and home-front personnel. The government's Crown Film unit, growing out of John Grierson's earlier Empire Marketing board and government post office film units, was manned by film makers who already had achieved world fame in the production of social documentary and information films.

In the postwar years the Central Film library of the Central Office of Information maintained large 16-mm. (and some 3j-mm.) film collections in England, Scotland and Wales. Production by the Crown Film unit ended in 1952. The Educational Foundation for Visual Aids was organized in London in 1948 to maintain its own comprehensive film library and to act as an information centre on the use of films in schools. The British Film institute has been a stimulus to the use of filins in schools.

British film makers. most of them trained in units established by Grierson, played major roles in setting up the National Film boards in Canada (1939), New Zealand (1941) and Australia (1945) and similar units in Malaya. the Gold Coast and elsewhere.

The Scottish Central Film library, mhich opened in Glasgow in 1939, had a collection of more than 3,500 titles which by the mid-19 jos were being booked about 65,000 times a year, approximately 80% going to schools. Although Scotland was recognized as a leader in visual education, lack of electric power in many outlying school districts hindered the use of films.

Canada.—The formation of the National Film board in 1939 set the pattern for the most systematic network of government-sponsored educational film showings in the world. Wartime needs for information and education in the remote areas of the country were so great that by 1945 there were 170 NFB fieldmen reaching an annual audience of about 4,000,000 people, many of whom had never before seen a motion picture. Although in 1954 the number of paid representatives had decreased to about 95, the film audiences increased to approximately 14,000,000, of which school audiences accounted for nearly half. The work of volunteer film councils and of film libraries and circuits in more than 400 communities was responsible for much of the increase.

As an agency of the federal government, the National Film board has been empowered to produce or negotiate the production of all films for Canada's government agencies.

Canadian documentary and educational films were widely distributed theatrically and nontheatrically, as well as on television, in the U.S., Britain and other countries. Particularly in the U.S., the Canadian films influenced techniques in animation and the style and content of mental health and discussion films; the generally high level of Canadian information and instructional productions won wide acclaim.

Other Countries.——Pioneer efforts in the production and use of educational films have been made in most European countries, but growth has been slowed up by the fact that relatively few teachers have been trained for the use of audio-visual materials. France. Belgium, the Netherlands and Italy have been particularly active in the production of filins about art, and these productions have been seen widely in other countries. The U.S.S.R., through its state-controlled film industry, has long favoured the production of motion pictures for information and indoctrination; its science films are among its best known. Czechoslovakia. Poland, Rumania and Yugoslavia also produce films for classroom use, as well as children's entertainment films for theatres.

A considerable number of the educational films used in South America. the middle east and parts of Asia and Africa have been revised versions of U.S., British or Canadian classroom films. The development of magnetic sound on film. which permits the sound track to be recorded separately in nhatever language is required, promises wider use of these films in small countries.

(C. SR.)

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MOTION SICKNESS, a term popularized by Sir Frederick Banting in 1939, replacing the more familiar but less general term seasickness. Since man took to the sea, many persons have experienced discomfort varying from a slight feeling of uneasiness to extreme prostration during rough weather. The common symptoms of motion sickness are pallor, cold sweating, nausea and vomiting. As other types of locomotion evolved, the symptoms have been recorded as train, swing, car and airplane or airsickness.

The balancing organ, or labyrinthine portion of the internal ear, is disturbed by out of level and by sudden turning movements. The former, said to be the more upsetting, result from changes of position of the head in relation to gravity and centrifugal force (the force that deflects a rotating object away from the centre). On the other hand there is evidence to show that even slight turning movements of the head in a plane other than that in which the body as a whole is moving may cause severe loss of balance. It has been suggested that some of the beneficial effects of lying down during motion sickness result because the head is thereby fixed in relation to the body.

Persons who have lost both labyrinths from disease are not susceptible to motion sickness. Animals that previously could be made motion sick were no longer susceptible following destruction of both labyrinths. Some persons become resistant to motion sickness—develop their "sea-legs," so to speak.

In addition to the disturbing effects of motion, there are a variety of contributing factors such as unpleasant sights and smells, anticipation from past experiences, etc.

The wartime transportation of large numbers of troops both by sea and air led to study of the causes and prevention of motion sickness by participating governments. It is important that a combatant be free from motion sickness during transportation, yet it is absolutely essential that he be alert and not drowsy when going into action. Likewise a pilot guiding a plane must be in full possession of his faculties. Most remedies for motion sickness (including the popular patented remedies) contain some form of sedative or quieting drug. It has been found that many of the antiallergic drugs lessen the tendency of the average person to succumb to motion sickness. Most of these drugs, however, have some sedative or other undesirable side effects.

Space travel is imminent. As the pull of gravity is lessened to the point where a state of weightlessness develops, the balancing mechanism loses one of its forms of stimulation, and the development of space sickness may be anticipated. *See* also EAR, ANATOMY OF; EQUILIBRIUM, ANIMAL.

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MOTIVATION is a term used to cover explanations of why a person behaves as he does. It is not synonomous with "causation" because it is generally restricted to only one class of events determining behaviour. For example, it is commonly contrasted with ability, another important determinant of behaviour: a person may be able to play a game of tennis, but he may not want to; *i.e.,* he is not motivated to play. Or on the other hand he may want to and not be able to. Both ability and desire jointly determine what he actually does. Motivation is ordinarily indicated by such words as want, wish, desire, need and strive.

Students of psychology have from earliest times identified a desiring element in human personality. In the *Bhagavad-Gita,* the mind is described as being composed of three parts: *sattwe,* or knowledge; *tamas,* or ignorance; and *rajas,* or passion. The passionate element is compared with a volcano which threatens to erupt and engulf the person in a life of greed and selfish desire unless it is brought under the control of reason or knowledge. In Plato's *Republic* the soul is again divided into three parts: reason and two motivational elements, spirit, which underlies courage in battle, and desire, which includes the basic biological needs for food, water and sex. Subsequently in the west, both within the Christian tradition and outside it, there was general acceptance of the notion that reason should be distinguished from desire and in fact was often in opposition to it. To the medieval Christian, reason alone was not strong enough to control the baser human urges represented so graphically in Dante's *Inferno.* It was necessary to invoke a higher type of motivation of divine origin (based on Faith and Grace) which would control the instincts. The notion that there are two opposing motivational forces and a third mediating force, reason, persisted in psychoanalysis (*q.v.*), which has had a very wide influence on psychiatry, psychology and humanistic descriptions of the nature of man. To Sigmund Freud the id represented the baser motives of man, which are opposed by the superego, representing the moral drives; whereas the ego (*q.v.*), representing roughly reason, mediates between the two opposing forces. Thus Freud regarded motivation as all-important, and the role he assigned to the ego functions, to realistic perception, to past experience and to reason was very small; later psychoanalysts in the 1940s and 1950s, however, turned their attention increasingly to such matters.

Experimental psychology initially was much less interested in motivation than was psychoanalysis. It had its origins in the school of psychology which argued that the mind was made up of nothing but a series of more or less complicated associations among ideas and between ideas and action. The mind was like a machine which would run automatically, once started, in accordance with the associations built up through experience. This view was modified, however, particularly in the United States, by its contact with the equally influential notion popularized initially by Charles Darwin that organisms struggle for survival and that in that struggle certain basic biological needs have to be satisfied. Thus, while U.S. experimental psychologists disavowed any interest in the subjective motivational forces of interest to psychoanalysis, they too turned their attention to the study of the basic needs such as hunger, thirst and sex which activated the organism in its struggle for survival.

By mid-20th century two widely influential but opposed psychologies of human motivation had developed. One, the simpler of the two, grew out of experimental work with animals, particularly by U.S. psychologists interested in studying the learning process. They found, for example, that if they deprived a white rat of food it would learn to run a maze more rapidly to get to a food reward; if it was well fed and all its other bodily needs were satisfied, it would run very little, if at all, in the maze. These

psychologists reasoned that under the latter circumstances the rat was not motivated to run. Food deprivation disturbed a state of equilibrium by introducing a strong persistent inner stimulus which made the animal active until it had located some food; eating the food removed the inner stimulus and restored equilibrium. The persistent stimulus produced by deprivation had obvious survival value in that it led the organism to be active, which increased the probability that it would find something that would do away with the deprivation and allow the animal to live. Anything which produced a strong stimulus — extremes of heat or cold. physical injury, lack of water — was conceived as a source of motivation. More complex social motives were thought to develop out of means of satisfying the primary biological needs. This school has not been conspicuously successful in accounting for complex human motives, but U.S. psychologists have widely believed that it would be able to do so by carefully building on an understanding of the way in which the simplest biological needs operate Its most particular weakness has been in measuring individual differences in human motivation, since it has been concerned primarily with biological needs in animals, and these are short-term and easily satisfied in contrast to the stable, enduring dispositions in the human adult.

The other view of human motivation, represented in its most extreme form in psychoanalysis, begins precisely with the problems the experimental psychologists have had so much difficulty in handling — with motives as enduring forces in the person. The reason for the difference is not hard to find. Psychoanalysis grew out of the clinic and the consulting room rather than out of the animal laboratory. Its practitioners had to deal with the complex strivings of adult neurotics. They struggled to discover the motivational forces that lay behind the bewildering variety of symptoms they encountered. Freud's own theory of motivation underwent many changes, but perhaps it can best be summarized by saying that he was primarily concerned throughout his long life with three major forces: the sex instinct (or libido), which was for him a kind of life force including a large variety of components only one of which was genital sexuality in the narrowest sense; the death instinct, which encompassed all of man's aggressive urges; and anxiety, which was not conceived as an instinct with an aim like the other two but which certainly motivated behaviour as it arose out of fear of ihe other two instincts and out of conflicts in their aims. Freud's theorizing has been criticized as unscientific and as failing to consider a number of motives which are important in normal as opposed to abnormal personalities, such as the need for achievement or for self-actualization. Certainly if experimental psychology attempts to explain human motivation with too few simple but carefully quantified drives, psychoanalysis attempts the same task with too many ad *hoc* motivational interpretations which do not follow the ordinary scientific canons of parsimony, quantifiability and predictive power.

While the two schools differ in subject matter and method, they do agree on a number of points. They both accept the fact that motives may be unconscious, whereas the man in the street may feel that he is aware of his motives if he only takes the trouble to think about them. Both argue that motivation is an important determinant of behaviour but only one determinant. the others being variously defined as ego functions in psychoanalysis or as habit and realistic perception in experimental psychology. Both tend to conceive of man as motivated primarily to reduce tension aroused by biological needs or instincts. Motives are, so to speak, disturbers of the peace, and human activity is devoted to trying to remove the disturbance.

There are of course many psychologists who do not fit clearly in either school, who try to reconcile the two points of view or to emphasize some aspect of motivation not stressed by either. The non-Freudian psychoanalysts like Carl Jung or Alfred Adler disagree with Freud primarily on his contention that the basic life urge is sexual in nature; the neo-Freudians like Karen Horney, Erich Fromm and Harry Stack Sullivan stress the importance of cultural as opposed to biological factors in shaping basic human motives. Other psychologists (such as Kurt Goldstein, Abraham Maslow and Carl Rogers) have argued from their clinical experience that the psychoanalysts have overstressed the negative, crippling human urges and not given enough credit to the creative drive for self-actualization. Still another group of psychologists, headed by Henry A. Murray, believes that it is too early to oversimplify human motivation in terms of a few basic urges and that it is necessary first to study the variety of human motives as they actually are found in the life histories of normal adults. Finally, some students of personality, such as Kurt Lewin and Gordon Allport, have had doubts as to whether it will ever be possible to find categories of human motivation which will apply equally to all people; rather the problem is to discover what uniquely motivates this person at this particular time. In general the wide variety in points of view as to the ultimate nature of human motivation reflects the fact that scientific knowledge about the subject is still extremely limited.

Methods of Studying Motivation. — A11 theories of human motivation must ultimately be based on simple observations of human behaviour. Fortunately among psychologists there is much greater agreement as to what observations are relevant to motivation than there is as to the ultimate nature of motives. These observations may be divided into two classes. those having to do aith ways of getting the organism to do something it would not otherwise do, and those dealing with behavioural peculiarities pointing to the presence of motives as opposed to other determinants of behaviour. In the first class are included all those techniques by which psychologists have experimentally aroused motives in animals or human beings. They may be grouped under four headings:

1. Deprivation. The organism is typically deprived of something it needs for biological survival, such as food or water, for varying lengths of time, and the effects on behaviour noted.

2. Strong stimulation. Electric shock is most commonly used for this purpose, but air blasts, immersion in water and needle-point showers have also been used to motivate both animal and human subjects to action.

3. Special lures. Among all the stimuli to which an organism is sensitive, certain particular ones seem to evoke innately either approach or avoidance responses. For example, kittens will chase small moving objects. Chimpanzees fear snakes, disentangle simple puzzles and spend time watching a moving object such as an electric train. Human infants will reach for toys and between the ages of three and six months will smile at any moving facelike object. Various psychologists have used such natural lures as a means of studying the motivational processes.

4. Special instructions. It has been demonstrated that human subjects can be motivated by verbal appeal to various motives, such as the desire to do well, to please the experimenter and to be liked by others.

By all four of these techniques the psychologist attempts to manipulate the strength of the induced motivation experimentally and to measure its effects on behaviour. There is a fifth technique which is similar to these except that the differences in motivation are produced not by actions of the experimenter but by the past history of the individuals concerned: one may compare a group of clergymen with men in general and assume that the former have a higher average level of religious motivation; or one may assume that a group of champion athletes has a higher competitive drive than a group of less successful athletes. The difficulty with this method is that since the motivational difference is not under experimental control, the two groups may differ in other ways than in the motive in question, and peculiarities of behaviour may be attributed to a motivational difference when they should be attributed to some other factor.

The other way of studying motivation starts not with what is done to the subject to produce motivation but with the behaviour he shows which is supposedly characteristic of motivation. There are tno ways in which behavioural signs of the presence of motivation have been identified. One is by observing the effects on behaviour when motivation is induced by any ot the techniques mentioned above; the other is by determining the characteristics of behaviour that cannot readily be accounted for in terms of

any of the other major determinants of behaviour. Both methods have been used to derive the three main effects that motivation is thought to have on behaviour as listed in the table. The effects have been placed in the left-hand column with two illustrations set out in parallel columns to the right. The first illustration is drawn from the experimental laboratory and shows the three ways in which a rat's behaviour is different when he is hungry from what it is when he is not hungry. The second illustration, drawn from the motivational interpretations of dreams and associative sequences common among psychoanalysts and clinically oriented psychologists, is taken from the story of Jonah in the Bible as analyzed by Erich Fromm. The Bible story simply tells how Jonah tries to escape from his responsibility to God by taking ship at Joppa. When the ship is at sea a great storm arises, Jonah falls asleep in the ship's hold, the men decide by lot that Jonah is the cause of the storm and cast him overboard into the sea, where he is swallowed by a whale. Jonah repents and the Lord causes the whale to cough him up on dry land. Fromm argues that the story is actually like a dream sequence in which a number of improbable events are actually tied together by Jonah's need for security. That is, he escapes from the Lord first into the ship, then into the ship's hold, then into sleep, then into the ocean and finally into the whale's belly. where he discovers that his efforts to escape have been so confining that he repents and goes back to his duty. The example is included here to demonstrate that while this kind of motivational interpretation is commonly rejected as incautious by experimental psychologists, it in fact relies upon the same criteria that experimental psychologists rely on in working with animal motivation (with one exception to be noted later).

The first unique effect that motivation apparently has is to activate the organism—to keep both the rat and Jonah on the move. It is unique in that without motivation the organism will often not respond even though past behaviour has demonstrated its ability to do so. For instance, a child may know his name perfectly well and may have given-it in response to requests on many previous occasions, but on a given occasion he may refuse to give it or say he does not know it. His past behaviour will not readily account for his present refusal, so the concept of motivation is invoked. It is said that he is not motivated to respond.

Motivation also operates to select out certain responses for repetition—namely, those that lead to satisfaction of the motive. The rat repeats those turns which get him to food, Jonah repeats those actions which give him security from the wrath of the Lord,

A motive	For a rat in a maze, hunger	For Jonah, need for security from the Lord's wrath
1. Drives behaviour	makes him persist in his efforts to find food,	makes him persist in his attempts to flee by hiding,
2. Selects behaviour	leads him to repeat those turns which got him to food,	leads him to try one method of hiding after another (in ship's hold, in sleep, in whale's belly),
3. Directs behaviour	organizes his successive acts into a correct sequence	ties his successive acts into an organized attempt to escape

at least temporarily. In this sense motivation is the key to understanding how many new responses are acquired.

Finally motivation directs or organizes behaviour. Somehow it enables the rat to tie together his turns in the maze into a smooth uninterrupted correct sequence. In Jonah's case, the inference that he has a need for security that ultimately defeats itself ties together or organizes a series of what otherwise would appear to be unrelated or improbable acts. The directive function of motivation is seen even more clearly if other motives are involved. For example, rats can be trained to turn right if they are hungry or to turn left if they are thirsty. If Jonah had been hungry when he entered Joppa, rather than frightened and running away, he undoubtedly would have directed his attention toward the market rather than toward the ship in the harbour. Motivation serves to make certain aspects of the environment especially significant! directing attention toward them and organizing behaviour in terms of them. In this case, too, it would be difficult to explain such a focusing of activity in terms of past habits or abilities.

Although the t o examples are similar, they differ in one important respect. In the case of the rat the motive had been induced by food deprivation and the effects on behaviour observed. In the case of Jonah the presence of the motive is inferred on the basis of effects similar to those observed in the rat in the maze, The first approach gives information only on temporarily induced changes in simple biological needs, while the second deals with a significant need in the life of an individual; but the experimental method helps establish the criteria used for the diagnosis of individual motivation, so that the two approaches are actually complementary.

Measuring Human Motives.—One problem of major interest to psychologists is how to assess the strength of a particular motive in a person and to compare his behaviour with that of another person who has less or more of the motive in question. For example, does a person with a strong motive to achieve work harder than other people? Is he more likely to get stomach ulcers? Is the need for achievement simply a sublimation of a frustrated sexual impulse? When and how are particular motives laid down in childhood? To answer such questions as these it is necessary to have sound, carefully derived measures of adult human motives. In general, psychologists have pursued three different methods of getting such measures.

1. The first method simply involves asking a person to report his motives, and in its most elaborate form employs a long and detailed questionnaire about motives, interests and values. The responses a subject makes are then searched either logically or statistically for groupings which hang together consistently, and the score on a group of such items is given a name in accordance with the meaning of the items. For example, a person who says that he likes a wife who is less intelligent than he is, that he usually initiates conversation with strangers and that he asks questions after public lectures may be given a high score on the need for dominance. Such questionnaires for assessing individual human motives or needs have some serious flaws. In the first place the subject may not know very well what his interests or motives are, simply because he has not paid much attention to the problem; his answers to the questions then may reflect momentary sets or influences which come up in the course of answering. In the second place, and more seriously, most psychologists have become convinced by the work of Freud and other psychoanalysts that people repress many of their most important motives, particularly the asocial ones, and conscious reports reflect merely rationalizations of those motives which may even be the direct opposite of what the person consciously wants; thus a person who says that he dominates in a variety of social situations may in fact do nothing of the kind and may say so simply as compensation for a deep feeling of inferiority.

2. As a correction for the distortions introduced by conscious reports, psychologists have commonly employed another method in which an outside observer infers what the subject's motives are from observation of many aspects of his behaviour—his dreams, free associations, conscious reports of motives and actual overt actions. This is the method employed by psychoanalysts, and it has been refined by such psychologists as Henry A. Murray who have asked observers to report their motivational inferences on rating scales of relative strength and more than once on the same person to check the reliability of such judgments. The reliability of independent judges, if they are well trained, has often been quite high, indicating that people can agree as to a person's motives. Many psychologists feel that such ratings represent the

best measures of human motives that can be obtained. However, they too have some serious drawbacks. In the first place a judgment is necessarily an impure measure of motivation since it represents a synthesis of many different aspects of the person's behaviour, only some of which involve motivation. For example. many judges would agree that a person who both works hard and dreams about great achievement has a higher achievement drive than a person who only dreams about great achievement; yet the motive to achieve may be equal in the two cases, and the fact that the first person works hard may be due to some other factor in his personality. In the second place. ratings unfortunately are determined by the point of view, training and personality of the judges as well as by the behaviour of the person being judged. It has been shown for instance that judges who themselves have a strong need for aggression tend to overemphasize the need for aggression in others. Using many judges will correct for bias only if all the judges do not have the same bias, and frequently they do because they have had the same kind of training; all of them may see the motivation they have been trained to see.

3. Still a third method of measuring human motives which attempts to get around the difficulties implicit in the other two methods has been employed. It involves arousing certain motives, such as the need for achievement and the need for affiliation. experimentally in subjects by instructions, and searching for the unique effects of the motives in standardized samples of fantasy (usually stories written to pictures) collected from the subjects. Unique effects are discovered by comparing the stories with those written by another group of subjects in whom the motive in question is not aroused. The method has the following advantages: It starts with no preconceptions either in the subject or in the observer as to how the motive will show itself. It employs the kind of behaviour (fantasy) which has been shown to be most readily influenced by motivation. Since the subject ordinarily does not know that his motivation is being tested. he cannot control what he says to make his motives appear favourable or consciously block out certain motives altogether as in the method of conscious report. The method is not influenced by the bias or training of the judges, since the coding of the fantasy material is done objectively by counting the frequency with which certain thoughts appear which are unique to the motive in question. Once the effects on fantasy of a given motive have been determined, those effects are used to diagnose the strength of that particular motive in a person under normal testing conditions. The method has been applied largely to the development of measures of the need for achievement, the need for affiliation and the need for power.

The three methods of measuring motivation do not yield identical results, perhaps because the first two methods have the defects mentioned.

Effects of Motivation on **Behaviour.**—In considering the observational basis for inferring the existence of motivation, some very general effects of motivation on behaviour were listed above. The development of methods of measuring individual differences in human motivation, however, has made it possible to go further and find more precisely how motives influence other aspects of behaviour.

Motivation and Performance. — One of the most studied problems of this sort is the relation between motivation and performance. Does higher motivation always lead to better performance? The answer in general is "yes," but with several important qualifications. If sheer response output is the measure of performance, it probably varies directly up to some physiological limit with increases in the strength of motivation. If efficiency in learning is the measure of performance, it increases up to some moderate level of motivation and then decreases as motivation goes still higher. In common-sense terms the person becomes overexcited, more fixed on his goal and therefore less flexible and efficient. Furthermore, an increase in any motive will not increase efficiency on any problem; the problem must be related to the motive. For example, subjects with high need for achievement will work harder on a task if it is to count for their record, but not if it is simply to gain time off from work or to please the experimenter. A hungry rat will not run a maze faster unless there is food at the end; *i.e.,* unless solving the problem is relevant to its need. To turn this observation around, the same act may be performed for a variety of motives — to gain food. to achieve or to please someone. So it is definitely not safe to try to infer a person's motive from what he is working hard at. It would be an error to conclude that, for example, a person who studies hard and does well in school must have a high need for achievement. He may study hard for a variety of reasons, and it is necessary to search beyond his actual performance to find them.

Motivation and Perception. — Another area of considerable interest to psychologists has been the effects of motivation on perception, memory and belief. Is the wish father to the thought? Does a person remember only what he wants to remember? Or are his values perhaps mere reflections of his unconscious motives? Psychological research has not yielded definitive answers to all such questions. but two points are well established. (1) First, a motive sensitizes the person in cognitive areas related to the motive. If a person has high need for achievement he tends to recognize achievement-related words quickly when they are briefly flashed on a screen; if he has a high need for affiliation he is likely to recognize pictures of people more quickly than he does pictures of objects; if he is poor he is more likely to see or remember coins as being larger in size than he does if he is rich; if he is hungry he is apt to judge food stimuli as larger than other stimuli. In other words, motivation makes certain aspects of the environment particularly salient for the individual, and he may well tend to exaggerate them. If his motivation is to avoid an anxiety-producing stimulus. he may demonstrate in reverse the salience of such a cue by seeing it more slowly than he does neutral stimuli, although evidence is less clear on this point. (2) Second. the sensitization effect is maximal when stimulus conditions are ambiguous or when reality factors determining memory. perception or belief are minimal. Ordinarily a person sees what is "out there," and remembers what really happened to him, regardless of his wishes in the matter. It is only when his information is poor that motivation begins to take over and determine what he sees, remembers and believes. In other words, wish may be father to the thought only when there is little or nothing else to be father to it. It has been demonstrated. for example, that a high need for achievement will lead subjects to estimate that they will get high grades on a final examination only if they have no good basis in their past performance for knowing what they will get.

Motivation and **Occupation.**—A third area of interest to psychologists is the extent to which motives influence the choices a person makes as to how he will spend his time. Again, research points to a very simple generalization: a motive will lead a person to engage in those activities in which he is most likely to satisfy that motive. Exactly what those activities are for various motives is only beginning to be worked out. For example, a person with a high need for affiliation will tend to choose a friend rather than an expert as a working partner, presumably because friendship is more important to him than solving the problem quickly. A person with a high motive to achieve mill do exactly the reverse. He will also engage in more community activities in college and in later life in order to increase the opportunities for a sense of accomplishment. For the same reason he seeks out situations involving moderate risks, where success is neither pure luck nor a sure thing. He remembers uncompleted tasks better, presumably because they represent an unfulfilled challenge for him. Even more interesting is the way in which the preference for certain activities leads a person to choose one occupation or another. It has been worked out in some detail, for example, how a high need for achievement is most likely to be satisfied in a business entrepreneurial occupation, where there is clear-cut knowledge of results, a sense of personal responsibility and the challenge of moderate risk. Furthermore there is some evidence that as the level of need for achievement rises in a culture. more and more of its members enter entrepreneurial occupations, and the general level of economic development advances so that the growth of civilization may, in part, ultimately depend on the level of achievement

motivation among its people.

Conflicts of Motives.—Psychologists also have been interested in the effect of conflicts of motives on behaviour. Much depends on the kind of conflict involved. A conflict relatively easy to solve is one between two approach motives, two desires to do something pleasant at the same moment (as the donkey caught between two piles of hay); usually the person vacillates awhile and then chooses one or the other. A much more serious conflict arises when the same activity elicits both an approach and avoidance motive. A rat may want some food but be blocked from approaching it by an electric shock. He is then more or less trapped in a permanent state of conflict between trying to approach and avoid the same object. Such conflicts as this are at the basis of neuroses. A person may want independence from the domination of his mother and yet fear that very independence; he is thus caught with no easy solution possible.

Experimental psychologists, notably Neal Miller, have attempted to determine what a person will do under such circumstances as the strength of the approach and avoidance tendencies are systematically varied. For example, Miller was able to deduce the commonly observed fact that psychotherapy may increase a person's anxiety beiore he improves. The reason lies in the reduction by therapy of the person's fear of his neurotic difficulty. Before therapy a weak avoidance tendency would keep him from approaching it. Aiter some therapy he approaches it more closely until it elicits a much stronger avoidance or anxiety reaction than formerly.

Clinicians have been concerned with the varieties of defense mechanism (*q.v.*) a person adopts in handling such approach-avoidance conflicts. For example, he may repress the conflict, deny one side of it, attempt to rationalize it away, develop some bodily symptom which reflects it or attempt to sublimate it in some substitute activity. In general, deiense mechanisms may be grouped according to whether they attempt to avoid the motive conflict, to attack and solve it directly, to convert it into something else or to find a substitute means of satisfying one or the other of the two motives. Ultimately an understanding of how conflicts of different motives lead to various deiense mechanisms in different kinds of persons is essential to the understanding of neurosis and psychosis.

Origins of Motives.—Explanations of the origins of human motivation involve both biological and social factors.

Biological.—On the biological side there are two schools of thought. The first follows the Darwinian position in placing its major emphasis on simple biological needs and stimuli which become associated with them. It contends in effect that the most complex human motives are nothing but elaborations through learning of the primary biological needs. As an example, take mother love. During the first months of liie the human infant is relatively helpless and subject to all kinds of primary drive stimuli—thirst, hunger, pain—which it cannot relieve by itself. The mother, on the other hand, is regularly associated with reducing those needs and hence acquires "secondary" reward value. That is, her reward value is not "primary," like that of food which reduces hunger innately, but is acquired through her regular association with satisfaction of the infant's needs. Furthermore the child soon learns to associate absence of the mother with discomfort and anxiety over not being able to reduce his needs, so absence of the mother eventually leads him to do things that he hopes will bring the mother to his side. The child then acts as ii he loves his mother, although in fact, he wants her because she has symbolic reward value; *i.e.,* the capacity to reduce his anxiety. While many U.S. psychologists have felt that such a scheme has an engaging simplicity and is perhaps particularly useiul in explaining the origin of anxiety, they have also felt that it is not adequate for explaining more complex human motives, particularly those which give no indication of being related to biological needs or anxiety reduction.

The second biological point of view places greater emphasis on species diiferences in instinctual responses. U.S. psychology lost interest in instincts around the beginning of the 20th century because of the great stress psychologists were then placing on the adaptability and flexibility of the organism. They demonstrated that nearly all behaviour could be modified by experience and found little place in their thinking for the rigid unvarying type of behaviour they thought characterized instincts. A dominant view was that all animals. including man. were endowed by nature only with a few simple biological needs, and the rest of behaviour was due to learning. By the 1940s and 1950s reaction had set in. particularly under the influence of biologists interested in the behaviour of lower animals. Investigators such as Konrad Lorenz, N. Tinbergen and Harry Harlow demonstrated by careful studies that different species of animals were differentially responsive to certain distinctive cues in the environment. The complex sequence of such cues which leads a male stickleback fish through its elaborate courtship behaviour or which enables a honeybee to learn irom the "dance" of another bee at what distance and in what direction honey lies has been worked out. The difference between these studies and earlier ones of instinct lies in the fact that they put more stress on the invariant nature of the "signs" in the environment which automatically evoke certain responses than they do on the invariant nature of the responses themselves. They also pay more attention to species differences in responsiveness to "sign" stimuli. A kitten will pursue and attack a small moving stimulus whereas a white rat will not. A chimpanzee will disentangle a puzzle while a kitten will not. While all species may have similar hunger drives, they differ very much in their innate responsiveness to other stimuli. (See also ANIMAL BEHAVIOUR; INSTINCT.)

How about the human species? Are there cues in the environment to which man responds selectively? One notion is that there are indeed many such stimuli but that the human being responds not with a specific overt response but with a diffuse pleasurable reaction to one class of stimuli and with diffuse signs of discomfort to another class of stimuli. Motives then may be associations based on these primary states of positive or negative affect. David McClelland and his co-workers have attempted to state the class characteristics of those stimulus situations which yield positive or negative affect. They suggest that small variations in stimulation over what the organism is "tuned to" or expects are innately pleasurable, whereas large discrepancies are innately unpleasurable. The chief advantage of such a theory is that it provides a changing base for the acquisition of new motives depending on how the "tuning" of the organism is altered by biological or social conditions. Motives are not exclusively tied to simple, unchanging biological needs. Such a view represents a return to older theories that motives are based on pleasure and pain, but with the important difference that more precision is provided as to what innately produces pleasure and pain.

Social.—The social origins oi motives may be conceived in terms of general conditions which favour the development of one motive or another. For convenience, conditions arising out of the physical environment, the economic structure of the society, the family, religion and culture will be considered in turn. In terms of the general theory of the development of motivation given above, social conditions may be thought of as providing certain regular experiences for individuals which lead them to expect certain things. The difference between what they expect and what they experience then yields positive or negative affect, providing the basis for motivation.

Several scholars, notably Ellsworth Huntington and Arnold Toynbee, have argued that geography is a major determinant of human motivation in the extent to which it stimulates man to action. Both men were impressed by the fact that most major civilizations seem to have developed in the temperate zone, and Toynbee has developed the notion that just the right amount of challenge from the environment is necessary to produce the most creative response from mankind. Too much challenge, as in the arctic regions, or too little, as in the tropics, will not motivate man optimally. Such theories do not stand up under close factual examination. For example! Maine, which Toynbee finds less stimulating than Massachusetts, has about the same climate as northern Ireland, which he finds more stimulating than southern Ireland. Or the climate of southern Australia appears to have been par-

ticularly challenging to the Australians while the same climate in the southern part of the United States he conceived as not very stimulating. Huntington makes a case for desert conditions producing certain motives in the Arabs who inhabit the Sahara region, but he fails to note that the same motives do not occur among the Navaho who also inhabit a desert region in the United States. If climate has an effect it is a marginal one, operating through other social institutions.

Social theorists have been particularly apt to point to the economy as a source of many of man's major motives. Karl Marx developed a whole theory of history based on the profit motive, on the need of the *bourgeoisie* to exploit the workers in order to make more money. Other theorists have spoken of conditions such as population growth, inflation or scarcity of goods which supposedly have motivated men to work harder or less hard. While such factors are undoubtedly of importance in a particular cultural context (especially the west)! psychologists urge caution in interpreting them as universal sources of particular motives. Population growth may motivate one people to work harder to get food for the extra mouths; it may produce apathy and hopelessness in another people. Economic conditions operate in terms of existing motives and values in the group. One of the few instances in which the economic situation seems to have been the primary determinant of motivation of a people is provided by the case of the southern Negro in the United States. When slaves were brought into the south they were effectively "decultured" by being mixed with other persons of different cultural backgrounds. In this situation their economic dependence on their white masters became of overriding importance in determining their motives. since no common cultural values existed to alter the significance of their economic condition.

The family influences motives in part by the way parents rear their children and in part through its structure. Much detail has been gathered by psychologists on what particular parental attitudes and practices affect given motives, and at what ages. For instance the children of authoritarian parents are likely to have greater needs for dominance and also for submission; their motivation, in other words. is centred around power, to be wielded or yielded to. Parents who stress achievement, particularly at an early age, on the other hand, are likely to produce children with stronger need for achievement. In general these studies support the view that the early formative years are more important for the development of basic motives than are the later years, which exert more influence on beliefs and values.

The structure of the family has been considered of special importance by psychoanalysts, who have emphasized the fact that many of the male child's motives develop out of the competition he feels with his father for his mother's love (the so-called Oedipus complex). The way in which the boy handles his jealousy of his father may he of major significance in determining his motivational pattern throughout the rest of his life, although there is not as yet a great deal of objective evidence on this point.

Religion also plays a role in the development of motivation. The German sociologist Max Weber argued around the turn of the 20th century that Protestantism had infused a new spirit into its members which led them to engage in a more vigorous type of capitalistic enterprise than had been characteristic up to the time of the Reformation. He found that such unusual energy could not readily be explained in terms of the minority status of Protestants in many countries, since in England Catholics, who had a minority status, did not appear to be motivated in the same way. Weber felt instead that it was the nature of Calvinism itself which drove its adherents to ever greater efforts to prove their perfection and to demonstrate thereby their predestined inclusion by God among the elect. Empirical studies in the 1950s by McClelland and his co-workers showed that there may have been a connection between Protestantism: early achievement training, higher achievement motivation and greater and more successful entrepreneurial activity. Here is a clear case where the values of the parents coming from their religious background influence their attitudes toward child rearing, which in turn affect children's motives. Studies of this kind are still few in number and need to be pursued further to demonstrate the interconnectedness of social influences on motives.

Finally, culture affects motivation. In a sense culture refers here to any set of values or institutions common to a people which cannot be ascribed to any of the conditions discussed under headings above. For example, French-Canadians appear to have a lower average level of achievement motivation than do Italians, even though the groups are matched for the physical environment in which they live (New England), their socioeconomic status, family structure and religion. The difference must be attributed to some cultural factor not yet clearly understood. It is especially noteworthy that cultural differences in the average level of motivation have been empirically demonstrated by the objective methods of measuring human motives discussed above. Such differences in motivational level among peoples have frequently been assumed in prescientific psychology but have been just as often discredited by psychologists, partly because there was no objective evidence for the differences and partly because they were often linked to racist theories of human nature. There is increasing objective evidence, however, that cultural differences in motivation do exist, though there is no evidence that they are due to heredity. The reason is simple. Historical studies have demonstrated that the same culture or racial group (*e.g.*, ancient Greece) may have a high average level of motivation (*e.g.*, need for achievement) at one period in its history and a low level at another period. The logical inference is that motivation level cannot be attributed to racial inheritance but must vary with child rearing attitudes, which in turn are a function of changing economic, social and religious conditions in the culture. *See* EMOTION; PERSONALITY; PSYCHOLOGY; PSYCHOLOGY, EXPERIMENTAL; PSYCHOLOGY, PHYSIOLOGICAL. *See* also references under "Motivation" in the Index volume.

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MOTLEY, JOHN LOTHROP (1814–1877), U.S. historian, was bdrn April 15, 1814, at Dorchester (now a part of Boston), Mass., and graduated from Harvard in 1831. He then studied at Gottingen and Berlin, becoming a friend of Bismarck at Gottingen. and after a period of European travel returned in 1834 to the U.S., where he continued his legal studies. In 1837 he married Mary Benjamin, and in 1839 he published anonymously an unsuccessful novel entitled *Morton's Hope*. In 1841 he entered the diplomatic service as secretary of legation in Russia. but resigned his post within three months. Returning to the United States, he soon entered definitely upon a literary career. Besides contributing various historical and critical essays to the *North American Review*, he published in 1849, again anonymously, a second novel, entitled *Merry Mount, a Romance of the Massachusetts Colony*. About 1846 the project of writing a history of the Netherlands had begun to take shape in his mind, and, after working in the United States, he spent five years at Dresden, Brussels and The Hague in investigation of the archives. *The Rise of the Dutch Republic* (1856) speedily passed through many editions, was translated into French and also into Dutch, German and Russian. In 1860 Motley published the first two volumes of its continuation, *The Gnited Netherlands*, which was brought down to the truce of 1609 by two additional volumes, published in 1868. Partly as a result of his letters to the *Times* (London) on the causes of the Civil War, Motley was appointed U.S. minister to Austria in 1861, a position which he filled with success until his resignation in 1867. Two years later he was sent to represent his country in London, but shortly after was recalled by Pres. U. S. Grant. After a visit to the Netherlands he again took up his residence in England, where the *Life and Death of John Barneveld* appeared in two volumes in 1874. Ill-health and the death of his wife now began to interfere with his literary work, and he died at Frampton court, near Dorchester, Dorsetshirc, on May 29, 1877. The merits of Motley as a historian were undeniably great. He told the story of a stirring period in the history of the world with full attention to the character of the actors and the vivid details of the action, showing

as well a most commendable thoroughness in research.

The Netherlands edition of Motley's *Writings* appeared in 1900, and an excellent edition of his historical works was published 1903–04.

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MOTMOT, name for about six genera and eight species of beautiful tropical American birds, inhabiting deep woods or dense thickets, and constituting the family Momotidae (order Coraciiformes), nearest related to todies, kingfishers and rollers (*qq.v.*). They appear like small jays, chiefly green with rufous, blue and black markings, but the excessively graduated tail of round-ended feathers in most species is long and peculiarly shaped; the middle pair is much longer than the next, and devoid of web subterminally for 1 in. or more, so that the tips are racquet-shaped. These feathers are entire in the young, but brittle in the stem region, where the web breaks off easily as the bird preens with its jay-like but serrated bill. Motmots are solitary, fly in small undulations or perch stupidly on branches of trees, occasionally twitching the long tail from side to side. They feed chiefly on insects caught on the wing, and on small reptiles and fruits, becoming omnivorous in captivity. Like the kingfishers and todies, they excavate holes in banks of streams, in some species seeking caves or rock crevices, and lay three or four glossy white eggs. The Mexican or chestnut-capped motmot (*Momotus mexicanus*), 12 in., of which 6 in. is tail, inhabits dryer thickets rather than dense forests, over arid western and southern Mexico to interior Guatemala, is green, more blue toward tips of wings and tail, more rufescent below, with black throat-tuft and ear-tufts. The blue-capped motmot (*M. momota*), 15 in., tail 9 in., ranges tropical forests from northeastern Mexico to eastern Brazil and northwestern Argentina. The great rufous motmot (*Baryphthengus ruficapillus*), 19 in., tail 11 in., Panama to eastern Brazil and northeastern Argentina, is bright green over the back and under the tail, black through the eye. The turquoise-browed motmot (*Eumomota superciliosa*), 14 in., southern Mexico to Costa Rica, is green above and on breast, throat black, cinnamon-rufous sides and belly. The keel-billed motmot (Elect?-on *carinatum*) ranges from Vera Cruz to northwestern Costa Rica, the broad-billed motmot (E. *platyrhynchum*) from eastern Honduras to northern Bolivia. The red-throated motmot (*Aspatha gularis*), 10 in., southern Mexico to Honduras, has no racquet. The tody-motmot (*Hylomanes momotula*), 6.5 in., southern Mexico to northwestern Colombia, has shorter tail feathers, without racquet. (G. F. Ss.)

MOTOR, ELECTRIC, a device for converting electrical energy into mechanical energy. It is the complement of the electric generator, the two devices together providing the link between electrical and mechanical systems. All generators may act as motors and, conversely, all motors may act as generators, they differ only in some construction details and in their auxiliary equipment.

The principal phenomena that may provide a coupling between electrical and mechanical systems are (1) electromagnetic, in which forces are established as a result of an interaction between magnetic fields created by the stationary and moving parts, (2) electrostatic, in which forces are produced by the interaction of electric fields created by the stationary and moving parts (see ELECTRICITY Electrostatics); (3) magnetostrictive, represented by the deformation of materials subjected to magnetic fields (see MAGNETISM: Stress *and Magnetostriction*); (4j piezoelectric represented by the deformztion of certain crystals when subjected to an electric field (see PIEZOELECTRICITY); and (5) magnetohydrodynamic, or the production of a force when a stream of charged particles is discharged or impinged upon a collector. By far the most commonly exploited phenomenon is the electromagnetic, because it makes possible the conversion of more energy per unit weight. volume and cost. Electric motors which utilize this phenomenon, may range in output from a fraction of a watt (0.0001 h.p.), for use in instrument control systems and servomechanisms, to several thousand horsepower, for pumps and wind tunnel drives.

BASIC PRINCIPLES

According to the Hamilton-Lagrange principle, as applied to electromagnetic devices such as the electric motor, a mechanical force is established when there is a change in magnetic field energy with movement. Thus, to have a unidirectional average force, the average change in energy with displacement must be positive, and in a motor the net average power input (after satisfying the-losses) must be positive.

Two more familiar (but less general) principles are those of Ampère and Faraday. Ampère's law says that a conductor will experience a force if a component of current in that conductor flows at right angles to a magnetic field. Faraday's law states that a potential difference will exist between the ends of a conductor if that conductor is given a component of motion perpendicular to the magnetic field These relationships are illustrated in fig. 1; it should be noted that the induced voltage (fig. 1[B]) opposes the voltage that would be necessary to force the current i through the conductor of fig. 1(A).

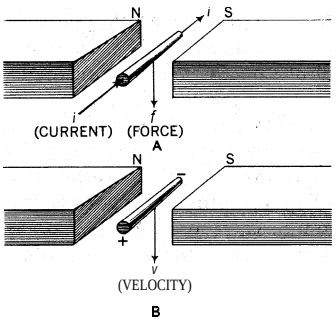


FIG. 1.—CURRENT AND POLARITY RELATIONSHIPS ASSOCIATED WITH (A) FARADAY'S LAW (')

To exploit these principles and convert electrical energy into mechanical energy, motors must consist of two parts—a rotor and a stator. The rotor is the moving portion and contains conductors to establish and shape the magnetic fields that will interact with those produced by the stator. The rotor also is comprised of a contacting device (slip rings or commutator) to connect it electrically with the stator, together with a supporting shaft and bearings*an integral blower for cooling. etc. The stator consists of similar magnetic and electrical conductors to establish and shape the magnetic fields, as well as the frame to support the whole machine. The manner in which the conductors are arranged (and in which the magnetic fields are controlled) determines the type of motor and its characteristics.

INDUCTION MOTORS

An induction motor has two sets of insulated-wire windings: one (usually on the stator) is connected to an external power source; the other, on the rotor, consists of continuous wire loops. The magnetic field established when currents flow in these conductors is concentrated in a narrow air gap between the stator and the rotor.

The purpose of the windings connected to the external energy source is to produce a rotating field that interacts with the induced currents in the rotor conductors, thereby establishing forces on those conductors.

To set up a rotating field, there must be at least two windings carrying currents whose phase relationships are not the same. Fig. 2(A) illustrates two alternating currents whose amplitudes are the same but whose phase relationship is 90°. Fig. 2(B) shows schematically a stator on which four coils have been wound; coils 1 and 3 are so connected that if the current i_1 is in the direction shown. the polarities of the magnetic field at the stator surface will be north at the upper and south at the lower coils; when the current i_1 reverses, so do the polarities of the fields. Coils 2 and 4 are also connected so that a current i_2 produces a similar field. As shown in fig. 2(A), at a given instant of time t_1, i_1 is a maximum and i_2 is zero. Under these conditions the field situation is as shown in fig 2(C). A quarter-period later, at t_2, the current i_1 is zero and i_2 has risen to a positive maximum The resulting field conditions are now as shown in fig. 2(D). At a third instant, t_3, i_1 has advanced to a maximum, but in the negative sense, while i_2 has fallen back to zero from a positive maximum. The field situation is now that of fig. 2(E). Finally, at t_4, i_1 has again become zero and i_2 has reached a negative maximum, and fig. 2(F)

shows the resulting fields. The north pole is found to travel around the periphery of the stator, making one complete revolution while the current goes through one cycle. Hence a revolving field is produced, and its speed depends solely upon the geometry of the coils and the time required for one cycle. For a 60-cycles per second (c.p.s.) power supply, 60 revolutions will be made in one second, or 3,600 revolutions in one minute. The speed of the revolving field is known as the synchronous speed.

If each coil is reduced in size so that it spans just one-half the stator surface (fig. 2[G]), the revolving field will travel only half as far for each cycle of the supply current and the speed of the revolving field will become 1,800 r.p.m. for a 60-c.p.s. supply. The coil arrangement of fig. 2(B) is said to produce a two-pole motor, since at any instant there are but one north and one south pole. The arrangement of fig. 2(G), on the other hand, will produce two north poles and two south poles at any instant and therefore is a four-pole stator. It is not uncommon to have as few as 2 or as many as 100 poles in a motor. The speed of the revolving magnetic field in revolutions per minute in any motor is $120\,f/p$, where f is the frequency in cycles per second and p is the number of poles.

In a practical motor the stator will have more coils than indicated here, and these will be distributed around its periphery in equally spaced slots. This arrangement makes better use of the available space than does the concentrated-coil arrangement described above, but the result is still the same—a revolving field is established.

If a set of conductors is uniformly spaced around the periphery of a rotor, as shown in fig. 2(H), and if the rotor is stationary and a two-pole revolving field is located in the position shown, a voltage will be induced (according to Faraday's law) in a direction out of the page in the upper conductors and into the page in the lower conductors. If these conductors are now short-circuited through an end ring, currents will flow in the same directions as the induced voltages. These currents in turn will produce their own magnetic field, and its direction will be as shown by the dash lines in fig. 2(H). The north pole of the rotor and south pole of the stator will attract each other, and a torque will be exerted on the rotor tending to turn it in the direction of the rotating field.

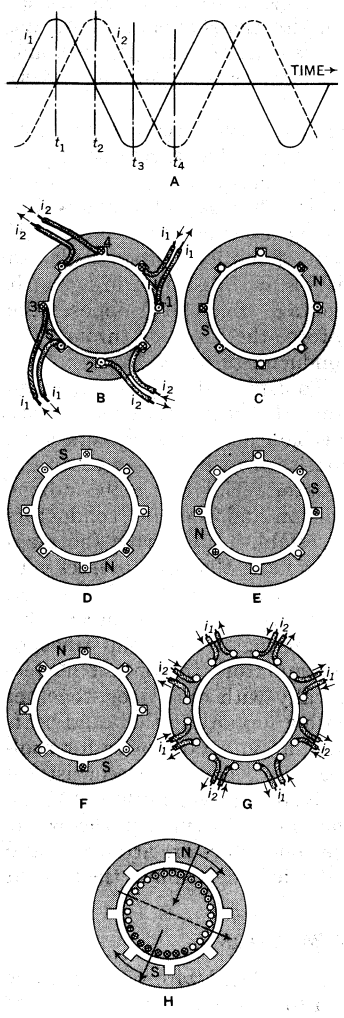


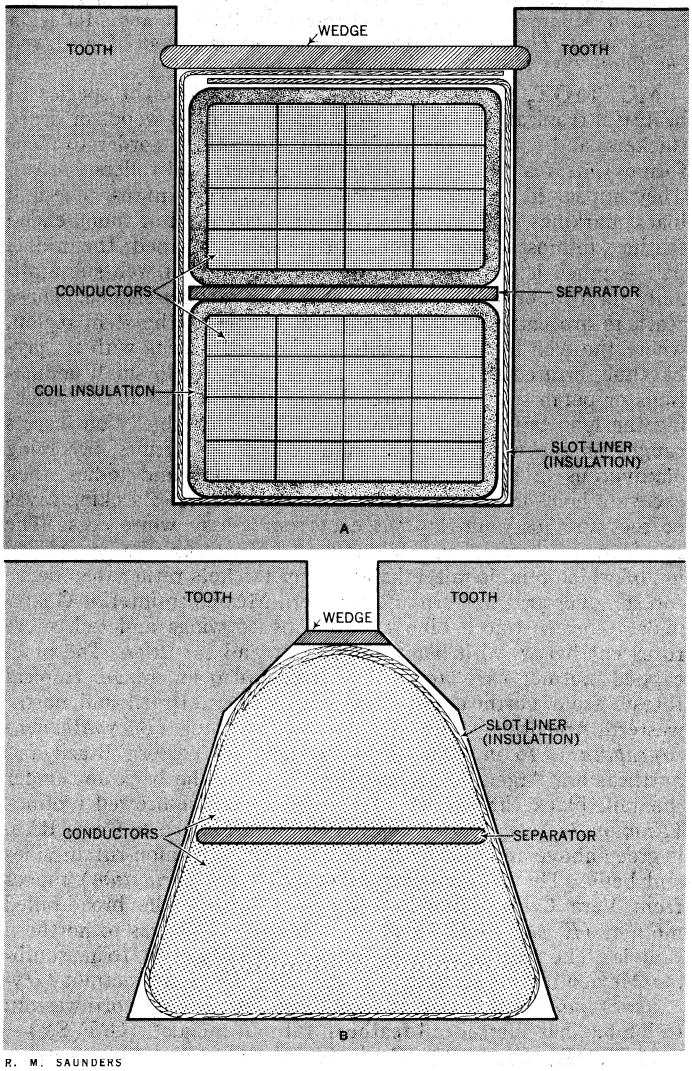
FIG. 2.—INDUCTION MOTOR FIELDS AND THEIR INTERACTION WITH ROTOR AND STATOR CONDUCTORS: ⊗ CURRENT DIRECTED TOWARD VIEWER, PERPENDICULAR TO PAGE; ⊙ CURRENT DIRECTED AWAY FROM VIEWER

If the rotor is traveling at the same speed as the revolving field, there will be no induced voltage in the conductors, no current flow and no torque. Hence, at synchronous speed the torque drops off to zero. If the rotor travels faster than synchronous speed, the motor is serving as an induction generator.

Construction **Features.**—The rotor and stator are built up of laminations of 0.25% to 3.50% silicon steel, from 0.025 to 0.014 in. thick. The laminations are sometimes coated with an insulating varnish to reduce eddy-current losses. Uniformly distributed slots are punched in the steel to receive windings.

The coils connected to the external energy source (usually the stator coils) may be preformed and insulated and then inserted into the machine, or the conductors may be placed directly into the slots and the insulation applied afterward. The former technique is used for motors rated at more than 600 v. or about 100 h.p. Fig. 3 shows slot cross sections for the two types of windings.

The conductors that form the secondary winding may be of three types: wound, squirrel-cage or solid. To make the wound type, a two- or three-phase winding is placed in the rotor slots and some of the terminals brought out to slip rings, which are insulated brass or bronze rings on which carbon brushes ride to provide an electrical connection to the rotor coils.



R. M. SAUNDERS

FIG. 3.—MOTOR COIL WINDINGS: (A) COIL CONDUCTORS PREFORMED AND INSULATED BEFORE INSERTION IN STATOR SLOT; (B) CONDUCTORS WOUND DIRECTLY IN SLOT ("MUSH" WINDING) AND THEN INSULATED

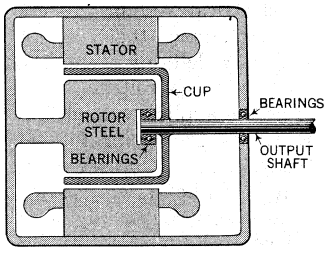
The squirrel-cage winding may be either cast from aluminum or copper or built up from copper or brass bars welded to a common end ring. To cast such a winding. a stack of rotor laminations is inserted in a centrifugal casting machine and molten aluminum or copper is introduced. The result, after the metal solidifies, is an integrally cast set of longitudinal conductors and two end rings. The cast winding is used for standard production line motors in sizes under 100 h.p. For larger motors the welded bar type is employed.

An example of the solid or continuous winding is the drag-cup motor (fig. 4), which consists of a piece of copper or brass rotating independently of the "rotor" steel, which actually is stationary. A solid copper sheath shrunk on the rotor steel will also provide a continuous conductor. The continuous-winding rotors are used principally for servomotors.

Polyphase Induction Motors.—The three-phase stator con-

nection is by far the most common, because most industrial power distribution systems are three-phase. In this type of motor the revolving field is produced by three different currents whose phase relationships are 120° instead of the **90**" shown in fig. 2(A).

Both squirrel-cage and wound-rotor motors may be used in polyphase service; however, the latter are usually reserved for speed-control applications. Squirrel-cage motors may also be classed in terms of their starting current and their speed-torque curves. Fig. 5 shows typical speed-torque curves for commercially available induction motors.



FROM R. A BRUNS AND R M SAUNDERS, "ANALYSIS OF FEEDBACK CONTROL SYSTEMS," 1955 REPRODUCED BY PERMISSION OF MC. GRAW HILL BOOK COMPANY

FIG. 4.— CROSS SECTION OF A **DRAG-CUP SERVOMOTOR**

Single-Phase Induction Motors.—In describing how a revolving field was produced it was pointed out that a necessary condition was that there be at least two currents out of phase in time and flowing in coils displaced in physical position from one another. While it is possible to satisfy the spatial requirement when a single-phase supply is used, it is more difficult to satisfy the time relationship for the currents flowing in the two sets of coils. The most common ways of solving this problem are described below.

Capacitor-start, Capacitor-run Motor.—For this type of motor the stator is built as for a two-phase motor; *i.e.*, with windings spaced 90° apart in a two-pole case. The main minding is connected directly across the power line and an auxiliary wind-

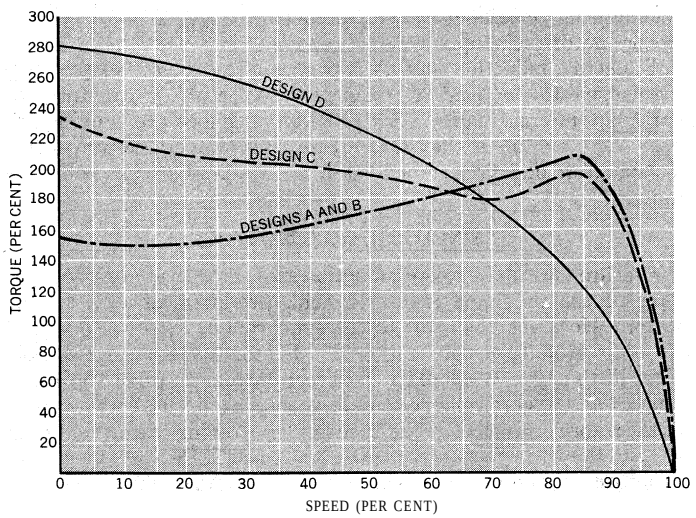


FIG. 5.— SPEED-TORQUE CURVES FOR INDUCTION MOTORS

ing is connected to the line through a suitable capacitor. The electric field in the capacitor tends to overcome the effect on the circuit of the magnetic field in the motor so that the current flowing in the auxiliary winding (containing the capacitor) is out of phase with that in the main winding and the necessary theoretical conditions are satisfied. One difficulty nith this arrangement is that the 90° phase relationship is obtained only for one condition of load at the rated speed. To obtain satisfactory characteristics during the starting period, another capacitor is placed in the circuit to retain the 90° phase relationship; the second capacitor is then taken out of the circuit at about 80% of rated speed by means of a centrifugal switch. Fig. 7 shows the speed-torque curve for a motor of this type.

Slzaded-pole *Motor.*—If a permanently short-circuited coil is placed over a portion of the main field coil. thus "shading" it as shown in fig. 6(B), the result will be a field similar to that produced by two out-of-phase currents. Because the winding cannot be displaced 90° and the currents cannot be 90° out of phase in time. this type of motor has a low speed-torque curve and is used principally for fans, phonographs and household appliances.

Other Types.—Another group of motors employs a revolving field only during the starting period and then runs on a pulsating field. which may be regarded as two counter-rotating fields of equal magnitude. If the rotor response was the same to both fields: the net torque would be zero and the motor would not run at all. However, the rotor impedance can be made higher to the field rotating in the reverse sense than to the field rotating forward; thus, less reverse current flows in the rotor bars and a net forward torque results. However, at a standstill the forward and backward torques are equal, and the motor will not start unless some special provision is made. For example, an auxiliary field may be put into the circuit for starting and then switched out when the motor attains about 80% of its rated speed; or internal connections may be provided that in effect make the motor a different type for starting (*e.g.*, the repulsion-start motor), after which the connections are changed automatically so that the motor runs on the pulsating field.

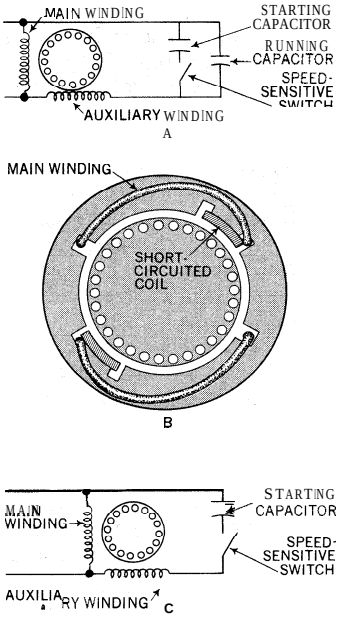


FIG. 6.— SINGLE PHASE MOTOR **CIRCUITS (A) CAPACITOR-START, CAPACITOR-RUN; (B) SHADED-POLE; (C) CAPACITOR-START**

Of the auxiliary field-types the capacitor-start motor is very common; its circuit is shown in fig. 6(C). In the resistance split-phase motor the capacitor is omitted. and consequently there is lower starting torque, since the currents cannot be shifted 90° out of phase. Repulsion-motor principles are also used for this purpose; during the starting period the motor operates as a repulsion motor until a centrifugal switch short-circuits the repulsion winding, and the machine operates thereafter as an induction motor.

Capacitor-start motors are used for refrigerators. compressors and other equipment in which the starting torque requirements are high. Resistance split-phase motors are used for light tools and other equipment starting unloaded. Repulsion-start motors have been largely replaced by capacitor-start, capacitor-run motors. The characteristics of several single-phase motor types are shown in fig. 7.

Servomotors.— The motors used in control systems may be operated from two-phase or single-phase supplies. Fig. 8(A)

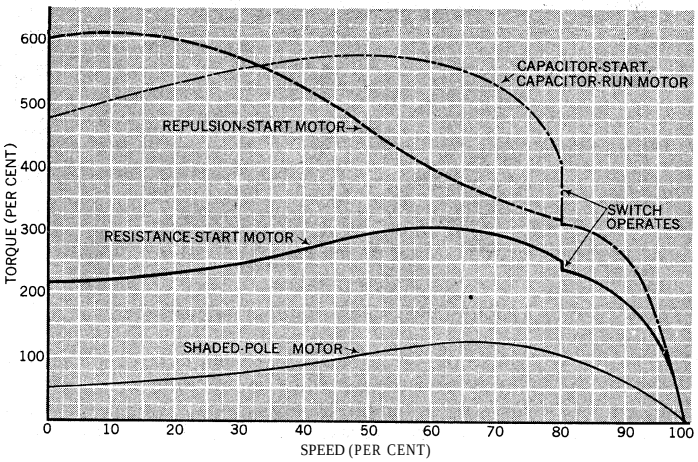


FIG. 7.—SPEED-TORQUE CURVES FOR SINGLE-PHASE INDUCTION MOTORS

shows the usual method of energizing a servomotor through an amplifier. The reference-phase voltage is constant, but the control phase has a variable voltage impressed upon it from the amplifier, which in turn receives its signal from the rest of the con-

trol system. If the rotor resistance is relatively high, the motor will exhibit variable speed characteristics. Fig. 8(B) shows a set of typical servomotor speed-torque curves.

These motors sometimes have drag-cup rotors, but they are more commonly of the squirrel-cage type. They are limited to small outputs because much of the power input appears as loss, and this loss must be dissipated as heat in the rotor.

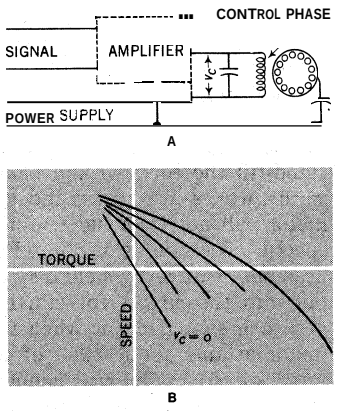


FIG. 8.— SERVOMOTOR OPERATING CHARACTERISTICS: (A) SCHEMATIC DIAGRAM OF MOTOR CIRCUIT; (B) SPEED-TORQUE CURVES AT VARIOUS VALUES OF CONTROL VOLTAGE V_C

Speed Control.— Induction motors basically are constant-speed devices and are used most frequently as such. However, if speed control is desired. several methods are available: frequency control, pole changing. addition of rotor or secondary resistance, stator voltage control and counter-rotor voltage control.

In discussing the revolving field it was pointed out that the speed of the field is a function solely of the power-supply frequency and the design of the winding. Thus if the frequency is varied, the synchronous speed of the field will change and. depending to some extent on the load, the shaft speed will also change. This method requires some external device to alter the ordinarily unvarying frequency of the power supply.

The pole-changing method involves connecting the individual stator coils (as in fig. 2[G]) externally. Thus, adjacent coils may be of either the same or opposite polarity, depending on how they are connected. If adjacent coils are of the same polarity, the result will be half as many magnetic poles as when the coils are of opposite polarity, and the synchronous speed will be doubled. However, this method makes it possible to change the motor speed only in discrete steps (usually 2:1); it does not provide for continuous variation.

Control of motor speed by varying the power-supply voltage is not very effective in A.C. induction motors (except in servomotors), but some speed variation is possible within narrow limits.

Secondary or rotor resistance control can be applied only to a wound-rotor motor. If external resistances are connected into the rotor circuit, the resulting speed-torque curves will be similar to those of fig. 9.

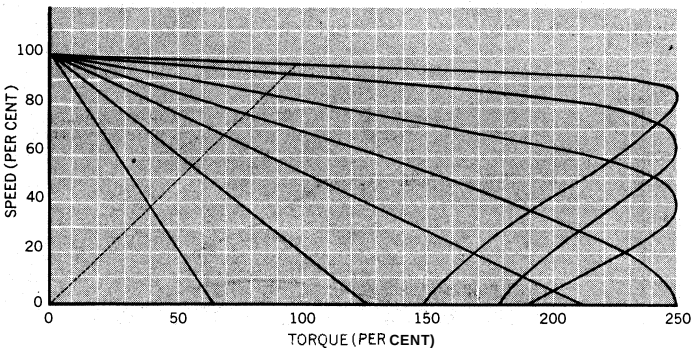


FIG. 9.— SPEED-TORQUE CURVES FOR WOUND-ROTOR INDUCTION MOTORS

One difficulty in using rotor-resistance speed control is that the losses in the external resistor may become so substantial that it is desirable to offset them by employing counter-voltage methods. These involve the use of auxiliary machines and are justifiable only when the rotor loss is sufficiently important economically to warrant the investment in additional equipment.

Starting and Protection.— Induction motors are extremely rugged and in the smaller sizes (under 25 h.p.) usually will withstand sudden application of full voltage at standstill without damage. However, for larger motors the electrical supply system must be protected against sudden surges arising from the large starting currents produced. All induction motors (except servomotors and those used in speed-control service) during the starting period draw from four to six times the normal running current. When the electrical system will not withstand such currents there are four techniques that may be used: reduced-voltage, resistor or reactor, Y-delta or part-winding starting.

For reduced-voltage starting an autotransformer is used to lower the applied voltage to 65%–80% of normal. Because the current is proportional to the square of the voltage, an 80% reduction in voltage will mean that only 64% of the full-voltage current will be drawn. However, because of derating, these autotransformers can be used only for very short periods of time

The second method involves simply the provision of resistors and reactors that can be switched into the supply lines to limit the current during starting.

For motors operating on three-phase power, the windings may be connected either with both ends across the line (delta) or with one end on the line and the other connected to the remaining two windings (Y), as in fig. 10. If a motor designed with delta-connected windings is reconnected Y. the voltage across the windings is reduced to 57% of normal and the current will be only one-third that drawn at full voltage.

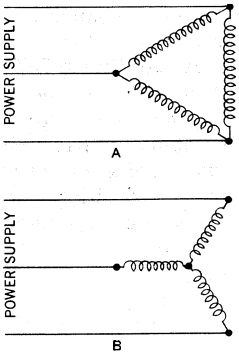


FIG 10— MOTOR WINDINGS FOR THREE-PHASE POWER SUPPLIES (A) DELTA-CONNECTED (B) Y-CONNECTED

Part-winding starting is possible if connections are provided so that only part of the motor winding is in the circuit during starting, the remainder being switched in as the motor picks up speed.

Protecting induction motors is primarily a problem of preventing damage to the windings from excessive heat. On motors under 5 h.p. internal temperature-sensitive switches are provided to open the main line if the temperature rises above a certain value. Temperature detectors embedded in the windings are used on large motors.

SYNCHRONOUS MOTORS

Synchronous motors, like induction motors, operate on the principle of the revolving magnetic field, produced usually by the stator. However, the rotor of the synchronous motor is designed so as to produce a constant field. If, for example, a two-pole rotor of this type is excited with direct current through slip rings, a north and a south magnetic pole will be produced on the rotor. If the rotor is traveling at the speed of a revolving stator field such as that shown in fig. 2([C]. [D], [E], [F]), the two fields will lock together and the rotor will be pulled around at the same speed as the revolving field.

Construction.— In most synchronous motors the winding that produces the revolving magnetic field (known as the armature winding) is on the stator, and the design of such a stator is essentially the same as for an induction motor. (For a synchronous motor that has its armature winding on the rotor, the design is much the same as for a wound-rotor induction motor.) A unidirectional field, to interact with the revolving field produced by the stator armature winding, is produced on the rotor by exciting a direct-current winding from a 125- or 250-v. D.C. source.

Motors using D.C. fields must have some means of starting. In most motors this is accomplished by installing a squirrel-cage winding in the pole faces of the rotor. Such a motor operates on induction motor principles up to about 95–97% of synchronous speed. at which point the D.C. field is applied. The motor then locks into synchronism. Motors with this type of field winding usually are more costly to build than general-purpose induction motors in sizes up to 300–500 h.p.

In small motors it is possible to eliminate the need for a D.C. power source by building the field structure from the same metals used for permanent magnets. The field structure then is given a permanent residual magnetic field that locks in with the revolving

field at synchronous speed. These so-called hysteresis motors have a lower power-to-weight ratio than the D.C.-excited types described above, but they are useful in some low-load applications where constant speed is important — as gyro-spin motors in navigational equipment, in phonographs and taperrecorders and in clocks.

Another type of field construction is found in the reluctance motor. in which no rotor winding is used at all. the toothed design of the rotor producing the synchronous motor characteristics. If the rotor lags behind the revolving field, the average energy stored in the air gap around it decreases. This produces a greater positive ratio between the stored magnetic energy and the displacement angle, and a greater torque is established, pulling the motor back into synchronism. The power-to-weight ratio here is even more unfavourable than in the hysteresis motor, but the reluctance motor can be used to power certain instruments and electric clocks.

Polyphase Synchronous Motors.—Like most induction motors, synchronous motors are designed to operate on three-phase power in sizes above 1 h.p. Furthermore, in such sizes they are always D C. excited.

The source of direct current may be rectifiers. D.C. generators (exciters) driven from the motor shaft or separate motor-generator sets.

One important feature of synchronous motors is that control of the field current affords a means of power factor control. When the D.C. field of a synchronous motor is overexcited, the motor must draw a demagnetizing component of current from the power lines to compensate for the overmagnetization that takes place. The demagnetizing current drawn by the synchronous motor will balance some of the magnetizing current drawn by other induction machines on the same power line. This component of alternating current transmits no energy but does cause additional loss in all associated equipment, such as transmission lines and transformers. In most cases power company rates are adjusted to reflect the cost of supplying magnetizing current. and it is often economically feasible to correct for this condition in a manufacturing plant rather than pay the power company. Thus a synchronous motor may serve the dual purpose of driving a load at constant speed and at the same time reducing the net magnetizing current drawn from the power lines. In fact, in some cases it is economically justifiable to operate a motor solely for the purpose of power factor correction A motor designed for this service has no output shaft and is referred to as a synchronous condenser.

Single-phase Synchronous Motors.—As was the case for induction motors, a revolving field is needed, and to produce it a capacitor may be inserted in the second phase of a two-phase motor or a shaded-pole structure may be used. Thus a revolving field is established, although it is inferior to that provided by a polyphase supply.

There is relatively little demand for D.C. field-excited motors in sizes under 1 h.p., so virtually all small motors are hysteresis or reluctance types. Such motors rarely develop more than 20% to 50% of the power that could be expected from a magnetic circuit of the same size in an induction motor.

Of special interest is the single-phase synchronous motor used in electric clocks. A two-pole rotating field is set up by means of shaded-pole construction. The resulting rotating field reacts with one or more thin disks of hardened steel especially chosen for their wide hysteresis loop characteristics and housed in a sealed metal container. The rotating field starts the motor by eddy current action in the container and brings the motor up to speed, usually 3.600 r.p.m. As the motor approaches synchronous speed, the rotating field magnetizes the disks and they then are locked in with the revolving field. A sealed gear train reduces the speed to 1 r.p.m. at the motor shaft. While these motors have efficiencies of less than 1%, they are very inexpensive to build and operate.

Speed Control.—Synchronous motors are less amenable to speed control than are induction machines. Only two methods are suitable: frequency control and pole changing. The principles are the same as for induction motors.

Starting and Protection.—Small synchronous motors of the hysteresis and reluctance type are started on full voltage and are protected (if at all) by a thermal cutout in the same fashion as for induction machines.

Larger machines using D.C. fields have more troublesome starting problems than any other class of electric motors. Not only must the current inrush to the motor from the power source be controlled, as was the case for the induction motor, but the field must be protected from high voltages arising from transformer action. Then, when the rotor has been accelerated up to synchronous speed, direct current must be applied to the field at the proper instant On the other hand, synchronous motors may be designed to have almost any type of starting torque characteristic without sacrificing good running features. Starting torques of from 40% to 600% of full load may be obtained, with corresponding starting currents 250%–600% of normal. The method of limiting current inrush to the armature winding is the same as for induction motors.

During the starting period the field winding is generally short-circuited. When the machine has accelerated to 95%–97% of synchronous speed, D.C. current is introduced to the field and the motor locks in to synchronism. Application of the D.C. field current at the proper moment can be done automatically by taking advantage of two motor characteristics: as the motor nears synchronous speed, the frequency in the rotor circuit approaches zero, and as the rotor "slips" with respect to the revolving field there are corresponding pulsations in the line current. These conditions can be detected either by a frequency-sensitive relay in the field circuit or by a special relay in the line. and the relays can then initiate the switching on of the D.C. field current.

The protection of synchronous motors. while more complicated than in the case of induction motors, centres on the same basic problem. prevention of damage to the windings from heat caused by excessive currents. Specifically, the problems encountered, and their solutions. are (1) excessive stator current, usually detected by external sensors or embedded temperature detectors; (2) excessive field current, detected by external sensors; (3) excessive field voltage. which can be controlled by short-circuiting the field winding through a resistance during starting or by the use of discharge gaps between the slip rings; (4) squirrel-cage overheating, controlled by external timers; and (5) phase failure (causing abnormally high current in the squirrel-cage winding), detected by external sensors.

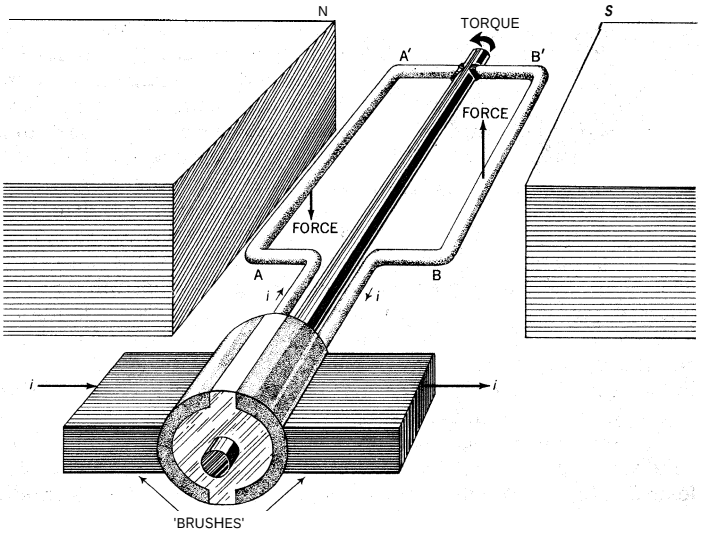


FIG. 11.— DIRECT-CURRENT MOTOR PRINCIPLES

COMMUTATOR (D.C.) MOTORS

Commutator motors excited with direct current (called D.C. motors) were the forerunners of induction and synchronous machines, because many cities had well-established D.C. distribution systems for both lighting and power while A.C. systems were still speculative. Hence the D.C. member of the commutator motor family was well established when Nikola Tesla invented the induc-

tion motor. Modern commutator motors find their main use in speed-control applications.

Basic **Principles.**—Unlike induction and synchronous machines, commutator motors (with a few exceptions) make use of stationary rather than revolving fields—in fact, the sole purpose of the commutator is to control the position of the rotor field irrespective of the speed of rotation or the frequency of the current in the windings. For the purpose of explaining how such motors work, it is best to develop the principles for D.C. motors and then extend those concepts to A.C. motors.

If the single conductor of fig. 1 is replaced by a coil, as in fig. 11, mounted on a shaft so that it is free to rotate in the magnetic field, and if current *i* is caused to flow in the directions shown, a downward force will be evident on the left side of the coil and an upward force on the right side, and the coil will tend to rotate in a counterclockwise direction. However, to maintain this rotation the current i must be reversed by the time the conductor AA' comes under the south pole. This is accomplished by the commutator, which consists of an insulating member, carrying two copper segments, that rotates with the coil. Riding on the commutator but fixed to the motor frame are two brushes, usually made of graphite. These provide the connection to the external circuit. When the current i is forced into the left brush, it flows through the copper commutator bar and thence into the coil side AA'. It returns through B'B to the other commutator bar segment and out the right-hand brush. When coil side AA' has moved around to BB' the current in the coil will have been reversed.

In an actual motor, greater field strength in the vicinity of the conductor will be achieved if the magnetic circuit cross section is like that of fig. 12. Also, in an actual motor the number of coils is multiplied so that there may be from 3 (in very small, low-voltage motors such as those used in models) to *300* or more (in very large steel mill motors). The number of commutator segments also will increase, for there must be one for every coil.

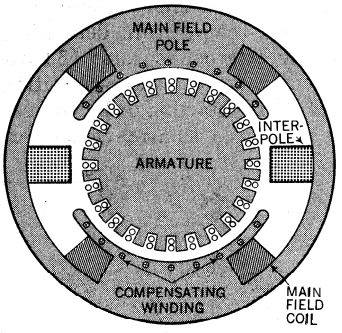


FIG. 12.—D.C. COMMUTATOR MOTOR CROSS SECTION

When the current in a rotor (armature) coil is suddenly reversed by the commutator, the coil is momentarily short-circuited and the voltage induced in it by the changed current may cause sparking at the brushes and consequent eroding of the commutator. In motors under 1 h.p. this is not a serious problem. but in larger motors it is customary to reduce sparking by inducing a voltage equal and opposite to that caused by the change in current. Shifting the brushes will do this, but a different angle of shift is needed for each load condition. The use of an interpole, or commutating pole. whose winding carries the same current as the armature, is a more satisfactory way of inducing an opposite voltage. The location and relative size of the interpoles is shown in fig. 12.

In large motors that must operate under rapidly changing load conditions, an additional winding may be used to reduce the problems created by rapidly changing armature current. Such a winding is called a compensating winding and is placed in the pole faces as shown in cross section in fig. 12. This winding is in series with the armature conductors. but it is arranged so as to oppose the field established by the rotor conductors.

The actual construction of a commutator motor is very similar to that of the induction and synchronous machines. Thin steel laminations are stacked together to form the armature and the field poles. Coils are usually preformed. although for some small motors the coils are wound on automatic winding machines that insert the wire turn by turn into the slots. The commutator is built up of segments of copper and then either cast in an insulating compound or fastened together with compression clamps.

D.C. Motor Characteristics. — The operating characteristics of D.C. motors are determined solely by the manner in which the main field is excited.

In the shunt motor, the main field coil is placed across the D.C. line (fig. 13[A]). This type of excitation tends to give a constant field flux. and the speed-torque characteristic would fall off only because of the resistance drop in the armature circuit. However, the armature field arising from the currents in the rotor conductors (armature reaction) tends to demagnetize the main field to some extent. The result is that the shunt motor usually has a slightly concave speed-torque characteristic, as shown in fig. 14.

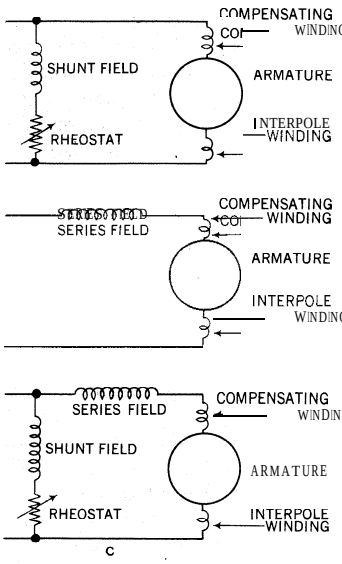


FIG. 13.—DIRECT-CURRENT MOTOR CONNECTION DIAGRAMS: (A) SHUNT MOTOR; (B) SERIES MOTOR; (C) COMPOUND MOTOR

A series motor (fig. 13[B]) has its field winding in the same circuit with the armature. This produces a speed-torque curve (fig. 14) with a high no-load speed. Because of their very great starting torque, these motors are useful for traction service.

Compound motors have both shunt and series windings (fig. 13[C]), giving them composite characteristics. Usually the series field has small effect under a normal load condition. For example, a motor whose series field aids the shunt field tends to run as a shunt motor under normal load. but it also will develop higher starting torques than a shunt motor because of the contribution of the series winding at standstill.

A.C. Commutator Motors. — An A.C. commutator motor presents two problems that do not arise in D.C. motors: the phase relationships between currents in different parts of the motor may not make interaction possible, and there are now voltages present due to transformer action.

In the series A.C. motor, the phase problem is not present because the currents in both the armature and field are the same. Hence the armature current reverses at the same instant the field current reverses and a unidirectional torque is produced. These motors are very common in such household appliances as vacuum cleaners, mixers and hand-held drills. These small motors for domestic use are sometimes called universal motors. since they may be used on D.C. or on any A.C. frequency to 60 c.p.s. In larger sizes, series motors are used for A.C. railway service, especially on 25- and $16\frac{2}{3}$-c.p.s. power.

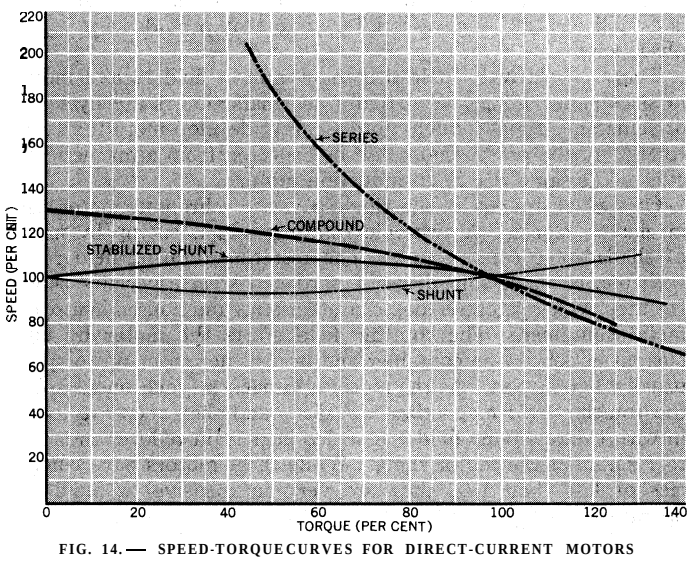
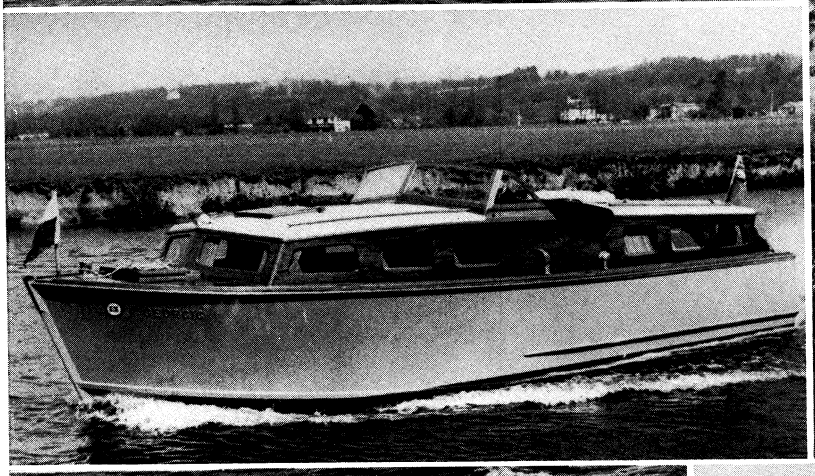
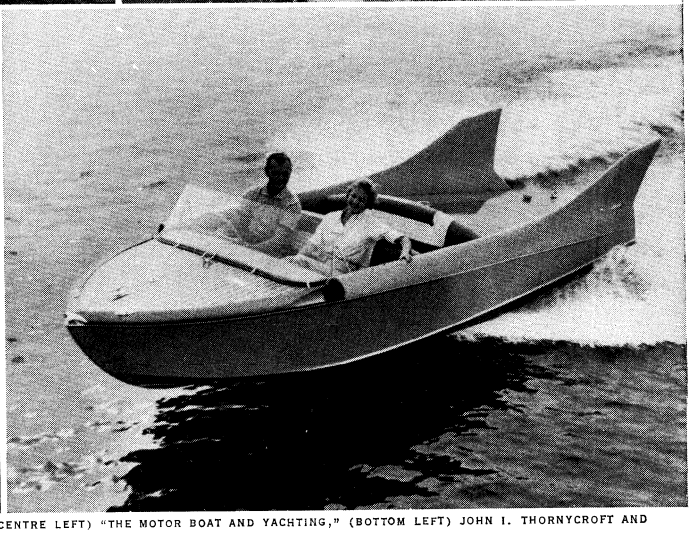


FIG. 14.— SPEED-TORQUE CURVES FOR DIRECT-CURRENT MOTORS





BY COURTESY OF (TOP LEFT) THE MATTHEWS CO., (TOP RIGHT) PENN YAN BOATS, INC., (CENTRE LEFT) "THE MOTOR BOAT AND YACHTING," (BOTTOM LEFT) JOHN I. THORNYCROFT AND CO. LTD., (BOTTOM RIGHT) ANCARROW MARINE, INC

U.S. AND BRITISH MOTORBOATS

Top left: Motor cruiser, U.S., 42 ft., with a double cabin, flying bridge and accommodations below for sleeping six persons

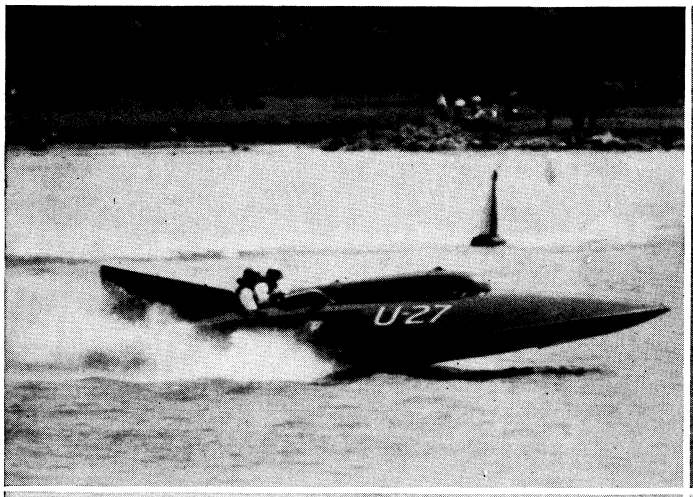
Top right: Motorboat, U.S., *14* ft., outboard

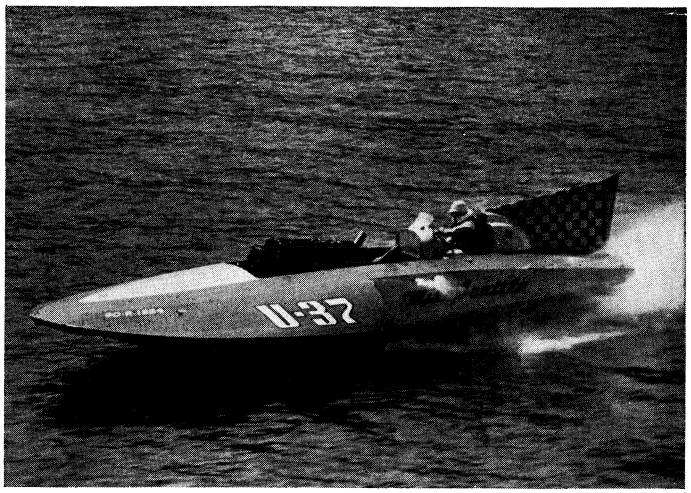
Centre left: Motor cruiser, British, 35 ft. Built for hire work. Living accommodation is provided for five persons

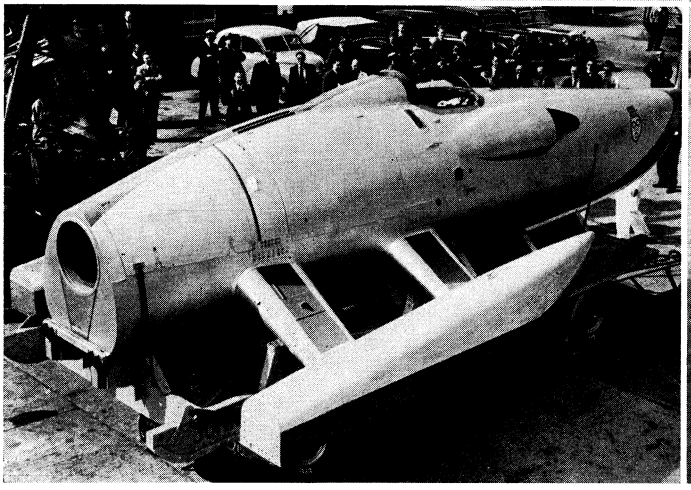
Bottom left: Work launch, British, 48 ft., with three 190-h.p. diesel engines

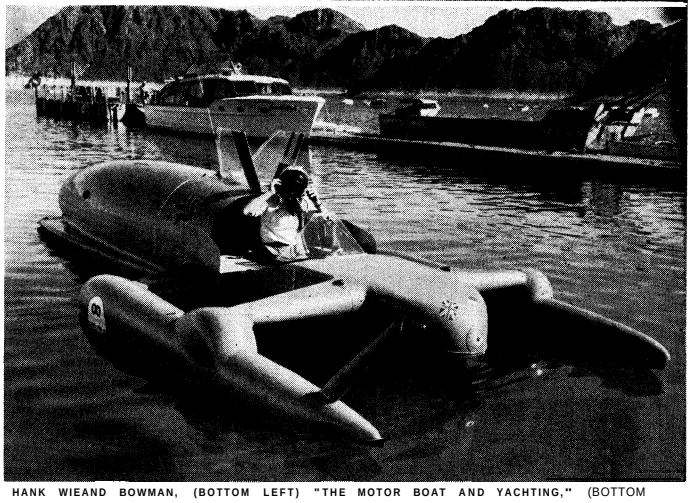
Bottom right: Two-seat runabout. U.S., 19 ft., inboard

MOTORBOAT









BY COURTESY OF (TOP RIGHT) BOB MILLER (CENTRE LEFT) FOTO SPORT, (CENTRE RIGHT) HANK WIEAND BOWMAN, (BOTTOM LEFT) "THE MOTOR BOAT AND YACHTING," (BOTTOM RIGHT) SOCONY MOBIL OIL CO PHOTOGRAPH, (TOP LEFT) UNITED PRESS

RACING HYDROPLANES AND JET-ENGINED BOATS

Top left: "Slo-Mo-Shun IV" (U-27), shown winning the 1950 Gold Cup race for unlimited class hydroplanes. In 1952, the boat established a water speed record of 178.49 m.p.h. for propeller-driven boats. It was powered with a 1,710-cu. in. Allison aircraft engine

Top right: "Miss Seattle," three-point unlimited class hydroplane. In 1954 under the name "Slo-Mo-Shun V" it set a record of 99.108 m.p.h. for the 90-mi. Gold CUP race

Centre left: "Massimo," an outboard hydroplane, driven by owner Massimo Leto di Priolo. In 1953 "Massirno" set a world water speed record for outboard hydroplanes of 83.473 m.p.h. The boat had a Swift-Molinari hull and a 95-h.p. Soriano motor

Centre right: Racing outboard hydroplanes, 13-ft. class D stock boats

Bottom left: "Crusader," jet-powered boat that John Cobb drove at 206.89 m.p.h. on Loch Ness, Scotland, before the boat overturned on its first run, killing Cobb, Sept. 29, 1952

Bottom right: "Bluebird II," jet-engined boat, with Donald Campbell in the cockpit. In 1957 Campbell established a world water speed record of 239.07 m.p.h. when driving the boat over Lake Coniston, Eng.

Speed Control. — Mention has already been made of the use of commutator motors for X.C. speed control: however it is the D.C. machine that is more commonly used for variable-speed applications.

The simplest way to control the speed of a shunt motor is to vary the field current or the armature voltage. Fig. 15(A) shows the circuit for a shunt motor with a variable armature resistor and a variable field resistor. If both of these are set for zero resistance, the motor will operate at its base speed. Decreasing the field current (*i.e.*, increasing the field resistance) but keeping the armature voltage unchanged will cause the motor to speed up. The maximum speed that can be achieved in this way is about double the base speed. If the field resistor is set at zero and if the armature voltage is decreased by inserting more resistance in series with the armature, the speed will be decreased. Fig. 15(B) shows the effects of these operations.

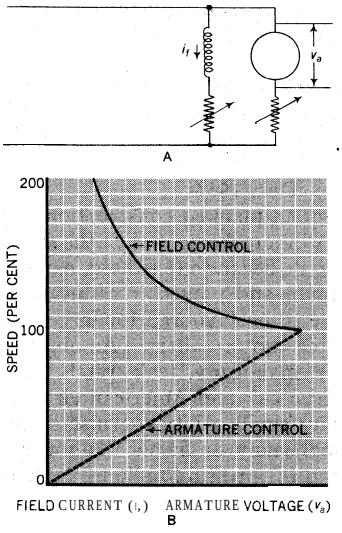


FIG. 15.— D.C. MOTOR SPEED CONTROL

Starting and Protection. — Except for very small sizes (& h.p.), all D.C. motors must have reduced-voltage starters. Oiten this is a simple rheostat in the armature circuit: as the motor comes up to speed. the external resistance is gradually reduced to zero. In many cases this is done automatically by using timers or current- or voltage-sensitive relays.

Overcurrent protection, a means of keeping the windings from being overheated. is quite common. Thermal relays, which remove the motor from the line when the motor is too warm, are often used. To protect the commutator from flashover. there is sometimes provided current trip set to open the circuit at 200–300% of rated current.

Overspeed is a problem not often encountered in synchronous and induction motors but it can be serious in many commutator motors. Centrifugal switches are commonly used to detect an overspeed condition and shut off or reduce the power.

Field failure on shunt motors produces very heavy armature currents and a tendency for the motor to accelerate dangerously. A field-protection relay therefore is provided to shut off power if the field current drops to zero.

See also references under "Motor, Electric" in the Index volume.

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MOTORBOAT, a small water-borne vessel, driven by internal-combustion machinery. Such a craft with a permanently installed engine is referred to as an inboard motorboat, while a boat propelled by a readily removable. comparatively portable engine clamped to the stern or in a motor well inside the hull is called an outboard motorboat. There is no generally accepted limit of size above which the term motorboat is replaced by motor ship; a total weight (displacement) of 200 tons represents a convenient dividing line. but most motorboats are very much smaller than that. Most motorboat engines use gasoline (petrol) as fuel. but small marine diesel engines gained in popularity following the end of World War I In some countries marine engines burning vaporizing oil were in wide use. After the 1940s many experiments were made in Great Britain, the United States and elsewhere in the application of the internal-combustion turbine to motorboat propulsion, experiments which began to see actual production usage in the middle 1950s. The engine of a motorboat usually turns a propeller acting against the water. Honever, some boats that commonly operate in shallow or needy naters have airscrews, internally disposed impellers or paddle nheels. By the late 1930s there had been considerable experimentation nith aircraft-type jet propulsion for high-speed uatercraft Donald Campbell of Great Britain became the first to qualify for official world water speed records nith jet power in 1939.

Types.—Motorboats are of many types, among them the following:

The outboard runabout is an open boat usually between 8 ft and 18 ft., generally with seats running laterally across the width of the craft and occasionally with decking over the bow area or perhaps between the several seats. This type is driven by an outboard motor, a self-contained unit arranged to clamp onto the stern This is the most popular of all pleasure motorboats as it is the least costly, easiest way to become a boat owner.

The inboard runabout ranging from 14 ft to upward of 25 ft.. is usually open but sometimes has a removable shelter top; there are fast. sport. cockpit models as well as open roomy utility craft. These boats are propelled by inboard engines. usually gasoline either in single or tnin installation: hull design is without steps, shingles or sponsons. Technically a displacement type hull. these runabouts are actually semiplaning craft.

Hydroplanes are crait built to skim over the surface of the water nith only a minimum of the hull in contact nith the nater when the boat is traveling at speed. The bottom can have a single or multiple step configuration, or it may have lateral pontonlike sponsons.

Three-point hydroplanes ride only on the after edge of each sponson and on the propeller nhen at speed.

The outboard cruiser, developed during the late 1940s and early 1950s ranges from 17 ft. to 24 ft. and provides sleeping and living accommodations for tno to four persons. including kitchen and toilet facilities, in a small, compact cabin. Usually it is powered with single or tnin outboard motors above 1j h p.

The inboard cruiser is a motorboat with sleeping, cooking and toilet facilities in a cabin. ranging upward from 18 ft and propelled by single, twin or sometimes multiple gasoline or diesel inboard engines. An inboard cruiser longer than about 50 ft. is generally called a motor yacht. This type of boat is usually designed for operation in less protected aaters, and large cruisers and motor yachts frequently navigate coastal oceanic routes.

The auxiliary sailboat, basically designed as a sailing craft, is powered nith an internal-combustion engine for use in adverse weather conditions and for maneuvering in confined spaces.

The motor sailer. in contrast to the auxiliary, is designed principally to operate as a motorboat but is equipped with sail as complementary power. A rugged, sturdy craft, nith the comparatively small sail area lending a steadying effect in a seauay, the motor sailer has living facilities and the roominess below of an inboard cruiser.

Work boats include ferries, fishing boats, motor barges. tugs, coasters, passenger boats, police and harbour officials' launches, canal boats, fuel and water boats. fire-fighting craft and many others. War boats include torpedo boats, gunboats, antisubmarine boats, rescue craft and numerous ancillary vessels.

Early Achievements — Thereis much doubt as to who first applied internal-combustion power to the propulsion of a boat. One of the first certainly was the German Gottlieb Daimler, who demonstrated a one-horseponer launch at Kannstatt, Württemberg, in 1887. About this time a number of Daimler motorboats were produced and put into service. In Great Britain. Priestman Brothers of Hull were pioneers. G. Priestman carried out trials in 1888 with a kerosene-engined craft, but the motor was ahead of jts time. having high-tension ignition. In 1890 barges powered by Priestman engines were being successfully used for canal work.

In 1904 the magazine the *Motor* Boat was brought out by the Temple press, London, and in the same year a magazine of the same name became the first United States periodical to be devoted to this young sport. It was the goal of these magazines to chronicle and encourage the development of the new type water craft, just beginning to be popular. The following year the first U.S. annual

National Motor Boat show was held in New York city, becoming an international market place for motorboats that was still flourishing in the mid-20th century. In 1903 Sir Alfred Harmsworth (later Lord Northcliffe) established the British International trophy for motorboat competition, the first international, perpetual trophy in the sport. It was won that year by S. F. Edge's "Napier I," a displacement craft, with a speed of 19.53 m.p.h., over the course at Queenstown, Ire. The go-mi. American Gold Cup race for motorboats under 40 ft. was inaugurated the following year and won by C. C. Riotte's "Standard" at 23.6 m.p.h.

Recreational Usage.—Motorboats lend themselves to many uses, including pleasure cruising, fishing, racing, water ski and aquaplane towing and family runabout activity. . Inboard cruisers, motor yachts and motor sailers larger than 3 j ft. are suitable for offshore angling expeditions for big game fish such as tuna, marlin and broadbill sword. They also are designed to accommodate six or more persons for considerable time afloat, and many owners and their families spend months at a time on their cruisers; a few live permanently on board. Smaller inboard cruisers and the outboard variety make excellent family living quarters for week ends or vacations, and are useful for fishing in semiprotected waters. Inboard and outboard runabouts and utilities, ranging in horsepower from 3 to well over 300, are used for fishing, water skiing, racing and family day cruising on protected and semiprotected waters.

Inboard **Engines.**—Most inboard, fixed motorboat propulsion units are four-cycle gasoline engines, designed specifically for marine use. However, there have been many successful nautical conversions of automotive power plants, and the fuel-oil burning diesel engine was recognized by boatmen as an efficient, economical source of boat power, particularly in the decade following World War II. Four- and six-cylinder models of gasoline marine engines were the most popular in the 1950s for cruiser and runabout power, but eight-cylinder V-8 models began to gain favour for high-speed operation. Early diesel engines for marine use were big and bulky with a low horsepower-to-weight ratio, but post-World War II engineering produced small, compact diesels designed to fit into craft as small as 25 ft. The initial cost of the diesel engine was higher than that of a comparable gasoline engine, but the fact that this type of power plant reduced fire hazards and utilized a relatively inexpensive fuel and in considerably less quantity than gasoline made it attractive to pleasure and work boat owners.

Outboard Motors.—A self-contained, detachable nautical propulsion unit was first introduced in 1902 in France, the Motogodille, a direct-drive engine hinged to the top of the transom and the crankshaft coupled directly to the propeller shaft, which led out at an angle over the stern of the boat. A few years later the American Cameron Waterman developed a small outboard in the United States. However, Ole Evinrude, of Milwaukee, Wis., is considered to be the man who popularized the outboard motor. He put his first Evinrude into production in 1909, a single-cylinder 1½-h.p. unit with the vertical shaft and bevel-gear drive to the propeller which was used in outboard motors for many years. The early motors were heavy for the power developed and did not always prove to be a dependable motive source. To correct these drawbacks manufacturers made use of lighter metals such as aluminum, and through progressive engineering developed a dependable engine that would start at the touch of an electric starter button or a single pull of the starter cord. A later development was noise reduction by means of rubber powerhead mountings.

An overwhelming majority of outboard motors are two-cycle units with the lubricating oil mixed directly into the gasoline fuel. Earlier motors had integral tanks for fuel. but as the units became bigger and more powerful, manufacturers provided separate fuel tanks permitting greater cruising range. Only the smallest motors were equipped with integral tanks in 1957.

Speeds.—From the early competitive speeds of 20 m.p.h. common in 1904, racing motorboats were developed to the point where the unlimited propeller-driven hydroplanes were turning in heats well over 100 m.p.h. by 1955. These huge craft would do 150 m.p.h. on the straightaways in competition, but had to slow down for the turns at each end of the course. Sir Malcolm Campbell held the world one-mile water speed record of 141.74 m.p.h. from 1939 until 1950. when the revolutionary three-point hydroplane "Slo-Mo-Shun IV." owned and driven by Stanley S. Sayres, captured the record with an average of 160.323 m.p.h. on Lake Washington at Seattle, Wash., in June 1950. Two years later Sayres, again driving the same boat, increased his mark to 178.497 m.p.h. Donald Campbell, son of Sir Malcolm, on July 23, 1955, became the first man successfully to pilot a jet-propelled boat over an official time trial course. His mark was 202.32 m.p.h. At least two men, John Cobb of England and Mario Verga of Italy, were killed in the 1950s trying to reach 200 m.p.h. The younger Campbell later boosted his record to 239.07 m.p.h. on Lake Coniston in England on Nov. 7, 1957.

While inboard speeds were approaching 200 m.p.h., the world's outboard pilots were making a concerted assault on 100 m.p.h. for their mile straightaway runs. Finally Massimo Leto di Priolo of Italy hit 100.36 statute miles an hour in a Molinari class X hydroplane with a special Lesco engine in Dec. 1954.

Boatbuilding Materials.—Wooden planked construction has been the perennial favourite for small motorboats, but in the years following World War II other materials began to take hold, namely sheet and molded plywood, aluminum and polyester resins reinforced with glass fibres. Steel came to be favoured for larger inboard cruisers, motor yachts and big motor sailers. Among the woods used for planking are cedar. mahogany, teak, pitch pine, English oak and silver spruce. White oak and American elm are popular for framing. A great many small utilities, cruisers and hydroplanes are built of marine mahogany or fir sheet plywood, while mahogany plywood is favoured for pressure molding of runabout and dinghy hulls.

The development of the lighter metals, particularly aluminum, as materials for boat hull construction greatly lightened the craft, making them more easily transportable atop automobiles or on boat trailers attached to automobiles. The reinforced plastic resin and glass materials, that were introduced in the later 1940s and further developed in the 1950s gave an added toughness to hull construction. eliminating much of the annual maintenance work needed on wooden hulls.

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(J. E. CE.)

MOTORCAR: *see* AUTOMOBILE.

MOTORCYCLE. This may be broadly described as a vehicle of transport in which the principles of the bicycle and of the internal-combustion engine are combined. The term covers a range of machines from 50 c.c. piston displacement or below (mopeds or motor bicycles) to 1,000-c.c. multiple-cylinder models, of which the U.S. Harley-Davidson and Indian V-twins, the British 1,000-c.c. square-four Ariel and the four-cylinder Italian MV Agusta are representative examples. The term motorcycle also covers motor scooters, which have power units of from 70 to 250 c.c.

An Englishman, Edward Butler, built the first motor tricycle in 1884; the first motorcycle to appear publicly was one built by Gottlieb Daimler of Kannstatt, Ger., in 1885. Motorcycles did not attain even slight public popularity until toward the end of the 19th century. French and Belgian designers were among the makers of the first practical motorcycle engines and motorcycles. They were followed by British, German, Italian and U.S. makers.

Rlanufacture and use of motorcycles increased steadily throughout the first 30 years of the 20th century. All the European combatants in World War I employed motorcycles extensively, particularly for dispatch riders. In the early 1920s there were 200 firms in Britain alone manufacturing motorcycles. By the 1930s, however, a decline in popularity had set in. In Britain, for instance, there were then only 40 significant producers and in the United States 3. The decline was attributed to the growing num-

ber of small cars available and also to the overspecialization that had led to the manufacture of fast racing and sports machines (see MOTORCYCLING) rather than to concentration on large-scale production of utility models.

In World War II motorcycles were again widely used for military purposes, though for many the jeep displaced them. Civilian sales were severely restricted, but many prewar models rendered sterling service in combatant countries as an economical means of transport between home and workshop, and also for many official purposes. It was this general recognition of the value of the two-wheeler that laid the foundation for the remarkable postwar revival of public interest in motorcycles, mopeds and scooters.

The British motorcycle and cycle industry was the one that gained most in export earnings from the world-wide expansion in motorcycle sales. Between 1945 and 1960 it earned a total of £250,000,000 ($700,000,000) abroad. Other large exporters were the Italian, German, French and Belgian industries. Many of the British export sales were to the United States and Canada, and also to the armed and police forces of Europe, Australia, Africa and Asia. Total British production of motorcycles ran at levels of between 150,000 and 200,000 a year.

While production in the United States did not return to the 1913 level of 70,000, the years after World War II witnessed a revival of interest that can be compared with that in western Europe. Most of the U.S. business was in British four-stroke motorcycles, notably of Triumph, USA, AJS, Matchless, Norton and Velocette machines, some of which had their own sales corporations in the U.S. Trade was largely in sporting models.

Although at times the continuing popularity of two-wheeled transport has been questioned, there is no doubt that it was more firmly established than ever in the second half of the 20th century. Its chief rival was the cheap small car. However, the motorcycle provided a means of individual powered transport, combining reliability, economy and comfort. In crowded cities and resorts its importance was more likely to grow than to diminish, on account of its slenderness in traffic and when parking.

Young people had always been quick to appreciate these advantages. Moreover, the sporting and travel appeal of the two-wheeler expanded yearly; scrambles, racing, trials, rallies and touring by means of motorcycles and scooters were never more popular than by 1960.

National shows featuring motorcycles are held in London, Frankfurt am Main, Geneva, Milan, Paris and Brussels. The world's largest and most representative motorcycle museum is at Beaulieu abbey, Hampshire, Eng., where about 180 motorcycle exhibits can be seen.

The Development of the Machine. — Development of motorcycles from the first machines, which were bicycles fitted with auxiliary engines, was steady. In the formative years positioning of the power unit varied, but by 1910 designers had recognized that the most practical point was low down and central, to ensure a low centre of gravity and steering stability and ease. Later, motorcycle engine units (consisting of engines and gearboxes) were carried in twin-tube cradles or were attached by long bolts and plates to the frame. Frames were built up from steel tubing, jointed by either welding or brazing.

The early commercial motorcycles were single-cylinder types, a style which persisted in the second half of the 20th century. Most models of more than 250 c.c. were four-strokes, in which valves were employed with the compression firing stroke in one direction (upward or outward) only; most below 250 c.c. capacity were two-strokes, compression firing being on both strokes through a succession of passageways and ports. The European method of rating an engine is by the volumetric displacement of the pistons in cubic centimetres. It can be calculated by the following formula:

$$\frac{n \pi d^2 l}{4 \times 1{,}000}$$

where n is the number of cylinders, d is the diameter of bore of cylinder in millimetres and l is the stroke of piston. The horsepower rating is used in some countries, including the United States: a rough equivalent is 1 h.p. per 100 c.c.

In the second half of the 20th century the capacities of modern machines ranged from 25 c.c. for engines used as auxiliaries on bicycles to 1,000 c.c. for models with two or four cylinders. Multiple cylinders ensure smooth running and, as lightweight models were cheap to run and easy to maintain, two of the foremost British designs, the four-stroke 192-c.c. water-cooled Velocette LE and the two-stroke 250-c.c. Ariel, had won for themselves foremost positions among "twins."

Carburetion and ignition were greatly improved over even the methods of 25 years before and bore little resemblance to the rudimentary forms on pioneer motorcycles. The carburetor was a compact and reliable instrument, measuring precisely the proportions of fuel and air admitted to the engine cylinder or cylinders for explosion and able to serve indefinitely without major adjustment. Elementary tube ignition had given way to advanced forms of electrical generation by means of a magneto or an induction coil. The magneto was either a separate piece of mechanism driven from the engine by means of gearing or chains, or was integral with the flywheel (the latter form becoming widespread on ultralightweight and lightweight two-strokes).

Transmission was usually by chain between engine and gearbox (two- and three-speed on smaller models; four-speed on larger ones); a few models employed shaft drive.

The earlier front-end springing of motorcycles by means of a compression spring operating inside parallelograms joined by link action had been superseded by hydraulic suspension, working telescopically, or by leading link; rear suspension, formerly rigid, was largely hydraulic as well. These improvements provided increased comfort and better control.

Braking developed consistently with the introduction of new metals for the drums and more effective antifriction linings. Braking surfaces increased, too, and hub barrels were increased in size to equal brake drums, ensuring a more stable hub and quick dispersion of heat generated by braking action. Internal-expanding brakes superseded other forms of braking. Control was helped, too, by improved clutches and by finer throttle adjustments. Modern clutches were multiplate, able to absorb the stresses brought about by constant gear changing in heavy traffic, on mountainous roads and in road racing. Throttle control and the use of lower gears assisted brakes as checks on speed.

Motor-Assisted Bicycles, Mopeds and Scooters. — Early in the 1950s, in western Europe and parts of the United States, auxiliary engines for use on bicycles became popular. One design, the Cyclemaster (a rear wheel embracing an engine unit of 32 c.c.), reached a total production of over 120,000. The engines being sold represented a revival of vogues of the 1920s and earlier.

Soon afternard there was a marked public demand for the moped, which originated in Germany as a 50-c.c. machine with simple controls, with lou initial and running costs, and largely free (except in England and France) of licensing and insurance complications. The moped attained popularity all over western Europe and was also introduced elsewhere, including the United States and Canada. The German Quickly and the French Mobylette were at first the leaders in European sales, but the Netherlands. Italy, Belgium, Norway and Britain also paid particular attention to mopeds. In 1958 large-scale manufacture of British mopeds began at the Raleigh and Phillips factories, and the Norman factory began to fit some of its mopeds with Villiers 50-c.c. engines. There is no reliable estimate of the number of mopeds in use, but by 1960 there were in Britain alone about 400.000 machines of 50 c.c. or less. representing a minor revolution in powered travel.

Even more significant than the moped advance on the European scene in the second half of the 20th century was the rapid expansion in the use of motor scooters, which had enjoyed a transient vogue in the 1920s. The modern scooter was born in Italy, where factories that had been engaged for war purposes were turned over to civilian production. The pioneer mas the 125-c.c. Vespa, which by 1958 was selling better than any other scooter in all western European countries except Britain. nhere its great Italian rival the Lambretta nas in the lead. German-made NSU Prima and Zundapp Bella models were also prominent, while in 1958 the

British factories of BSA and Triumph began to make scooters. At the same time Villiers began to sell to assemblers in Britain and elsewhere a range of British-made two-stroke engines in single- and twin-cylinder types.

The scooter had smaller wheels than the conventional motorcycle — anything from 8 to 14 in. in diameter (cf. 18 or 19 in. for motorcycles); its welded-tube or pressed-steel frame was well shielded; the rider sat inside the machine (not on it, as with a motorcycle or moped); and the riding position was lower. Power units were ordinarily positioned low down and close to the rear wheel, which was driven by bevel gearing or by the more conventional chains, as used on motorcycles and mopeds. Controls followed those of motorcycles, nith the important exception that the clutch movement and gear changes were often worked by a dual hand control. The large shieldings of scooters (covering most of the working parts and much of the uheels) lent themselves to brilliant and two-tone finishes.

The differences between motorcycles and scooters, in seating position, controls and colours especially, led them to appeal to women who might otherwise never have driven a two-wheeled vehicle. By 1960, out of a total of over 1,500,000 British motorcycle riders, approximately 400,000 were scooter enthusiasts. Perhaps the greatest factor in the advances made in moped and scooter engineering was the perfection attained in the design and machining of the small parts required for engine construction.

The enclosure of parts and wheels seen on scooters was not without its repercussions on standard motorcycle design. Unit construction of power units; noticeable in the late 1940s in the Czech CZ-Jawa and the British BSA Bantam, had brought about a starkness and simplicity of appearance that matched the mood of the riding public. To add to riding comfort, the next step was the enclosure of the frontal area (with a windshield incorporated) and part of the sides by means of fibreglass shroudings. At first, these semienclosures of the riding position were regarded as extras, but in 1958 the British Royal Enfield company listed most of its models with "fairings" as well as in standard trim.

Sidecars.--Sales of sidecars for attachment to motorcycles never rose to great levels in any country, the normal British output being about 6,000 annually. Before 1939 the lowest engine capacity regarded as desirable for sidecar use was 350 c.c. However, the improvements in two-stroke techniques led to the fitting of lightweight sidecars to motorcycles and scooters of capacities as low as 125 c.c. Lower gears had to be fitted to the machines, however. Developments in chassis and body design made sidecars more attractive. One-point chassis fixing became more pronounced as lighter metals and fibreglass came to be employed widely in bodywork. Braking and better waterproofing of sidecars also helped to retain their appeal. Additionally, the direct steering and general stability of motorcycles fitted with sidecars made insurance premiums lower than those for solo machines.

(HD. B.)

MOTORCYCLING. Although most motorcycles, scooters and mopeds (motor bicycles) in Britain are employed for strictly utilitarian purposes, an important minority of owners also use these machines for competitive sport. In the United States and Canada, pleasure motorcycling, including competitions, accounts for most of the use. The international controlling body for motorcycle sport is the Fédération Internationale Motocycliste, which normally meets in Europe and has its headquarters in Britain. The controlling body in Great Britain is the Auto-Cycle union, and in the United States it is the American Motorcycle association.

Reliability Trials and **Roughriding.**—The commonest type of competitive event is the reliability trial, which may last for any period up to a meek. These contests are held on public highways, with riders starting at intervals of a minute or longer. Time checks are taken, there are observed "rough-stuff" or hilly sections or both, and the rider who loses the fewest points is judged to be the winner. In their more strenuous forms, reliability trials are run over moorland or broken country, with water splashes and steep rock-strewn pathways as common hazards. Such an event is the annual Scottish Six-Days trial in May; its route includes some of the roughest and most remote mountain tracks in the northwest Highlands. For experienced teams from many countries, the international Six-Days trial is the most grueling event of its type; after World War II it generally was held either in central Europe or in Wales. Motorcycle manufacturers and traders everywhere regard reliability trials as the most searching tests possible of their standard models. Trade-supported teams are usual in the major trials. although enthusiastic amateurs compete.

Scrambling or roughriding generally takes place on rough enclosed circuits and is easier for the spectator to witness than are reliability trials. Cash prizes are an incentive to riders, who start en masse and make very many circuits of the course. The machines used are usually tuned-up lightweight two-strokes with generous ground clearance.

Racing. — Even more specialized is motorcycle racing, which may take place on closed and cleared roads, on private circuits or on sand. Full-scale racing requires motorcycles of proved reliability with top-grade tuning, and drivers who are both fit and also masters of roadcraft. While it is primarily a young man's pursuit, it is not unusual for men in the 40s and 50s to ride.

The Isle of Man T.T. (Tourist Trophy) race was first run in 1907, being won by C. R. Collier on a Matchless at 38.33 m.p.h. The Isle of Man Mountain course, the most famous motorcycle road-racing circuit in the world, was first used in 1911. It consists of well-surfaced highways running mostly through the pleasant Manx countryside, but also traversing parts of two towns. Hairpin corners and steep rises and falls abound, the highest point being 1,400 ft. above sea level. The two most important races, the Senior and Junior International events (in June), are each of seven laps, or 264.13 mi. The fastest lap record in the Senior event was put up by John Surtees, of England, in 1960, with 104.08 m.p.h. on an Italian MV Xgusta. Other leading motorcycle races in Europe are the German Grand Prix (May), the French Grand Prix (May), the Dutch T.T. (June), the Belgian Grand Prix (July), the Glster Grand Prix (August) and the Italian Grand Prix des Nations (September).

In the United States the first recorded fast time was established in 1902 by Albert Champion, who covered a mile on a circular track in 1 min. $10\frac{2}{5}$ sec. The 100-mi. amateur and 200-mi. professional events are held annually on a circular course at Daytona Beach, Fla. Speed-record trials are held every year at the Bonneville, Ctah, salt flats, where in 1956 W. Herz set a world kilometre solo record of 210 m.p.h. on a 499-c.c. NSU. Other important annual events include the Big Bear run; the Langhorne, Pa., 1-mi. track 100-mi. championship; the Dodge City, Kan., 200-mi. and 50-mi. championships; the Laconia, N.H., T.T. championship; and the Peoria, Ill., National T.T. championship.

Scooter Rallies. — After World War II a number of international, national and local motor-scooter rallies were established. The larger ones usually include a long-distance driving test, contests for "scooter queens" and the most attractive machines and timed tests over extended circuits. In the Isle of Man, 12- and 24-hour time trials were introduced in 1958. One of the most popular British scooter rallies is the ***Daily Mirror*** event held in the south midlands, on Whitmonday; in 1959 this attracted 12,000 spectators and 3.000 scooter drivers. (HD. B.)

MOTORING. Touring for pleasure is widespread and considered by many as one of the distinguishing characteristics of contemporary U.S. life. This use of automobiles for pleasure was traditionally combined with the need for intermediate transportation, especially in rural communities. In addition, a number of suburban areas and outlying business and industrial developments in the C.S. became dependent on automobile transportation.

In 1902 the American Automobile association was founded in Chicago. Ill. In 195j there were more than 3.750,000 members and more than 750 affiliated clubs and branches in the U.S. and other countries.

There were only about 27,000 mi. of surfaced roads in the U.S. in 1830, mostly near more populous areas. The appearance of the bicycle in 1877 spurred the demand for improved roads, and the first census of rural roads. conducted in 1904, reported a total mileage of 2.151,379, of which 153,530 mi. were surfaced.

There were over 3,000,000 mi. of rural roads by the mid-1950s,

of which over 60% were surfaced. Many roads were still inadequate for the increased volume of traffic in the second half of the 20th century, however. To relieve growing highway congestion, congress in 1956 authorized a 13-year construction program to cost $32,900,000,000 in federal and state funds. A 41,000-mi interstate network of superhighways to cost approximately $27,500,000,000 (90% to be provided by the federal government) and six-lane roads connecting every city of more than 100.000 population was planned.

Accidents.—The first fatal motor-vehicle accident on record, according to the National Safety council, occurred in Sept. 1890, in New York city. Assisting a woman alighting from a trolley, H. H. Bliss was struck by a passing car and died the following day. As motor-vehicle traffic increased over the years, motor-vehicle accidents also rose. In 1955 there were approximately 9,900,000 such accidents, resulting in 38,300 fatalities and 1,350,000 nonfatal injuries.

TABLE I.—Motor Vehicle Fatalities

Year	Total deaths	Per 100,000 population	Per 10,000 motor vehicles	Per 100,000,000 vehicle miles
1913–17 av.	6,800	6.8	23.8	*
1918–22 av.	12,700	11.9	13.9	*
1923–27 av.	21,800	18.8	11.1	*
1928	28,000	23.4	11.4	16.2
1929	31,200	25.7	11.8	15.8
1930	32,900	26.7	12.4	16.0
1931	33,700	27.2	13.0	15.6
1932	29,500	23.6	12.2	14.7
1933	31,363	25.0	13.2	15.6
1934	36,101	28.6	14.4	16.7
1935	36,369	28.6	13.9	15.9
1936	38,089	29.7	13.5	15.1
1937	39,643	30.8	13.3	14.7
1938	32,582	25.1	11.1	12.0
1939	32,386	24.7	10.6	11.3
1940	34,501	26.1	10.8	11.4
1941	39,969	30.0	11.6	12.0
1942	28,309	21.2	8.7	10.6
1943	23,823	17.8	7.8	11.5
1944	24,282	18.3	8.1	11.5
1945	28,076	21.2	9.2	11.3
1946	33,411	23.9	9.8	9.8
1947	32,697	22.8	8.7	8.8
1948	32,259	22.1	7.9	8.1
1949	31,701	21.3	7.2	7.5
1950	34,763	23.0	7.2	7.6
1951	36,996	24.1	7.2	7.5
1952	37,794	24.3	7.2	7.4
1953	37,955	24.0	6.8	7.0
1954	35,586	22.1	6.1	6.3
1955	38,300	23.3	6.2	6.4

*Data prior to 1925 inadequate for computing rates.
Source: National Safety Council, *Accident Facts* (1956)

In 1924 a national conference of street and highway safety agencies recommended the establishment of a uniform vehicle code which would serve as a model for the traffic laws of the states. The code was adopted in 1926 and a set of model traffic ordinances, in 1928; both were revised in many details from 1930 to 1956. Measures taken by states to reduce accident rates include licensing and examination of drivers. inspection of vehicles and setting uniform standards for accident reports and records.

Organized in 1912–13, the National Safety council early recognized the value of educational programs and in 1923 established its education division. The council's Traffic and Transportation conference was organized in 1948 to act as the chief national agency for compiling and analyzing statistics on traffic accidents and prevention programs.

At the 1946 and subsequent meetings of the president's highway safety conference, recommendations were made to co-ordinate the activities of federal, state and local governments and agencies. National groups participating in the safety program included the Federal Committee on Highway Safety, the State Officials' National Highway Safety committee and the National Committee for Traffic Safety, composed of more than 80 national organizations. See further for U.S. history AUTOMOBILE and ROADS AND STREETS.

(J. H. BN.; X.)

GREAT BRITAIN

Motoring in Great Britain may be said to have begun when Evelyn Ellis brought a four-horsepower Panhard gasoline-driven motorcar from France to England in 1895.

In 1895 every mechanically propelled vehicle on British roads was restricted to a speed of four miles per hour, and one member of the minimum crew of three had to walk at least 20 yd. in front to warn others of its approach. Although there is some doubt on the point, it is probable that the carrying of a red flag by the pedestrian, laid down by the Locomotive act of 1865, had ceased to be a legal requirement with the passing of the Highways and Locomotives (Amendment) act in 1878. Then, in 1896. by the Locomotives on Highways act, the speed limit was raised to 14 m.p.h. and. for obvious reasons, the la no longer insisted upon the man on foot. To celebrate this newly won freedom, the Motor Car club organized an "emancipation run" from the Hotel Metropole in Northumberland avenue, London, to the Hotel Metropole in Brighton on Saturday. Nov. 14, 1896. It is recorded that a red flag—as the symbol of oppression—was ceremoniously torn to pieces before the run began. This is commemorated annually in the Brighton run organized by the Royal Automobile club.

British engineers, the Lanchester brothers prominent among them, were already building motorcars, and in 1896 the manufacture of Daimler cars, first started by Gottlieb Daimler in Germany, was begun in Coventry. Sunbeam, Riley. Humber and Wolseley cars were all being made before 1900. The Society of Motor Manufacturers and Traders was founded in 1902, largely through the foresight of Frederick R. Simms, and by 1904, when the Motor Car act came into force. there were 8.465 private cars, 5,345 "hackneys" and about 4.000 trucks in use in Great Britain

Antimotorists were legion, and many of them went to remarkable lengths to give tangible proof of their opposition. In 1903 the Motor Car act nas passed, raising the speed limit to 20 m p h. but providing for the registration of mechanically propelled vehicles and the licensing of drivers. It came into force on Jan. 1, 1904, and began a period of intensive persecution that threatened to drive the motor vehicle from the roads of Great Britain The chief crime for which motorists were prosecuted was exceeding the speed limit; but having number plates and rear lights "obscured" by even a light covering of mud or dust—almost inevitable after a few miles of travel on the poor roads of the period—was often added to the indictment. Local justices mere drawn almost exclusively from the ranks of the horse-loving gentry. and convictions and fines on the flimsiest evidence were the order of the day.

Motorists, however, were not slow to retaliate. A number of enthusiasts banded together and, at week ends, hired the services of a handful of cyclists to spy out in advance the speed traps on the Brighton and other roads to the coast where the police were most active and to warn drivers of the danger ahead. The scheme was a great success, and in Aug. 1905 the Automobile association was formally founded to organize it on a permanent basis. After several years of active struggle the A.A., inspired by its secretary, Stenson Cooke (who was knighted in 1933), established itself as a service as well as a protective organization, and the menace of speed-trapping was considerably abated.

Motoring by this time had caught the popular imagination, and after World War I such men as William R. Morris and Herbert Austin developed the manufacture of "motors for the million." In

TABLE II.—Vehicles and Roads in Great Britain, 1925–57

Year	Vehicles registered			Miles of roads	Vehicles per mile
	Cars	Motor-cycles	All vehicles		
1925 (Aug.)	579,901	571,552	1,509,627	177,682	8.5
1930 (Sept.)	1,056,214	724,319	2,273,661	179,286	12.7
1939 (Aug.)	2,034,400	418,000	3,148,600	180,527	17.6
1957 (Sept.)	4,186,631	1,471,392	7,427,161	189,037	39.3

1920 there were 186,801 private cars, 287.739 motorcycles and 175.608 other vehicles registered in Great Britain, a total of 650,148. Within five years the number had been more than doubled and by 1939 it had been more than doubled again. By 1952 a further increase of 50% had taken place; Table II also shows how

little the road system has grown since 1925.

The number of driving licences current in Great Britain in Feb. 1957 was 8,734,000: 8,009,000 full licences and 725,000 provisional.

The remarkable success of the "popular" car of small horsepower was largely responsible for the immense increase in the number of private cars and—until 1939—for the decline in that of motorcycles. During the 1930s the difference between the cost of running a motorcycle and sidecar and the cost of running a small car was steadily reduced. Saloon (sedan) cars, moreover, almost completely replaced the open tourers of an earlier decade, except in the choice of the enthusiast for whom performance per se was the principal point of interest. After World War II, however, motorcycles recovered much lost ground because of the increased cost of petrol (gasoline) and of public transport fares. The search for economy further manifested itself in the rapid growth in popularity first of very small gasoline engines (up to about 100 c.c. in capacity) of the type designed for easy attachment to a pedal cycle and later of motor scooters with engines of about twice this size. (See MOTORCYCLE)

The usefulness of personal motor transport is now generally recognized, and mass production has brought the motor vehicle to men and uomen of moderate income. Many who previously never ventured more than a few miles from their homes or who at most traveled by train to a seaside resort for an annual holiday can now journey far and nide every week end. Motor transport has also given the businessman greater mobility in calling upon his customers. made skilled labour more readily available over a wider area and facilitated the delivery of goods from producer to consumer (*see* MOTOR TRANSPORT, COMMERCIAL). While the town dweller has been given the freedom of the countryside, people living in remote localities have been brought within reach not only of the towns but also of the services that may come from them.

Laws and Regulations.—The principal laws and regulations governing the use of private cars and motorcycles on British roads are as follows:

Driving Licences.—Application for a driving licence must be made to the council of the county or county borough (or, in Scotland, burgh) in which the applicant resides; applicants with no permanent address in the United Kingdom or in the Republic of Ireland may apply to any council. The minimum ages are 17 years for a car and 16 years for a motorcycle, and the form of application incorporates a declaration of physical fitness to drive. Licences are valid for a year and may be either issued or renewed at any time within the two months before their validity begins. The annual fee is 5*s*. in the U.K. and £1 in the Republic of Ireland. In Great Britain, under the Road Traffic act, 1956, the minister of transport began to extend the period of currency to three years at a fee of 15*s*. The holder must sign the licence in ink.

Driving tests were introduced in Great Britain in April 1935, but anyone who had held a licence before could claim exemption. The tests are conducted by local examiners appointed by the ministry of transport, and application for a test must be made to the traffic headquarters for the area in which the applicant lives. The driving-test fee is £1. Holders of provisional licences may drive only when accompanied by a driver who has passed the test or who has held a "full" licence in the same group for at least two years. The vehicle must also carry, at front and rear, a white plate bearing the letter L in red, 4 in. high, 34 in. wide and 1½ in. in breadth of stroke. Provisional licence holders may ride unaccompanied on solo motorcycles or on motorcycle combinations not constructed to carry passengers, but any pillion passenger whom they carry must comply with the above qualification of experience (this does not, however, apply to tandem pedal cycles to ahich small gasoline motors have been attached). The minister has increased the period of validity of provisional licences from three to six months and the fee from jc. to 10*s*

Driving licences can be endorsed by the courts for any conviction relating to actual driving, but not for obstruction. **A** new licence free of endorsement may be obtained after the expiry of three years, or one year in the case of convictions for exceeding the speed limit. Details of endorsements still in force must be entered on the licence renewal application form. Unless an applicant has previously been disqualified by order of a magistrate from holding a licence, he may not be refused a licence by the local authority to which he makes a bona fide application, provided that he completes the application form satisfactorily and is not suffering from one of the prescribed diseases or disabilities.

Registration.—,411 vehicles used on roads in the United Kingdom, except those of the sovereign personally, have to be registered uith a county, county borough or burgh council, which issues a registration book—often called a logbook—and an index mark of up to six letters and figures. Plates bearing this index mark in white (which includes silver or light gray) on a black background must be carried at front and rear. The registration book must be returned to the council when the licence is renewed, when the vehicle is altered, sold, destroyed or taken permanently out of the United Kingdom or when there is a change of address by the person in whose name the vehicle is registered. This person, however, need not be the legal owner of the vehicle.

The licence disk must be mounted on the vehicle in such a way that it is clearly visible by daylight to a person standing at the nearside, whether the vehicle is moving or stationary. The normal position is on the lower left-hand corner of a car's windshield or on the handle bar or front number plate of a motorcycle.

Taxation.—The annual rates of private-car tax are as follows (1958): for three-wheeled cars of not more than 8 cwt., £5; for electric cars, £7 10*s*.; for cars up to 6 h.p. first registered before Jan. 1, 1947, £9; for cars of between 6 h.p. and 7 h p. first registered before Jan. 1, 1947, £10 10*s*.; and for all other private cars, £12 10*s*.

Quarterly licences may be obtained on payment of 27½% of the yearly rate. A licence may be surrendered at any time to the council which issued it, and a refund may then be claimed equivalent to one-twelfth of the full year's tax—or one-third of the quarterly tax—for each whole month unexpired.

Insurance.—No mechanically propelled vehicle may be used on the public highway unless its use is covered by insurance, or a suitable security, against the claims of third parties arising from bodily injury or death. A certificate of insurance must accompany each application for a vehicle licence. It must be shown to a police officer on demand and, after an accident causing injury to another person, to anyone having reasonable grounds for seeing it; otherwise, it must be produced to the police within 24 hours.

Vehicle Lighting.—For the purpose of vehicle lighting the hours of darkness are from half an hour after sunset to half an hour before sunrise throughout the year. During these hours, two white lights of not more than seven watts each must show to the front so as to mark the approximate width of the vehicle. Solo motorcycles need carry only one such light. Other, nonobligatory lights must comply with certain antidazzle requirements, and lamps with beams permanently deflected downward and fitted with their centres less than 2 ft. (2 ft. 2 in. in the case of vehicles first registered on or after Jan. 1, 1952) above ground level may be used only in fog or falling snow. Under the Road Transport Lighting act. 1953, and subsequent regulations. all vehicles must carry two efficient red reflectors at the rear (solo motorcycles, onej and two red rear lights (solo motorcycles. one). Such rear lights may be combined with reflectors.

Speed Limits.—A speed limit of 30 m.p.h. is in force on roads in "built-up" areas; *i.e.*, where there is street lighting with lamp-posts at intervals of not more than 200 yd. The boundaries of built-up areas are marked by suitable signs. Some lengths of road outside built-up areas are restricted; others inside built-up areas are not. but in these latter cases every lamppost should display a small derestriction sign to remind drivers that the speed limit does not apply. Special limits of less than 30 m.p.h. are imposed in a number of places; *e.g.*, in parks and on certain bridges and seaside promenades. A 40 m.p.h. limit is also in force on some roads. Heavy vehicles such as coaches,, omnibuses and trucks are subject to restricted speeds at all times.

The **Road** Fund.—The roads of Great Britain may be said to have been neglected by successive governments. which seem to have been more than content to spend a minimum on the roads

while diverting the ever increasing volumes of motor taxation to the general exchequer. When the road fund was set up in 1909 it was made clear that the moneys paid into it from petrol and other motor taxes would be devoted solely to the upkeep and development of the road system; but repeated "raids" were made upon it until by 1937 it had ceased to have any effective independence as a store for the proceeds of special motor taxation. After World War II the amount of general revenue obtained from all forms of motor taxation — directly by licence duties and indirectly by means of petrol tax — rose by leaps and bounds, while grants from the road fund by no means kept pace. Table III illustrates this point.

TABLE *111.—State Revenue From Motoring and Road Grant Funds*

Year ending March 31	Motor fuel tax		Motor vehicle duties (£000)	Total receipts* (£000)	Road fund grants (6000)
	Per gallon	Receipts (£000)			
1939	9d.	51,615	35,608	87,223	20,599
1950	9d.	50,700	55,772	106,472	25,891
1952	1s. 10½d.	186,339	65,211	251,550	28,399
1956	2s. 6d.	268,900	86,987	355,887	44.761
1957	2s. 6d.	280,500	90,610	371,110	†

*Excluding purchase tax on new vehicles **If** 116,800,000 in the year 1956–57).
†Not available.

The parsimonious attitude of successive governments is reflected in the number of road accidents (which according to the Royal Society for the Prevention of Accidents cost the country about £170,000,000 a year) and in the loss of time and motor fuel wasted by traffic congestion, with the consequent lowering of efficiency through impatience and frustration (estimated to cost £70,000,000 a year in London alone).

Petrol Rationing. — From Sept. 22. 1939, after World War II had broken out, until May 26, 1950, petrol was rationed. and only a meagre "basic" — or later "standard" — ration was issued for domestic purposes. The amounts available varied from time to time but were never intended to provide more than about 300 mi. of motoring a month — usually much less; indeed, they were entirely withdrawn between Oct. 1, 1947, and June 1, 1948. During all this time the only petrol to be bought was of a generally low standard and was marketed under government control under the name of "Pool."! Not until Feb. 1953 were the producing and distributing companies permitted to sell petrol under individual brand names.

Rationing, with a basic allowance of fuel for 200 mi. a month for private motoring, was introduced from Dec. 17, 1956 to May 14, 1957, as a result of the closing of the Suez canal.

Foreign Travel. — One result of the severe restrictions placed upon motoring in Great Britain during the postwar years was the remarkable increase after World War II in the popularity of touring abroad. A great number of British motorists took their cars and motorcycles abroad for the sheer pleasure and satisfaction of road travel in countries where ample petrol could be obtained and where it was a cardinal point of official policy to foster the native tourist industry in this way. Whereas in 1938 the number of sets of foreign customs documents supplied to its members by the Automobile association alone had been 23.000, it was 27,100 in 1948, 45.000 in 1949, 52,800 in 1950 and 62,850 in 1951. Thereduction in the annual amount of foreign currency obtainable for travel outside the sterling area caused a decline to about 49,000 in 1952. but the figure rose again to 60.000 in 1953, 73,000 in 1954 and 95,000 in 1955. In 19j6 it exceeded 100.000 and in 1957 was more than 127,000.

For many years the principal document used for taking a motor vehicle temporarily from one country to another has been the *carnet de passages en douanes* (note of customs clearance), in effect the vehicle's passport, but from April 1958 this uas no longer required for entry into Austria. Belgium, Denmark. France, the German Federal Republic, Luxembourg. the Netherlands, Sneden or Switzerland. The *carnet* contains a number of pages showing the details of the vehicle, and in it are recorded the vehicle's entry into and exit from different countries; it is finally returned for discharge to the organization which issued it—in Great Britain the Automobile association or the Royal Automobile club—to show that the vehicle has not been sold or othernise disposed of in one of the countries visited. Other internationally recognized documents are also supplied by the motoring organizations when needed; they include the international certificate for motor vehicles, the international driving permit and the international insurance certificate or "green card."

Rallies and **Racing.**—After 1946 there mas a remarkable growth in the popularity of motor sport of all kinds in Great Britain. Whereas before World War II motoring events had rarely attracted more than a few thousand spectators — with the exception of the Donington Grands Prix in 1937 and 1938, when the presence of the German Mercedes-Benz and Auto-Union cars proved magnetic — competitive events after the war were attended by enormous crowds, sometimes in excess of 100,000 people. While many can watch motor racing. however. relatively few can take part. and keen private owners wishing to put their own driving skill to the test have been attracted in increasing numbers to the annual motor rallies.

There are usually several starting points in or near widely separated towns. From each of these, competitors are sent off at one-minute intervals to follow routes of approximately equal length to a common rallying point: thence a single route is taken to the finishing point, which is often located at some well-known seaside resort. The total distance covered by each competitor may well be in the region of 1,500 to 2.000 mi., either continuously day and night or in four or five daily runs with overnight halts. In either case, a strict time schedule must be maintained, and consistent driving is needed to avoid late arrival and consequent penalty marks at the various control points, since no allowance is normally made for meals or other stops, and minimum average speeds are often in the neighbourhood of 30 m.p.h. The terrain chosen usually includes some of the remoter parts of Wales, the Lake district or Scotland with winding roads and severe gradients, and special tests of driving skill are held in difficult country en route. These tests and others at the finishing point are made against the stop watch. and the results are used, in combination with the penalty marking system for general timekeeping, in assessing the winners in the different classes.

Similar events of great severity are held throughout western Europe. sometimes with one starting control in Great Britain. Among the best known are the Monte Carlo rally, the Alpine rally, the Lisbon rally, the Liège-Rome-Liège rally and the Tulip rally. which ends at Noordwijk-aan-Zee in the Netherlands.

While rallies are for normal cars. highly specialized small cars have been developed in Great Britain for trials involving the climbing of freak hills very much off the beaten track. As these trials are held almost entirely during the winter they usually justify the title of "mudplugging" which has been applied to them.

It was, however. in automobile racing (*q.v.*) that the most notable gain in popularity occurred. Although Brooklands track and Donington park were not available after World War II, several new circuits were brought into use, most of them on the perimeter roads of airfields, and Goodwood, Silverstone, Snetterton, Castle Coombe, Thruxton and Charterhall became familiar names to a wide cross section of the public.

The governing body for motor sport in Great Britain is the Royal Automobile club. founded in 189;. No competitive event of any consequence can be held without a permit from the club. which is also the issuing authority for both national and international competition licences for drivers. The club's general competition rules, based upon those drawn up by the International Sporting commission of the Fédération Internationale de l'Automobile, provide the framework within which the regulations for any race, rally or trial are determined. It was the R.A.C. which acquired the Silverstone airfield circuit near Towcester and staged, on Oct. 2. 1948, the first international Grand Prix to be run in England for ten years. After a series of race meetings that made Silverstone the leading British venue, the R.A.C. was succeeded by the British Racing Drivers' club, which continued to organize the chief races at the circuit with great success. Silverstone is also used for meetings by numerous other motor clubs. Two weeks before the first Grand Prix at Silverstone, the Goodwood circuit near Chichester was opened on Sept. 18. 1948, by the

Junior Car club, which later changed its title to British Automobile Racing club. In addition to these and other airfield circuits, the Crystal Palace road circuit near London, popular before World War II, was reopened in modified form in 1953, in which year races were also run on an entirely new road circuit at Oulton park, near Tarporley in Cheshire. A circuit has also been built at Aintree, Lancashire, alongside the famous steeplechase course. Races are also held at Brands Hatch, near Farningham in Kent.

(L. E. E.)

MOTOR RACING: **see** AUTOMOBILE **RACING.**

MOTOR-SHIP: see MARINE ENGINEERING; SHIP: *Motor Ships*

MOTOR TRANSPORT, COMMERCIAL. The system of motor transport in the United States is comprised of (1) intrastate vehicle operation, regulated by state motor vehicle departments, and (2) interstate vehicle operation, regulated under a national transportation policy adopted by the federal government. The system is operated by private enterprise. Length, width, height and weight of trucks and trailers are regulated by state statutes that set definite limits to size of vehicles.

To compensate for use of streets and roads traversed by the vehicles, each state has established a schedule of registration fees graduated according to size and type of vehicle. The state fees, plus a state and national fuel tax per gallon. are paid by vehicle ouners on each vehicle operated. In addition, vehicles for hire are required in some states to pay a ton-mile tax, a vehicle-mile tax or an axle-mile tax. or other fees

Development of trucks and buses began during the last decade of the 19th century at about the same time as that of private motorcars At first the commercial motor vehicle did not progress so rapidly because in its field there was no equivalent to the enthusiasm of pioneer, motorists to sustain the movement. Later on, however, it profited from much of the technical progress originally made in connection with private passenger cars, and in a decade and a half it attained a state of development that enabled it to play a part of considerable importance in World War I. Its early development was delayed by lack of good roads, but the advent of the so-called giant pneumatic tire shortly after World War I, and the constant increase in mileage of hard-surfaced and otherwise improved roads and highnays — both of nhich enabled trucks and buses to increase speeds greatly — opened up a new field in long-distance hauling that was to provide serious competition for railroads By mid-20th century about 54,000 communities in the United States uere served by no other form of transportation than that on the highways.

Since its birth in 1900, truck transportation in the United States has staged a remarkable growth From 1904 to 191j, trucks increased in number from 700 to 158,506 In 1935 the total was 3,675,865,and by the late 1950s the number was well over 10,000,000. During World War II the U S motor truck manufacturing industry alone produced military vehicles (essentially trucks) and parts at the rate of $2,500,000,000 worth per year, or tno and one-half times the total value of trucks and parts produced during the best peacetime year More than 200 different and specialized types of truck transport and combat vehicles were at one time or another in production.

With the passage of the Federal-Aid Road act of 1916, new emphasis was placed on concrete pavements for intercity freight transportation. In order to qualify for federal funds in interstate highway construction. states were required to match those funds. In 1930 federal action provided larger loans to states for road building. At the same time, appropriations by state legislatures for roads increased and intercity road construction expanded greatly. Under the federal acts of 1921 and 1944 a nen pattern was developed for a U.S interstate highway system totaling 40,000 mi.

The Federal Highway bill passed by congress in July 1956 provided for a 13-year federal interstate highway building program, including expenditures of nearly $2 5,000,000,000 of federal funds for a master interstate highway system of modern construction. Under this program operators of heavy-duty vehicles nould be assessed additional taxes, and size limits were placed upon vehicles.

Development and Regulation. — With the coming of hard roads and improved vehicles, commercial trucking in the period 1918 to 1934 developed rapidly. Automotive engineers, following World War I. developed multicylinder engines of greater power and better chassis design, capable of higher speeds. Shippers were attracted by the advantages of fast door-to-door transport of general freight, merchandise and supplies, and throughout the country motor freight lines came into being to handle intercity trucking on a scheduled basis. During this period control of interstate trucking mas exercised by the states under regulatory statutes administered by state agencies such as public service commissions and commerce commissions. However, there was no uniformity of pattern in state regulations, nor were there any set standards for administering the regulatory provisions. By 1928. 33 states had statutes regulating motor carriers of property and 43 likewise had laws governing passenger traffic by bus lines.

In the absence of federal regulation many states attempted to control interstate traffic within the boundaries of their states, but two rulings by the U.S. supreme court decreed that state regulatory bodies did not have the right to restrict or restrain interstate motor carriers. Uncontrolled rate wars thereafter began to develop among interstate operators, and shippers were often the victims of irresponsible carriers. As a result, state regulatory bodies sought to promote the passage of a federal act to regulate interstate motor carriers nationally.

During 1933, as an economic measure during a period of depression, congress passed the Emergency Railroad Transportation act and Joseph B. Eastman was appointed co-ordinator of transportation. Eastman, in a report issued in 1934 on the crisis in public transportation. recommended the enactment of federal control measures for the regulation of interstate trucking and bus operations. His recommendations formed the basis of the Motor Carrier act of 1935.

Interstate Commerce Commission. — Administration of this act was placed in the hands of the Interstate Commerce commission (ICC), an agency with experience in regulating competitive transport agencies since 1887. Later the Motor Carrier act of 1935 was incorporated in part II of the Interstate Commerce act of 1940. It included provisions for safety and economic regulation of interstate motor carriers under a board of motor carriers functioning under the ICC.

Under the act, all common carriers were required to qualify for certificates of convenience and necessity (grandfather rights by virtue of bona fide operations were protected), and contract carriers likewise mere required to apply for operating permits. Carriers are divided into three groups: class I, with annual gross operating revenues of $200,000 or more; class II, with annual gross operating revenues of $50,000 to $200,000; and class III, having gross revenues of less than $50,000 per year. (Previous to 19jo the classifications were: class I, over $100,000; class II, $25,000–$100,000; and class III, under $25,000.)

Class I motor carriers must submit quarterly and annual reports to the bureau of motor carriers, using a uniform accounting system designed to provide financial and operating statistics. Class II and class III carriers must submit a simple annual report on their operations. which provides the commission with information on revenues, expenses, mileage, tonnage and equipment. In 1953 class I motor carriers of property comprised 13% of the total interstate regulated for-hire motor carriers in this classification.

The ICC consists of 11 members appointed by the president for terms of seven years at an annual salary of $15,000 for each commissioner. The chairmanship is rotated annually among the members. Supervision and control of carriers comes under the bureau of motor carriers, nhose budget for personnel and field staff services is approved by congress. For the 1956–57 fiscal year, the ICC field staff was increased by 33 district supervisors to a total of 124, by 54 safety inspectors to a total of 100, and by 13 rate agents and 3j additional clerical employees.

Motor Carrier Act Provisions. — Interstate motor carriers of property operating under the Motor Carrier act are divided into four groups: common carriers; contract carriers; brokers of property transportation; and private carriers. For-hire carriers

are classified into spheres of service as follows: regular route scheduled service; regular route nonscheduled service; irregular route radial service; irregular nonradial service; and local cartage service.

The Motor Carrier act exempted specific types of operation, principally in the agricultural field, newspaper distribution, air-cargo service and other specialized services. Exempted were farm trucks engaged in farm chores and the transportation of crops, cattle, poultry, dairy products and other agricultural products from farm to market. Because of the increasing list of exempt commodities, regulated common carriers issued protests, declaring that the trend toward liberalization favoured the private carrier at the expense of for-hire carriers.

Household-goods motor carriers comprise an extensive specialized carrier group governed by the act. These carriers transport household-goods effects by truck and trailer van from the household to the patron's new location. The service requires little crating and packing, eliminates rehandling and saves time in delivery for the customer over other methods of transportation. Tank truck operation, another specialized service group, likewise comes under ICC supervision. Approximately one-fourth of all the tonnage hauled by class I intercity carriers is hauled by tank trucks.

Local cartage carriers are for the most part exempt from ICC control. However, such carriers, where they cross interstate lines carrying shipments regularly in commercial zones set up in metropolitan areas, are regulated as to hours of service of employees and safety of operation and standards of equipment.

All interstate carriers of the for-hire type and specialized groups mentioned, together with private carriers engaged in interstate trucking, must conform to safety regulations, operating rules and maximum hours of service by employees as established by the ICC. Daily logs must be filed reporting the hours that drivers are on the road. Carriers must report all accidents in which vehicles are involved where a fatality or injury occurs, or where property damage exceeds $100. Reports must be filed within 15 days of the accident to the ICC district field director in one of the 16 ICC districts. Under a complete revision of the motor carrier safety regulations, effective Feb. 1, 1952, drivers must be re-examined every 36 months after July 1, 1954. New standards were also set forth for equipment and accessories to improve safety of operation.

Labour, Rates, Railroad **Co-operation.**—Drivers and workers in interstate motor carrier operation are, for the most part, members of the International Brotherhood of Teamsters, Chauffeurs, Warehousemen and, Helpers of America, commonly called the Teamsters' union. Membership in this union totals nearly 1,500,000, of whom about 30% are truck drivers. Principal spokesman for the organized freight and affiliated carriers is the American Trucking Associations, Inc., established in 1933, with headquarters in Washington, D.C. It is comprised of 50 state and affiliated association groups, representing all branches of the trucking industry.

Motor carriers of property under the Motor Carrier act are required to publish rate tariffs and to file them with the ICC. Rate-making agencies, comprised of operator members, were created to secure uniformity in rates for various sectional areas. The national motor freight classifications were patterned principally after the consolidated freight classification system used by the railroads. Because of the door-to-door delivery permitted by motor truck, shippers often prefer motor service at higher rates than competitive services.

Commodity rates are specified by motor carriers, as well as class rates, truckload, less-than-truckload and volume rates. Volume rates, which basically are lower in cents per 100 lb. for larger than for small shipments. have enabled motor carriers to compete with the railroads on carload traffic. Under the act of 1935, the ICC was empowered to prescribe the "lawful rate," or the maximum and minimum rates. In cases where minimum rates have been prescribed by the commission, such rates frequently have become, in practice, maximum rates because they are the rates charged.

A trend that promises closer co-operation between the trucking industry and the railroads is the "piggyback" type of operation. Loaded trailers, under this system, are loaded aboard special flatbed rail cars, and delivery of the trailers is then made by rail to city of consignee. There the tractor hauls the trailer to the consignee's platform. U.S. railroads own about 130,000 motor trucks. For-hire motor carriers authorized under the ICC act total approximately 20.000. Of this group, more than 90% are property carriers, while the remainder are passenger bus lines. The property carriers, it is estimated, operate approximately 350,000 vehicles. In the exempt group operating interstate service, there is an estimated total of 35,000 carriers, operating approximately 245,000 vehicles. In the private carrier group, there are approximately 120,000 carriers operating an estimated 770,000 vehicles. For a discussion of motor vehicle construction, *see* AUTOMOBILE; for information on public passenger-carrying vehicles, *see* OMNIBUS. *See* also Index references under "Motor Transport, Commercial" in vol. 24.

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Europe.—The large-scale development of commercial motor transport began, in Europe as in the United States, in the decade after World War I. Encouraged by the experience gained during the war, when trucks had proved valuable for transporting munitions and troops, the sale of surplus army stocks, and the ability of motor vehicles to deal with goods immobilized by the railway strike in England of 1919, road transport began to compete with the railways in the carrying of general merchandise. The development of the struggle between road and railways is summarized in the article TRANSPORT: *Land Transport.* After World War II competition became even more intense. The rapid recovery and expansion of industry provided a growing volume of business for the road hauler and the bus user, and good roads and the rapid improvement of vehicle design enabled them to take advantage of it.

Although statistics on road transport are far from complete, some idea of the rate of expansion may be obtained from the numbers of motor vehicles in use as tabulated in the *United Nations Statistical Yearbook* for 1957. Thus in the United Kingdom the commercial vehicle population rose from 837,000 in 1948 to 1,254,000 in 1956. In France the increase was from 625,000 in 1949 to 1,426,000 in 1956. In the German Federal Republic an even more striking expansion took place, from 399,000 vehicles in 1948 to 1,199,000 in 1956. In Italy, which has Europe's fourth largest commercial vehicle population, numbers rose from 196,000 to 389,000 over the same period.

Where it is possible to analyze commercial vehicle population in terms of carrying capacity, it is noticeable that increases occurred mainly in small vehicles (that is, those up to two tons' capacity), which are used almost entirely for transport on own account, and in the heavy carriers of five tons and over, which are mainly owned by haulage concerns. Thus, in the United Kingdom, in 1954, 59% of the trucks on the road were of carrying capacity up to two tons, and the corresponding figures for Italy, the German Federal Republic, Norway and Sweden were 64%, 58%, 56% and 44% respectively. These figures emphasize the obvious superiority of road over rail for light transport over short distances, and this is again reflected in figures, where they are available, showing relative tonnages carried by road and rail. In the United Kingdom, for example, 74% by weight of the total traffic was carried by road in 1952 and 24% by rail. If, however, distance is taken into account, as well as weight, it appears

that, in the same year, the railways contributed 54% of the total ton-mileage and road transport 45%.

A similar relationship may be seen in the German Federal Republic, one of the few other countries for which the relevant figures are available. In this case road transport carried 63% of the total tonnages in 1952 and the railways 26%, while the remaining 11% went by inland water transport. In terms of ton-miles, however, the German railways carried 56% of the total and motor transport only 21%.

In the United Kingdom road transport became the subject of prolonged political controversy after World War II. The British Transport act of 1947 instructed the Transport commission to provide an economic and properly integrated national transport system, and in 1948 the road transport executive was appointed to run a nationalized road haulage system. In Oct. 1951 a Conservative government was elected, pledged to denationalization, which was embodied in the Transport act of 1953. The denationalization process proved difficult, however, and in the late 1950s heavy road transport was still partly under state control. (WE. J. H.)

MOTOR VEHICLE INSURANCE applies to all classes of motor-propelled vehicles. and insures against accidents to the person, damage to property, and damage to the insured and other vehicles.

UNITED STATES

U.S. practice must be divided into several major categories—insurance on private vehicles, public conveyances, motor carriers, cargo, garage liability, fleet and nonownership coverages.

An insurance policy upon a private vehicle is broken down into four principal parts: (1) declarations; (2) insuring agreements; (3) exclusions; (4) conditions. The declarations are statements made by the insured, or inserted by the insurer, to define the risk. These include the name of the insured, ownership of the vehicle, the insured's occupation, description of the vehicle, its purchase price, place of use, nature of use and prior cancellations or refusals to insure. Incorrect statements may bear upon the protection afforded.

Insuring agreements refer to the obligation of the insurer to pay all sums which the insured may become legally obligated to pay as a result of the ownership, maintenance or use of the vehicle—up to, certain limits. depending upon the premium paid. Such limits fluctuate widely. from the policy of one company of only $1,000 to a coverage of $300,000 for injuries to one person or $500,000 for injuries to all persons resulting from a single occurrence, and property damage of $250,000. The most common limits in the 1950s were $10,000/$20,000/$5,000, which were not adequate. Under a large limit policy, the company "lays off" all over a certain retained risk with a reinsurance company.

The insuring agreements also require the insurer to defend all suits brought against the insured, or to settle them within the policy limits, which correlatively gives it the right to control such litigation. The "omnibus clause" extends liability protection. with certain exceptions, to others operating with the insured's permission. A "drive-other-cars" provision may extend protection to the insured and his wife while operating automobiles owned by persons other than themselves. Automatic insurance will cover substituted vehicles while the vehicle insured is out of service, and protect newly acquired vehicles until time is given to report the replacement to the insurer.

Exclusions most commonly found are those avoiding liability where: (1) passengers are transported for a consideration; (2) liability is assumed by contract; (3) a trailer not insured with the same company is being transported. Injuries to employees, the named insured and property in the insured's custody are frequently excluded.

The principal conditions require prompt notice to the insurer of any accident, prompt forwarding of any summons and cooperation in the defense of any litigation. It is also provided that no third person shall have any greater rights than the insured, but that bankruptcy or insolvency of the insured shall not release the insurer.

Other primary coverages upon the private vehicle are: (1) Collision insurance, which indemnifies against damage to the insured vehicle. This is usually written upon a deductible basis. (2) Comprehensive. This indemnifies against any damage to the vehicle, with few exceptions, other than that caused by collision. In older forms, this is written separately as fire, theft and windstorm. (3) Medical payments. This is in the nature of a personal accident policy upon each occupant of the vehicle to pay all medical expenses not in excess of a certain amount per person—usually $500. (4) Emergency road service. This pays the expense of towing or emergency calls when the vehicle breaks down outside of city limits and away from its place of garaging. (5) Bail bond. This pays the cost of a bail bond to permit the driver's release if arrested for traffic violation.

Public conveyances, such as taxicabs and buses, are required by law to carry liability insurance in minimum specified amounts. Frequently one who is injured by a vehicle required by law to carry insurance has greater rights against the insurer than has the named insured; and in some states direct suit may be brought against the insurer for loss without first obtaining judgment against the insured as is customarily required. Similarly, long-haul truckers and other carriers must furnish proof of insurance in order to comply with their certificates of convenience and necessity issued through the appropriate commerce commissions. Coverage by such carriers includes both public liability and property damage insurance, plus cargo insurance to protect the shippers of goods from loss resulting from damage to such cargo.

Garage liability insurance is a composite type of coverage rather closely resembling that issued upon a private automobile, but covering liability resulting from the operation of automobiles owned by, used in or brought into such place of business by customers and others. It generally is so written as to include. also, damage to or theft of such vehicles. However, private pleasure use by the proprietor or his family generally will not be afforded unless a separate premium is paid for that purpose.

Fleet coverages are usually issued, at a lower rate than would apply to individual policies upon the same vehicles, at the instance of an employer owning a number of trucks or private automobiles used by employees, to protect both employer and operators from liability and to indemnify against damage to the vehicles. Nonownership policies are those carried by a person, such as an employer. who may be legally liable for the acts of another who owns and drives his own vehicle but acts in behalf of such insured.

See John A. Appleman, *Automobile Liability Insurance* (Chicago, 1938), *Insurance Law and Practice* (1941–47). (J. A. AN.)

GREAT BRITAIN

Motorcar insurance in England, in practical form, dates from 1898, and its growth has corresponded to the development of the motor industry. Some 60 years later there were about 7,000,000 insured motor vehicles in the United Kingdom, insurance on which was spread over 106 companies and many underwriting syndicates at Lloyd's. Income figures for United Kingdom business are not disclosed by the companies. but the world-wide total of premiums for motor vehicles received each year by British offices and Lloyd's underwriters then approximated £220,000,000.

Legislation. — An outstanding development in this insurance was the introduction of compulsory third-party insurance under part 2 of the Road Traffic act, 1930. Insurance is compulsory only in respect of accidental personal injury to third parties: there is no requirement that liability for material damage be insured. Although it is obligatory for a person to insure, no compulsion is placed upon the insurer to accept the risk. Refusal by insurers to grant insurance in accordance with the act is, however, a step taken only in extreme circumstances. Changes necessitated in the practice of motor insurance business included the issue of certificates of insurance; the withdrawal of days of grace; the revision of policies to the requirement that compulsory insurance be for an unlimited amount of indemnity; and the drafting of a new "act" policy for those who wished to cover the bare liabilities for which it is compulsory to obtain insurance protection. The act imposed upon the insurer a liability for payment for emergency

and hospital treatment; a liability subsequently revised and extended under provisions of the Road and Rail Traffic act, 1933, and the Road Traffic act, 1934.

In spite of the statutory compulsion to insure, cases can arise where for one reason or another the injured person has at law no redress. To correct this position, insurers have taken the recommendations of the Cassel Committee on Compulsory Insurance as their guide and voluntarily established the Motor Insurers' bureau, which, in effect, is a central fund to protect third parties injured in road accidents in those cases where ineffective insurance, or complete absence of insurance, prevents them from recovering damages to which they are entitled.

The impact of the Law Reform (Miscellaneous Provisions) act, 1934, and the Law Reform (Contributory Negligence) act, 1945, on the transaction of motor insurance resulted in heavy additional burdens upon insurers. The death of the motorist no longer puts an end to a claim for personal injuries, the liabilities of the deceased being continued in his personal representatives. In cases where the injured person dies, his rights of action survive, and such rights are in addition to those of the dependents under the Fatal Accidents acts.

By the provisions of the act of 1945, contributory negligence no longer defeats a plaintiff's claim absolutely but extends to such plaintiff a modified right to recover damages.

Variable Cover.— There are three types of insurance cover: "act" liability only; full third-party; and comprehensive. The full third-party contract grants indemnity in respect of both personal injury and property damage. Fire and theft risks and other benefits may be added by agreement to a third-party policy. As applied to private cars, the comprehensive policy covers: (1) loss of, or damage to, the insured vehicle; (2) full third-party liability and liability to passengers, the indemnity being unlimited in amount and inclusive of all law costs; (3) hospital charges; (4) medical expenses up to £20 per person to any occupant of the insured car sustaining bodily injury; (5) personal accident benefits to the insured, comprising capital sums for death, loss of limbs, etc.; (6) rugs, coats and luggage against loss or damage (limit £20). A modified comprehensive policy is granted for commercial vehicles and motorcycles.

Differential Rating.— The type, the age and the value of the vehicle, the nature of its use and the district where it is ordinarily garaged—a higher rate schedule applies to certain areas—are factors in the computation oi premium rates.

The various uses are rated according to classification. In addition to the use of the vehicle for social and domestic purposes, class 1 for private cars allows business use by the insured in person provided that such business does not involve commercial traveling or the carriage of goods or samples. The use of the car for business or trade purposes and also the transport of goods is allowed under class 2; but here again commercial traveling and certain other uses are excluded and made the subject of a further classification. The exact purpose for which the car is used should be clearly defined, as the Road Traffic acts certificate is prepared in accordance with particulars given. Premium reductions are allowed in particular circumstances; *e.g.,* when the insured party agrees to bear the first amount of each and every loss under any section of the policy, or when the policy is restricted to one named driver only. An accumulative discount is usually allowed where no claim has arisen under the policy during a specified period of insurance. Premiums for commercial vehicles are based upon district, trade and carrying capacity; and the class of vehicle licence held is a further factor in rating. For motorcycles, no distinction is made between private and business use.

The **Proposal.**—The proposal is the basis oi the contract between insurer and insured, and the provisions of the declaration at the foot of the form should not be overlooked. It is not sufficient simply to answer the specific questions on the proposal. The duty of good faith requires the proposer to make a full disclosure of all facts material to the risk.

Foreign Extension.— By prior notification to insurers a motorist in the United Kingdom can arrange for his policy to be extended to cover him in continental Europe. British motorists visiting certain European countries are provided with an international motor insurance card as evidence of insurance against third-party risks. Motorists coming to the United Kingdom from Europe have similar facilities. Compulsory insurance laws in varying forms obtain in many European countries, and the provision of the international insurance card is advisable in order to avoid difficulties in the event of accident On the continent of Europe premium rates are generally much higher than in the United Kingdom; and, because of the cost, damage cover is usually dispensed with and comprehensive cover little sought. In some countries unlimited indemnity for third-party risks is difficult or impossible to obtain. Policy cover is built up in separately rated sections, special conditions applying to each section. (P. Ss.)

MOTT, JOHN RALEIGH (1865–1955), U.S. evangelist who was awarded the Nobel prize for peace (with Emily Greene Balch) in 1946 for his work in international church and missionary movements, was born in Livingston Manor, N.Y., May 25, 1865. He graduated from Cornell university, Ithaca, N.Y., where he was active in student affairs. In 1888 Mott became student secretary of the International committee of the Young Men's Christian association (Y.M.C.A.), which position he held until 1915. He was chairman of the Student Volunteer Movement for Foreign Missions, 1915–28, the International Missionary council, 1921–42, and president of the World's Alliance of Y.M.C.A.'s, 1926–37.

Among his works are *Strategic Points in the World's Conquest* (1897); *The Future Leadership of the Church* (1909); *Five Decades and a Forward View* (1939); and *The Larger Evangelism* (1944). Mott died in Orlando, Fla., Jan. 31, 1955.

MOTT, LUCRETIA (née COFFIN) (1793–1880), U.S. reformer and proponent of women's rights, was born at Nantucket, Mass., on Jan. 3, 1793. At 13 she was sent to a Friends' boarding school at Nine Partners, near Poughkeepsie, N.Y., where James Mott (1788–1868), whom she married in 1811, was then teacher. The Motts spent their married life in or near Philadelphia, where James Mott was a commission merchant. Concerned members of the Society of Friends, they associated themselves after the Quaker "separation" of 1827 with the "Hicksite" branch, followers of Elias Hicks. As an acknowledged minister in the society, Lucretia Mott preached ultraliberal religious views that did much to carry the "Hicksite" Friends toward a quasi-Unitarian position. Both husband and wife took an active part in the campaign against slavery.

In 1840 Mrs. Mott went to London to attend the World's Anti-Slavery convention. Her exclusion from the convention because of her sex led her to take up the cause of women's rights. In 1848 with Elizabeth Cady Stanton she called a convention at Seneca Falls, N.Y., "to discuss the social. civil and religious rights of women" which issued a "Declaration of Sentiments" modeled on the Declaration of Independence. This gathering marked the formal beginning of the organized women's rights movement in the U.S. An eloquent and effective public speaker, she also enlisted in other reform movements of the day. including anti-Sabbatarianism, temperance and peace.

Mrs. Mott died on Nov. 11, 1880, at "Roadside," near Abington, Pa.

See Otelia Cromwell, *Lucretia Mott* (1958) and Anna Davis Hallowell, *James* and *Lucretia Mott* (1884). (F. B. T.)

MOTT, NEVILL FRANCIS (1905–), a leading authority on solid state physics, particularly on the theory of electrons in metals and on dislocations and other defects in the crystalline structure, was born on Sept. 30, 1905, and educated at Clifton college and at St. John's college, Cambridge. In 1929–30 he was lecturer at Manchester university, and from 1930 to 1933 he was fellow and lecturer, Gonville and Caius college, Cambridge. Later he was Melville Wills professor of theoretical physics at Bristol university (1933–48) and then Henry Overton Wills professor and director of the Henry Herbert Wills physical laboratories there (1948–54). In 1954 he became Cavendish professor of experimental physics at Cambridge. He was elected a fellow of the Royal society in 1936 and received the society's Royal medal in 1953, and many other honours. Mott's publications include *An Outline of Wave Mechanics* (1930); *The Theory of Atomic Collisions,* with H. S. W. Massey (1933); *The Theory of the Properties of Metals and Alloys,* with H. Jones (1936); *Electronic Processes in Ionic Crystals,* with R. W. Gurney (1940); *Wave Mechanics and Its Applications,* with I. N. Snedden (1948); *Elements of Wave Mechanics* (1952); and papers on atomic physics, metals, semiconductors and photographic emulsions. (D. McK.)

MBTTEUX, PIERRE ANTOINE (1663–1718), English translator and dramatist, of French parentage, was born at Rouen on Feb. 25, 1663. After the revocation of the Edict of Nantes he settled in London. After six years in England he began to edit the monthly *The Gentleman's Journal,* which contained verses by himself and by the chief wits of the day. In 1693 he edited the third book, hitherto unpublished, of Sir Thomas Urquhart's translation of Rabelais, and in 1694 he completed Urquhart's work by a translation of the fourth and fifth books. The translation, though not to be compared with the racy, nervous writing of

Urquhart, shows a perfect mastery of colloquial English and an intimate sense of Rabelais's meaning. His History of the Renowned Don Quixote de la *Mancha* (1700–03), "translated from the original by many hands and published by Peter Motteux," is one of the most masterly and spirited translations in English. His plays include Beauty in Distress (1698). His later years appear to have been given to the shop in Leadenhall street. He was murdered on Feb. 18, 1718, near St. Clement's church, London.

MOTTEVILLE, FRANÇOISE BERTAUT DE (*c.* 1621–1689), French memoir writer, daughter of Pierre Bertaut, a gentleman of the king's chamber. In 1642 the queen summoned Mme. de Motteville to court. Her chief work is her *Mémoires,* which are in effect a history of Anne of Austria.

The best edition of her *Mémoires* is that of M. F. Riaux, 2nd ed., 4 vol. (1891; Eng. trans., 3 vol., 1902).

MOTTL, FELIX (1856–1911), Austrian conductor and composer known for his performances of Wagner. Born at Unter-St.-Veit, near Vienna, Aug. 24, 1856, he studied at the Vienna conservatory, and in 1876 conducted Wagner's *Ring* des *Nibelungen* at Bayreuth. His direction of the Karlsruhe opera from 1881 to 1903 was remarkable for his performances of the works of both Wagner and Berlioz. He conducted the *Ring* in London (1898), Parsifal in New York (1903) and was director of the Munich opera in 1907. He wrote three operas and orchestrated Wagner's *Wesendonck* Lieder and works by Liszt and Chabrier.

Mottl died at Munich. July 2, 1911.

MOUCHEZ, AMÉDÉE ERNEST BARTHÉLÉMY (1821–1892), French astronomer and naval officer, whose most memorable work was the inauguration of international co-operation for charting the heavens, was born at Madrid, Spain, on Aug. 24, 1821. In 1878 he was made director of the Paris observatory with the rank of rear admiral. A spectroscopic department was established, and the gigantic task of reobserving all Lalande's stars was completed.

He published 21 volumes of *Annales,* and the first two volumes of the Catalogue de *l'observatoire* de Paris. The advances in stellar photography made by Paul and Prosper Henry and others, suggested to him the magnificent idea of obtaining, through the collaboration of astronomers in all parts of the world, a chart of the entire celestial sphere containing more than 50,000,000 stars. He died at Wissous, near Antony, on June 25, 1892.

MOUFLON (MUFLON, MOUFFLON), the wild sheep (Ovis *musimon*) of Corsica and Sardinia. The rams carry good horns, and in summer show a conspicuous light saddle-shaped mark on the otherwise dark reddish-brown coat. The Armenian and Persian mouflon (*O. orientalis*) is a larger and redder sheep, with horns curving widely, so the points are near the back of the neck. A small race (*O.* orientalis *ophion*) inhabits Cyprus, where, however, it was so extensively hunted that it nearly became extinct; protective measures have saved it. (J. E. HL.)

MOULINS, LE MAÎTRE DE ("THE MASTER OF MOULINS") (fl. *c.* 1480–*c.* 1500), French painter, miniaturist and possibly a designer of stained-glass windows, unidentified author of the "Triptych of the Cathedral of Moulins." The master of Moulins is perhaps the most significant exponent of the French spirit in late Gothic painting, cherishing as he did decorative and monumental composition, refined form, aristocratic gesture and a feeling of delicate life, particularly striking in the faces of children.

The Moulins triptych was painted about 1498–1500 for Duke Peter II of Bourbon and his wife Anne, the daughter of King Louis XI. By comparison with this triptych the following group of works has been assembled, undoubtedly by the same hand: "Nativity With the Cardinal Jean Rolin" (c. 1480, Autun); "Portraits of Peter II of Bourbon and His Wife Anne of France" (1488, workshop replica of a lost original, Louvre); the two wings of a diptych (c. 1490): "Cardinal Charles de Bourbon" (Munich) and "Madonna With Child and Angels" (private collection, unpublished); "Portrait of Margaret of Austria" (c. 1491, Lehman collection, New York); "Title Page of the Statutes of the Order of St. Michael" (miniature, *c.* 1494, Bibliothèque Nationale, Paris); "Madonna With Child and Angels" (*c.* 1495, Brussels); "Portrait of a Praying Child" (c. 1495, Louvre); "Female Donor With St. Magdalen" (c. 1495–1500, Louvre); "Meeting at the Golden Gate" (c. 1500, London); "Annunciation" (c. 1500, Chicago); "St. Maurice (?) and a Donor" (c. 1500, Glasgow); and, possibly, the painted window at the cathedral of Moulins given by the Popillon family, about 1500.

GIRAUDON

"PORTRAIT OF A PRAYING CHILD" CREDITED TO LE MAITRE DE MOULINS. IN THE LOUVRE, PARIS

These works reveal one of the most important French painters of the late 15th century, working for King Charles VIII, for the Bourbon family and for the archduchess Margaret of Austria. The style, although strongly influenced by Hugo van der Goes, is unmistakably rooted in French artistic traditions, those of Bourges and the Bourbonnais.

One hypothesis, based on the sitters of his portraits, identifies the master of Moulins as Jean Perréal, official painter of Charles VIII and of Margaret of Austria; another, based only on a strong similarity of style, with Jean Hay of Flemish origin, the painter of a beautiful "Ecce Homo" (1494, Brussels museum); and a third, a purely conjectural interpretation of documents, with Jean Prévost (also called "Jean le Peintre"), a stained-glass painter active in Lyons (1470–99).

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(C. Sc.)

MOULINS, a town of central France, capital of the *département* of Allier, 121 mi. N.W. of Lyons. Pop. (1954) 22,677. The town is situated on the right bank of the Allier, which is there crossed by an 18th-century bridge about 1,000 ft. in length. Moulins did not attain any importance till the 14th century, before which it consisted chiefly of some mills belonging to the dukes of Bourbon. About the middle of that century it became the residence of the dukes and in the late 15th century the capital of the duchy. The medieval town occupied a small area. The town makes beer, cloths, chemicals and furniture.

MOULMEIN (MAULMEIN), the port and headquarters of Amherst district and Tenasserim division of lower Burma. Pop. (1953) 102,777. Shipbuilding, which formerly was an important industry, was given up, but there is a considerable export of teak and rice, and there are several steam rice- and sawmills.

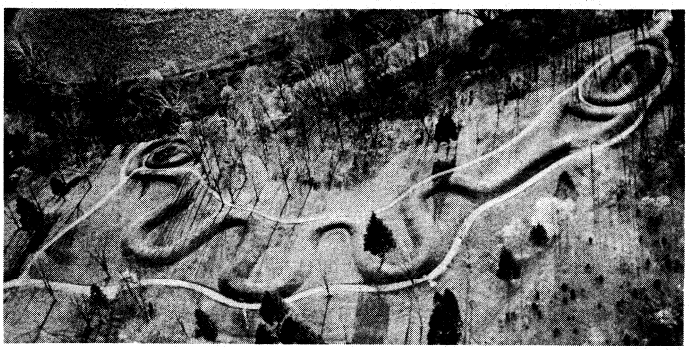
The town is protected from the sea by Bilugyun Island. The picturesque port, however, is silting up.

MOULTRIE, WILLIAM (1730–1805), American soldier, was born in Charleston, S.C., on Nov. 23, 1730. Although he was connected by many ties to the British, he espoused the American cause on the outbreak of the Revolutionary War, and was a member of the provincial congress of South Carolina in 1775–76. On Ft. Johnson, on James Island in Charleston harbour, he raised what is said to have been the first American battle flag—blue, with a white crescent in the dexter corner, inscribed with the word "Liberty"; the flag was devised by him in Sept. 1775. In March 1776 he took command of a palmetto fort which he had built on Sullivan's Island off Charleston, which he held against the attack of Adm. Sir Peter Parker on June 28, and which soon after the battle was renamed Ft. Moultrie by the general assembly. He dislodged the British from Beaufort, S.C., in Feb. 1779, and made it possible for the city of Charleston to put itself into a state of defense. He was one of those who advised against the surrender of Charleston, where he commanded the garrison until the arrival of Gen. Benjamin Lincoln. His imprisonment after the surrender of Charleston (May 1780) lasted until Feb. 1782. He was gover-

nor of South Carolina in 1785–87 and in 1792–94. He died in Charleston. Sept. 27, 1805.

MOUND BUILDERS, in North America, the name applied in the 19th century to a large segment of the prehistoric inhabitants from the Great Lakes to the Gulf of Mexico. It once was thought that the builders of a wide variety of earthen mounds were a distinctive group of people more advanced in their culture than the historic Indian tribes, but this interpretation was not valid. A large number of distinctive prehistoric Indian cultures associated with various types of mounds are recognized by archaeologists.

The commonest mound type is the burial mound, which is



BY COURTESY OF STATE OF OHIO DEPT. OF INDUSTRIAL AND ECONOMIC DEVELOPMENT

THE GREAT SERPENT MOUND IN ADAMS COUNTY, O.

usually subconical or elliptical in form and varies from 2 or 3 ft. to more than 70 ft. high, and from 15 ft. to 275 ft. in diameter. Many different kinds of burials were placed in these structures. In more complex mounds log tombs or stone cysts enclosed the remains of the dead. The Adena and Hopewell mounds of the Ohio valley are outstanding examples of this mode of burial. Burial mounds were first built about 1000 B.C. and continued in use but in decreasing numbers until the early historic period.

The other major mound form was a platform of earth on which the important buildings of the agricultural communities were constructed. In large prehistoric centres as many as 50 of these were built, often in groups around a plaza area in which important ceremonies were held. The pyramidal or temple mound construction began about A.D. 700 in the southeast and lasted until the early historic period. Many of the historic tribes of the southeast from the Shawnee and Illinois on the north to the Natchez and Creeks on the south built such mounds in their permanent villages.

See also CAHOKIA MOUND; HOPEWELL; INDIAN, NORTH AMERICAN: Culture Provinces: Eastern North America; SERPENT MOUND, GREAT.

See H. C. Shetrone, The Mound Builders (1930); J. B. Griffin (ed.), Archaeology of the Eastern *United* States (1952). (J. B. GN.)

MOUNT, WILLIAM SIDNEY (1807–1868), U.S. painter, one of the first and best American anecdotal painters, was born at Setauket, L.I., N.Y., on Nov. 26, 1807. He studied at the National Academy of Design, New York. He was pre-eminent in the genial portrayal of country life.

His notable works include "Dancing on the Barn Floor" (Suffolk museum, Stony Brook. N.Y.); "Bargaining for a Horse" (New York Historical society); "The Long Story" (Corcoran Gallery of Art, Washington, D.C.); "The Power of Music" (Century association, New York); "Eel Spearing at Setauket" (New York State Historical association, Cooperstown, N.Y.); "Long Island Farmhouse" and "Raffling for the Goose" (Metropolitan Museum of Art, New York). He also painted numerous portraits.

He died at Setauket, Nov. 19, 1868.

His brother, SHEPARD ALONZO MOUNT (1804–68), was a portrait painter.

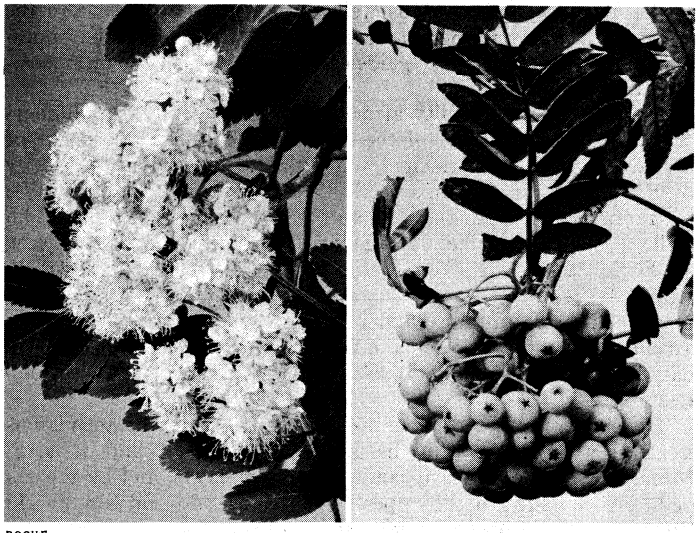
See Bartlett Cowdrey and Hermann W. Williams, Jr., William Sidney Mount *1807–1868*, an American Painter (1944). (HN. W. W.)

MOUNTAIN ASH, an urban district in the Aberdare parliamentary division of Glamorganshire, Wales. in the Aberdare valley on the Cynon, a west-bank tributary of the Taff, 18 mi. N.E. of Cardiff by road. Pop. (1951) 31,521. Area 16.4 sq.mi. In the early 19th century Mountain Ash was a small village known only by its Welsh name of Aberpennar, but from 1850, with the development of its collieries, the population rapidly increased. The district comprises. besides Mountain Ash, the villages of Cwmpenar, Penrhiwceiber, Abercynon and Ynysybwl. The development of the region is associated with the coal-exporting phase in the rise of the south Wales industrial area, and with the rest of south Wales it was seriously affected by the trade depression of the 1930s (see WALES).

A huge pavilion, built in 1906 for the national Eisteddfod, has played an important part in the life of south Wales; many mass meetings have been held there and it was used for the Three Valleys festivals (Merthyr, Aberdare and Rhondda) from 1930 until 1937.

MOUNTAIN ASH (*Sorbus aucuparia*), a tree of the rose family (Rosaceae: tribe Pomeae), native to Europe and Asia, so called because of its resemblance to the true ash in its smooth gray bark, graceful ascending branches and form of leaf.

The American mountain ash (S. americana), a similar but smaller tree, grown for ornament, is native from Newfoundland to Manitoba and south to New York and Minnesota, and in the mountains to North Carolina and Tennessee. The still smaller,



ROCHE

BLOSSOMS AND FRUIT CLUSTER OF THE MOUNTAIN ASH (SORBUS AUCUPARIA)

often shrublike. western mountain ash, S. *sambucifolia,* occurs from Labrador to New England and northwestward to Alaska and Washington and southward in the Rocky mountains to Colorado and Utah. In Scotland the European variety is known as the rowan tree.

The mountain ash attains a height of 50 ft. and is widely cultivated both in Europe and North America for its handsome foliage and bright red clustered fruit. (E. S. HR.)

MOUNTAINEERING. Mountaineering is the sport of attaining, or attempting to attain. high points in mountainous regions. difficult of access, primarily for the pleasure of the climb. For the untrained, it is a dangerous pastime. While the term is often loosely applied to walking up low mountains which offer only moderate difficulties, it is more properly restricted to climbing in localities where the terrain and weather conditions present such hazards that, for safety, a certain amount of previous experience will be found necessary. Rock climbing, snow and ice climbing and. to a degree, skiing in high mountains are typical examples. Mountaineering differs from other outdoor sports in that its participants rely almost entirely on their own powers of physical endurance and judgment to reach their goal, and they require no artificial fields, courts; links, rinks or tracks. Nature alone provides the field of action — and just about all of the opposition — for the mountaineer.

The question, "Why do men climb mountains?" often has been

asked. Some answer that it is man's desire to conquer nature, others that it is the desire to achieve what appears impossible. No doubt man's great spirit of adventure and his curiosity to explore unknown regions provide much of the real driving force behind the mountaineer. Perhaps Rudyard Kipling had the answer when he wrote:

> Something hidden—go and find it;
> Go and look behind the Ranges.
> Something lost behind the Ranges;
> Lost and waiting for you. Go!

(From: "The Explorer" from The Fzve Nations, by Rudyard Kipling. Copyright 1903 by Rudyard Kipling, reprinted by permission of Mrs. George Bambridge, Doubleday & Company. Inc., and Methuen & Co. Ltd.) Offering a combination of self-reliance, simplicity and freedom from man-made rules and regulations, the sport is peculiarly attractive to the explorer's temperament. In tracing the sport's history, it will be found that Anglo-Saxons have been largely responsible for its origin and development.

History.— Modern mountaineering started in the Alps, and may be said to date from about 1850, when Englishmen first began to climb there for pleasure, although a few Alpine summits, including the Jungfrau (13,642 ft.), Finsteraarhorn (14,022 ft.) and Mt. Blanc (15,771 ft.), had been climbed previously. In those early days, climbing was restricted to men, and expeditions included professional guides as well as amateur sportsmen. In the late 19th century, women entered the field and soon made reputable marks. At this time, guideless climbing was also on the increase.

With surprising rapidity after 1850, groups of British climbers scaled one after another of the hitherto unclimbed high peaks of Switzerland; all the principal summits had been climbed, chiefly by English parties accompanied by Swiss, French or Italian guides, by 1870. Pioneer British climbers of this period included John Ball, W. A. B. Coolidge, C. T. Dent, J. D. Forbes, E. S Kennedy, C. E. Matthews, A. W. Moore, Leslie Stephen, John Tyndall, Alfred Wills and Edward Whymper. After 1870 climbers began to develop new and more difficult routes on Alpine peaks already ascended. As the few remaining minor virgin peaks uere eliminated one by one, climbers began to turn to other mountain districts.

The early prominence of British climbers in more distant regions is attested by the expeditions of D. W. Freshfield and of A. F. Mummery to the Caucasus and to the Himalayas, and by the expeditions of Edward Whymper, E. A. Fitzgerald and Sir Martin Conway to the Andes, all during the 19th century.

Climbers from the continent of Europe, while not so prominent in the early intensive exploration of the high Alps, made several important pioneer ascents elsewhere, notably the ascents of Mt. St. Elias (18,008 ft.) in Alaska-Canada, and of the Ruwenzori group (highest summit, 16.814 ft.) in east Africa, by the duke of Abruzzi, and the (unsuccessful) attempt by Vittorio Sella on K-2, Mt. Godwin-Austen (28,250 ft.) in the Karakoram Himalayas, second highest peak in the norld.

With the turn of the 20th century, U.S. climbers began to come into prominence. Mr. and Mrs. William Hunter Workman made five successive expeditions to the Himalayas, reaching a summit 23,300 ft. high; Howard Palmer in 1912 ascended Mt. Sir Sandford (11,590 ft.), the highest peak in the Selkirks in British Columbia; Archdeacon Hudson Stuck, in a remarkable tour de force in 1913, ascended Mt. McKinley (20,320 ft.) in Alaska, the highest peak in North America.

After World War I, American climbers roamed the high peaks of Alberta, British Columbia and Alaska. Among the outstanding ascents made by them were Mt. Logan (19,850 ft.), Mt. Fairweather (15,300 ft.), Mt. Robson (12,972 ft.) and a large proportion of all the remaining unclimbed high peaks of the Canadian northwest.

Among these climbers may be particularly mentioned Allen Carpé, Georgia Engelhard. A. H. MacCarthy, J. Monroe Thorington, H. Bradford Washburn, Jr., and Walter A. Wood, Jr. In 1932, also, an American party ascended Minya Konka (24,606 ft.) in China, and later, American parties, led by Charles S. Houston and Fritz Wiessner, respectively, made two unsuccessful attempts on K-2.

The British, meanwhile, were concentrating largely on the Himalayas, especially on Mt. Everest (29,028 ft.), which straddles the Nepal-Tibet border and was named after Sir George Everest, surveyor general for India, in 1852. Several all-British expeditions had to turn back when 1,000 ft. or less short of the summit. Other British groups ascended Nanda Devi (25,645 ft.) (joint British-U.S. party), Kamet (25,447 ft.), as well as many other lesser-kno n peaks during the 1930s. Among prominent British climbers in those parties were T. Graham Browne, C. G. Bruce, George Leigh-Mallory, N. E. Odell, Hugh L. Ruttledge, H. W. Tilman, Eric E. Shipton and F. S. Smythe. German, French, Swiss and Polish parties also were scaling high peaks of the Himalayas about the same time. Particular note should be made of the German ascent in 1936 of Siniolchu (22,620 ft.) and of the Polish victory over the east peak of Nanda Devi (24,379 ft.) in 1939. Willi Merkl, Paul Bauer, Marcel Kurz and Mr. and Mrs. Dyhrenfurth were among the leading Himalayan climbers from continental Europe.

Between World Wars I and II, British and local parties thoroughly climbed the New Zealand Alps, and various peaks in the central and southern Andes were climbed by German, Swiss and Italian expeditions. The French, except for one trip to the Himalayas, concentrated on new and more difficult routes up the rocky aiguilles of Mt. Blanc. A Russian party climbed Mt. Stalin (24,590 ft.) in the Tajik republic, U.S.S.R., in 1935.

The greatest triumph in mountaineering history occurred May 29, 1953, when two members of a British expedition attained the summit of Mt. Everest (*q.v.*), highest mountain in the world. They were Edmund P. Hillary, a New Zealand beekeeper', and Tenzing Norkay, Sherpa guide and veteran mountaineer. News of the feat reached London June 1, on the eve of Queen Elizabeth II's coronation. Knighthood was conferred on Hillary, as well as on Col. John Hunt, who led the expedition, and the George medal was awarded to Tenzing. The previous year, 1952, Tenzing had accompanied the Swiss on two abortive attempts, reaching 28,200 ft. with Raymond Lambert before being turned back. Colonel Hunt, who had climbed in the Himalayas in 1933, 1937 and 1940, received much credit for his organization and leadership of the expedition and for its completion without injury to any of its members. The other Britons in the party were George C. Band, Thomas D. Bourdillon, Charles Evans, Alfred Gregory, George Lowe, Wilfrid Noyce, L. G. C. Pugh, T. R. Stobart, Michael Ward. Michael Westmacott and Maj. Charles Wylie. This was the 11th team in 30 years to have attempted Everest. Most of the early assaults had been made from the northern side of the mountain before that approach was closed by political changes in Tibet. No sign was found of George L. Mallory and Andrew Irvine who disappeared in a cloud high on Everest's northeast ridge in 1924, nor of a Russian party that disappeared on the same ridge late in 1952.

Further Everest history was made in 1956. From the South col, where the British had launched their final attack, the Swiss sent out two parties; Ernest Schmidt and Jurg Karmet reached the top on May 23; and Adolf Reist and Hans Rudolf von Gunten made the third ascent on May 25. Each of these parties, under the leadership of Albert Eggler, used oxygen for the highest climbing, as had the British. On May 18, 1956, also from the South col, Fritz Luchsinger and Ernest Reiss made the first ascent of neighbouring Lhotse (27,890 ft.), the world's fourth highest mountain. This triple victory constituted a major mountaineering feat and completed the conquest of nine of the world's ten highest mountains, except for the sixth, Dhaulagiri (26,790 ft.).

The French ascent of Annapurna (26,391 ft.) on June 3, 1950, under trip leader Maurice Herzog, made a deep impression on mountaineers and general public alike and helped spur ascents of the next few years. When Herzog and Louis Lachenal reached the top of Annapurna, it was the highest peak man had then mastered. Caught in a blizzard on the descent, both men suffered severe frostbite that afterward cost them parts of their fingers and toes.

Nanga Parbat (26,660 ft.) was long regarded as the most treach-

erous mountain in the Himalayas because of its high toll of climbers. It was finally climbed on July 4, 1953, when Hermann Buhl, member of a friction-ridden German-Austrian expedition, made a solo climb from high camp to the summit. Reaching the top late in the day, he was forced to bivouac in the open all night a short distance below the summit. and next day regained high camp. Nanga Parbat had previously claimed 31 lives over a period of 60 years. 16 being lost at once when an avalanche trapped members of the 1937 German expedition,

The second highest mountain in the world. K-2 (Mt. Godwin-Austen) (28,250 ft.), was topped by two members of an Italian party. Achille Compagnoni and Lino Lacedelli, on July 31, 1954. Under the leadership of Ardito Desio, the party overcame early discouragements of weather and the death of one of their party, Mario Puchoz. They owed much to the attempt by an American team the previous year under Charles S. Houston. This party was marooned for nine days at Camp 8, 25,500 ft. up the mountain; on the enforced descent Arthur K. Gilkey, geologist, was lost, and two other members of the expedition were seriously injured.

Cho Oyu (26,750 ft.), slightly lower than Dhaulagiri, was reached on Oct. 19, 1954, by an Austrian party including Herbert Tichy, Sepp Jochler and the Sherpa, Pasang Dawa Lama The Sherpa had proceeded in three days from an altitude of 13,000 ft. to the summit.

On May 1 j, 16 and 17, 19 jj, a French party succeeded in getting all of its members, plus a Sherpa, to the summit of Makalu (27,790 ft.). A neighbour of Everest, Makalu had resisted a number of previous attempts, including an American party that had been turned back the previous year after reaching 23,200 ft. The first summit pair consisted of Jean Couzy and Lionel Terray.

Kanchenjunga (28,146 ft) has often been considered the world's toughest mountaineering problem. Under the leadership of Charles Evans, who had been deputy leader of the 1953 British ascent of Everest and had reached that mountain's south peak, a British party succeeded in overcoming Kanchenjunga on May 25, 1955, George Band and Joe Brown completing the first ascent. The next day, from the same high camp, Norman Hardie and Tony Streather repeated the climb. using a slight variation of the route at its upper extremity. The actual summit remained untrodden in deference to a request of the government of Sikkim whose country forms the eastern side of the mountain, the Sikkimese regarding the summit as sacred to their gods. Because of the severe problems involved, the Kanchenjunga achievement was regarded as more noteworthy even than the ascent of Everest.

On May 9 and 11, 1956, two separate Japanese parties climbed Manaslu (26,658 ft.), the world's eighth highest mountain. This was the successful conclusion to a series of setbacks the Japanese had encountered in attempting Manaslu in previous years. Later in 1956, on July 6 and 7, British climbing teams led by John Harr tog ascended the Karakoram's Mustagh Tower (23,800 ft.). an enormous spirelike peak previously regarded as unassailable. On July 12 a French party led by Guido Magnone reached the top from the south, the British having used the west ridge.

South America's many unclimbed summits had meanwhile received the attention of mountaineers. American and French parties having made a number of successful forays. In 1955 a German expedition achieved a number of first ascents in Peru's Cordillera de Huayhuash, three with peaks of over 19,500 ft., the rest of summits in excess of 16,500 ft.

Mountain Craft. — Mountaineering may be divided into two sections, rock climbing and snow and ice climbing, with many devotees specializing in one or the other. However, to attack peaks which possess sheer rock walls as well as glacial ice and snow formations, the successful climber must be skilled in all phases of the sport.

Rock climbing is usually to be found only on the uppermost slopes of a high peak, after surmounting its lower reaches of snow and ice, as typified by the Grepon, the Zinal Rothorn and the Dru-Grepon — examples of rock climbs in the Alps; however, rock climbs in the Dolomites (eastern Alps) and the great majority of rock climbs in the United States are devoid of snow or ice in summer.

Rock climbing on typical climbs may involve: climbing steep slabs or ridges; climbing cracks (too small for more than a hand or foot to enter); climbing chimneys (cracks large enough for the entire body to enter); and *couloirs* or gullies (too wide for the climber's limbs to touch both walls at once). Normally, the party will be roped, usually at intervals of 30 to 40 ft. Peculiar to chimney climbing may be mentioned the back-and-knee technique, in which the climber, uith his back to one wall, wedges his knees and arms against the other and works himself up, using alternately his arms and his knees. Coming down, an extra rope passed through a rope sling may be used for descending *en rappel*.

The possibilities of rock climbing were first called to general attention by A. F. Mummery on the occasion of his first ascent of the supposedly unclimbable Grepon (Alps) in 1881. Among climbers from continental Europe and in several climbing centres in the United States, there is considerable interest in specialized rock climbing, in which special techniques and unusual items of equipment are required, but because such equipment may seem to violate the fundamental simplicity of mountaineering, there are many who strongly disapprove of attempting climbs which are possible only by such aids.

Snow and ice climbing is construed by many to require greater skill and experience than rock climbing. On ice slopes, steps must be cut with the ice ax. The experienced leader will cut steps so that they furnish a secure footing and are not too dangerously far apart, yet require a minimum of ax work. Cutting steps is more difficult down a slope than up one, and only long experience can enable a man to maintain a safe balance while so occupied.

On the leader's judgment of the condition of a snow slope the safety of the entire party may depend, and the leader must have almost a sixth sense to detect concealed crevasses or hidden snow cornices. On steep ice slopes it is essential that the rope be constantly belayed about the shaft of the ice ax, firmly fixed or secured.

No climber can ascend any of the great peaks of Alaska, the Andes or the Himalayas, or even of the Alps, unless he is a good man on snow and ice and he should be at least moderately proficient on rocks. Skis are used occasionally, more particularly for an approach to a peak over long, snow-covered glaciers, as in Alaska.

Wznter climbing increased greatly in popularity after 1920, along with the growing interest in skiing. While some great peaks, either snow or rock, that have been climbed in summer can also be climbed in winter, winter climbing is generally restricted to snow climbs, where cross-country skiing finds its greatest possibilities. As crevasses of a glacier are largely filled up with snow in winter, certain ascents may be actually easier at that time. On the other hand, any rock climb will be much more difficult in winter.

Dangers. — In mountaineering, dangers are many and present serious risks for the inexperienced or for those climbers who work without the aid of guides well acquainted with local conditions. Objective dangers are attributable either to weather. loose or falling rocks, avalanches of snow or ice or concealed crevasses or cornices. A careful study of weather conditions is essential, especially in the higher mountainous regions where sudden changes are common. The Himalayas, with their extreme heat of the day and freezes at night and their monsoon season, present grave risks for climbing parties.

Sleet on rocks can instantly transform easy conditions into the most difficult. Rock falls are almost always localized on certain parts of the face of a peak, in gullies or *couloirs* which provide natural funnels for stones that may be loosened higher up on the face. Climbers who take a route up such gullies are thus exposed to the dangers of other falling rocks, while a route which clings to a ridge is practically immune from such risk. The character of a section's rock has much to do with the relative danger. Dolomite rock or the granite of the aiguilles of Chamonix are outstandingly secure. the sandstone and shale of the Canadian Rockies presenting the other extreme. Loose rocks are most likely to fall when the ice of the previous night, in which they have been held, begins to melt in the morning sunlight. Avalanches are similarly restricted to recognizable parts of a peak. and the experienced explorer learns

to identify such places quickly and plan his ascent to avoid them. The condition of mountain snow may, in itself, greatly increase the danger of avalanches. Dry flakes, when first fallen, do not cohere, and with an angle of repose of around 25° any slope of fresh snow steeper than 25° must be considered with caution until the fresh powder snow has become packed into settled sno for more secure footing. Settled snow mill not normally avalanche, but if seeping water percolates under an accumulation of snow on an ice base, on smooth rocks or on grass slopes of even moderate steepness the wet snow is liable to avalanche. Slides of wet snow are particularly dangerous to the entrapped climber for then there is the added danger that when the avalanche comes to rest the heavy, wet snow may settle into a solid frozen block of near-ice, from which the mountaineer cannot extricate himself. The dangers of being caught in a powder snow avalanche are the possibilities of suffocation or of being swept over a cliff. The competent climber never ventures forth when snow conditions are in themselves dangerous. Concealed crevasses on glaciers and unsuspected snow cornices that give way suddenly are also dangers often encountered. The more subjective dangers are related chiefly to inexperience and lack of training. An experienced leader can avoid many of the objective risks such as those named above and can also foretell bad weather. Physical condition, requiring not only muscular training but acclimatization to the rarefied air of high mountains. is most important. Failure to become acclimatized often results in mountain sickness on a climb One climber in poor physical condition is a source of real danger to an entire party.

Equipment.—*Normally Indispensable.*—Clothing: woolen underwear; windproof outer garment, preferably of parka type; headgear and mittens of suitable warmth; cleated boots; heavy socks. Necessary equipment includes snow glasses. sunburn preparations, compass. map, waterproof matchbox or other lighters, scout knife, ice ax, climbing rope, crampons, rucksack and folding lantern or flashlight.

Occasionally Required.—Extra rope of lighter weight; *pitons*, snap rings, hammer (for difficult rock climbs); tents, sleeping bags and cooking equipment (for long expeditions); skis, willow uands (for major snow climbs); aneroid barometer; oxygen tanks (used at high altitudes such as found in the Himalayas). If a camera is carried, care must be taken that it will operate properly under mountain temperature conditions.

Improved Equipment—The training of alpine troops and the improvement of equipment that resulted from research during World War II and the postwar era did much to aid the mountaineer. Lighter although warmer clothing for freezing weather, collapsible stoves and light oxygen tanks and masks were only a few of the items that appeared. Featherweight boots and other articles of clothing known as "Thermowear," originally designed for the armed forces to combat subzero conditions, were introduced and ensured the climber greater comfort without any restriction on mobility. The lighter portable radio, especially the walkie-talkie, enabled the bigger expeditions to keep in almost constant contact with various members as camps were established on the ascent of the once unconquerable mountains. The Mt. Everest expedition of 1953 was equipped with a mortarlike avalanche gun with which to dislodge loose and dangerous snow which might have started an avalanche in its path to "the top of the world," but it was not used.

Personnel.—A balanced party of climbers can be selected only by a leader from individual personal knowledge of the experience and records of the climbers under consideration. Personalities of individuals have a way of becoming more pronounced under the strain of constant close contact; at high altitudes all human responses tend to deteriorate—soundness of judgment as well as normal courtesy.

For a single day's climb, a party of three is ideal—the smaller the party, the less the delay in traversing unusually difficult terrain when only one of the party may safely move at one time. With a party of fewer than three, rescue of one member, if he falls into a crevasse, is extremely difficult at best. For an expedition into unexplored regions, however, a party should be larger, even if porters can be hired locally.

Example of a Typical Ascent.—The party should ordinarily consist of three experienced amateurs. if guideless, or two amateurs and a guide. Such a party would start from its bivouac or camp close to the snow line (or above) as early as possible in the morning—preferably several hours before sunrise. The air would be crisp; suitable clothing must be worn; a folding lantern is used. The party should be roped together at intervals of about 20 to 30 ft. as soon as it steps on to the *névé* of the glacier. The most experienced climber leads on the ascent with the weakest of the three members in the middle. Once the sun rises, snow glasses are de *rigeur* on snow or ice. If soft snow is found or much step cutting in ice is necessary, each climber spells the others as leader.

The gait should be slow, so slow that no one in the party gasps for breath. While at low altitudes, a strong party may ascend as much as 2,000 ft. vertically per hour, yet 1,000 ft. per hour, vertical ascent, is ordinarily fast climbing. The speed of ascent may drop to as little as 100 vertical feet per hour, or even less, if serious difficulties are encountered, such as step cutting or difficult rocks. There may also be quite a delay in finding a point where the *bergschrund* can be crossed—the bergschrund is the large crevasse just beneath the rocks at the head of the glacier. Each one takes care that his feet are securely placed at every step, whether on snow or on rock; on rock, also, care is taken not to dislodge any loose stones, lest they fall on those below. If it is necessary to use the hands in climbing rocks, they are used rather to assist balance than to pull the weight up, except in the most difficult passage. Always, too, the rope is constantly kept taut between members of the party, to check instantly any incipient slip. If unusually difficult rocks are encountered, it is necessary to use some pitons. A piton, or pierced iron spike, is driven by the leader into a crack above him, as high up as he can reach; a snap ring is then slipped through the piton; the leader will pass his rope through that ring; then, hauled up with that rope by the others of the party to the level of that piton, he ties himself fast with a separate spare rope and proceeds to drive yet another piton still higher, and works his way up to it the same way. laboriously continuing with piton after piton until he overcomes the difficult pitch of rock. The last man on the rope retrieves the snap rings, and pitons if practical.

Halts during the ascent are made as rarely as possible—at low altitudes every two hours or so, but at high altitudes the human physique requires a halt more often. The leader must be constantly alive to changes in the condition of the snow, dangers of avalanches, falling rocks, concealed crevasses on glaciers, or unsuspected cornices, and possible changes in the weather. In crossing wide snow fields, willow wands may be set; stone cairns may be erected at strategic points on rocks.

On the descent, the strongest man is placed at the rear. being thus best able to hold any of the others with the rope, should they slip. In difficult spots, on the descent even more than on the ascent, the rope is belayed about a projecting piece of rock, or about an ice ax wedged into rocks or driven into snow, and only one man moves at a time under such conditions. In very difficult parts, on the descent, the party may descend en rappel. Care is peculiarly necessary on the descent. Fatigue or a feeling of relaxation makes for carelessness, and a surprisingly large number oi serious accidents on mountains have happened on the descents.

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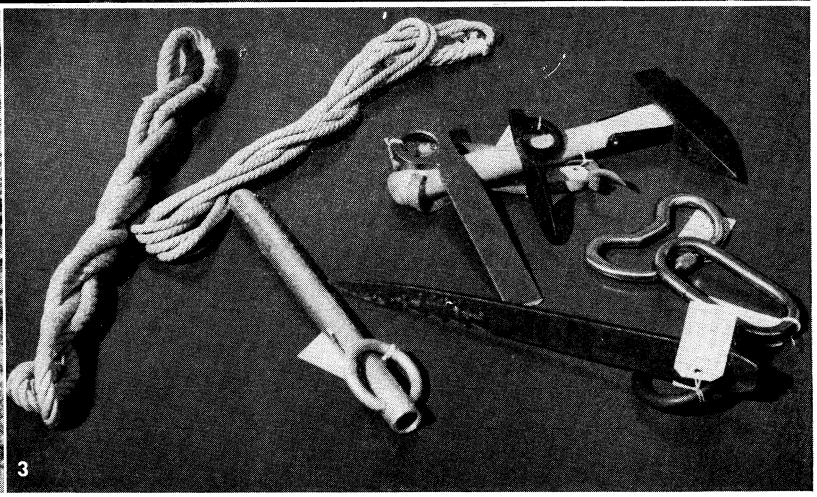


COURTESY OF (3) SWISS NATIONAL TOURIST OFFICE; PHOTOGRAPHS, (1) BURTON HOLMES FROM EWING GALLOWAY, (2) GEORGE ALAN SMITH

MOUNTAIN PEAK AND TYPICAL CLIMBING EQUIPMENT

1. The Matterhorn, in the Alps. Switzerland, elevation 14,688 ft. 2. (Left) Rock-climbing shoes with thin, cleated rubber soles and heels; (right) mountaineering hoots with heavy, cleated rubber soles and tricouni nails at the heels. 3. Typical mountaineering equipment, showing heavy rope for climbing use and lighter rope for slings, ice pitons, rock pitons, two types of carabiner, piton hammer

MOUNTAINEERING

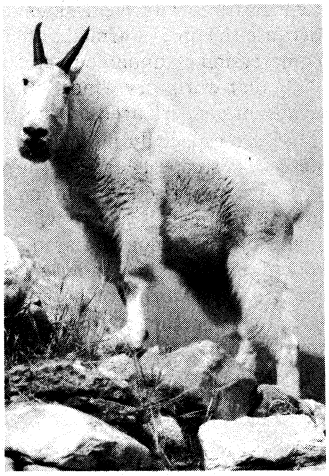
COURTESY OF (3) SWISS NATIONAL TOURIST OFFICE. (4) AMERICAN ALPINE CLUB, PHOTO BY BRADFORD WASHBURN, JR.. (5) AMERICAN ALPINE CLUB, PHOTO BY CHARLES S. HOUSTON; PHOTOGRAPHS, (1) EWING GALLOWAY. (2) EWING GALLOWAY, PHOTO BY SELLA. (6, 7) GEORGE ALAN SMITH. (8) CHRISTINE L. ORCUTT

FAMOUS MOUNTAIN PEAKS AND METHODS OF CLIMBING

(1) Mount **Everest** (29,028 ft.) and (2) K-2 (28,250 **ft.)** in the Himalayas, the two highest summits in the world; (3) Descending a mountain "en rappel"; (4) Mount McKinley (20,320 **ft.),** highest peak in North America; (5) Parka clothing worn on high mountain-climbing expeditions; (6) Climbers on a glacier using ice axe, rope and crampons: (7) Rock climbing; (8) Use of pitons — the climber is doubly secured by ropes passed through pitons which he has driven in

Lambert, *Forerunners to Everest* (New York, 1954); Charles Evans, *Kangchenjunga, the Untrodden Peak* (London, 1956); Karl M Herrligkoffer, *Nanga Parbat* (New York, London, 1954), Maurice Herzog, *Annapurna* (London, 1952; New York, 1953); Charles S Houston and Robert H Bates, *K2, the Savage Mountain* (New York, 1954); Sir John Hunt, *The Conquest of Everest* (New York, 1954); W H Murray, *The Story of Everest* (1953). (J. E FI.; GE. A. S.)

MOUNTAIN GOAT (ROCKY MOUNTAIN GOAT), the sole species (Oueamnos americanus) of a genus of North American hollow-horned ruminants of the family Bovidae, order Artiodactyla (*q.v.*). It occurs from the Yukon to the northern Rockies of the United States. It is more closely related to the antelopes than to the true goats. The body, 35–40 in. high, is stocky and slightly humped at the withers. Both sexes bear short, slightly backward-curving horns. The coarse white hair is long and shaggy over a thick woolly underfur, and a beard frames the slender muzzle. Mountain goats are white at all seasons; the blackish snout, hooves and horns stand out in contrast. These surefooted relatives of the chamois (*q.v.*) live among the rugged, craggy mountain peaks, usually above timber line. They excel even the bighorn (*q.v.*) in climbing rocky precipices where no animal of equal size can follow.



H. ARMSTRONG ROBERTS

MOUNTAIN GOAT (OREAMNOS AMERICANUS)

Mountain goats live in small bands. Mating takes place in November, and the males fight for possession of the females. A single kid, rarely two, is born in late spring, in a nursery group. A few minutes later the kid is walking about and nursing. The food of mountain goats consists of a variety of vegetation—moss, lichen, scrub foliage—and seemingly little is required. The slow gait is a stiff-legged walk. They are agile climbers and are capable of leaping more than 12 ft. (K. R. KN.)

MOUNTAIN LAUREL (Kalmia latifolia), a North American shrub of the heath family (Ericaceae), called also calico bush and spoonwood. It is native to rocky soils from New Brunswick to Ontario and southward to Florida and Louisiana. Usually it is a shrub with stiff branches, forming dense thickets, 10 to 20 ft. high, but may become a tree 40 ft. high. It bears smooth, oval, pointed laurellike leaves and handsome pink or white flowers, about one inch across, in large terminal clusters. A closely related species (*K. angustifolia*), commonly known as lambkill, sheep- or dwarf-laurel, has similarly coloured but usually smaller flowers and smaller leaves. It is found from Newfoundland and Hudson bay to Georgia.

ROCHE

MOUNTAIN LAUREL (KALMIA LATIFOLIA)

MOUNTAIN METEOROLOGY. This article deals with the special weather phenomena associated with mountainous terrain.

Temperature. — On the average, the temperature of the lower atmosphere into which the mountains penetrate decreases by between about 5° and 10° C. per kilometre of height. This fall in temperature is the most significant feature of weather on mountains and it is the chief cause of the change in vegetation with altitude.

Rainfall. — On account of the ascent of air streams on the windward sides of mountains, the condensation and rain-forming processes are intensified. Rainfall is generally greater on mountains across which winds frequently blow than over the surrounding low ground. There is often a rain shadow in the lee, which is important if the winds are predominantly from one direction. Rainfall is also greater over mountains because cumulo-nimbus clouds are better developed there.

When stable air ascends in passing over a mountain it is cooled, so that the temperature on the mountain may be a few degrees colder than that in the air at the same altitude over the plains and valleys. This increases the fall-out of snow and rain, and also loners the level of the cloud base and snow line.

When the cloud has its base below the mountaintop it is called hill fog. Cloud droplets are caught on grass and leaves and the rainfall may thereby be augmented. Where the ordinary rainfall is small, this may be important to the vegetation.

Cumulus and Cumulo-nimbus Clouds. — Cumulus clouds are formed by thermals. These are masses of warm buoyant air ascending through the surrounding air as a result of having been heated by proximity to the ground which has been warmed by the sun. On a mountain surface the heat is transferred to the air at a greater altitude than over the plains and so thermals are more buoyant and reach higher than thermals rising from lower ground. At the same time an anabatic (upslope) wind may blow up the warmed mountainsides, maintaining an almost continuous supply of air rising from the mountains into the cumulo-nimbus. There is also a compensating sinking motion of the air as a whole over the valleys. which reduces the amount of cloud there.

When small cumulus clouds appear in the morning, they appear first over the mountains. These gradually grow into large cumulus and then, on favourable days, into cumulo-nimbus, often with heavy showers and thunderstorms in the afternoon. In the evening the supply of heat from the sun to the ground decreases, while at the same time the sunshine is cut off by the spreading anvil-shaped tops of the cumulo-nimbus.

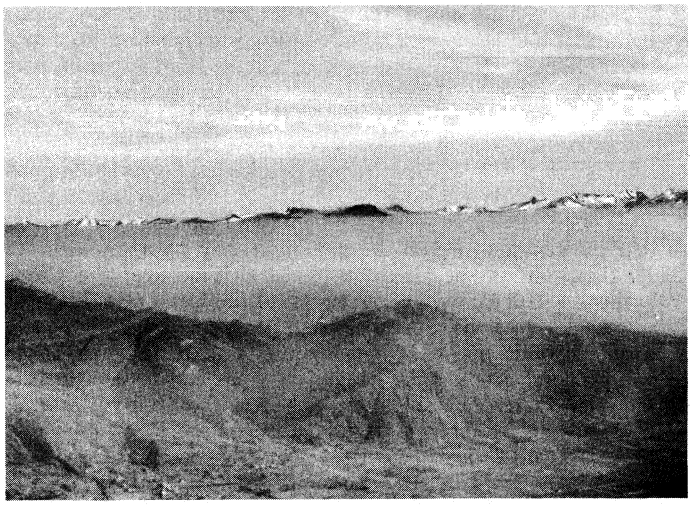
The rain partially evaporates into the air through which it falls, cooling it and causing it to flon as a torrent down the mountain slopes. Sometimes it flows far across the plains in the afternoon and evening. This cold air is a shallow layer, perhaps only from 50 to roo m. deep, producing a sudden squall when it first arrives.

As night draws on and many of the cumulo-nimbus evaporate, the air over the mountains is cooled and caused to sink. At the same time the air over the plains ascends bodily, and if there have been any cumulus over the valleys, they may grow into cumulo-nimbus during the night. If the air is not unstable enough for cumulo-nimbus to be formed, the evaporation of the cumulus over the mountains may often induce the formation of a layer of strato-cumulus over valleys at night. This, however, soon disappears in the morning sunshine.

Stable Air in Valleys. — In the evening katabatic winds begin to flow down the slopes as they become cool. These winds are only two to three metres deep and can be blocked by high walls which are frequently built to protect houses and gardens from them. In quiet weather, valleys may be filled with stably stratified air for several days on end. During the day there may nevertheless be anabatic winds about 50 m. deep blowing up sun-warmed slopes, even though the main mass of air in the valley is almost motionless. The air in these upslope currents spreads out horizontally at the level of the mountaintops and causes the valley air to sink and be warmed. At such times if smoke is produced in the valleys it is carried up to the level of the mountaintops but no higher and a very marked haze top is produced. When the air in the valleys is stably stratified the thermals over some mountains may be warm enough to rise into the air above and produce cumulus, or even cumulo-nimbus, above the haze top.

Winds. — The effect of a mountain barrier on the horizontal movement of air is most noticeable when the air on one side is colder and therefore denser than on the other. This happens when the progress of a cold front is halted by a mountain range.

When the colder air is only just deep enough to flow through



R. S. SCORER

FIG. 1.—AERIAL VIEW OF HORIZONTAL HAZE TOP. SMOKE POLLUTION, CARRIED UP SUN-WARMED MOUNTAINSIDES BY ANABATIC WINDS, SPREADS OVER THE VALLEYS

narrow passes it blows with great force down the valleys on the lee side, like a flood overwhelming an embankment. On a larger scale the cold mistral blows down the valleys of the Rhône and other rivers in southern France between the Pyrenees and the Alps. The mistral is often a deep wind extending to well above the mountaintops, and may persist for several days when there is an inrush of cold air into the Mediterranean. It blows especially during the early months of the year, but may occur at all seasons. In some places the wind is strongest in the valley bottoms, so that dwellings on small hills and mountain shoulders are often more protected from it.

Within the canyons of the Rocky mountains, winds are often observed to blow along the canyon toward the low-pressure end, while the wind above more nearly follows the direction of the isobars with low pressure on the left. The same can be seen at other mountain gaps such as the Straits of Gibraltar, where the wind usually blows through the straits from the east or from the west while the wind above the mountains blows according to the larger scale weather systems. Thus when the wind aloft is from the southwest the wind below the mountaintops often blows through the straits with gale force from the east.

A similar situation exists when the Mediterranean is filled like a lake with cool damp air, especially around midsummer. A persistent east wind called the Levanter blows out through the Straits of Gibraltar, often for weeks almost continuously. There are related phenomena at other gaps in long mountain barriers, such as between the North Island and South Island of New Zealand.

When cold fronts advance to a mountain range, small centres of low pressure are often formed on the lee side as the progress of the cold air is held up. They are, for example, in the western Mediterranean and in the Gulf of Italy when deep cold air spreads southward to the Alps and Pyrenees, and the mistral blows.

The air passing down the lee side of the mountains may have originated far above the ground on the windward side, the cold lower layers being blocked by the mountains. Unusually high temperatures with clear skies are then experienced on the lee side because the air is warmed and all the cloud in it evaporated by the compression it undergoes as it descends to lower altitudes.

Similar warm dry winds, but on a larger scale, known as chinook winds, are experienced on the plains east of the Rocky mountains. They are especially noticeable in the state of Colorado where the descent is steepest. When they begin to blow at Denver, the temperature may rise by as much as 40° C. In the Alps such winds are called foehn (Fohn) winds. but this name is also applied to many other phenomena associated with the passage of air across mountains, and it is now given to similar winds in many other parts of the world. The sudden changes in humidity and temperature, together with the oppressive appearance of the clouds and the noise and physical force of the wind, are said to produce physiological and psychological disturbances in the local inhabitants, often leading to feelings of depression, headaches, sickness, etc. Large falls in temperature usually accompany the arrival of the cold air if it has passed over the mountains.

Berg winds, which blow down from the plateau around Basutoland, appear sometimes to have originated above the mountaintops. They give very warm, dry sunny weather at Durban, and consequently the highest temperatures of the year are sometimes recorded there in midwinter.

Waves.—Air streams are often deep enough to flow directly over a mountain range. The air then takes an undulating path. Aircraft flying in air where the motion is not horizontal experience strong up-and-down currents whose magnitude commonly reaches five metres per second. The first wave occurs above the mountain causing it but in most deep air streams there is a series of lee waves extending downwind. These waves are most important when they have their largest amplitude in the middle levels of the atmosphere and die away at greater heights, for then they may produce clouds and have an important effect on the weather.

The circumstance most favourable for the occurrence of lee waves is when a deep air stream with the wind stronger in the higher levels, and with a layer of stably stratified air in the lower levels, flows across a long ridge having a steep lee slope. The strongest upcurrent is then found not over the wind-facing slope of the mountain—as was thought by the early glider pilots—but

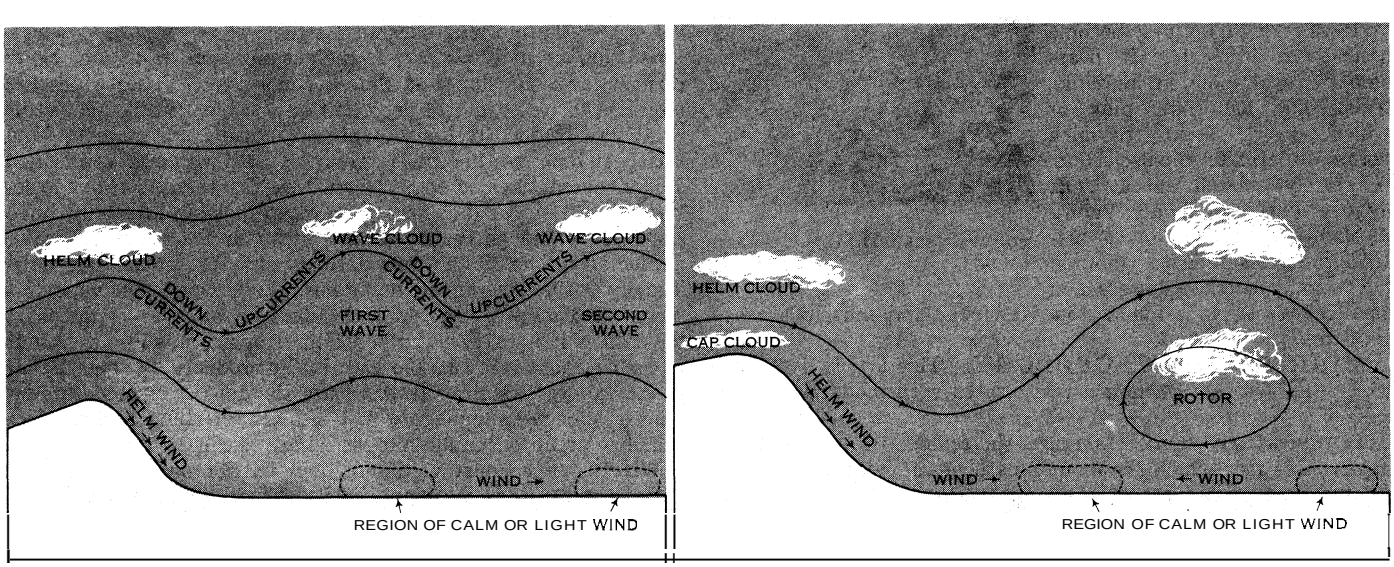


FIG. 2.— LEFT. LEE WAVES: RIGHT. LEE WAVES WITH ROTOR

at the front of the first lee wave.

There may be a series of several lee waves, and over 100 have been reported where the air stream passes out over the sea nhere the waves are not interfered nith by other mountains.

When the lee slope is very steep and high, the waves may be of sufficient amplitude for there to be a rotor beneath, as indicated in fig. 2. In a rotor the air circulates, and the wind at the ground is reversed. At the front of the rotor the air rises vertically from the ground.

The regular spacing between the waves is usually between two

H KLIEFORTH

FIG. 3.— SIERRA WAVE WITH TURBULENT ROTOR CLOUD BELOW. SMOOTH WAVE CLOUD IN MIDDLE AND BILLOWED ICE WAVE CLOUD ABOVE. THE WIND AT GROUND UNDER THE WAVE IS OFTEN REVERSED (see FIG. 2, RIGHT)

and eight kilometres. If this spacing coincides nearly with the spacing of the hills, the waves become large; otherwise the lee waves of one mountain may be annulled as the air passes over a second.

In hilly country with a complicated topography intense waves may be temporarily set up in one or two places. Under the nave troughs such strong winds may occur that acres of forest are blown down. The locations of the blowdowns are difficult to predict or even explain on account of the complexity of the wave system. It is notable that on account of the stable stratification of the atmosphere. which gives rise to the waves, the flow is quite different from the flow over a similarly shaped model surface in an ordinary wind tunnel. The strongest winds are almost invariably experienced downwind of steep slopes.

By day the anabatic winds up a lee slope inhibit the formation of lee waves by inducing the flow to break away from the hilltops. At night the shallow katabatic wind induces the air flow to adhere to the slope so that waves are formed and a deep strong wind then blows down the lee slope.

Wave Clouds.--If the air is sufiiciently lifted in passing through a wave, the water vapour in it is condensed into cloud. The cloud remains in an almost fixed position and assumes a characteristic smooth shape to which the name lenticularis is given in the international cloud classification. Wave clouds are very common in middle and high latitudes at ail times of the year, even over small hills less than 200 m. high, and may occur at any height at which clouds are normally formed. Wave clouds make many waves visible, though by no means all waves have clouds in them.

Very well-developed wave clouds have long been observed in the Alps in association nith foehn winds, in Bohemia. and in Silesia, where there is some folklore about them. In high latitudes seamen have called them whaleback clouds. Many wave clouds are called helm clouds. and the strong downslope winds helm winds, from the name given to them in Cumberland, Eng.

Over the Southern Alps in New Zealand a wave cloud, called the southern arch, extends the full 600 km. of the range. It may remain stationary over the mountain crest for many hours when the wind is from the northnest. Lee waves are then found over the plains to the east and have been used by glider pilots to soar to over 7,000 m.

One of the most fully explored and spectacular of the lee wves is the Sierra wave which is found in a westerly wind over the Owens valley to the lee of the Sierra Nevada range in California. It is best developed when a jet stream, associated with a front, is blowing across the range. In it gliders have soared to over 14,000 m., the greatest height which can be safely reached without a pressurized cabin. The rotor is frequently well developed under the first lee wave.

When the air stream is very deep the wave over the mountain may extend to very great heights. "Mother-of-pearl" clouds: so called because of the iridescent colours seen in them after sunset while they are high enough to be still in the sunshine, have been seen most often in waves over Norway and have been measured to be at about 30 km. above the ground. They have also been seen in Alaska and Iceland. They are rare because air currents with constancy of direction up to that height are uncommon

See also WIND. (R. S. Sc.)

MOUNTAIN MINT, the common name for about 1 j or more species of hardy herbacebus perennial species belonging to the genus *Pycnanthemum* of the mint family (see LABIATAE), with a pungent mintlike flavour. simple entire opposite leaves and small white or purple flowers! in many-flowered whorls with numerous bracts, forming small terminal heads. Although of relatively little value as garden plants, they are often abundant and conspicuous in old fields and open woods when in flower. (J. M. BL.)

MOUNTAIN PROVINCE, in northern Luzon, Republic of the Philippines. is the largest province in the republic and almost wholly mountainous (Central Cordillera); it is drained toward the west by headwater streams of the Abra; toward the north by the Abulug; toward the east by the Chico and Magat, both tributaries of the Cagayan; and toward the south by the Agno. Area 5.458 sq.mi. Pop. (1959) 340,710.

There are many significant peaks, including Mt. Pulog (9,606 ft.), the highest mountain on Luzon and second highest in the Philippines. Southern Mountain province is a primary mining area. with the three largest gold mines and one of the two major copper mines of the country.

The Ifugao rice terraces: between Bontoc and Banaue and near Sagada, are world famous. Often narrow terraces extend from the floor of the valley to a height of almost 4,000 ft. Although some terraces have been constructed within the past century, most of them were built 2,000 to 3,000 years ago and have been under continuous cultivation since construction.

Mountain province is inhabited primarily by non-Christian tribes of Indonesian origin, and administratively it is divided into five subprovinces largely on the basis of ethnic and cultural lines. Apayao in the north (capital, Kabugao) is the most remote and the people are the most primitive, having had less contact with modern world conditions.

In the central district, from north to south, are Ralinga (capital, Lubuagan), Bontoc (capital, Bontoc) and Ifugao (capital, Kiangan). Benguet (capital, Baguio), in the southwest, whose people are commonly called Igorots, is the most accessible and the best-known area of the province. It is the mining centre and a resort area. Baguio (*q.v.;* pop., [1959] 35,847) is a modern city with considerable western influence. At an elevation of 4,500 ft., and with good highway connections with Manila, it is the foremost vacation land of the country. John Hay base, a C.S. military rest camp for far east personnel, lies on the outskirts of Baguio. (AN. C.)

MOUNTAIN SICKNESS is a disease which may occur in an individual several hours or days after he has ascended a mountain to an altitude of about 7,000 ft. or higher. The cause of this disease is the rarefied air at high altitude and the resultant prolonged

lack of an adequate supply of oxygen in the blood and body tissues. The symptoms of this disease consist of one or more of the following. headache. sleeplessness, lassitude, mental depression. irritability, rapid heart beat, shortness of breath. lack of appetite, nausea and vomiting.

After a stay of several days at high altitude. the body usually begins to adapt itself. after which the symptoms tend to disappear. The process of adaptation consists of an increase in respiration. an increase in the number of red blood cells and the amount of hemoglobin in the blood and other bodily changes, the nature of which was still unknonn in the mid-1950s.

People who reside permanently in high mountainous regions are able to live comfortably and nork effectively at altitudes up to 18,000 ft Attempts to reside permanently at higher altitudes invariably result in an attack of mountain sickness. However, especially well-acclimated individuals have been able to withstand short exposures to a height of about 28,000 ft. Occasionally. an individual who resides at less than 18,000 ft may suddenly lose his adaptation, and this condition is referred to as chronic mountain sickness.

The treatment of both the acute and chronic forms consists of either having the patient breathe oxygen or having him brought to a lower altitude. (H. G A)

MOUNTAIN VIEW, a city of California, U S.. 39 mi S E. of San Francisco and gateway to the naval air station Moffett field, is a centre of aeronautic research, electronic components manufacture, book publishing, food processing and production of deciduous fruits and nuts. truck vegetables and cut flowers. It is served by the Southern Pacific railroad and by bus and truck lines.

Settlement began in 1852 as a stagecoach station but slow gronth postponed incorporation 50 years. In 1857 the community hosted the first religious camp meeting in California. The 1859 attempt to locate the state university in the community failed but Stanford university. University of Santa Clara and San Jose State college are within a 13-mi. radius. The coming of the railroad in 1864 ended stagecoaching and decreased schooner sailings from the town's docks. Industrial development began after incorporation in 1902, a municipal land grant encouraging Pacific Press Publishing association to move its religious book publishing plant to Mountain View in 1904.

In 1929 citizens joined with neighbouring communities in buying a 1 000-ac. site for the first west coast dirigible base. After rejecting more than 100 other locations the government accepted title in 1931 and two years later Moffett field nas commissioned a naval air station. permanent home of the U S.S. "Macon." its hangar towering 198 ft. and covering 8 ac. Hangar doors, each weighing 500 tons, opened for the airship in Oct. 1933 but the crash of the dirigible off Point Sur in Feb. 1935 ended the navy's need for the facility which was then transferred to the army. Research in high-speed aerodynamics began in 1940 when the Ames laboratory of the National Advisory Committee for Aeronautics was located on the post The station reverted to the navy in 1942, first serving as a base for coastal patrol blimps, later as a centre of naval air transport service (NATS) operations. The jet era began in Dec. 1950 and 36 months later Xloffett field became the first master jet airbase.

Sylvania Electric Products, Inc., subsidiary of General Telephone and Electronics corporation, specializing in electronics manufacture for defense, is the city's largest employer.

The council-manager plan of government was adopted in 1952. Summer and winter temperatures average 73° and 61° F. respectively and rainfall of 16–20 in. is confined to the November–May period. For comparative population figures see table in CALIFORNIA: Population. (R. C. Rs.)

MOUNTAIN WARFARE. Mountain warfare is as old as war itself. In 480 B.C the Greeks and Persians battled in the rocky passes and heights of Thermopylae. Hannibal of Carthage crossed the Alps with an entire army, transporting his supplies on elephant back to invade Italy. During World War I the same Alps became the battleground for Italian and Austrian mountain troops.

Mountain warfare tactics and techniques were largely modified following lessons learned in World War II. The greatest experience was gained in Italy. where during a 20-month campaign the U.S. 5th and British 8th armies fought through 400 mi of rugged hills and mountains. There the German defenders made skillful use of terrain and fortifications, fighting stubbornly for control of the mountains in the path of the slowly advancing superior Allied force. The Korean war (1950–53) offered still newer and more significant lessons. Its two foremost tactical innovations, the transport helicopter and modern body armour made of lightweight plastics. had a revolutionary effect on supply, transportation and evacuation of casualties in mountain operations.

OPERATIONS

Mountain terrain lends itself particularly well to surprise, but successful surprise action depends on mountain-trained soldiers. Decentralization of control is forced upon commanders of large units by prevailing terrain and weather conditions. Hence, the initiative, resourcefulness and judgment of small-unit commanders is taxed to the utmost as they will be operating independently or semi-independently for extended periods.

Mountain combat lacks the unity characteristic of warfare in rolling terrain, particularly in the offensive phase. The configuration of the terrain tends to give battle a piecemeal character and to divide it up into more or less isolated conflicts difficult to control by higher commanders. In the terminology of mountain warfare. the topographical crest is the highest point in altitude; the military crest is the highest point permitting a field of fire to and from the foot of the forward slope. The reverse slope is the opposite side of the hill or mountain, usually assumed in military problems to be held by the enemy.

It has been truly said that time and space factors are extremely fluid in mountain warfare, varying sharply in response to weather, altitude and lines of communication. Distance must be measured in terms of time and energy in terrain where the distance between two points is as much vertical as horizontal. Mass is not as important as velocity in campaigns where numbers are often an encumbrance along with road-bound vehicles and tanks.

Offensive Combat.—Offensive action is characterized in all its phases by surprise attacks and attempts at flanking maneuver, combined with frontal action on a broad front. In all offensive operations, the seizure of dominant terrain features as intermediate and final objectives becomes the core of the commander's plans. Specific effort to capture vantage points for artillery observation must be emphasized.

Flanking action sometimes is impossible, and the unit is required to attack frontally. Frontal daylight attacks in narrow sectors have little chance of success. Such attacks are bound to be canalized and observed, thus giving the enemy the opportunity to shift his reserves for counterattack. The necessity for movements under darkness in mountainous country affording the enemy dominant observation is readily apparent. Night operations were widely employed in Italy during World War II; they were especially effective against towns and villages constituting small strong points against which daylight assault proved costly in casualties. The Chinese Communists in Korea confined their offensive operations almost entirely to night attacks. In the daytime they held defensive positions on the reverse slope, where log-faced bunkers afforded protection from artillery or mortar fire. The spade was as useful as the rifle to Chinese troops. They frequently burrowed through the crest from reverse slope to forward slope. where their mortars fired from camouflaged openings on targets of opportunity. In the event of enemy counterbattery fire the mortars could be quickly withdrawn to safety.

The crossing of a lateral valley and assault of a well-defended ridge are similar to the forcing of a river crossing. The purpose is to move a force across quickly and economically and establish a bridgehead to permit the ,crossing of the main body.

Attack against a fortified position is extremely difficult in mountains and requires more time for planning, organization and preparation than in ordinary terrain. Careful and continuous reconnaissance. supplemented by the study of vertical and oblique aerial photographs, is essential. The gaps in fortified positions. deiended only by mobile troops. are usually mined more heavily

and in a more irregular pattern than in ordinary terrain.

It will be possible in many instances to bypass strong points under cover to the flanks or at night. This practice was adopted with marked success by Allied troops in Italy in World War II.

Defensive Combat. — Regardless of the size or composition of the units involved. defensive combat in the mountains has the following advantages: (1) dominant terrain provides the defender and denies the attacker observation and firing positions; (2) the slopes and other terrain features impose difficulties on the attacker; (3) there are zones which are either impassable or extremely difficult for the enemy to negotiate; (4) the lack or scarcity of roads places restrictions on the use of tanks or other combat vehicles and renders them extremely vulnerable.

The disadvantages of defense in mountains are: (1) the compartmentation makes it difficult or impossible to shift fires of supporting weapons readily; (2) it is usually difficult to maneuver support and reserve units to execute counterattack plans; (3) grazing fire is often impossible in rugged terrain; (4) mountains with wooded slopes and moderately difficult cliffs enable the enemy to make decisive surprise attacks at several points; (5) difficulty of digging necessitates longer time for organization of positions.

An outstanding illustration of mountain defensive combat was the German defense of the Italian peninsula in World War II. Along the whole Allied front, German engineers made skillful use of terrain and fortifications. They laid mines on the roads and trails, at the heads of gullies and in the natural cross-country approaches. All bridges and culverts were destroyed and sites for bypasses were mined. Machine-gun and mortar emplacements, many of them dug four or five feet into solid rock, covered nearly every path.

Although the Germans' main concern was to control the dominating mountains in the path of the Allied armies they also used the few small towns on the mountain slopes for organized defense and delaying tactics. The Italian houses, built of solid masonry, could be transformed into effective strong points, forcing attacking troops in many cases to reduce by artillery fire or by street fighting a town which otherwise might have been bypassed. Demolitions, mines and booby traps were used to full effect in delaying tactics afforded by the village fortresses.

EMPLOYMENT OF ARMS AND SERVICES

Infantry. — Because of its self-sufficiency. mobility and versatility in the use of its many weapons, infantry must necessarily carry the chief weight of combat in mountains and must often fight for long periods without the support of other arms. As in flat country, infantry acts by means of fire. shock action and maneuver, but this method has a somewhat different application in the mountains. In general, the effect of fire is less than in ordinary terrain. since mountainous regions offer considerable natural cover such as rocks and cliffs. Maneuver is constantly hampered by the difficulties of the terrain and fire support from adjacent units cannot always be counted on. Movement will usually take the form of individual infiltration or successive rushes by small groups for very short distances.

Artillery. — The basic tactical principles for artillery remain valid in mountains, subject to limitations imposed by the terrain and weather encountered in mountains. All types can be used. Light and medium artillery may be brought into position with the aid of trucks, tractors, horses or mules and by the use of block and tackle or winches. Heavy motorized artillery is limited to roads and their immediate vicinity. Pack artillery, which can follow the infantry off mountain trails over comparatively rough ground, is the most dependable for close and continuous support.

Communication between artillery and the attacking echelon of the infantry and the co-ordination of its fire with that of the infantry heavy weapons require special care. Unless the attacking echelon has highly effective support up to the very point of penetration, it is likely to draw fire just before reaching its objective. An infantry attack over rising terrain is easier to support up to the moment of penetration than is one over descending terrain, although artillery fire may dislodge rocks which will endanger the advancing troops. In the final stage of the attack, machine guns and mortars must often take the place of artillery.

Because of the difficulty of supplying ammunition, the selection of targets and the allotment of ammunition are of great importance. Care must be taken to avoid wasting ammunition on unprofitable targets. Because of the decentralized nature of mountain operations, targets warranting great masses of artillery fire may be fewer than in other terrain. One type of target that is especially profitable, however, is a narrow defile being used as a route of supply advance or withdrawal by the enemy and upon which interdiction fire or heavy surprise concentrations can be placed. Another type often found in the more precipitous mountains is that presented by a large mass of snow or rocks above enemy positions Such masses can be converted into highly destructive rockslides and avalanches by artillery fire. Avalanches accounted for more than half the casualties inflicted in the alpine fighting of World War I.

Air Forces. — The primary missions of the air forces in mountain operations are to gain and maintain air superiority; to observe and attack communication routes. personnel, matériel and installations; to maintain an active air defense system; to furnish visual, photographic. radar and weather reconnaissance information for use of air and ground forces; and to facilitate liaison and supply of units separated by impassable terrain obstacles. Aerial reconnaissance can penetrate ravines, slopes and defiles in a manner not easily done by ground means. Aerial photographs can disclose roads, trails, watersheds, the sky line, defiles and defiladed areas. They may also disclose many enemy installations, minor defenses and concentrations. Interpretation of photographs taken in the mountains is more difficult than those taken elsewhere, however, and requires thorough knowledge of mountain terrain characteristics.

Engineers. — The conditions of mountain warfare require that a large proportion of troops be engineers. Extensive engineer work is required for the construction, maintenance, improvement and repair of routes of communication.

The construction of roads in mountainous terrain is one of the most important duties of an engineer unit. All roads built on slopes in such areas are usually the cut-and-fill types. Roads must be built as the situation changes, rather than according to a preconceived plan. Supply routes should, as far as possible, follow the contour lines. To avoid the silhouetting of men and vehicles, no roads should be built along crests of ridges.

Supply and Transport. — Before the Korean war, three types of transportation were used in mountain combat—wheeled vehicles where roads permitted, pack animals in more rugged country and individual soldiers or porters where there were no roads. In Korea, however, the military helicopter offered a new solution to problems of supply and transport. Even though high altitudes reduced the lifting capacity of rotary-wing aircraft, a U.S. marine corps squadron demonstrated in mountain operations that one helicopter could do the job of several trucks as a means of supply. Combat-equipped troops could be transported to the main line of resistance in much less time than it would have taken them to march, and upon arrival they were not exhausted by hours of climbing.

Both motor trucks and animal pack trains still had their uses in Korea after the advent of the helicopter, and on the main line of resistance the human back was not to be despised. But there could be no doubt that the helicopter had revolutionized methods of supply and transport in mountain warfare.

Evacuation of Casualties. — The evacuation of wounded in mountain aarfare presents another problem that the helicopter solved to a great extent in Korea. Where it would have taken six stretcher bearers as much as half a day to evacuate a severely wounded man, the helicopter was capable of landing in roadless terrain and flying him to the aid station in 20 minutes. This difference in time often meant the difference between life and death to a patient suffering from shock.

Another tactical innovation of the Korean war, modern body armour made of lightweight plastics, also had a marked influence on mountain operations by preventing a large percentage of serious wounds, which became light, while preventing altogether many light wounds. This capability was of special importance in terrain

where consideration had to be given to the conservation of manpouer (C. W. HE ; LN. MS)

MOUNTBATTEN, the name of a family of English peers. In 1917 the English members of the house of Battenberg, that is, the descendants of Princes Louis Alexander and Henry Maurice of Battenberg, renounced their German title and took the surname Mountbatten. GEORGE LOUIS MOUNTBATTEN (1892–1938), who succeeded his father as marquess of Milford Haven in 1921, married Countess Nadejda de Torby, by whom he had one son, DAVID MICHAEL (1919–), the 3rd marquess, and one daughter. His eldest sister, ALICE, married Prince Andrew of Greece (1882–1944); their only son. PRINCE PHILIP (1921–), took the surname Mountbatten when he became a British subject in 1947 and married Princess Elizabeth, who succeeded to the throne as Elizabeth II in 1952. His second sister LOUISE (1889–) married Gustavus Adolphus, crown prince of Sweden, and his brother LOUIS, 1ST EARL MOUNTBATTEN OF BURMA (1900–), married Edwina Ashley, elder daughter of the 1st Baron Mount Temple. PRINCE HENRY OF BATTENBERG (1858–96) married Beatrice, youngest daughter of Queen Victoria. His eldest son ALEXANDER (1886–) was created marquess of Carisbrooke and earl of Berkhamsted; he married Lady Irene Denison. *See* also BATTENBERG; MILFORD HAVEN, LOUIS ALEXANDER.

MOUNTBATTEN OF BURMA, LOUIS MOUNTBATTEN, 1ST EARL (1900–), British-naval officer, was born on June 25, 1900, at Windsor, Eng.. the son of Prince Louis of Battenberg, first sea lord in 1914, afterward marquess of Milford Haven, and Princess Victoria of Hesse, a granddaughter of Queen Victoria. He entered the Royal Navy in 1913, and at the outbreak of World War II was in command of the destroyer "Kelly" and the 5th destroyer flotilla. He was appointed commander of H.M.S. "Illustrious" (aircraft carrier) in 1941 and, as acting admiral, served as supreme Allied commander, southeast Asia, 1943–46. He successfully conducted the campaign against Japan that led to the recapture of Burma. Viceroy and later governor general of India, 1947–48, he was successful in effecting the transfer of power to India and Pakistan at the time of partition of the subcontinent. He was later fourth sea lord, 1950–52; commander in chief of the Mediterranean fleet, 1952–54; and from 1955 first sea lord. He was created viscount in 1946 and earl in 1947.
(J. B HN)

MOUNT DESERT ISLAND, an island off the eastern coast of Maine. U.S., 15 mi. long and about 8 mi. wide, offers an exceptional combination of sea, islands, mountains, lakes and fiords. Area 108 sq.mi. The island was discovered in Sept. 1604 by Samuel de Champlain in exploration of the Acadian coast from St. Croix westward and named by him from his vision of the bare rock summits of its mountains. A bridge connects the mainland and the island's network of excellent roads, bridle paths and foot paths which join the four towns on the island—Bar Harbor, Mount Desert, Southwest Harbor and Tremont.

In 1947 the island was swept by a tremendous fire that destroyed many buildings and natural attractions. Mount Desert Island's bare rock summits including Mt. Cadillac (1,530 ft.), the highest elevation along the east coast, are the highest on the Atlantic coast north of Rio de Janeiro and, in the opinion of many, the most beautiful. The first eastern national park in the United States, Acadia National park, was established on the island in 1919; it also includes picturesque Schoodic point on the mainland
(E. F. I.)

MOUNT McKINLEY NATIONAL PARK, a scenic U.S. nature reserve in south central Alaska, was established by con-'gress Feb. 2j, 1917, and increased in 1922 and 1932 to 3,030 sq.mi. Included are over 110 mi, of the most spectacular part of the Alaska range, with Mt. Russell (11.670 ft.), Mt. Foraker (17,395 ft.) and the highest peak in North America, Mt. McKinley (20,320 ft.). Vast snow fields and many glaciers feed cloudy, silt-laden rivers which flow swiftly north toward the Kuskokwin. In the valleys narrow strips of white spruce forest extend up to timber line (2,500 to 3.000 ft.). Between that elevation and permanent snow, the tundra is clothed by shrubs such as dwarf birch, willows, alder, blueberry, crowberry, great mats of *Dryas* and many herbs.

Caribou, Toklat grizzly bears and ground squirrels live on the tundra, while Dall sheep, marmots and conies stay close to rocky hills and cliffs. Alaska moose, red fox, marten, lynx and snowshoe hares range chiefly in the wooded valleys. Beaver and mink live along streams and lakes; wolverines and wolves may be encountered anywhere in the park. The most notable of the 120 recorded bird species are the short-billed gull, ptarmigan, golden eagle, jaeger. surfbird and wandering tattler. Fishermen catch Mackinaw trout in the lakes and grayling in the clearer streams. No guns are allowed, but highways, trails, trackless wilderness, mountains and wildlife offer many opportunities for those who hunt with cameras.

The park may be reached via the Alaska railroad, by automobile from Richardson highway and by private aircraft. Visitors stay at the park hotel and campgrounds or at a privately-operated camp near Kantishna. (V. H. C.)

MOUNT RAINIER NATIONAL PARK protects 241,782 ac. in the Cascade range of the state of Washington where the massive, symmetrical volcano which gives the park its name rises 14,410 ft. above sea level. Mt. Rainier covers about 100 sq.mi. and is surrounded by deep ice-carved canyons radiating from the peak.

Twenty-six glaciers originate in the perpetually ice-clad summit or in the glaciated cirques on the upper flanks, renewed each winter by the cooling of moisture-laden winds from the Pacific ocean. Emmons glacier is five miles long. The view of Mt. Rainier with its ice crown glowing in the rosy hues of dawn or sunset is an outstanding spectacle.

On the slopes of the mountain stand deep green forests of conifers, interspersed with mountain meadows; and on the high subalpine tundra wildflowers grow in great profusion and variety. Black-tailed deer, bear and elk inhabit the forest and mountain goats climb the higher cliffs; many species of smaller mammals and birds are found throughout the park. Mt. Rainier presents a challenge to mountaineers and its long, snow-covered slopes offer fine skiing. Highways lead to scenic elevations and circle through the lower slopes, and there are more than 100 mi. of trails for the hiker.

Although the park receives as much as 100 in. of precipitation annually, the climate from July into September is pleasant and that season is often followed by Indian summer. (F. M. PD.)

MOUNT RUSHMORE NATIONAL MEMORIAL, 25 mi. from Rapid City in the Black hills of southwestern South Dakota, U.S., is a gigantic sculptured relief of the heads of George Washington. Thomas Jefferson, Abraham Lincoln and Theodore Roosevelt, carved in granite on the northeast side of Mt. Rushmore. Each head is approximately 60 ft. high.

The sculptor was Gutzon Borglum (*q.v.*). The original idea for the memorial is credited to Jonah Leroy "Doane" Robinson, who was superintendent of the South Dakota State Historical society for many years.

The memorial was conceived as a "shrine of democracy," with the presidents representing the founding, expansion, preservation and unification of the C.S. Work on the carving was begun in 1927 and finished in 1941, representing six and a half years of actual labour. Private donors supplied the initial funds but the United States government paid the greater part of the total cost.

The Mt. Rushmore reservation of 1.278 ac., administered by the national park service, lies near two U.S. highways. About 1,000,-000 persons visit the park each year. (J. E. CL.)

MOUNT VERNON, a residential and industrial city of Westchester county, N.Y., U.S., on the Bronx river, is directly north of and adjacent to the Bronx, New York city, between New Rochelle and Yonkers.

Originally a part of Eastchester township, Mount Vernon was settled in 1664 on the property where Anne Hutchinson, religious enthusiast banished from the Massachusetts Bay colony in 1638, was killed by Indians in 1643. These first settlers were ten families invited from Connecticut by Thomas Pell, who had purchased the land from the Indians. St. Paul's church, used during the American Revolution as a British military hospital, was made

a national historic site in 1943.

The original church building was the scene of the election of Lewis Morris to the provincial assembly on Oct. 29, 1733. Morris, chief justice of the provincial supreme court, had been summarily removed from that position by Gov. William Cosby for declaring the governor's chancery court illegal. After the election, Morris became one of the backers of the antiadministration newspaper of John Peter Zenger (*q.v.*).

During the Revolution a stubborn delaying action there by Glover's brigade on Oct. 18, 1776, probably saved Washington's army, in retreat from New York city to White Plains, from being annihilated by Gen. William Howe. The modern history of Mount Vernon begins in 1851 when the Industrial Home Association No. One, a co-operative building group founded in New York city by merchant tailor John Stevens, purchased 367 ac. of land in the area for its 1,000 members.

Manufactures include pharmaceuticals, cosmetics, metal and wire products, electrical and electronic equipment, baby carriages and truck bodies. Mount Vernon was incorporated as a village in 1853 and chartered as a city on March 12, 1892.

Pop. (1960) 76,010. For comparative population figures *see* NEW YORK: *Population.* (M. D. HH.)

MOUNT VERNON, the former home of George Washington, is located in Fairfax county, Va., on the Potomac river, 15 mi. below Washington, D.C. The mansion house, which stands on a bluff overlooking the river, is built of wood, but the siding is of wide, thick boards so paneled as to give the appearance of cut and dressed stonework. The rooms contain much of the furniture that was in them when they were occupied by Washington and his family; most of the pieces on the first floor and all of those in Washington's bedchamber are original. The furniture that had been lost has been in part replaced by other furniture of historic interest and of the style in use in Washington's day. Additional articles relating to Washington and his life at Mount Vernon are housed in a museum building north of the spinning house. In the main hall hangs a glass casket containing the key to the Bastille, presented to Washington in 1790 by Lafayette.

From each end of the house a curved colonnade leads to a row of outbuildings. A spacious lawn surrounds the mansion, with shaded drives, walks and beautiful gardens. A short distance southwest of the mansion house is a plain brick tomb built by Washington's direction on a site chosen by himself. It contains the remains of Washington and Mrs. Washington (removed to this tomb from the old family vault in 1831) and of a number of other members of the family.

The estate, originally called Little Hunting Creek plantation, consists of about 5,000 ac. It descended by inheritance from John Washington, the first of the family in America, to his son Lawrence, who in turn devised it to his daughter Mildred. From Mildred it mas purchased in 1726 by her brother Augustine, George Washington's .father. In 1735, when George was three years old, the Augustine Washington family settled on the estate and lived there for several years. It is believed that the central part of the house was built during that time. In 1740, however, Augustine conveyed the plantation to his son Lawrence, elder half-brother of George, and Lawrence settled there three years later. He renamed the plantation Mount Vernon in honour of his former commander, Adm. Edward Vernon (1684–1757), under whom he had served in the Caribbean. Augustine Washington died in 1743; young George, after his father's death, spent part of his youth at Mount Vernon with Lawrence and Lawrence's wife.

The title to the plantation passed to George Washington in 1755, but active military service kept him away from his inheritance for another few years. In Jan. 1759 he married Martha Custis, widow of Daniel Parke Custis, and soon thereafter took up residence at hfount Vernon. In the next few years he planned and executed the enlargement of the villa into the mansion house, the addition of the smaller wings, the erection of several of the outbuildings and the extension and adornment of the gardens. After about 15 peaceful years there, he was again called into public service, and it was not until Dec. 1783, when he tendered his resignation to congress as commander in chief of the Continental army, that he could again settle at Mount Vernon. Even then his retirement was not to last. In 1789 the plantation life he so much enjoyed was broken when he became the first president of the United States and could be little at home for eight years. During his absences, his manager and distant kinsman, Lund Washington, carried on, according to George Washington's plans, the continuous improvements that invariably constitute part of the activity of a large estate.

Washington's final retirement ended with his death on Dec. 14, 1799. At his death, under the terms of his will, a life interest in Mount Vernon went to his widow, and the estate passed to his nephew, Bushrod Washington; from Bushrod it descended, by successive inheritance, to John Augustine Washington, Jr., who was, in turn, authorized by will to sell it to the U.S. government. An offer to sell the property to the government was accordingly made, but was refused.

In 1858, through the efforts of the Mount Vernon Ladies' Association of the Union, founded by Miss Ann Pamela Cunningham of South Carolina, a purchase contract was signed by which the mansion house and 200 ac. of the original estate, fast falling into decay, were to be bought. About a third of the purchase money was raised through the efforts of Edward Everett (*q.v.*). The association, under its charter (1858), bound itself to restore the estate as far as possible to the condition in which it was in the lifetime of Washington and to keep it sacred to his memory; the state of Virginia agreed to exempt it from taxation as long as these terms were fulfilled. The association became an influential pioneer in the restoration of historic places, serving as an inspiration and example for similar projects. *See* also WASHINGTON, GEORGE.

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MOURNING: *see* FUNERARY RITES AND CUSTOMS.

MOUSE, in its original sense probably the name of the house mouse (*Mus musculus*), the type of the genus *Mus* and of the family Muridae. The distinctive characters of the typical mice, *i.e.*, those included in the genus *Mus,* are dealt with in the article RODENTIA. The name is now applied to most small rodents, qualified by terms such as "white-footed." "pocket" or the like.

With the exception of Madagascar, the genus *Mus* and its allies range over practically the whole of the old world, having indigenous representatives even in Australasia, while the house mouse has established itself throughout the civilized world. *M. musculus,* the house mouse, originally a native of central Asia, has spread to all the inhabited parts of the globe. *Apodemus sylvaticus,* the wood or long-tailed field mouse, is common in many parts of England, often taking to barns and outhouses for shelter during the winter. It is of about the same size as *M. musculus,* but of a bright reddish-gray with a white belly. *Micromys minutus,* the harvest mouse, is the smallest of the European mice, $2\frac{1}{2}$ or 3 in. in length, and a yellowish-red, with short ears and tail. It lives in wheat or hay fields, where it builds a round grass nest the size of a cricket ball, in which it brings up its young. Its range extends from England to Japan. In central Asia there exist wild mice *M. bactrianus* and *M. wagneri* with the habits of the house mouse, both closely allied to *M. musculus;* while there is a third kind (M. *gentilis),* also nearly related, in the deserts of north Africa. Mice derived from M. *musculus* are kept as pets in many parts of the world. Numerous breeds are known, of which the Japanese waltzing mice, which have the habit, resulting from a defect in the labyrinth of the ear, of spinning round and round after their tails, are perhaps the most remarkable.

JOHN H. GERARD

HOUSE MOUSE (MUS MUSCULUS)

See also Index references under "Mouse" in the Index volume.

MOUTH, in anatomy, is an oval cavity at the beginning of the gastrointestinal tract. The walls of the oral cavity are specialized to a high degree, in order to serve the functions of mastication, salivation, swallowing, tasting and speaking.

Anatomy. — The mouth opening is situated between the lips and, at rest, its width reaches to the first premolar tooth on each side. The entire cavity communicates in front with the exterior through the oval fissure, and behind with the pharynx (throat). The walls are formed by the flexible lips and cheeks, the roof by the hard palate and soft palate; the movable floor is formed by the tongue, the sublingual tissue and the lower jaw (mandible).

The lips are fleshy folds surrounding the opening of the mouth, and are formed, from without inward, by skin, superficial fascia, orbicularis oris muscle and submucous tissue. They contain glands (sebaceous, mucous and serous), branches of the maxillary and mandibular divisions of the trigeminal nerve, branches of the labial arteries, corresponding tributaries of the anterior facial vein and a wealth of minute lymphatic vessels. In the midline is a reflection of the mucous membrane onto the gum, forming the fraenum labii.

The cheeks form the sides of the mouth and are continuous with the lips, with which their structure is almost identical save that the buccinator muscle replaces the orbicularis oris and the glands are buccal (cheek) rather than labial (lip). In the subcutaneous fascia is a distinct mass of fat, specially large in the infant, known as the sucking pad. On the inner surface of the cheek, opposite the second upper molar tooth, is the papilla that marks the opening of the parotid duct, leading from the parotid salivary gland in front of the ear. Just behind are four or five mucus-secreting glands, the ducts of which open opposite the last molar tooth. The mucous membrane of the cheek, like that of the rest of the mouth, is of the stratified squamous variety (see EPITHELIUM) and is reflected onto the gums.

The gums consist of mucous membrane connected by thick fibrous tissue to the membrane surrounding the bones of the jaws. Round the base of the crown of each tooth the gum membrane rises to a little collar. The gum tissues are rich in blood vessels, receiving branches from the alveolar arteries; these vessels also supply the teeth and the spongy bone of the upper and lower jaws, in which the teeth are, lodged. The veins and lymphatics correspond essentially to the arteries.

The roof of the mouth is concave transversely and anteroposteriorly, and is formed by the hard and soft palate. The hard palate consists of mucous membrane continuous with that of the gums and bound to the upper jaw and palate bones by firm fibrous tissue. In the midline is a slight ridge, the palatine raphe, which ends in front in the palatine papilla, marking the position of the anterior palatine canal, which carries an artery. From the anterior part of the raphe five or six transverse ridges or rugae of the mucous membrane run outward. (For a description of the soft palate see THROAT.)

The floor of the mouth can be seen only when the tongue is raised; then the reflection of the mucous membrane from the gums to it is exposed. In the midline is a prominent fold (frenulum linguae), and on each side of this a sublingual papilla, onto the summit of which the duct of the submaxillary gland opens. Running outward and backward from this is a ridge (plica sublingualis), which marks the upper edge of the sublingual salivary gland and onto which most of the ducts of that gland open.

For a description of the tongue, teeth and salivary glands, see separate articles.

Comparative Anatomy.—In the lancelets, the simplest vertebrates, the mouth is developed on the left side and gradually shifts to the midline; later an extra chamber, the oral hood, is formed in front of it, the external opening of which is provided with bristle-like cirri, so that in the adult the mouth is merely an aperture in the membrane that separates the oral hood from the pharynx.

In the lampreys and hagfishes the mouth is a sucking organ and resembles a funnel, the narrow end of which opens into the pharynx. It is always open and is provided with horny teeth and a tongue. At this low stage of the vertebrate scale no jaws appear. but in the larval lamprey (ammocoetes) an oral hood, resembling that of the lancelet, is present. In the fishes jaws are present and the mouth can be closed at will.

In the sharks and rays the opening is crescentic and situated well on the ventral surface of the head, but in other fishes it is at the anterior end of the body.

Until the mudfish is reached there is no communication between the mouth and the nose, but in these fishes the internal or posterior nares open into the front part of the roof of the mouth, thus adapting them to air breathing. In the Amphibia the mouth has usually an enormous gape, and the position of the posterior nares resembles that of the mudfish. At this stage of phylogeny the condition resembles that of the ontogeny of man before the palatal processes appear. The premaxillary part of the frontonasal process separates the nasal cavity from the mouth in front, but behind that the cavity is the rudiment of the mouth and nose, which no palate has yet appeared to separate. In reptiles the hard palate appears, and from this point upward in the scale the digestive and respiratory tracts form only one passage in the pharynx.

In mammals definite lips provided with muscles first appear, though the monotremes have such specialized mouths that lips are not found in that order. Many monkeys have the vestibule enlarged to form the cheek pouches.

Embryology. — The foregut (see GASTROINTESTINAL TRACT) at first ends blindly, ventral to the hindbrain; in front of it is the overhanging forebrain. When the heart develops, ventral to the foregut, it also projects forward toward the forebrain, so that a transverse cleft, without any lateral boundaries and lined by ectoderm. is left between these t o structures. This is the stomatodeum or primitive mouth, the ectoderm of which rests against the entoderm of the foregut to form the buccopharyngeal membrane, and so separates the two chambers. The position of this membrane does not correspond to the fauces or hinder limits of the adult mouth, but is much more oblique, so that the front part of the roof of the pharynx is formed by stomatodeum while the greater part of the floor of the permanent mouth is foregut. During the third week the membrane disappears, and no traces of it can be seen in the adult.

Growing down from the region of the forebrain is the frontonasal process, which forms the nose and the middle piece of the upper lip, while the lateral parts of the mouth are closed in by two processes, on each side of which the lower or mandibular process rapidly meets its fellow in the midline to form the lower jaw and lip, thus separating the heart from the mouth cavity. The upper or maxillary process grows inward more slowly, but at last joins with the frontonasal process, and in the adult the lines of union are seen on each side as ridges of skin that run down from the nostril to the margin of the lip and enclose that slightly depressed vertical gutter to which the term philtrum is given.

Besides forming the philtrum the frontonasal process is responsible for that part of the roof of the mouth bounded by lines drawn on each side from between the lateral incisor and canine teeth to the palatine papilla. At first the cavities of the mouth and nose are one, but they are later divided by the palatal processes, which grow in like shelves from the maxillary processes and meet in the midline.

Diseases. — Most of the conditions affecting the mouth and salivary glands are described under separate headings (see TONGUE, DISEASES OF; DENTISTRY and articles on the separate dental specialties; CALCULUS (IN MEDICINE); DIPHTHERIA; PHARYNGITIS; TONSILLITIS; MUMPS; ACTINOMYCOSIS), while as constituting the beginning of the respiratory and gastrointestinal systems the mouth shares in some degree in the affections of these systems, as well as in general diseases (see SCARLET FEVER; MEASLES AND GERMAN MEASLES; SCURVY; VENEREAL DISEASES; TUBERCULOSIS). A few other aspects of the subject remain to be considered.

Relaxed or Unduly Long Uvula. — Either because of its inordinate length or because it shares in a general pharyngitis, the uvula may touch and irritate the back of the tongue, leading to irritable cough or repeated attempts at clearing the throat. Usually an astringent gargle is sufficient treatment; formerly a portion of the uvula was burned with caustic or snipped off with scissors, but this procedure is undesirable since removal of too much leads

to regurgitation of food or drink through the nose in swallowing, from failure of complete coaptation of the uvula and anterior pillars of the fauces.

Ranula.—This is a cystic tumour in the floor of the mouth filled with clear fluid; it results from accumulation of saliva in the duct of the salivary gland behind an impacted salivary calculus.

"Phossy Jaw."—This condition disappeared after the manufacture of matches with red phosphorus superseded use of the amorphous variety. Formerly it was common due to the fact that the fumes attacked the jaws of workers in the region of carious teeth; extensive necrosis of the bones of the jaw and falling out of teeth, followed by severe constitutional disease, often resulted, and death was not uncommon.

Macvoglossia and *Macrocheilia.*—These are rare conditions in which the tongue and lips respectively are enormously enlarged from blockage of their main lymphatic channels. The condition is therefore akin to elephantiasis (*q.v.*). The tongue may be so large that it protrudes from the mouth for several inches.

Cleft Palate and Harelip.—Persistence of a congenital fissure in the roof of the mouth (cleft palate) is sometimes associated with a similar rift in the upper lip (harelip). Such a labial cleft may be single, or there may be one on either side of the median line. They are the result of arrest in normal development—a failure in union of the nasal and maxillary processes of the embryonic face. These deforming anomalies, in their many variations, can be dependably corrected by surgery. (See SPEECH DISORDERS.)

Double Lip.—.This type of congenital deformity is uncommon, rarer in the upper lip than in the lower. The malformation consists of a paramedian sulcus or pit, situated just within the vermillion border of the lip. Double lip is corrected surgically by excision of the prolapsed area of mucous membrane and joining of the edges of the incision.

For the functions of the mouth in mastication, salivation and swallowing, see DIGESTION. See also articles on SALIVARY GLANDS; TEETH; THROAT; TONGUE.

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MOUTH ORGAN: see HARMONICA.

MOVIES: see MOTION PICTURES.

MOVIMAN, a tribe or small group of tribes of South American Indians, constituting an independent linguistic stock. The Moviman live in northeastern Bolivia, on the Yacuma river, a western tributary of the Mamore, in S. lat. 14°. They are a tall people, speaking a very harsh and disagreeable language. Their culture was much like that of the Moxos tribe, who were their neighbours on the south.

See A. D'Orbigny, *L'Homme Américain* (1839).

MOWATT, ANNA CORA (1819–1870), U.S. playwright, novelist and actress, whose many contributions to literature and the theatre made her one of the outstanding figures of the 19th century, was born in Bordeaux, France, the daughter of a New York merchant, Samuel Ogden, on March j, 1819. A precocious child. she acted at the age of five, and had read all of Shakespeare's plays before she was ten. Her early marriage at 15 to James Mowatt, a New York lawyer who doted on her, gave her ample opportunity to continue dabbling in the arts.

In 1841. after her husband lost his wealth, she turned to performing and writing in earnest, giving poetry readings and writing articles for the popular magazines. In 1845, at the suggestion of Epes Sargent, she wrote Fashion, the play with which she has since been associated. A devastating social satire, Fashzon brilliantly expressed the growing feeling in the United States against emulation of European manners. In June 1845 Mrs. Mowatt made a successful debut as an actress and entered another phase of her many-sided career.

In addition to Faslzion, she wrote the plays *Gulzara* (1840) and *Armand* (1847) and, in 1854. her Autobiography. James Mowatt having died in 1851, she married William F. Ritchie in 1854 and retired from the stage. She died in London, July 28. 1870.

(S. W. H.)

MOWBRAY, the name of an English baronial family, derived from Montbray near St. Lo in Normandy. It was founded by Geoffrey de Montbray, bishop of Coutances (1049–93), a great feudal prelate who was as much statesman as churchman. Orderic Vitalis, the chronicler, remarked that he knew more about marshaling mailed knights than edifying psalm-singing clerks, although, in fact, his early career was devoted to the reorganization of his diocese and the rebuilding of his cathedral. After 1066 his life was spent mainly in England as a principal adviser of William the Conqueror, whom he served as soldier, administrator and judge. His reward was a great fief of about 280 manors in 12 counties, which passed after his death to his nephew (his brother Roger's son) Robert de Mowbray, earl of Northumberland. Both Geoffrey and Robert rebelled against William II in 1088, and when Robert again rebelled in 1095 he was imprisoned for life and forfeited his estates. Only a part of his Norman lands passed to the founder of the second house of Mowbray, Nigel d'Aubigny, who was also a kinsman of Bishop Geoffrey and had married Maud, Robert's widow. His loyalty to Henry I brought Nigel rich rewards: to his midland estates he added the forfeited lands of the Stutevilles in north Yorkshire and the Isle of Axholme in Lincolnshire. Nigel's son Roger (d. 1188), who took the name of Mowbray, was a leader of the rebellion of 1174–75 against Henry II, his northern castles of Thirsk and Kirkby Malzeard being destroyed when the revolt failed. But he is best remembered as a munificent patron of north-country monasticism. A founder of Newburgh priory, he was also a generous benefactor of the monks of Fountains, Byland and Rievaulx abbeys, and of the Knights Templar. His piety found further expression in the crusading movement. He went to the Holy Land with the second crusade in 1147 and returned there in 1187, when he was captured by Saladin at the battle of Hattin and died soon after his release. His 50n Nigel was to die there also. at the siege of Acre in 1191.

His grandson William (d. 1224) was one of the 25 barons appointed to enforce Magna Carta, but the Mowbrays played little part in 13th-century politics. Roger (d. 1297) was summoned to parliament as a baron by Edward I. John, his son, added to the family fortunes by his marriage to Aline de Braose, heiress of Gower (*q.v.*) in south Wales and Bramber in Sussex. Alarmed by the ambition of the Despensers, he joined the opposition to Edward II in 1321 and was hanged at York in 1322 after the rebels' defeat. The marriage of John, 4th Lord Mowbray, brought immense accessions of territorial power; his wife Elizabeth was heiress of the Segraves, and of her grandfather, Thomas of Brotherton, earl of Norfolk, whose half-brother Edward II had settled on him the great East Anglian estates of the Bigod family. The elevation of their son Thomas (d. 1399) to the dignities of earl of Nottingham, earl marshal and duke of Norfolk was an indication that the Mowbrays now ranked among the greatest magnates in the realm. Their influence was temporarily eclipsed by the banishment of Thomas (1398) and the loss of his ducal title; and by the treason of his young son Thomas, earl marshal, whose share in the rising of Archbishop Scrope brought about his summary execution at York in 1405 and the forfeiture of his estates. The loyalty of Thomas' brother John (d. 1432), who served Henry V well in France, enabled him to recover the family fortunes and he was restored to the dukedom in 1425.

John Mowbray, 3rd duke (d. 1461), proved a somewhat lukewarm Yorkist, but his son John, 4th duke. was one of the chief supporters of Edward IV. The male line of the Mowbrays became extinct when John died in 1476. His infant daughter Anne, who was married to Edward IV's second son Richard, duke of York, survived only until 1481. The titles and estates of the Mowbrays then passed to the Howards, who were descended from a sister of the 1st duke (see NORFOLK, EARLS AND DUKES OF).

See J H. Le Patourel, "Geoffrey of Montbray, Bishop of Coutances," *English Historical Review,* vol lix (1944). (C. D. R.)

MOWBRAY, H(ENRY) SIDDONS (1858–1928), U.S. mural painter, was born of English parents at Alexandria, Egy.,

Aug. 5, 1858. Orphaned in infancy, he was raised by an uncle in Titusville. Pa., and North Adams, Mass. After a year at the United States Military academy, West Point, N.Y., Mowbray went to Paris in 1878 in order to study painting under Léon Bonnat.

Settling in New York in 1886, he turned to mural painting about 1890, and did especially notable work for the Morgan library and the University club. New York city. He was director of the American Academy in Rome in 1903–04 and later a member of the National Fine Arts commission.

He died on Jan. 13, 1928. (D. H. W.)

MOWINCKEL, JOHAN LUDWIG (1870–1943), Norwegian statesman, shipowner and philanthropist, entered public service as mayor of his native town. Bergen. In 1906 he became member of parliament (storting) for the Liberal party. and president in 1916. Most of the time between World War I and 1935 he was prime minister and minister of foreign affairs.

In 1911 he was instrumental in founding the Norwegian-America line. and in 1925 he became a member of the Nobel Peace Prize committee.

Mowinckel took the initiative for the Oslo convention in 1930 to encourage free trade between the Benelux and Nordic countries, thus anticipating postwar efforts toward European union.

He also took an active interest in the League of Nations, serving on the council and becoming president in 1933. He condemned the menace of Nazi philosophy, and when Germany overran Norway in 1940 he escaped with the government in exile. He died Sept. 30, 1943, in New York city, where he was representing his country.

He was considered to be the outstanding statesman of his time in Norway. (J. A. ML.)

MOXA: see ACUPUNCTURE.

MOZAMBIQUE, a town of Mozambique, in 15° 4′ S., 40° 11′ E.. situated on a small coral island (3 mi. from the coast) at the mouth of the Mossuril bay. In 1950 it had a pop. of 12.109, of which about 500 were Europeans. The town is an important commercial centre in the Nyasa province and has good harbour facilities with a solidly built mole (depth over the bar, 28 ft.). Lumbo, on the mainland (5 mi. S. of the town), is the terminal of a railway.

Drawing on the hinterland, Mozambique exports large quantities of maize, cotton? sisal, peanuts, coffee and wax. After 1934 mica was exported.

Mozambique, like most East African towns, was originally an Arab settlement. After Vasco da Gama discovered it in 1498. the Portuguese settled there in 1508 and erected the St. Sebastian fort, built of granite quoins brought from Portugal. Until 1897 it was the capital of Portuguese East Africa but declined in influence after the development of Beira and Lourenço Marques. Throughout the centuries the town has changed very little, many of the solid houses with barred windows and heavily bolted doors, as well as the paved streets! having been built during the 16th century. Its forts, churches, monasteries and the old palace of the governor give the town an attractive appearance. Although small in size. Mozambique is cosmopolitan and oriental in population; Europeans, Indians and Arabs mix with the Makwa natives; there are many Moslems.

In the rainy season (November to March) malaria is prevalent. The average temperature varies between 83° F. in December and 73° F. in July; rainfall is about 40 in. annually. (See PORTUGUESE EAST AFRICA.) (H. A. WF.)

MOZARAB, a general term for persons not Arab by birth who have assimilated themselves to the Arabs (Spanish *Mozárabe,* a corruption of the Arabic *Musta'rib,* coll. *Musta* riba). It was applied. by the Moslems in Spain to the Christian communities existing among them, in Cordova, Seville, Toledo and other large cities. The ancient liturgy used by the Christians of Toledo is commonly known as Llozarabic.

MOZART, WOLFGANG AMADEUS (1756–1791), Austrian composer, was born at Salzburg on Jan. 27, 1756. (In the baptismal register his name stands Joannes Chrysostomus Wolfgangus Theophilus [Lat. Amadeus, Ger. Gottlieb].)

He was educated by his father, Leopold Mozart, a composer with a high reputation as a violinist in the service of the archbishop of Salzburg. When only three years old he shared the harpsichord lessons of his sister Maria ("Nannerl"), five years his senior. A year later he played minuets and composed little pieces, some of which are still preserved.

In 1762 Leopold Mozart took "Wolferl" and Nannerl on a musical tour, during the course of which they played before most of the sovereigns of Germany. The little Wolferl remained unspoiled by all the petting he received from royalty. At Vienna the emperor. Francis I, sat by his side while he played and called him his "little magician." When he slipped one day on the polished floor the archduchess Marie Antoinette, afterward queen of France, lifted him up, whereupon he said, "You are very kind; when I grow up I will marry you."

Childhood and Youth. — In 1763 the whole family started on another tour. Wolferl now sang, composed and played on the harpsichord, the organ and the violin, winning golden opinions everywhere, but not enough money for more than bare necessities after the irreducible expenses of travel. In Paris they lodged at the Bavarian embassy. performing on a grand scale both there and at Versailles, where Wolferl's organ playing was especially admired. Here also he published two sets of sonatas for the harpsichord and violin, having already composed several smaller pieces. In April 1764 Leopold Mozart took his family to England, where Wolferl astonished the royal family with his playing at sight and accompanied the queen in a song. He composed a symphony, published a third set of sonatas, dedicated to the queen, and wrote a tiny anthem (Spruch) for four voices, God is Our Refuge, for presentation to the British museum. (The autograph is numbered "Select Case C, 21 d.") Barrington contributed to the Philosophical Transactions for 1780 a paper on Mozart's prodigious talent as shown during his visit to London at eight years of age. In Sept. 1765 the family left England for The Hague, where, in March 1766, Wolferl made his first attempt at an oratorio, astonishing the Dutch as he had astonished the English and playing with great effect, at Haarlem, on the largest organ in the world. In Sept. 1767 he paid a second visit to Vienna, and at the suggestion of the emperor, Joseph II, composed an opera *buffa,* La *finta* semplice, which, though acknowledged by the company for which it was written to be "an incomparable work," was suppressed by an intrigue. The archbishop of Salzburg thereupon commanded a representation of it in his palace and gave Wolferl an honorary appointment as maestro di cappella. Since this did not involve residence, Leopold Mozart took his son to Italy, in Dec. 1769, as the proper measure to complete a musician's education.

Wolfgang, now nearly 14 years old, received at Milan a commission to write an opera for the following Christmas. Arriving in Rome on the Wednesday in Holy Week, he went at once to the Sistine chapel to hear Allegri's famous Miserere, which afterward he wrote down from memory, to the consternation of all who heard of the feat; for the composition was guarded as a mystery, and the singers were forbidden to transcribe it on pain of excommunication. Toward the end of June the pope made him a cavaliere of the order of the Golden Spur, an honour which had some years previously been conferred on Gluck. Mozart prized it the more on that account. but soon gave up signing himself with the title, whereas the chevalier Gluck insisted on it to the end of his life. In July the Accademia Filarmonica of Bologna gave Mozart the degree of cornpositore in spite of a statute restricting this title to persons at least 20 years oi age. His degree exercise in strict counterpoint on the antiphon, Quaerite *primum,* is extant (Kochel's catalogue. No. 86). His friendship with the learned padre G. B. Martini (*q.v.*) was delightful to the boy and the sage. and it foreshadowed for Wolfgang what was afterward to come to him from another spiritual father, "Papa" Haydn. On Dec. 26 Wolfgang's new opera, Mitridate Re di Ponto, was triumphantly produced under his direction at Milan after a nerve-racking struggle with hostile intrigues. Mozart had been baulked of his hope to be allowed to set an opera by Metastasio; but the poetaster from Turin did his best; and the first rehearsal

settled all doubt as to the capacity of a German child of 14 to write an Italian opera and to control the orchestra of La Scala, the largest in Europe. The piece had a continuous run of 20 nights, a record for those times; and it established the boy as a master needing no apologies.

After this triumph, and after a concert-tour through many Italian cities, Wolfgang returned with his father to Salzburg, in March 1771, with large commissions for a dramatic serenata for the approaching marriage of the archduke Ferdinand, and an opera for La Scala, to be performed in 1773. The wedding took place at Milan on Oct. 21, and the serenata, *Ascanio* in *Alba*, was produced with an effect which eclipsed Hasse's new opera, *Ruggiero*, composed for the same occasion. The good Hasse prophesied: "This boy will cause us all to be forgotten." During the absence of Wolfgang and his father the good archbishop of Salzburg died; and in 1772 a successor was elected for whom nobody but the electors had a good word then or since. For his installation Wolfgang composed an opera, *Il Sogno di Scipione*, but the new prelate's interests were not intellectual; and before five years were past he made Salzburg a miserable place for musicians. The new opera for Milan, *Lucio Silla*, was produced at La Scala at Christmas, with a success equal to that of *Mitridate*, and it had a still longer run. Wolfgang was developing rapidly and beginning to create styles and forms that changed the nature of music. His opera buffa, *La Finta giardiniera*, produced Jan. 13, 1775, at Munich, tackles the action of an absurdly complicated play with unmistakable foreshadowings of the technique of *Figaro*. In March he set Metastasio's dramatic cantata, *Il re pastore*. Concertos, masses, symphonies and sonatas poured forth with a steady increase of power and resource. The *Missa brevis* in *F* (*see* MASS) is the last word in Neapolitan Church music, and the style of the symphonies and string-quartets of these years is full of wit and of terse formal devices. But these achievements did not earn money, and in 1777 Leopold Mozart asked the archbishop for leave of absence for a concert tour. The archbishop disapproved of "that system of begging." Wolfgang thereupon resigned his honorary appointment after furious protests from the archbishop; and on Sept. 23 started with his mother for Munich.

Manhood.—The results were not encouraging. Leopold discovered with surprise that a young musician of 21 could not make as much impression in palaces as an infant prodigy. Moreover, at Mannheim, where Stamitz (*q.v.*) had created a new standard of playing, Wolfgang not only imitated the Mannheim musicians but fell in love with Aloysia Weber, the daughter of the poorly paid prompter of the theatre. (Carl Maria von Weber, born 11 years later, was her cousin.) Leopold, dreading an improvident marriage, ordered his wife and son to start instantly for Paris, where they arrived on March 23, 1778. But in spite of the success of his Paris symphony (with its diplomatic initial *coup d'archet* and the unexpected pianissimo opening of the finale, which evoked an interruption of several minutes for applause), he found himself neglected by the aristocracy; and his mother fell seriously ill and died on July 3. After this catastrophe he left Paris in September and found Aloysia Weber cruelly changed towards him when he stopped at Mannheim. In June 1779 he returned to Salzburg and succeeded in inducing the archbishop to attach a salary of 500 florins to his "concertmeister's" appointment, with leave of absence in case he should be asked to write an opera elsewhere.

Two years later he was engaged to compose an opera for Munich for the carnival of 1781. The libretto was furnished by the abbate Varesco, the archbishop's court chaplain. On Jan. 29, 1781, the work was produced under the title of *Idomeneo, re di Creta* and made a great impression. It reveals Mozart's full powers of orchestration, vocal and choral style, accompanied recitative and nobly pathetic melody. In these respects it was incontestably the finest opera that had ever yet been placed upon the stage. Dramatically, it is not mature. Mozart, though profoundly influenced by Gluck in the accompanied recitative of the oracle-scene in the temple of Neptune, could as yet resist the temptations neither of coloratura singing nor of symmetrical form. And he had not yet learnt the art (and duty) of bullying his librettist. And now the archbishop realized that Mozart was an adornment to his servant's hall. On hearing of the success of *Idomeneo* he instantly summoned the composer to Vienna, where he was spending the season. Mozart soon found his position intolerable. Musicians of his standing were already becoming restive at being made to dine with flunkeys, but the archbishop's flunkeys copied their master's insolence. Mozart's salary was reduced from 500 to 400 florins, he had to pay his own travelling expenses, and he was forbidden to give concerts on his own account or to play anywhere but the archiepiscopal palace. Archbishop Hieronymus found himself omitted from the list of the emperor's summer guests and he quitted Vienna in disgust, sending his household to Salzburg, but leaving Mozart to find lodgings at his own expense. Thereupon Mozart resigned. The archbishop's language thereat was unprintable, but Mozart remained in Vienna in a house rented by his old friends, the Webers, vainly hoping for pupils in the dead season. One good thing we owe to the archbishop. Michael Haydn was also in his service and had been commissioned by him to write six duets for violin and viola. He fell ill after writing four and the archbishop refused to pay him unless all six were forthcoming. Mozart came to the rescue with two duets in his richest style; and Michael Haydn sent them in with his own. The archbishop showed no suspicion.

The emperor protected Mozart and commissioned him to write a German opera, *Die Entfiihrung aus dem Serail*, which, on July 16, 1782, had great success in Vienna and afterwards at Prague. This great work was the first imperishable monument of the German *Singspiel* (or opera with spoken dialogues) as *Idorneneo* was the last living monument of the old Italian *opera seria*. Mozart had now mastered the art of bullying his librettist, whose chief characters he idealized to heroic proportions, while he himself exercised an extraordinary facility of comic rhyme and created the gigantic *buffo* character of Osmin.

On Aug. 16 Mozart married Constanze, the younger sister of Aloysia Weber, and the namesake of the heraine of *Die Entfiihrung*. Much sour wisdom has been poured forth on this improvident marriage by biographers, who, accepting uncritically Mozart's steadfast creed of "Next after God, papa," are shocked by the fact that Constanze was not a good manager, and are disposed to see serious infidelity, in the freedom of Mozart's manners with singers and actresses.

From the day of his marriage to that of his death Mozart was always in difficulties for lack of money. The happiness of Mozart's most private affairs is revealed to us by the exquisite quality of the works which he wrote especially for his wife; but of course these were the only works he could afford to leave unfinished! Life in the Mozart home could never have been comfortable, nor could its irregular hours have been good for children, such as Mozart's own, and his pupil, J. N. Hummel, who lived in his home, and who used sometimes to be roused at midnight to sing or play his master's latest piece while Frau Mozart gave him a glass of wine. But his children were devoted to his memory; and his widow afterwards married one Nissen, who spent untold efforts in collecting material for his biography and for a catalogue and canon of his works.

The court and nobility were kind, though not munificent, and Mozart had many friends. "Papa Haydn" told Papa Mozart that Wolfgang was the greatest musician he had ever seen or heard of; and that all the crowned heads of Europe would compete for his services if they could only be made to see his worth. But he had enemies also. His ability was terrifying ana he was naively unconscious of the devastating sharpness of his criticisms. Salieri hated him, and laid up terrible odium for himself after Mozart's death, by having openly shown his dislike and baulking Mazart of a good appointment. Rumour accused him even of poisoning Mozart, and the slander is perpetuated in Rimsky-Korsakov's opera, *Mozart and Salieri*. Let us set against this the affection Beethoven and Schubert had for the poor old man, who sent for Moscheles in 1825 to make a death-bed statement in these words: "I did not poison Mozart."

Closing Years.---On Feb. 7, 1786, Mozart produced at Schönbrunn an exquisite little *Singspiel* in one act, *Der Schauspieldirektor*, and in less than three months followed it by *Le Nozze di*

Figaro. The emperor was afraid of Beaumarchais' subversive satire, but Mozart was able to assure his majesty that the abbé Da Ponte had made the libretto quite harmless. After an enthusiastic reception of *Figaro*, Mozart's enemies succeeded in so far spoiling his success that he declared he would never produce an opera in Vienna again. Fortunately, *Figaro*, like *Die Entfuhrung*, was repeated with brilliant success at Prague, and Mozart there received a commission to write an opera for the next season, with a fee of 100 ducats. Da Ponte furnished a libretto, founded, not on Molière's *Festin de pierre*, but directly on Tirso de Molina's *Burlador de Sevilla* and entitled *Il Don Giovanni*. By Oct. 28, 1787, the whole was ready, except the overture, not a note of which was written. Yet the overture is the most elaborate Mozart had yet composed, and it was all written the night before the performance, while his wife kept him awake with coffee and amusing tales as he tossed page after page of the score to the copyists. The opera was produced on Oct. 29 with extraordinary effect, and the overture, though played without rehearsal, was as successful as the rest of the music. Michael Kelly, in his *Reminiscences*, has left a delightful account of the circumstances. Yet, when reproduced in Vienna, *Don Giovanni* was soon withdrawn in favour of Salieri's *Tarare*.

On returning to Vienna Mozart was appointed kammercompositor to the emperor, with a salary of 800 gulden. In April 1789 he accompanied Prince Lichnowski to Berlin, where King Frederick William II. offered him the post of kapellmeister; with a salary of 3,000 thalers (£450). Though most unwilling to quit the emperor's service, he informed him of the offer. "Are you going to desert me, then?" asked the emperor; and the goodnatured Mozart remained, to starve. The emperor now commissioned Mozart to compose another Italian opera, which was produced on Jan. 26, 1790, under the title of *Cosi fan tutte*. The libretto, by Da Ponte, was designed to give Mozart unlimited opportunities for mock heroics. The public seem to have seen the point of Mozart's delicious three hours of parody, but the run of the opera was stopped by the emperor's death on Feb. 20. The well-meaning 19th century took *Così fan tutte* on a solemn estimate of the probability of its plot, and it did not come again into its rights until Richard Strauss produced it properly at Munich and inaugurated our better understanding of Mozart's irony.

In March, Schikaneder, the manager of a small suburban theatre, approached Mozart with a project for a fairy opera addressed cryptically to Freemasons, who were frowned upon by the empress, Marie Thérèse, and the Church, but of whose brotherhood Mozart was an enthusiastic member. As in the case of *Die Entfuhring*, he soon whirled Schikaneder off his feet and raised the fairy tale to sublime heights.

While he was working at *Die Zauberflöte* a stranger called on him, requesting him to compose a *Requiem* and offering to pay for it in advance. The stranger's behaviour was so mysterious that Mozart, who was already out of health, came to take him for a supernatural messenger of death. Meanwhile he received a commission to compose an opera, *La Clemenza di Tito*, for the coronation of the new emperor, Leopold II. at Prague. He carried out this work piece-meal, night and day, in travelling coaches and during rehearsals. The coronation took place on Sept. 6; the new empress called the opera "another German piggishness," but Metastasio's worst libretto had received better music than it deserved; and this was the swan song of opera seria. *Die Zauberflöte* was produced on Sept. 30 and had a splendid run. But the *Requiem* still remained unfinished; the stranger therefore made another appointment, paying a further sum in advance. Mozart put his greatest music into it, and became more and more convinced that he was writing it for his own death. When the stranger called the third time the composer was dead, and his terrified widow had induced Siissmayer to finish the score in an imitation of Mozart's handwriting. Sussmayer surely must have known how Mozart intended to carry out the *Lacrymosa*, of which he had only written seven bars. The rest of Siissmayer's work does him extraordinary credit. The mysterious messenger was afterwards found to be an emissary of a Count Walsegg, who wished to perform Mozart's *Requiem* as his own.

Mozart died Dec. 5, 1791, apparently from typhoid (which in Germany is called typhus) though he himself believed that he had been poisoned Constanze broke down, and when she recovered and visited the churchyard his grave could not be identified.

Works.--The first period in Mozart's development must be taken seriously as beginning at the age of five and merging into the second somewhere about the age of 16 or 17. It was fortunate that the infancy of the sonata-forms (*q.v.*) coincided with the infancy of Mozart; for in no earlier or later epoch could his juvenile work have had so normal a relation to the musical world at large. The little pieces composed by Mozart in his fifth and sixth years show an unswerving progress in which every step is represented, and the same mistake is never made twice, nor is a form once mastered ever repeated mechanically. The violin sonatas, written in London and Paris at the age of seven, are full of inventiveness, and technically as competent as most contemporary works. Mozart's studies in strict counterpoint gave him the greatest mastery of choral music attained since Handel, and more than one movement of Church music, written before he was 15, deserves to take rank as a true masterpiece. There was a loss of freshness at the age of 15, especially in the numerous operas; but by this time the machine could run without effort, and the depths of the adolescent mind could mature in peace while the hand was reeling off coloratura arias. *Lucio Silla* is almost evenly divided between such automatic stuff and evidences that the boy of 17 was developing the cogency of a man. Some of its recitatives and choruses strike a solemn dramatic note hitherto undreamt of in stage music, except by Gluck. *La Finta giardiniera* contains Mozart's first concerted opera-finale and marks the beginning of his dramatic vitality, just as the masses in F and D, written in the same year, mark the close of his first period as a composer of Church music. But we must beware of trying to assign periods according to art-forms; for in every year of his life Mozart practised all art-forms at once; and his mastery depends neither on method nor on inspiration. Some early violin sonatas assigned by Kochel to his 13th year really belong (as Wyzlewa and Saint Foix have shown) to his adolescence, and are full of the romantic pathos of C. P. E. Bach and J. Schobert.

Idomeneo *and* Die **Entführung.**—*Idomeneo* is the only opera of Mozart in a form which could show the influence of Gluck. Its wonderful choruses and its mature orchestration and profound counterpoint are as far beyond Gluck's range as its formalities and hampered action are repugnant to Gluck's dramatic reforms. The problems of comic opera were far more suggestive to Mozart. In *Die Entführung* his exuberant music still needed (and to a slight extent received) pruning, but his dramatic genius, as shown in the part of Osmin, began to run away with his music instead of his music running away with the action. And his power of musical characterization was genuine, and not dependent on tagging each person with a mannerism. After *Die Entfuhrung*, Mozart's record is a series of masterpieces, accompanied, but not interrupted by a running commentary of popular trifles, which often served him as studies. Almost every composition solves an art-problem, sometimes with the queerest materials. The répertoire of the modern organist contains, since Bach, no grander piece than the two fantasias which Mozart wrote for the barrel of a musical clock. Shortly before his death he wrote a beautiful adagio and rondo for the glass harmonica, in combination with flute, oboe, viola and violoncello, a perfect scheme which nobody else could have imagined. He wrote some effective processional music for two flutes, five trumpets and four drums; a beautiful adagio for two clarinets and three basset-horns (practically five clarinets), and a nice little sonata for bassoon and violoncello. His work in the larger instrumental forms is further discussed in the article SONATA FORMS.

Le **Nozze** di **Figaro.**—Mozart's later operas, from *Figaro* onwards, represent the nearest approach to a perfect art-form attainable in pre-Wagnerian opera. We cannot guess what he might have attained in serious opera had he lived to see the solemn triumphs of the French operatic stage in the austere sincerity of Cherubini and Méhul. We cannot doubt that he would have taught Beethoven to bully his librettist betimes, and that *Fidelio*

would not have stood in perilous and lonely splendour as an opera with a serious plot. But Mozart knew serious opera only as an Italian art form, which Gluck himself could not permanently rescue from the tyranny of singers. After *Idomeneo* he handled it only perfunctorily in La *Clemenza* di *Tito*. Comedy gave him full scope, and in Figaro he had the advantage of a libretto which was already a famous product of consummate stagecraft before it ever became an opera. Its absurdly complex intrigues do not worry the spectator, for no one attempts to follow them; but they keep every person on the stage in a state of excitement which is so idealized by the music that, while Beaumarchais' *Mariage* de Figaro has its place in literature, Mozart's Figaro is one of the greatest classics in all music. The subject is a social satire; but Mozart lives in Cloud-cuckoo-land. His characters are as irresponsible as fairies. Theirs is the world described by Lamb—the Utopia of gallantry, where pleasure is duty and the manners perfect freedom. The countess, however, is human. Producers destroy the purposes of Beaumarchais and of Mozart when they make her seem no longer young. It is only two or three years since she was Rosina in Le *Barbier* de *Séville;* the young Cherubino is in love with her; and the Count's intrigues have no excuse.

Don **Giovanni.**—In Don Giovanni Mozart rises, not only in the music of the ghostly statue, but also in that of Donna Anna and Donna Elvira, to heights that must be called sublime; the comedy of gallantry is in conflict with real human issues. Donna Anna's cadences are conventional when her grief has become a memory that stands between her and her lover; but at the first shock of her father's death her music is as tragic as Beethoven could have made it, cadences and all. Elvira, Don Giovanni's deserted wife, ought, like the Contessa in Figaro, to be represented as quite young. She enters in search of her vanished husband and sings Italian formulas which Wagnerian critics tell us are inadequate for the expression of her sorrows. Look at the *sforzando* in the second violins at the words Ah se *ritrovo l'empio.* Mozart is telling us that this inexperienced girl has not as yet come to any determination more serious than the wish to scratch Don Giovanni's eyes out. As soon as his character is revealed to her in Leporello's comic aria of the "catalogue," she determines that others at all events shall not suffer as she has suffered; and from that moment she becomes majestic. In the second act she weakens and Don Giovanni fools her to the top of her bent. Yet Mozart realizes better than Da Ponte a consistent development of her character. Her last confession of weakness, Mi tradi, was, like Non mi dir, inserted by Mozart afterwards. Both arias may be omitted; but at all events we need not make nonsense of Elvira's behaviour by putting Mi tradi into the first act as her second utterance, in immediate response to Leporello's catalogue aria! The final impression made by a well-conceived performance of *Don Giovanni* is of something grander than comedy. Da Ponte's stage directions should be respected; Don Giovanni should be carried off by little Italian pantomime devils, and the music should be allowed to rise undisturbed by the efforts of pantomime scenery to follow it. The beautiful final scene afterwards added by Mozart should be omitted, though with regret. Don Giovanni's indomitable courage should be that of a nobleman; and there should be no buffoonery in the comic figures of Leporello, Masetto and his fairylike Zerlina, whom Elvira snatches from the wicked hero's toils.

Die **Zauberflöte** and the Requiem. — In Cosi fan tutte, Da Ponte's wit and Mozart's irony were above the heads of musicians before Richard Strauss; but this work is now recognized as a subtle parody that constantly totters on the verge of reality. In Die *Zauberflöte* Mozart is in a masonic lodge of a degree higher than is known on earth. Though Mozart's head was in the heavens, his feet were very firmly planted on the stage, and he and Schikaneder understood each other perfectly and united to achieve something unique in opera; combining the gorgeousness of a pantomime with the solemnity of a ritual and the contemporary interest of a political satire.

From the solemnity of freemasonry there is but one step to that mosl pathetic of unfinished monuments, Mozart's *Requiem.* Its finished portions contain the most sublime Church music between Bach and the Missa *solemnis* of Beethoven. Süssmayer's completion is so well designed that even the slightness of his themes has the effect of a gesture of reverence and love. The return of the music of Te decet *hymnus* at the words Lux *aeterna,* which enables Sussmayer to end with ten pages of authentic Mozart is placed like a stroke of genius (though Mozart is reported to have contemplated an independent final number); while the latter part of the Lacrimosa, though not in Mozart's handwriting, must surely have been dictated by him. The instrumentation of Mozart's skeleton score is almost entirely ascertainable by the rules of his scheme; but that of the supplied numbers goes wrong at once. In the Requiem, as in some wonderful polyphonic designs before it, Mozart was forming a new style which might have transcended everything we know of him. Nevertheless, what he has left us is unique, and the intelligent love of Mozart's music is a liberal education in the meaning of art.

The Mozart Catalogue. — Mozart's extant works are catalogued by Kochel in 626 items, beginning with minuets written at the age of four and ending with the Requiem. In addition to these 626 there are many tantalizing fragments. Köchel's work was very necessary and, with corrections from the researches of Wyzlewa and Saint Foix, it remains necessary to-day, for no composer has had so many spurious works thrust upon him as Mozart.

The famous "Twelfth Mass" and four others in Novello's edition ought never to have deceived good musicians. They were the work of one Zulehner, whose avowed compositions remain unpublished in the archives of Schott at the present day. Nor are such deceptions unknown in the 20th century. A concertante for four wind instruments went round Europe in 1905 as a long-lost work written in Paris in 1778.

On the other hand, five little divertimenti for two clarinets and bassoon were, in 1911, found to be Mozart's nork in his ripest manner as soon as tno spurious and hideous horn-parts were removed. A seventh violin concerto appeared in Nov. 1907 and, though inferior to earlier ones, is exactly in keeping with Mozart's progress in 1777, its alleged date. (D. F. T.)

MTSKHET (Georgian *Mtskheta*), a town in the Georgian S.S.R. in 41° 54′ N., 44° 42′ E., 13 mi. N. of Tiflis with which it is linked by rail. It stands at the confluence of the Kura (Mtkvari) and Aragva (Aragvi) rivers and at the junction of the main routes from the Darial gorge through the Aragva valley and from the Caspian and Black seas through the Kura and Rion basins. Classical *Mestleta,* it was the capital of the Georgian kingdom of Iberia (Kartli) from about the 2nd to the 5th century, succeeding to the neighbouring acropolis of Armazi or Armaz-Tsikhe (Classical Harmozica, Harmastis or Armactica), which had been the capital from about the 4th century B.C.

Mtskhet, once the seat of the primates of Georgia, is chiefly famous for its cathedral of the Pillar (Sveti Tskhoveli), dating from the 4th century and renewed in the 15th and 18th century. Many kings of Georgia are buried there, including the last king, George XIII. (See GEORGIA.)

MU'ALLAQAT. Al-Mu'allaqat is the name given to a collection of seven pre-Islamic Arabic poems, each considered the finest piece of its author. Since the authors themselves are among the dozen or so most famous poets of the 6th century A.D., the collection enjoys a unique position in Arabic literature, as representing the finest flower of the earliest Arabic poetic production.

The idea of grouping together these particular poems is commonly attributed to the 8th-century collector of early poetry, Hammad al-Rawiyah (*q.v.*). The critic Nahhas (d. 949) says that, "When Hammad al-Rawiyah saw how little men cared for poetry, he collected these seven pieces, urged people to study them, and said to them, 'These are the renowned poems (*al-mashhurat*)'." No evidence has been produced to controvert this statement, and it is generally accepted as factual. Indeed, Theodor Noldeke suggests a further argument in favour of Hammad's responsibility for the collection; namely, that this would explain the inclusion of the poem by al-Harith ibn Hillizah, who is less famous than the other poets represented. The motive for this

would have been to please Hammad's patrons, the Arab tribe of Bakr ibn Wa'il, to whose glory al-Harith's poem is dedicated, and this would, according to Noldeke, have served as a counterpoise to the inclusion of the poem of 'Amr ibn Kulthum in praise of the Taghlib tribe, traditional rivals of the Bakr ibn Wa'il tribe.

Derivation of the Title.—Considerable obscurity surrounds the origin and implication of the name Mu'allaqat. According to a frequently repeated legend, which first makes its appearance in the *'Iqd* of Ibn 'Abd Rabbihi (d. 941), these poems were pieces selected for their excellence, written down in golden letters on scrolls of Egyptian linen, and hung on the walls of the Kaaba (shrine) in Mecca. This, however, can be dismissed as only a fable invented to explain the name on the basis of the everyday meaning of the word *mu'allaq* ("suspended").

Nahhas: Ibn 'Abd Rabbihi's contemporary, alludes to the legend of their being hung in the Kaaba only to reject it as a fabrication devoid of all ancient authority. And in fact, no mention of such a practice is made by any of the 8th- and 9th-century scholars who concerned themselves with the antiquities and early history of Mecca. The designation "the gilded poems" also mentioned by Ibn 'Abd Rabbihi must be taken in a purely metaphorical sense, of something splendid.

Another legend is also told by Nahhas, to the effect that the pre-Islamic kings of Arabia used to say, when they heard a specially fine poem, "Copy it down (*'alliquha*) and deposit it in my library." This too is certainly false. It is hardly possible that any pre-Islamic king can have possessed a library, and the verb *'allaq* in the sense of "copy, transcribe" is unlikely to have been in use before the age of intensive book production, which only began in the Islamic lands with the introduction of paper from the far east in the middle of the 8th century.

Several distinguished authorities (R. A. Nicholson, Noldeke, C. J. Lyall) have held the view that Mu'allaqat in this context is a derivative of the noun *'ilq,* "a precious thing," so that its meaning would be "the poems which are esteemed precious." Another theory has been propounded in an article by J. Robson (Journal *of* the Royal Asiatic Society [1936], pp. 83–86). He suggests that the word is an allusion to Koran iv, 128, where the word *al-mu'allaqah* is employed in connection with a wife who is neglected or deserted by her husband, without being actually divorced or widowed. Robson suggests that the point of the allusion is "to indicate that the poems are still attributed to their authors, but are not given their rightful position, which would be in the authors' collected works." If we could be sure that Hammad himself used the name *Mu'allaqat,* there would be an even more cogent point in the allusion than the one mentioned by Robson, for it would fit in neatly with Hammad's remark cited above about the undeserved neglect into which the best ancient poems had fallen.

It is, however, by no means certain that Hammad himself did use the name. If he did; it is odd that none of the scholars of the generation immediately following him mention it. They normally speak simply of "the seven poems," and the first occurrence of the name *Mu'allaqat* is in the *Jamharat ash'ar* ul-'Arab, a compilation dating probably from c. 900. It is an anthology of 49 poems, divided into seven groups of seven, and to each group a fanciful name is attached: *al-Mu'allaqat* (the first group) *al-Mujamharat* ("the amassed"), *al-Muntaqayat* ("the choice ones"), etc. And if the view that the real meaning of *al-Mu'allaqat* is "the poems esteemed precious," is correct, it is not impossible that the name was first coined by the compiler of the *Jamharah* in order to fit in with the plan of his work.

At all events! it was known in the early 10th century, since it is used by Ibn 'Abd Rabbihi. On the other hand, Nahhas (in the passage to which reference has been made above) does not employ the name *Mu'allaqat;* he speaks of the poems only as "the seven renowned ones." *al-sab' al-mashhurat,* in conformity with Hammad's reported remark. It could possibly be deduced from this that the name *Mu'allaqat* was at that time of recent origin and had not yet gained general currency.

Poems Included.—A further puzzle is connected with the precise poems included in the group. The list usually accepted as standard is the one recorded by Ibn 'Abd Rabbihi, namely: poems by Imru' al-Qays (*q.v.*), Tarafah (*q.v.*), Zuhayr (*q.v.*), Labid, Antarah (*q.v.*), 'Amr ibn Rulthum (*q.v.*) and al-Harith ibn Hillizah (*q.v.*). Yet the distinguished critic Ibn Qutaybah (*q.v.*) cites a poem by 'Abid ibn al-Abras with the remark that it is "one of the seven." And the *Jamharah* cites Abu 'Ubaydah (d. 82j) as saying that the greatest poets of the ancient period are Imru' al-Qays, Tarafah, Zuhayr, Labid, 'Amr, al-Nabighah (*q.v.*) and al-A'sha (*q.v.*) (with these last two names instead of Antarah and al-Harith of the ordinary list); and this remark is followed up by one ascribed to "al-Mufaddal," namely, "These are the authors of the seven long poems which the Arabs call al-Sumut ("the Pearl-Strings"), and anyone who says that the 'Seven Poems' are by anyone else than these goes against the consensus of scholarly opinion."

The reliability of the *Jamharah* has however been questioned specially by Nöldeke; and "al-Mufaddal" cited therein seems not to be the 8th-century critic but somebody less distinguished, for he is given a genealogy which suggests that he must have lived in the late 9th century. Nahhas, although he commented on nine poems, including those of al-Nabighah and al-A'sha as well as the commonly accepted *Mu'allaqat,* does so with the express warning that "according to the opinion of the best scholars the poems of al-Nabighah and al-A'sha are not among the 'Seven Renowned Ones'."

The simplest way out of this tangle is to conclude that in 8th-9th-century scholarly circles several rival lists of "seven poems" were in circulation: (1) the selection ascribed to Hammad, which at first is normally referred to as the "renowned ones" (*al-Mashhurat*), but which by the 10th century had come to be known as *al-Mu'allaqat;* (2) Abu 'Ubaydah's list, excluding Antarah and al-Harith and including al-Nabighah and al-A'sha, which went by the name of *al-Sumut;* (3) a list including 'Abid, with what others we do not know, favoured by Ibn Qutaybah.

Following the example of Nahhas, Tibrizi (d. 1109) wrote a commentary on the same nine poems as Nahhas, to which he added "by way of completeness" a commentary on the poem of 'Abid; but again with the cautionary note that the poems of al-Nabighah, al-A'sha and 'Abid were not among the recognized "seven odes." In spite of this, one or two modern editions have published the text of all ten poems under the title The Ten *Mu'allaqat,* a phrase for which there is no ancient authority.

Ibn Khaldun (d. 1406) mentions seven poets "from among the nine *Mu'allaqat* authors and others." "Kine" here may well be a scribal error! for seven and nine are very similar in Arabic script; but in any case he evidently did not intend to give a precise list of *Mu'allaqat* authors, since he includes Alqamah, who has never been reckoned as such.

Lives of the Authors.—Of the authors of the *Mu'allaqat,* the earliest is Imru' al-Qays, who seems to have lived in the early part of the 6th century. The others belong to the latter half of that century: and Zuhayr and Labid are said to have survived into the time of Islam, though their poetic output belongs to the pre-Islamic period. The critics and anthologists have handed down numerous anecdotes about their lives, and a summary of these accounts will be found in A. J. Arberry's The Seven Odes (see *Bibliography*). But all these tales contain at best only a small kernel of historical fact. The greater part is either folklore or simply the conjecture of later critics designed to explain passages in the actual poems.

Form and Content of the Poems.—The *Mu'allaqat* are all in the classical *qasidah* (ode) pattern. The characteristics of this verse-form (of about 60 to 100 lines) are that a single rhyme runs through the entire piece at the ends of the lines, and the same rhyme also occurs at the end of the first half of the first line; and that it begins with a short passage constituting a romantic prelude, called the *nasib*, in which the poet calls to mind the remembrance of a former ladylove. Imru' al-Qays is said to have been the first to use this device, and nearly all subsequent composers of formal odes copied him. In the *Mu'allaqah* of 'Amr, the conventional romantic passage is preceded by eight lines of a Bacchanalian nature; but many critics have concluded that this is an independent wine song and not part of the original *Mu'alla-*

qah.

After this conventional beginning, most of the rest of the poem is occupied with descriptive passages: similes and descriptions of the poet's horse or camel, of desert animals, scenes of desert events, bedouin life and warfare, etc. It is true, each poem has according to the critics a main theme, which is either self-glorification (of the poet or his tribe), or a panegyric on someone else. Yet the amount of space devoted in the *Mu'allaqat* to these themes in some cases is small in relation to the luxuriance of the descriptive passages. In the *Mu'allaqah* of Imru' al-Qays, only three lines in the middle of the poem of about 80 lines are devoted to self-glorification; the rest, apart from the *nasib,* is description. And it is in these descriptive passages that the chief glory of the *Mu'allaqat* rests; their vivid imagery, exact observation and deep feeling of intimacy with nature as it manifests itself in the Arabian desert, entitle the *Mu'allaqat* to be reckoned among the masterpieces of world literature. The lively description of a desert storm, with which the *Mu'allaqah* of Imru' al-Qays ends, is a splendid example.

To western taste the physiological exactitude of the descriptions of horse and camel may appear tedious and even repulsive but it was to the possession of camels (and to a lesser extent, the Arab horse) that the bedouin had owed their freedom from domination by the Byzantine and Sasanian empires; furthermore, the camel was the mainstay of their life, without which existence in the desert would have been impossible. Little wonder, therefore, that they felt a passionate, even romantic, interest in every detail connected with these animals.

Imru' al-Qays, the earliest of these poets, seems to have felt no need for closing his poem with any peroration, and it breaks off abruptly at the end of one of the descriptive passages. His successors apparently came to feel the need to round off the arbitrary succession of descriptive passages with something in the nature of an *envoi.* Thus the *Mu'allaqat* of Labid, Antarah, 'Amr and al-Harith end on the note of self-glorification, while those of Tarafah and Zuhayr conclude with lines of a gnomic and sententious character.

Little in the way of historical data can be gleaned from the actual text of the *Mu'allaqat.* The only one with a definite historical background is that of Zuhayr, which is a panegyric on two men of the Murrah clan who acted as peacemakers in a tribal war. Yet even here, it is the commentators who supply us with all the details of the affair. According to them, a quarrel over a horse-race led to bitter fighting between the nearly-related tribes of 'Abs and Dhubyan (knonn as the "war of Dahis," from the name of the race horse which occasioned the quarrel), until al-Harith ibn 'Awf and Harim ibn Sinan negotiated a truce by agreeing themselves to pay all the blood money involved; the truce was broken by an individual named Husayn ibn Damdam, and the two had to pay further blood money to restore peace. But the poem itself contains only the slightest and most allusive references to these events. Husayn ibn Damdam and Dhubyan are mentioned by name, but not the two peacemakers nor 'Abs; there is a description of the horrors of mar, praise addressed to two individuals who "laboured for peace," and a reference to blood money "paid in parcels successive by one who sinned not in the strife," and that is all. Yet although the *Mu'allaqat* are deficient in precise historical data, they give us a picture of bedouin life, manners and modes of thought which is of immense value and interest.

BIBLIOGRAPHY.—There are many editions of the text, but none fully critical. For a survey of the textual variants *see:* T. Koldeke, "Fünf Mo'allaqat hbersetzt und erklart," in *Sitzungsberichte der Kazserltchen Akademie der Wissenschaften in Wien; philosophisch-historische Classe,* vol. 140–144 (1899–1902); and B. Geiger in *Wiener Zeitschrift für die Kunde des Morgenlandes,* vol. 19 (1905). Eng. trans by A. J. Arberry, *The Seven Odes* (1957), with survey of European translations, summary of the poets' lives and discussion of the authenticity problem. On the meaning of the name *Mu'allaqat* see also *Bulletin des ktudes arabes* (Alger), vol 6 (1946). (A. F. L. B.)

MUBARRAD, AL- (nickname of ABU-L-'ABBAS MOHAMMED IBN YAZID AL-THUMALI AL-AZDI) (826–898), Arab philologist, remembered for his book *al-Kamil fi 'l-Adab* ("The Perfect in Literature"). He was born in Basra on March 25, 826, but moved to Baghdad, where he spent his life teaching, and competing with the Kufan scholar Tha'lab for the caliph's favour. He died in Baghdad in Oct. 898. His book is a formless work dealing with several subjects, but valuable as a storehouse of linguistic knowledge. It is a standard textbook in Arab countries. There is also an edition by W. Wright (1884–92).

See also *G.* Flügel, *Die grammatischen Schulen der Araber* (1862); C. Brockelmann, *Geschichte der arabischen Litteratur,* vol. i, p. 108 (1898), and suppl., vol. i, p. 168 (1937). (J. A. HD.)

MUCH WENLOCK: *see* WENLOCK.

MUCKRAKERS, an unorganized group of U.S. writers, identified with pre-World War I reform and the "literature of exposure." The name was given to them pejoratively, deriving from Pres. Theodore Roosevelt's speech of April 14, 1906, which, borrowing a passage from John Bunyan's *Pilgrim's Progress,* denounced "the Man with the Muckrake . . . who could look no way but downward." But "muckraker" also took on honourable connotations of social concern and courageous exposition.

The muckrakers' work grew out of the yellow journalism of the 1890s, which whetted the public appetite for news arrestingly presented, and popular magazines, established by such entrepreneurs as John Brisben Walker, Cyrus H. K. Curtis and especially S. S. McClure, Frank A. Munsey and Peter F. Collier. The emergence of muckraking was heralded in the Jan. 1903 issue of *McClure's Magazine* by articles on municipal government, labour and trusts, written by Lincoln Steffens, Ray Stannard Baker and Ida M. Tarbell.

The intense public interest aroused by articles critical of political and financial rings, housing, labour, insurance and other problems rallied writers, editors and reformers. Leader of the reform writers mas Charles Edward Russell, whose exposés ranged from *The Greatest Trust in the World* to *The Uprising of the Many,* the latter seeking to report methods being tried elsewhere in the world to extend democracy. Brand Whitlock wrote *The Turn of the Balance* (1907), a novel opposing capital punishment, and was also reform mayor of Toledo, O. Thomas W. Lawson, a Boston financier, in "Frenzied Finance" *(Everybody's,* 1904–05) provided the decade's major exposé of corporate irresponsibility. Eduin Markham's *Children in Bondage* was a major attack on child labour. Upton Sinclair's *The Jungle* and Samuel Hopkins Adams' *The Great American Fraud,* combined with the work of Harvey W. Wiley and Sen. Albert J. Beveridge, brought about passage of the Beef Inspection act and the Pure Food act. David Graham Phillips' series "The Treason of the Senate" *(Cosmopolitan,* 1906), which inspired President Roosevelt's remarks about "the Man with the Muckrake," was influential in leading to the passage of the 17th amendment to the constitution, providing for popular senatorial elections. Muckraking as a movement largely disappeared between 1910 and 1912.

See also biographies of various muckrakers; and Louis Filler, *Crusaders for American Liberalism* (1939). (L. FR.)

MUCUNA, a genus of twining plants, belonging to the family Leguminosae, and a native of the tropics. *M. pruriens* is popularly known as cowhage or cowitch, a corruption of the Hindu *Kiwach.* It is a tall annual climber with large dark purple pealike flowers, and golden-brown velvety pods, the hairs or bristles on which often raise blisters on the skin. It is common in the tropical regions of India, Africa and America, and the hairs on the pod have long been used in medicine as a vermifuge. An allied species, *Mucuna deeringiana,* is the Florida velvet bean. a fodder plant.

MUDEJAR, in architecture, the mixed style which was developed in Spain during the middle ages by the merging of Christian and Mohammedan traditions, especially applied to the style developed after the Christian conquest by Mohammedans working under Christian supervision.

The style affected particularly brickwork, tile work and carpentry, in the detail treatment of which Moorish forms and methods persisted long into the Renaissance. Good examples of the style are the tower of S. Andres at Calatayud (probably 15th century), the dome of Saragossa cathedral (c. 1412, modern form 1500–20), the chapter room at Tordesillas (c. 1363) and many elaborate wooden ceilings, known as *artesonados.*

MUDFISH, a name given to several very different fishes, in-

cluding the North American bowfin (*q.v.*) and the three living genera of lungfishes (*q.v.*).

MUD PUPPY, vernacular name for the American aquatic salamander (*q.v.*) *Necturus maculosus,* which, with the European *Proteus* forms the family Proteidae. See PROTEUS.

MUD RAIN occurs when a rainstorm and a dust storm combine. Falling raindrops always pick up some dust particles. But when an unusually large amount of dust is present, as with a dust storm, the drops actually become muddy and can deposit tons of dust per square mile over thousands of square miles of the earth's surface. Mud rains are far from rare and occur in many parts of the world, such as Europe, central United States, eastern China and Australia, but are probably most common in the lands surrounding the Mediterranean sea.

These rains need not occur in or even near the arid regions producing the dust storms, because large clouds of dust can be carried hundreds of miles by the winds aloft. For example, mud rains have occurred in England in association with dust storms originating in northern Africa. Mud rains have a wide variety of colours, depending upon the type of soil involved. Most common are the grays, yellows, browns and reds. The red rains at times have been brilliant enough to be called "blood rains." Other forms of precipitation also become involved with dust storms, although less frequently, resulting in coloured snow and coloured hail.

(L. A. Hs.)

MUELLER, PAUL HERMANN (1899–), Swiss chemist awarded the 1948 Nobel prize in medicine and physiology "for his discovery of the high efficacy of DDT as a contact poison against several arthropods." was born at Olten. Switz., on Jan. 12, 1899. After receiving his early education at Basle he worked for two years in the electrical and chemical laboratories of industrial firms, an experience which he considered to have been of the greatest value in his later work. In 1918 he resumed his academic studies and in 1925 obtained his doctorate at the university of Basle, taking chemistry as his major subject. In the same year he entered the tanning research laboratories of the J. R. Geigy company of Basle, where he worked principally on dyes and tanning agents. Among his early achievements was the invention of synthetic tanning substances. About 1935 Mueller began work on insecticides, and after fruitlessly testing hundreds of different substances synthesized dichlor-diphenyl-trichloroethane (DDT), a compound which seemed to possess practically all the properties required of the ideal insecticide. The substance was produced in Sept. 1939 but did not become commercially available until 1942.

DDT insecticides have been applied to many spheres of insect control, often nith spectacular results. It has been used with great success to control epidemics of typhus and other diseases conveyed by insects. The fact that certain insects appear to have developed resistance to DDT does not detract from the great importance of Mueller's work. His discovery yielded great practical results and stimulated further research. (W. J. Bp.)

MUFADDALIYAT, an anthology of ancient Arabic poems, which derives its name from al-Mufaddal ibn Mohammed ibn Ya'la, a member of the tribe of Dabbah, who compiled it some time between A D. 762 and 784. the year of his death. Al-Mufaddal was a contemporary of Hammad al-Rawiyah and Khalaf al-Ahmar, the famous collectors of ancient Arab poetry and tradition, and was somewhat younger than Abu'Amr ibn al-'Ala, the first scholar who systematically set himself to preserve the poetic literature of the Arabs. He died about 50 years before Abu 'Ubaydah and al-Asma'i (*q.v.*), to whose labours posterity is largely indebted for the arrangement, elucidation and criticism of ancient Arabic verse; and his anthology was put together between 50 and 60 years before the compilation by Abu Tammam of the *Hamasah* (*q.v*).

Al-Mufaddal was a careful and trustworthy collector of both texts and traditions, and is praised by all authorities on Arab history and literature as in this respect greatly the superior of Hammad and Khalaf, who are accused (especially the latter) of unscrupulous fabrication of poems in the style of the ancients. He was a native of Kufah, the more northerly of the two great military colonies founded in 638 by the caliph 'Omar. In Kufah and Basra were gathered representatives of all the Arab tribes who formed the fighting force of the Islamic empire, and from these al-Mufaddal was able to collect and record the compositions of the poets who had celebrated the fortunes and exploits of their forefathers. He, no doubt, like al-Asma'i and Abu 'Lbaydah, also himself visited the areas occupied by the tribes for their camping grounds in the neighbouring desert; and adjacent to Kufah was al-Hirah, the ancient capital of the Lakhmid kings, whose court was the most celebrated centre in pre-Islamic Arabia, where, in the century before the preaching of the Prophet, poets from the whole northern half of the peninsula were wont to assemble.

The date of al-Mufaddal's birth is unknown; but he lived for many years under the caliphs of the Umayyad line until their overthrow by the Abbasids in 750. In 762 he took part in the rising led by Ibrahim ibn 'Abdallah ibn al-Hasan, the 'Alid, called "The Pure Soul" against the caliph al-Mansur and after the defeat and death of Ibrahim mas imprisoned. Al-Nansur, however, pardoned him, and appointed him the instructor in literature of his son, afternard the caliph al-Mahdi. It mas for this prince that, at al-hfansur's instigation. al-Mufaddal compiled the Mufaddaliyat.

The collection, in its present form, contains 126 pieces of verse, long and short; that is the number included in the recension of al-Anbari, who had the text from Abu' lkrimah of Dabbah, who read it with Ibn al-A'rabi, the stepson and inheritor of the tradition of al-Mufaddal. We know from the *Fihrist* of Mohammed al-Nadim (A D. 988) that in his time 128 pieces mere counted in the book; and this number agrees with that contained in the Vienna manuscript, which gives an additional poem, besides those annotated by al-Anbari, to al-Muraqqish the Elder, and adds at the end a poem by al-Harith ibn Hillizah. The *Fihrist* states that some scholars included more and others fewer poems, uhile the order of the poems in the several recensions differed; but the correct text, the author says, is that handed down through Ibn al-A'rabi It is noticeable that this text. and the accompanying scholia, as represented by al-Anbari's recension, are wholly due to the scholars of Kufah. to which place al-Mufaddal himself belonged.

The collection is one of the highest importance as a record of the thought and poetic art of Arabia during the time immediately preceding the appearance of the Prophet. Not more than 5 or 6 of the 126 poems appear to have been composed by poets who had been born in Islam. The great majority of the authors belonged to the days of Jahiliyyah ("the Ignorance.") and though a certain number (*e.g.,* Mutammim ibn Nuwairah, Rabi'ah ibn Maqrum, 'Abdah ibn al-Tabib and Abu Dhu'aib), born in paganism, accepted Islam, their work bears few marks of the new faith. The ancient virtues — hospitality to the guest and the poor, profuse expenditure of uealth. valour in battle. faithfulness to the cause of the tribe — are the themes of praise; wine and gambling, forbidden by Islam, are celebrated by poets nho professed themselves converts; and if there is no mention of the old idolatry, there is also little spirituality in the outlook on life. The 126 pieces are distributed among 68 poets, and the work represents a gathering from the compositions of those nho were called *al-Muqillun,* "authors of nhom little has survived," in contrast to the famous poets whose works had been collected into *diwans.* At the same time many of them are extremely celebrated, and among the pieces selected by al-Mufaddal several reach a very high level of excellence. Such are the two long poems of 'Alqamah ibn 'Abadah (No. 119 and 120), the three odes by hfutammim ibn Nuwairah (No. 9, 67, 68), the splendid poem of Salamah ibn Jandal (No. 22), the beautiful *nasib* (love poem) of al-Shanfara (No. 20), and the death song of 'Abd-Yaghuth (No. 30). One of the most admirable and famous is the last of the series (No. 126), the long elegy by Abu Dhu'aib of Hudhail on the death of his sons; almost every verse of this poem is cited in illustration of some phrase or meaning of a word in the national lexicons. Only one of the poets of the *Mu'allaqat* (*q.v.*), al-Harith ibn Hillizah, is represented in the collection. An interesting feature of the work is its treatment of the tno poets of Bakr ibn Wa'il. uncle and nephew, called al-Muraqqish, who are perhaps the most ancient in the collection. The elder Muraqqish was the great-uncle of Tarafah of Bakr, the author of one of the poems in the *Mu'allaqat,* and took part in the long marfare between the sister tribes of Bakr and Taghlib, called the war

of Basus. which began about the end of the 5th century A.D. Al-Mufaddal has included ten pieces (No 45–54) by him in the collection, nhich are chiefly interesting from an antiquarian point of view. It is probable that the compiler set down all he could gather of this ancient author. and that his interest in him was chiefly due to his antiquity. Of the younger Muraqqish, uncle of Tarafah, there are five pieces (No. 55–59). The only other authors of whom more than three poems are cited are Bishr ibn Abi Khazim of Asad (No. 96–99) and Rabi'ah ibn Maqrum of Dabbah (No. 38. 39, 43 and 113).

The *Mufaddaliyat* differs from the *Hamasah* in being a collection of complete odes (qasidas), while the latter is an anthology of brilliant passages specially selected for their interest or effectiveness, all that is prosaic or less striking being pruned away. It is of course not the case that all the poems of al-Mufaddal's collection are complete. Many are mere fragments, and even in the longest there are often *lacunae;* but the compiler evidently set down all that he could collect of a poem from the memory of the *rawi* (professional reciters) and did not, like Abu Tammam, choose only the best portions. We are thus presented with a view of the literature of the age which is much more characteristic and comprehensive than that given by the brilliant poet to whom we one the *Hamasah,* and enables us to form a better judgment on the general level of poetic achievement. The most famous medieval recensions of the *Mufaddaliyat,* nith commentaries, are those of al-Anbari (d 916) and al-Marzuqi (d. 1030). Editions include those by H. Thorbecke (incomplete 1885); by A. M. Shakir and A. S. M Harun (1952); and a complete edition of al-Anbari's text and commentary, with English translation, by Sir Charles Lyall, 3 vol. (1919–1921). (C.ˆJ. L.; X)

MUFTI, a consulting canon lanyer in Islam, who, upon application, gives *fatwas* or legal opinions on points of the sacred law (see ISLAMIC LAW). These are asked and given in strictly impersonal form. but the cadi, or judge, then applies them to the case and decides in accordance with them. In theory, any learned man whose opinion is respected and whose advice is sought can give *fatwas.* But generally in a Moslem state there are muftis specifically appointed by the government, one for each school of law in each place. In Turkey the chief mufti of Constantinople, nith the title of Shaykh al-Islam. was the head of the ecclesiastical side of the state, nhile the grand vizier was at the head of secular matters. but his office nas abolished in 1924 by the Turkish republic. The use of the word for plain or civilian clothes worn instead of uniform is originally Anglo-Indian. It may have been suggested by the loose flowing robes of the "mufti."

See Sir Charles Eliot, Turkey in Europe, ch. v; art. "Shaikh al-Islām" in the *Encyclopaedia* of *Islam.*

MUGGER (MUGGAR, MUGGUR), the vernacular name for *Crocodylus palustris,* the best-known Indian species of crocodile; also known as the marsh crocodile. In times of drought it undertakes long emigrations overland and has even been known to invade tonns. See CROCODILIAN. (K. P. S.)

MUGGLETON, LODOWICK (1609–1698), English sectarian was born in Bishopsgate street, London. His father was a farrier, but he himself was bred to be a tailor. In 1651 he began to have revelations, and to proclaim himself and his cousin John Reeve, nhose journeyman he was. as the two witnesses mentioned in Rev. xi, 3. In 1652 they put out their "commission book" under the title The *Transcendent Spirituall* Treatise. An exposition of their doctrines was published in 1656 under the title of *The* Divine *Looking-Glass.*

Among other viens (besides the doctrine of the divine mission of the authors) this nork taught that the distinction of the three persons in the Trinity is merely nominal, that God has a real human body, and that He left Elijah as His vicegerent in heaven nhen He Himself descended to die on the cross. Muggleton's opinions gained some notable adherents, but also called forth much opposition. In 1653 he was imprisoned for blasphemy, and tnice (1660 and 1670) his own followers temporarily repudiated him. His attack on the Quakers drew forth William Penn's book, *The New Witnesses Proved* Old *Heretics* (1672). In 1677 Muggleton was tried at the Old Bailey, convicted of blasphemy and fined £500. Reeve died in 1658; Muggleton in 1698.

His collected works, including the posthumous Acts of the *Witnesses,* were published in 1756; and in 1832 about 60 Muggletonians subscribed to a new edition of The Works of J. Reeve and L. *Muggleton* (3 vol.). As late as 1846 The Divine *Looking-*Glass was reprinted by the then almost extinct sect.

MUGWORT, a plant name given to *Artemisia vulgaris,* found in Great Britain and widely naturalized in the United States and Canada; it is sometimes given also to A. absinthium (wormwood, absinthium). In North America the name is applied to numerous herbaceous species of Artemisia native to the Great Plains region and westward. the shrubby species of the arid districts, as *A. tri-*dentata, being usually designated sagebrush. In Great Britain the crosswort (*Galium cruciatum*) is sometimes called mugwort.

MUGWUMP, in U.S. political slang, a name applied to any independent voter, and especially to those independents in the Republican party who refused to support James G. Blaine when he was nominated by that party for the presidency in 1884; as since adopted in England it usually means one who stays neutral and votes for no party.

Originally "mugwump" (mogkiomp) was a North American Indian word, in the Rlassachusetts dialect of the Algonquian, meaning "great man" (*mogki,* "great"; *omp,* "man"); and in New England it was used of self-conceited politicians.

MUHAMMAD: see MOHAMMED.

MUHLENBERG, the name of a distinguished U.S. family, long associated with the state of Pennsylvania and the Lutheran Church, and numbering among its members teachers, college presidents, soldiers and members of congress.

HENRY MELCHIOR MÜHLENBERG (1711–1787), the founder of the family, was born in Einbeck, Hanover. Ger.. Sept. 6, 1711. He entered the University of Gottingen in 1735 and in 1738 went to Halle, where he finished his theological studies and was a devoted norker in the orphan school established there in 1695 by A. H. Francke (q v.). He was deacon at Grosshennersdorf, in Upper Lusatia in 1739–41. In 1742, in reply to a call from the Lutheran churches of Pennsylvania, he went to America. Mühlenberg occupied himself more particularly with the congregation at New Providence (now Trappe, Pa.), though he was practically overseer of all the Lutheran churches from New York to Maryland. In 1748 he organized the first Lutheran synod in America He married in 1745 Anna Maria Weiser, by whom he became the father of six sons and five daughters. Throughout the Revolutionary War he and his sons nere prominent patriots. He died at Trappe, Oct. 7, 1787.

See W. J Mann. Life and *Times* (1887); Margaret R. Seeback, *An* Eagle *of* the *Wilderness* (1924).

JOHN PETER GABRIEL MUHLENBERG (1746–1807), eldest child of Henry illelchior Miihlenberg, was born at Trappe on Oct. 1, 1746. He entered the Lutheran ministry, had charge of churches at New Germantown and Bedminster, N.J., and after 1772 of a church in Woodstock, Va. There in 1775 he raised a German regiment, of nhich he was made colonel; in Feb. 1777 he became a brigadier general in the Continental army. Muhlenberg took part in a number of battles, and at Yorktown commanded the first brigade of light infantry. After the war he moved to Pennsylvania. He was a representative in congress for several terms and in 1803 became collector of the port of Philadelphia. He was a friend of Thomas Jefferson and of James Monroe. He died on Oct. 1. 1807.

See H A Muhlenburg, Life of Major-Gen. Peter Muhlenberg (1849).

FREDERICK AUGUSTUS CONRAD MUHLENBERG (1750–1801), brother of John Peter Gabriel, third child and second son of Henry Melchior, was born on Jan. 1, 1750, at Trappe. He was pastor'of the Christ (or Swamp) German Lutheran church of New York city from 1773 to 1776. He was a member of the Continental Congress and of the national house of representatives, of which he was the first speaker. He died in Reading on June 4, 1801.

GOTTHILP HENRY ERNEST MUHLENBERG (1753–1815), fifth child and third son of Henry Melchior, born at Trappe on Nov. 17, 1753, was, in addition to being a Lutheran minister, a botanist of some note, his published works in that field being numerous. He

was the first president of Franklin college (1787) in Lancaster. His death occurred on May 23, 1815.

HENRY AUGUSTUS PHILIP MUHLENBERG (1782–1844), son of Gotthilf Henry Ernest, was born on May 13, 1782, at Lancaster, Pa., and was ordained in the Lutheran ministry in 1804. He served in congress (1829–38) and was first U.S. minister to Austria (1838–40). He died in Reading on Aug. 11, 1844, while campaigning for the governorship of Pennsylvania.

WILLIAM AUGUSTUS MUHLENBERG (1796–1877). a grandson of Frederick Augustus Conrad, mas born in Philadelphia on Sept. 16, 1796. and graduated at the University of Pennsylvania in 1814. Though baptized a Lutheran, circumstances led to his being brought up an Episcopalian. He was ordained priest in 1820. During his rectorship at St. George's, Flushing, L.I., N.Y., he founded in 1828 the Flushing institute, which developed after a time into St. Paul's college and was probably the first Protestant Episcopal school in the United States. Muhlenberg made the Church of the Holy Communion in New York city a pioneer in the practical Christianity to which his later years were devoted. He founded there the first American order of Protestant Episcopal deaconesses, the Sisterhood of the Church of the Holy Communion (1852). As a result of the work of the sisters he established what he called his "hospital-church," St. Luke's, in 1858. St. Johnland. his "church village" begun on Long Island in 1866 as an embodiment of Evangelical brotherhood — and partly modeled on the institutions of A. H. Francke with which his great-grandfather had been associated — was designed to better the condition of the working class, particularly to provide healthful shelter for children and indigent old people. He died in New York city, April 8, 1877.

See Anne Ayres, *The Life and Work of William Augustus Muhlenberg* **(1880)**; *W.* **W.** Newton, *Dr. Muhlenberg* (1890).

FREDERICK AUGUSTUS MUHLENBERG (1818-I~OI), grandson of Gotthilf Henry Ernest, was born at Lancaster, Pa.. on Aug 25, 1818. He too was a Lutheran clergyman and teacher, who contributed, as professor or president. to the life of five Pennsylvania colleges. He was first president (1867) of Muhlenberg college, Allentown. He died in Reading on March 21, 1901.

MÜHLHAUSEN (MÜHLHAUSEN IN THÜRINGEN), a town of Thuringia, Germany, in the district of Erfurt, on the right bank of the Unstrut, 25 mi. N.N.W. of Gotha by rail. Pop. (1950) 48,769. Muhlhausen is one of the oldest towns in the area. and is said to have been fortified in 925. Its early importance is shown by the grant of privileges made to it by the German king Kenry I. and by the diet held there in 1135. The Teutonic Order established itself at Muhlhausen in 1200. During the Reformation period Muhlhausen became one of the chief seats of the Anabaptists. In 1802 it lost its independence and passed to Prussia, in 1807 it was attached to the kingdom of Westphalia, but in 1815 it again became Prussian. It consists of a new and an old town, and has numerous old churches and towers. The churches of St. Mary and of St. Blasius date respectively from the 14th and the 12th century; the town hall is also a fine medieval structure. Muhlhausen is noted for its textile industries.

MUIR, JOHN (1810–1882), Scottish orientalist. was born on Feb. 5, 1810, in Glasgow, was a servant of the East India company from 1829 to 1853. He had a distinguished career in India. In 1862 he endowed the chair of Sanskrit in the University of Edinburgh, and was the main agent in founding the Shaw fellowship in moral philosophy. He died on March 7, 1882. Muir's most important work is his *Original Sanskrit Texts* (j vol., 1858–70), of the utmost importance for the study of the Vedic age.

MUIR, JOHN (1838–1914), U.S. naturalist, was influential in establishing national forest conservation and park policies. Born at Dunbar, Scotland, April 21, 1838, he emigrated with his family in 1849 to a backwoods farm near Portage, Wis. *(Story of My Boyhood and Youth,* 1913). He attended the University of Wisconsin from 1859 to 1863, but took no degree because of his dislike of the strictures of required courses. He went on many walking trips through the midwest and into Canada, continuing work on mechanical inventions until an accident in 1867 made him fear the loss of an eye. From this time. he devoted himself to nature. He walked to the Gulf of Mexico, keeping a journal as he went *(A Thozisand-Mile Walk to the Gulf,* 1916); and in 1868 went to the Yosemite valley in California. from which he took many trips into Nevada: Utah. Washington, Oregon and to Alaska, largely inspired by his predominant interests in glaciers and forests. In 1880 he married and for the next ten years so successfully devoted himself to horticulture that by 1891 he retired and resumed his travels, going so far afield as Australia, South America and Africa to study trees. To him is largely due the establishment of the Yosemite and other areas as national parks. He died at Los Angeles, Calif.. Dec. 24, 1914.

His writings, 10 vol. (1916–24) were edited by W. F. Badè, who also wrote *The Life and Letters of John Muir,* 2 vol. (1923–24). His unpublished journals were edited by Linnie M. Wolfe as *John of the Mountains* (1938).

See Linnie *M.* Wolfe, *Son of the Wilderness* (1945).

MUIR, SIR WILLIAM (1819–1905), British administrator and scholar, best remembered as a historian of Islam, was born in Glasgow on April 27, 1819. Appointed to the East India company's civil service he had a distinguished career in India (1837–76), becoming, after long service as a settlement officer, foreign secretary to the government of India (186 j) and lieutenant governor of the North-West provinces (1868). He was created knight commander of the star of India in 1867. Amid his official duties Muir found time to study Arabic and Islamic history. His works include a *Life of Mahomet and History of Islam to the Era of the Hegira,* 4 vol. (1858–61; ed. by T. H. Weir, 1923); *The Corân: Its Composition and Teaching* (1877); *Annals of the Early Caliphate* (1883); *The Caliphate: Its Rise, Decline and Fall* (1891; ed. by T. H. Weir, 1924); *The Mohammedan Controversy* (1897). Muir, who was a brother of the Sanskrit scholar John Muir (*q.v.*), also rendered important services to education: in Allahabad he instituted the central college (Muir's college) and the university; and he mas principal of Edinburgh university (1885–1903). He died in Edinburgh July 11, 1905.

MUKAČEVO (MUNKÁCS, MUKACHEVO), a town of Zakarpatskaya *oblast,* Ukrainian S.S.R., U.S.S.R., on the left bank of the Latorica where it leaves the East Beskid highlands. Traditionally believed to be near the point where the Magyars entered the plain, the old fort on a hill in the vicinity played an important part in Hungarian history as a defense and later as a prison.

The town is a market for the hill and plain peoples and has several distilleries, breweries and small tobacco and flour-milling interests. Pop. (1956 est.) 44,000. In 1938 the town was transferred from Czechoslovakia to Hungary, after the pact of Munich. After 1945 it became a part of the U.S.S.R.

MUKDEN (SHEN-YANG), the centre of administration and transportation of the Chinese northeast (Tung-pei), and capital of the Liaoning province. Pop. (1953) 2,299,900. It is situated on the right bank of the Hun Ho, a tributary of the Liao Ho.

Mukden controls the main north-south route which traverses the Liao corridor and the still narrower coastal sill giving access to the north China plain. Moreover the valley of the upper Hun Ho, which here debouches on to the lowland, affords one of the chief routes through the east Manchurian highlands. The strategic and focal significance of its position was realized at an early stage. In the 12th century it was the northernmost of the three capitals of the empire of the Kin Tatars (Golden Horde), originally from the steppes of northern Manchuria. About the same period Aisiu Goro, from whom ultimately descended the Manchu dynasty, had his capital in the neighbourhood of the Ch'ang-pai Shan (mountains) north of the Korean peninsula. In the early 17th century his descendant Nurhachu. for the purpose of organizing and uniting the various Manchu tribes and with a view to the conquest of China. moved his capital down to the plain of the Liao Ho toward the Chinese frontier. Mukden was then known as Shengking and proved an admirable organizing base for the conquest of China. In 1644 when the Manchus supplanted the Mings on the Imperial throne the capital was transferred to Peking. Shengking, however, retained its prestige as the older capital of the reigning dynasty; the treasures of the royal house were deposited in its palaces and the tombs of the earlier emperors (particularly the mausoleum of Tatsung, d. 1644 at Peilung, *i.e.,* North Mausoleum, about 4 mi.

from the city) are among the most famous monuments of China. In 1658 the provincial government of Feng-t'ien was established and the city became knoan as Feng-t'ien.

In the period of struggle between Russia and Japan for dominance in Manchuria, Mukden was inevitably one of the key positions. It was for a time a Russian stronghold and was the scene of the protracted "battle of Mukden" which lasted from Feb. 19 to March 10, 1905, when the city fell to the Japanese. After the Russo-Japanese War the Japanese concession in Mukden had been one of their chief bases for the exploitation of south Manchuria, but it had also been the seat of government of the Chinese "viceroy" of the three Manchurian provinces (Feng-t'ien, Kirin and Heilungkiang). During the civil war and warlord period Chang Tso-lin, a former bandit, governed the Manchurian provinces from Mukden under Japanese tolerance and participated with other warlords in the struggle for the control of the shadowy government in Peking. He was the last warlord to resist the advance of the Kuomintang armies against Peking in 1928, and when he. with his defeated troops, retreated, his train was blown up near Mukden at a Japanese guarded railway bridge. His son and successor Chang Hsueh-liang adhered, against Japanese advice, to the new Nanking government.

On Sept. 18, 1931, the Mukden incident, an explosion on the railway track near Mukden, gave the signal for the Japanese occupation of Manchuria. A surprise attack on the Mukden garrison, and arsenal brought the Japanese control of the city and after protracted fighting the Chinese forces were driven out of the Manchurian provinces. On Sept. 24, 1931, in Mukden, the first puppet organization was set up with the Committee for Preservation of Local Peace and Order. But after the establishment of Manchoukuo the capital of the puppet state was moved to Ch'ang-ch'un, which the Japanese renamed Hsinking.

The Soviet Union declared war on Japan in early Aug. 1945, and Mukden was soon occupied by Russian forces. After the surrender of Japan on Aug. 14, 1945, Mukden was occupied by Nationalist Chinese troops who were flown there in U.S. transport planes. However, Chinese Communist forces controlled large rural areas of Manchuria. During the civil war that ensued from 1946 to 1948. Mukden was a stronghold of the Nationalists. Following a series of mobile offensives, the Communists captured the city on Oct. 30, 1948. It then served as a major base for the subsequent conquest of the entire Chinese mainland in the following two years by the Communist forces.

See also MANCHURIA: *History;* JAPAN: *History;* CHINA: *History.*

Since 1949 Mukden has developed into a leading industrial centre of China. It is supplied with abundant raw materials in nearby iron, steel and coal centres such as An-shan, Fu-sung and Pen-ch'i. The city has the largest transformer plant of China. and factories for manufacturing switchgears, machine tools, pneumatic tools. wires and cables. About one fourth of China's machinery is manufactured amounting to nearly one half of the city's output by value. Light industries include flour, textiles, oilseeds. paper, leather, soap and chemicals. The city is supported by agricultural products from the rich surrounding plain and forested highlands to the east. which include kaoliang, soybeans, sugar beets, other grains and forest products of various kinds.

Metropolitan Mukden consists of four parts—the old walled city in the east containing the imperial palace and government offices; the new town developed by the Japanese after 1905; intermediate commercial districtst and the Teihsi ("west of the railway"), which has become the hub of heavy and metal-fabricating industries and workers' residences. The Greater Mukden municipality covers an area of 1,200 sq.mi., embodying the satellite cities of Fu-sung, Pen-ch'i, Anshan and Liao-yang (*q.v.*). Railways radiate from the Mukden industrial focus toward the north China plain, Korea and northern Manchuria. (KN. C.)

MULBERRY, botanically *Morus* (family Moraceae), a genus of 12 species growing in the temperate regions of the northern hemisphere and in the mountains of the tropics. They are deciduous trees or shrubs with alternate, toothed, often three-lobed leaves and unisexual flowers in catkinlike inflorescences. The North American red mulberry (M. rubra) is the largest of the genus, often reaching a height of 70 ft. It produces dark-red berries much inferior in flavour, however, to those of M. nigra. Both the white and the red mulberry have been grown in the eastern United States since colonial times and both have sparingly escaped from cultivation. The paper mulberry, often planted for ornament in the southeastern United States, has run wild in various localities from New York to Florida. The black mulberry (M. nigra), a native of western Asia, spread westward in cultivation at an early period; it was cultivated by the Greeks and Romans, and in northern Europe by the 9th and 10th centuries. Up to the 15th century it was extensively grown in Italy for rearing silkworms, but has since been superseded by M. alba. It is now mainly cultivated for its oblong purplish-black fruit. The mulberry succeeds as a standard in the warmer parts of England, especially in sheltered situations. but in the north of England and the less favoured parts of Scotland it requires the assistance of a wall. The tree succeeds best in a rich, deep and somewhat moist loam, but grows well in any good garden ground. It is usually propagated either by cuttings or layers. The mulberry may be grown in pots, and gently forwarded in an orchard house and under these conditions the fruit acquires a richness of flavour unknown in the fruit ripened out of doors.

The white mulberry (*M.* alba), so called from its nearly white fruit, is the one mainly employed in silkworm culture. It is a native of China and has been cultivated from the earliest times in Asia and since the 12th century in Europe, especially in the Mediterranean region. There are many varieties, among which the Philippine mulberry (var. *multicaulis*) is perhaps most highly esteemed. The Indian species, *M. indica* (not to be confounded with *Morinda citrifolia,* a tree of the family Rubiaceae, sometimes called Indian mulberry), is cultivated for the same purpose.

Broussonetia papyrifera, a member of a closely allied genus, is the paper mulberry, a native of Burma, China and Polynesia, and widely cultivated in Japan, where the bark is used for papermaking. The tapa cloth of the South sea islands is also made from it. The plant is a shrub or small tree with large mulberrylike lobed or entire hairy leaves. Several forms are cultivated, differing chiefly in the shape of the leaves.

MULCAHY, RICHARD JAMES (1886–), Irish politician. was born in Waterford, Ire. He took part as a lieutenant in the Irish rebellion of 1916. and was afterward interned in Frongoch. In Dec. 1918 he was returned as Sinn Fein M.P. for the Clontarf division of Dublin and retained his seat until 1922. He took part in the reorganization of the Irish volunteers, of which he had become chief of staff in 1918. He sat in the dail from 1921 to 1923 as a member for the northwest division of Dublin, and after the treaty of 1922 became minister of defense for the Irish Free State. He succeeded Michael Collins. after the latter's death in 1922. as commander in chief of the Free State forces. and had the chief conduct of operations until the ceasefire order of 1923. in which year he was returned to the dail for Dublin city north. He resigned office in the spring of 1924 upon the executive's requiring the resignation of three of his principal officers in connection with troubles arising out of demobilization and reorganization. From 1927 to 1932 he was minister for local government He was returned to the *dail* for County Tipperary in 1944; and in 1948 he became minister for education.

MULCASTER, RICHARD (1530?–1611), English schoolmaster, was educated at Eton, during Nicholas Udall's headmastership, and at Cambridge and Oxford. In 1561 he became the first headmaster of the newly founded Merchant-Taylors' school, later acting as high master at St. Paul's. Mulcaster's fame rests mainly upon his two books *Positions* and The *First* Part *of* the *Elementarie.* He recommended special university training for teachers, parallel with that for doctors or lawyers; careful selection of and adequate pay for teachers; assignment of the best teachers to the lowest grades; and close association between teachers and parents. He emphasized the importance of individual differences in children and the adjustment of the curriculum to them, and the use of readiness rather than age in determining progress. His ideas were so far in advance of his times that his significance, as an

early advocate of many of the pedagogical theories now universally accepted, was not appreciated until at least 250 years after his death, which took place on April 15, 1611.

See J. Oliphant, *Educational Writings of* Richard Mulcaster (1903); R. H Quick, Positions *of Richard Mulcaster* (1888). (L. CE.)

MULE, a term applied to a hybrid of the asinine and equine species (see Ass; HORSE). There are two kinds of mule: the commonest results from mating a jackass and a mare; the less common, the hinny, is the offspring of a stallion and a female ass. Mules are hardy animals able to endure hardships and perform under adverse conditions, nhich make them favoured work animals. They are rarely fertile.

Mules were raised in Asia Minor at least 3,000 years ago and exported to Greece

The mule resembles the horse in its height, the shape of the neck and croup and the uniformity of the coat. It resembles the parent ass in its short, thick head, long ears, thin limbs, small hoofs, short mane. lack of chestnuts (horny growths) inside the hocks, and tail destitute of hair at the root. The mule's voice is a bray, not like that of the horse but something like that of the jackass. The colour of the coat is generally brown or bay-brown.

The five commonest types of mules bred in the United States are called draft, farm, sugar, cotton and mining mules. The various grades and weights fall into the following classes: choice, good, medium, common and inferior. Largest is the draft mule, which ranges from 16 to 17½ hands high and weighs from 1,200 to 1,600 lb.; the smallest is the mining mule, which weighs from 600 to 1,350 lb. and is 12 to 16 hands high.

Spain and the United States have the finest mules, followed by Portugal and Italy. There were approximately 2,000,000 mules in the U.S. in the mid-20th century, the mule population having declined 50% since 1930. The majority was distributed through ten southern and southeastern states. (C. C. S.)

MULHEIM-AN-DER-RUHR, a town in North Rhine-Westphalia, Ger., on the Ruhr, an affluent of the Rhine, about 7 mi. W.S.W. from Essen and at the intersection of several railways. Pop. (1950), 149,589. Miilheim was formerly included in the duchy of Berg, and became a town in 1508. In 1815 it passed to Prussia. It has a 12th-century parish church. Its chief industry is ironworking and it has numerous blast furnaces, rolling mills, foundries and engine works; it also manufactures leather, tobacco, paper and beer. Traffic is carried on in coal: and timber and colonial produce. In the neighbourhood are sandstone quarries, glassworks and a carpet manufactory.

MULHOUSE (MÜLHAUSEN), a town of France, capital of an *arrondissement* in the *département* of Haut-Rhin, about 29 mi. E.K.E. of Belfort, j6 mi. S. of Strasbourg and 21 mi. K.W. of Basel by rail. Pop. (1954) 97,285. It stands on the Ill river, there a part of the Rhône-Rhine canal system. Mulhouse was a free imperial city in the 14th century, and in 1648 was added to the Swiss confederation, with which it had been allied from 1466 and to which it belonged until 1798 when it joined France. From 1871 till 1918 it belonged to Germany. It is the great textile centre of Haut-Rhin and also manufactures machinery and chemicals. The *hôtel* de *ville* (16th century) has curiously painted walls and a covered outside stairway. An interesting attempt at industrial town planning was made there by Jean Dollfus in 1853.

MULE, the largest island of the Inner Hebrides, Argyll, Scot. Pop. (1951) 2,420. It is hounded on the west and south by the Atlantic, on the north and northeast by the Sound of Mull, and on the east and southeast by the Firth of Lorne. Its greatest length is 27 mi., and its greatest breadth 20 mi. The coast is deeply indented, and between Salen on the east and Loch na Keal the island is only 2 mi. across. There are several fresh-water lakes and the principal mountains are Ben More (3,169 ft.), Ben Buie (2,354 ft.) and Ben Creach (3.540 ft.). The island is terraced, as are also those of Ulva and Gometra off the west coast, and bracken grows abundantly, with trees in the sheltered places. In the south, on the peninsula of Laggan, is a small private deer park. In the basaltic cliffs near Carsaig are numerous arches and caverns. Sheep and cattle are raised, and barley, oats and potatoes grown, though due to the damp climate the island is better suited for grazing than for cultivation. Granite is quarried. There are several ancient castles, the principal being those of Aros and Duart (restored in 1912 and again the seat of the Macleans). South of the latter is a lighthouse erected in memory of William Black, the novelist (1841–98), and about 1½ mi. off the lighthouse is the Lady rock, visible at low water, on which, in 1523, Lachlan Maclean of Duart exposed his wife, a daughter of the 2nd earl of Argyll, who was saved by her clansfolk.

Tobermory. which rises from a picturesque bay. is the only town (pop., 1951, 693). Founded in 1788 as a station for fishing boats, it has a harbour and considerable local trade. It is also a summer resort. with communication by steamer with Oban. A Spanish galleon lies sunk in Tobermory bay.

MULLAH, in Mohammedan countries a learned man, a teacher, a doctor of the law (Arabic maula, a term which originally expressed the legal bond connecting a former owner with his manumitted slave).

In India the term is applied to the man who reads the Koran and also to a Moslem schoolmaster. In countries like Afghanistan the mullahs exert an influence over the populace which sometimes rivals that of the amir himself.

In the Indian frontier risings of 1897–98 the "mad mullah" of Swat led the attack upon the Malakand. while the Hadda mullah was largely responsible for the risings among the Mohmands, Afridis and Orakzais. The leader of the risings in Somaliland in 1899–1910 was similarly known as the "mad mullah."

RUTHERFORD PLATT

MULLEIN (VERBASCUM THAPSUS)

MULLEIN (Verbascum *thapsus*), a densely woolly, biennial herb of the figwort family (Scrophulariaceae), extensively naturalized in North America, and native to Europe and Asia, common in the British Isles. It grows erect, two to seven feet high. with stout unbranched stems, conspicuously winged by the decurrent bases of the large. thick, oblong, slightly toothed leaves.

The pale yellow flowers, about an inch broad, appearing from June to September, are closely crowded in a long. dense spike. In some districts the mullein is a troublesome pasture weed.

MÜLLER, FERDINAND, BARON VON (1825–1896), German botanist and explorer well known for his pioneer botanical exploration of Australia, was born at Rostock on June 30, 1825, and was educated in Schleswig. In 1847 he emigrated to South Australia and five years later was appointed government botanist for Victoria. As phytographic naturalist, he joined the expedition sent out under Augustus Gregory by the duke of Newcastle, secretary of state for the colonies. From 1857 to 1873 Miiller was director of the botanical gardens at Melbourne. He not only introduced many plants into Victoria, but made the excellent qualities of the blue-gum tree (*Eucalyptus* globulus) known and introduced it into the south of Europe, north and south Africa, California and portions of South America. He was decorated by foreign countries, and was created baron of the kingdom of Württemberg in 1871. Miiller died at Melbourne on Oct. g, 1896.

His publications include Fragmenta phytographica Australiae, 11 vol. (1862–81), Plants of Victoria, 2 vol. (1860–65), and works on the eucalyptus, Myoporaceae, acacias and Salsolaceae.

MÜLLER, FRIEDRICH (usually known as MALER, *i.e.*, "painter," MÜLLER) (1749–1825), German poet, dramatist and painter whose prose idylls showed remarkable realism, was born at Kreuznach on Jan. 13, 1749. In 1777 he became court painter at Mannheim, but in the next year left for Italy, where he lived until his death, in Rome, April 23, 1825. Miiller abandoned paint-

ing soon after his arrival in Italy. His principal works are *Fausts Leben dramatisiert* (1778). *Golo und Genoveva* (begun 1776, publ. 1811) and the idylls. *Die Schafschur* (1775) and *Das Nusskernen* (1811). His poetry ranged from the Anacreontic manner to that of the folk song, and his idylls were similar to those of Salomon Gessner. His *Werke* were edited by L. Tieck, 3 vol. (1811–25), and by M. Oeser, 2 vol. (1916–18).

See F. Meyer, *Maler Müller-Bibliographie* (1912); **M. Oeser,** *Maler Müller* (1928). (A. Gs.)

MÜLLER, HERMANN (1876–1931), German politician, was born May 18, 1876, at Mannheim. From 1899 to 1906 he was editor of the Socialist newspaper the *Gorlitzer Volkszeitung,* and from 1906 onward was a member of the directing board of the German Social Democratic party. From 1916 to 1918 he was a member of the *Reichstag.* On Aug. 1, 1914, he went to Paris with the object of finding out whether international action by the Socialists of France and Germany could be initiated in order to avert World War I. His mission mas unsuccessful, and he had great difficulty in making his way back to Germany through the French lines. His report did much to determine the attitude of the German Social Democrats in voting in the *Reichstag* for the first war credit. On June 21, 1919, he was appointed minister for foreign affairs—under the chancellorship of Gustav Bauer—and in this capacity went to Versailles and with the colonial minister, Hans Bell. signed the peace treaty for Germany on June 28, 1919. After the resignation of the Bauer ministry. following the Kapp *Putsch* (March 1920), Müller was appointed chancellor of the reich, an office which he held till the following June. when the result of the general elections for the *Reichstag* necessitated the formation of a coalition ministry with Konstantin Fehrenbach of the Catholic Centre party as chancellor. Müller continued to play a leading part in the affairs of the Social-Democratic party, whose chairman in the *Reichstag* he was. After the general election of May 1928. which brought a swing to the left, he was asked by the president to form the new government. After wearisome negotiations with the different parties concerned, he succeeded in forming a "cabinet of personalities," based on the idea of the great coalition including all parties from the Social Democrats to the German People's party; he himself was chancellor.

MULLER, HERMANN JOSEPH (1890–), U.S. geneticist and Nobel prize winner, born in New Tork city on Dec. 21, 1890, was educated at Columbia university (B.A., 1910; M.A., 1911; Ph.D., 1916). He early made outstanding contributions to an understanding of the arrangement and recombination of hereditary units or genes, linkage, crossing over and multiple-factor analysis (1916), explanations of so-called mutations in the evening primrose (1917), balanced lethal factors (1918) and the manner of occurrence of mutations (1920). These studies on the theory of the gene (*q.v.*) and its importance in mutation and evolution *(see* EVOLUTION, ORGANIC; VARIATION: *Experimental Variation)* led him to produce artificial transmutations of the gene by X-rays (1927), for which he was awarded the American Association for the Advancement of Science prize for 1927 and the Nobel prize for medicine in 1946.

Muller wrote *The Mechanism of Mendelian Heredity* (with *T. H.* Morgan and others. 1915; rev. 1922); *Out of the Night* (1935; rev. 1936–38); and *Genetics, Medicine, and Man* (with C. C. Little and L. H. Snyder, 1947). (G. F. Ss.)

MÜLLER, JOHANN (REGIOMONTANUS) (1436–1476), German astronomer and one of the most advanced mathematicians of his age, was born at Konigsberg on June 6, 1436. Because of his birthplace, he called himself Johann de Monteregio, later modified to Regiomontanus. In 1452, he went to Vienna and studied under Georg Purbach (1423–61), later assisting him in the preparation of a work on Ptolemaic astronomy. The inadequate translations of Ptolemy's works hindered them, but a year after Purbach's death Regiomontanus visited Italy, where he studied Greek and consulted a Greek text of the *Almagest.* In 1463 he completed Purbach's *Epitome in Cl. Ptolemaei magnam compositionem,* which was published in Venice in 1496. In 1468 Regiomontanus returned to Vienna, and from there was summoned by the king of Hungary to Buda to collate Greek manuscripts. He settled in Nürnberg in 1471. Bernhard Walther became his pupil and patron and they constructed the first European observatory, Regiomontanus himself constructing instruments of an improved type; these are described in his posthumous *Scripta* published in 1544. In 1472, he made extensive observations of a great comet, probably Halley's comet, and established a printing press in Walther's house. A series of popular calendars issued from the press and Purbach's *Theoricae planetarum novae* was published, while in 1474 Regiomontanus published ephemerides for 1474–1506, in which he described the method of "lunar distances" for determining longitude at sea. Pope Sixtus IV summoned him to Rome in 1472 to assist in calendar reform, and during a subsequent visit there Regiomontanus was assassinated on July 6, 1476.

Regiomontanus had great mechanical ability, as shown by his observatory instruments and his construction of a mechanical eagle which greeted the Emperor Maximilian I on his entry into Nürnberg; but he was primarily an advanced mathematician. His *De triangulis,* written in 1464 and published in Nurnberg in 1533, gives the earliest modern exposition of plane and spherical trigonometry, using general methods of exposition and algebra to assist in the solutions. Regiomontanus was also the first in Europe to discuss the algebra of Diophantus (*fl.* 4th century A.D.) and in 1475 published his *Tabulae directionum.* (CN. A. R.)

MULLER, JOHANNES PETER (1801–1858), German physiologist and comparative anatomist who discovered that sensation is not controlled by the stimulus but rather is dependent on the particular sense organ involved, was born in Coblenz on July 14, 1801. He studied at Bonn university, where he taught from 1824 until 1833, when he received the chair of anatomy and physiology at Berlin. He died on April 28, 1858. The appearance of his *Handbuch der Physiologie des Menschen* (1833–40; Eng. trans. by William Baly, 1842) marked the beginning of a new period in the study of physiology, by showing its dependence on the other sciences. The most important part of the work deals with the physiology of the nerves and the senses. Here Muller first declared that the kind of sensation following stimulation of a sensory nerve depends not on the mode of stimulation, but upon the nature of the sense organ which transmits it to other nerve terminals, and expounded the mechanism of voice, speech and hearing. Müller is also noted for his early investigations of specific nerve energies, his discoveries of the fetal Miillerian duct (1825) and of the lymph hearts in the frog (1832), his work on tumours (1838) and his description of the parasitic disease, psorospermosis (1841). In the later part of his life he devoted himself to the study of ocean fauna and comparative anatomy.

MÜLLER, JOHANNES VON (1752–1809), Swiss historian, was born on Jan. 3, 1752, at Neunkirch, near Schaffhausen, where his father was pastor. From 1774 to 1780 he lived at Geneva where he produced his *Allgemeine Geschichte,* a brilliant study of universal history (not published till 1810). In 1780 he completed the first volume of his *Geschichten der Schweizer,* bearing the imprint of Boston, U.S.A., on account of difficultieswith the Swiss censor. His *Reisen der Päpste* appeared in 1782.

In 1786 he became librarian to the elector-archbishop of Mainz, who obtained his elevation to nobility from the emperor in 1791. In June 1786 he issued vol. i (reaching to 1412) and two years later vol. ii (to 1436) of the definitive form of his Swiss history.

After the capture of Mainz by the French (1792), he entered the service of the emperor Leopold as an imperial aulic councillor. At Vienna he became chief librarian of the imperial. library in 1800, and in 1795 he issued vol. iii (to 1443) of his Swiss history. In 1804 he became historiographer, war councillor and member of the Academy at Berlin. In 1805 vol. iv (to 1475) appeared. But in 1806 he became strongly inclined toward Napoleon, from whom he accepted (end of 1807) the office of secretary of state for the kingdom of Westphalia. At the end of 1808 he published vol. v (to 1489) of his great work. He died at Cassel on May 29, 1809. His *Swiss History,* based largely on the chronicles of Tschudi (*q.v.*), now possesses a literary value only, but it remarkably stimulated Swiss patriotism.

Miiller's *Werke* were published at Tiibingen, in 27 vol. (1810–19), and reissued, in 40 vol., at Stuttgart (1831–35). The *Swiss*

History was reissued at Leipzig and Zurich, in 15 vol. (1824–53). A French translation of the German edition appeared, in 18 vol., at Paris and Geneva (1837–51). His *Universal History* was translated into English by J. C. Prichard (1818).

MÜLLER, KARL OTFRIED (1797–1840), German scholar, was born at Brieg in Silesia on Aug. 28, 1797. He was educated partly in Breslau, partly in Berlin, and his first book, *Aegineticorum liber,* was published in 1817. In 1819 he became professor of ancient literature at Gottingen, but in 1839 political disturbances led him to travel. After investigating Athens and other places, he started excavations at Delphi. He died of intermittent fever at Athens on Aug. 1, 1840. His aim was to form a conception of Greek life as a whole, and his work marks an epoch in Hellenic study.

Among his historical works the foremost place belongs to his *Geschichte hellenischer Stämme und Stadte: Orchomenos und die Minyer* (1820) and *Die Dorier* (1824; Eng. trans. by H. Tufnell and Cornewall Lewis, 1830). He introduced a new standard of accuracy in the cartography of ancient Greece. In 1828 he published *Die Etrusker,* a treatise on Etruscan antiquities. His *Prolegomena zu einer wissenschaftlichen Mythologie* (1825; Eng. trans., J. Leitch, 1844) prepared the way for the scientific investigation of myths; while the study of ancient art was promoted by his *Handbuch der Archaologie der Kunst* (1830; Eng. trans., J. Leitch, 1847) and *Denkmaler der alten Kunst* (1832), which he wrote in association with C. Osterley. In 1840 appeared in England his *History of the Literature* of *Ancient Greece* (published in Germany, 1841).

See memoir of his life by his brother Eduard, prefixed to the posthumous edition of K. O. Miiller's *Kleine deutsche Schriften* (1847). A biography composed from his letters was published by O. and E. Kern, K. *O. Muller, Lebensbild in Briefen an seine Eltern* (1908).

MULLER, (FRIEDRICH) MAX (1823-~900), Anglo-German orientalist and comparative philologist, whose works stimulated nidespread interest in the study of linguistics, mythology and religion. was born at Dessau on Dec. 6, 1823. He was the son of Wilhelm Müller (1794–1827), the German poet celebrated for his phil-Hellenic lyrics, who was ducal librarian at Dessau. Felix Mendelssohn, who was Miiller's godfather, dissuaded him from indulging his natural bent toward the study of music; Hermann Brockhaus of the University of Leipzig, where Müller matriculated in 1841, induced him to take up Sanskrit; Franz Bopp. at Berlin (1844), transformed the Sanskrit student into a comparative philologist; Friedrich Schelling, at the same university. inspired him with a love for metaphysical speculation. though he failed to attract him to his own philosophy; Eugene Burnouf, at Paris in the following year. by teaching him Zend, started him on the study of comparative religion and impelled him to edit the Rig-Veda: and when, in 1846, Miiller came to England upon this errand. Baron von Bunsen, in conjunction with H. H. Wilson, prevailed upon the East India company to undertake the expense of publication. Bunsen gave him introductions to Queen Victoria and the prince consort. and to Oxford university. In 1848 the printing of his Rig-Veda at the Cniversity press obliged him to settle in Oxford. Müller was appointed deputy Taylorian professor of modern languages in 1850, and became an honorary fellow of Christ Church and a fellow of All Souls. During this period he published the essays collected as *Chips From a German Workshop,* and his *History of Ancient Sanskrit Literature* (1859).

When at last the chair of Sanskrit fell vacant in 1860. Müller failed to secure election; it was the one great disappointment in his life and made a lasting impression upon him. Sanskrit philology received little more from him, except in connection with his later undertaking of *The Sacred Books of the East,* though he appealed to Sanskrit evidence in his *Science of Languages,* two courses of lectures delivered at the Royal institution in 1861 and 1863. Müller sought to popularize the study of Indo-European comparative philology, but he was on less sure ground in another department of the study of language—the problem of its origin. His essays on mythology are among the most alluring of his writings, but their value is impaired by too uncompromising adherence to the seductive generalization of the solar myth.

Müller's studies in mythology led him to the comparative study of religions. His *Introduction to the Science of Religion* (1873: the same year in which he lectured on the subject in Westminster abbey) was followed by the four volumes of Gifford lectures delivered between 1888 and 1892; but the most tangible result was the publication under his editorship, from 1879 onward, of *The Sacred Books of the East* in 51 volumes, including indexes, all but three of which appeared under his superintendence during his lifetime. These comprise translations by competent scholars of the important non-Christian scriptures of oriental nations. Müller also wrote on Indian philosophy in his later years, and he urged the search for oriental manuscripts and inscriptions which resulted in discoveries of early Buddhist scriptures, in their Indian form, made in Japan. He was on friendly terms with Japanese scholars, and after his death his library was purchased by the University of Tokyo.

In 1868 Müller was elected to a newly established chair of comparative philology, but he ceased to lecture in 1879 when he entered upon the editorship of *The Sacred Books of the East.* He was a curator of the Bodleian library and a delegate of the University press. His hospitality was ample, especially to visitors from India. where he was well known. His distinctions, conferred by foreign governments and learned societies! were numerous. He became a naturalized Englishman, was in high favour at court, and was sworn of the privy council. He died at Oxford on Oct. 28, 1900.

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MULLER, WILHELM (1794–1827), German lyric poet, was born at Dessau on Oct. 7, 1794, and died there on Sept. 30, 1827. His reputation was made by the *Gedichte aus den hinterlassenen Papieren eines reisenden Waldhornisten* (2 vols., 1821–1824), and the *Lieder der Griechen* (1821–1824), a collection inspired by the Greek war of independence. Two volumes of *Neugriechische Volkslieder,* and *Lyrische Reisen und epigrammatische Spaziergänge,* followed in 1825 and 1827. Miiller also translated Marlowe's *Faustus,* and edited a *Bibliothek der Dichtungen des 17. Jahrhunderts* (1822–1827; 10 vols.). Schubert set many of his lyrics to music, among others "Die Schöne Müllerin" and "Winterreise."

Wilhelm Müller's *Gedichte* were first collected in 1837 (4th ed., 1858); edited by his son, F. Max Miiller (1868); there are also numerous more recent editions, notably one in Reclam's *Universalbibliothek* (1894); critical edition by J. T. Hatfield (1906). Miiller's *Vermischte Schriften* were edited with a biography by G. Schwab (3 vols., 1830).

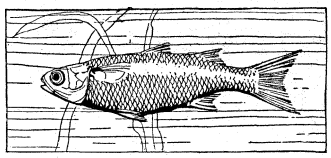
MÜLLER, WILLIAM JOHN (1812–1845), English landscape and figure painter, was born at Bristol on June 28, 1812, his father, a Danziger, being curator of the museum. He studied painting under J. B. Pyne. His early subjects deal mainly with the scenery of Gloucestershire and Wales. In 1833 he figured for the first time in the Royal Academy with "The Destruction of Old London Bridge—Morning." The next year he made a tour through France, Switzerland and Italy. Four years later he visited Athens. extending his travels to Egypt, and in the sketches made during this period and the paintings produced from them his power and individuality are apparent. After his return he settled in London, where he exhibited regularly.

In 1840 Miiller again visited France, where he executed a series of sketches of Renaissance architecture, 25 of which were lithographed and published in 1841 in a folio entitled *The Age of Francis I of France.* In 1843 he accompanied Charles Fellows to Lycia, where he made a number of masterly sketches. He died at Bristol on Sept. 8, 1845.

MULLET, the name of two different kinds of fishes, distinguished as red mullets and gray mullets.

Red mullets (genus *Mullus*) are marine fishes, with two short dorsal fins, the first composed of feeble spines, the second of branched rays. The body is covered with large thin scales. The anterior profile of the head slopes downward to the small mouth,

which has small, feeble teeth. There are two sensitive barbels on the lower jaw, generally laid back in a groove, but capable of erection when needed. About 40 species are known, chiefly from the tropical and subtropical parts of the Indo-Pacific ocean. In European waters two species occur (*Mullus surmuletus* and *M. barbatus*). The former, in addition to the general red colour, has three to five bright yellow bands along the sides from head to tail; these are absent in the other form. The striped form is usually found on the coasts of England, while in the Mediterranean both kinds occur.



BY COURTESY OF THE NEW YORK ZOOLOGICAL SOCIETY

THE GRAY MULLET

The largest red mullets weigh only two or three pounds. They are ground-feeders, using their barbels in discovering their food, which consists of crustacea, worms and. in the larger species, small fishes. Their brilliant colours are simple and evanescent; in many, red prevails. All the species are esteemed as food, but none equals the European species. During winter the fish retire into deep water, late in spring and during summer they approach the coasts and enter even brackish water, but they do not come toward the shore to breed. At Naples they spawn from May to August; their ova are buoyant and transparent.

The gray mullets form a very distinct family, Mugilidae. They enter brackish water, live always close to the shore, and some of the tropical forms inhabit the fresh water without, however, penetrating far inland. Their body is elegantly formed, streamlined, and covered with scales of moderate size. The anterior of the two short dorsal fins is composed of four stiff spines. The caudal fin is strong and bilobed. The mouth is narrow, transverse in the true *Mugil,* and without, or with but feeble, teeth. About 70 different species are known, from most parts of the temperate and tropical zones; they swim in small schools and are abundant wherever they occur. The commonest British species is *Mugil cephalus;* found also on both coasts of North America and elsewhere. Some of the fresh-water gray mullets of the tropics have been formed into a separate genus, *Agonostoma.*

Gray mullets may grow to a weight of 10 or 12 pounds. Those in which distinct teeth are developed feed on small aquatic animals, while the diet of those without teeth consists of animalcules, confervae or minute organic debris mixed with the mud and sand, which they swallow in large quantities. To prevent the gills from being clogged by sand or mud, each branchial arch is provided with a series of closely set gill rakers, each series fitting into the series of the adjoining arch; they constitute a sieve permitting the passage of the water, while retaining other substances. Gray mullets are plainly coloured, generally greenish on the upper parts and more or less silvery on the side. They are wholesome food. Gray mullets are cultivated in fish farms in Italy.

MULLINGAR, the county town of County Westmeath, Ire., on the river Brosna, 51 mi. W. by N. of Dublin by road. Pop (1956) 5,884. It contains the county administration headquarters and is a large road and railway junction and the centre of a cattle-raising area. The Royal canal almost encircles the town which contains the Roman Catholic cathedral for the diocese of Meath. The principal industries are the manufacture of furniture and pencils.

Mullingar is the centre of excellent trout fishing on the adjoining loughs Ennell, Owel and Derravaragh and was once the site of an Augustinian convent *(1227)* and a Dominican convent (1239) —both dissolved bv Elizabeth I

MULLION, in architecture. a slender, vertical division between adjacent lights or subdivisions in a window, or between adjacent windows in a group. Mullions appear with the invention of tracery (*q.v.*), and are particularly characteristic of Gothic architecture throughout. and early Renaissance in north and west Europe. In traceried windows, mullions are frequently chamfered or beveled on the edges. and sometimes decorated, in addition, with a colonnette; but in late Gothic work, more elaborate moldings are common. In the rectangular window groups common in late Gothic and early Renaissance secular work, the face of the mullion is usually set back from the face of the wall so that one molding or series of moldings runs unbroken round the entire group.

A. F. KERSTING

WINDOW OF CROWCOMBE CHURCH, SOMERSET, WITH MULLIONS FROM THE ENGLISH DECORATED PERIOD, 14TH CENTURY

The mullion itself is usually molded or chamfered and this molding or chamfer is continued around the top and sides of each light. In windows 11-hose tracery subdivides the whole into more than three lights, mullions may be of different sections, with certain mullions increased in size, or may carry an additional molding. The entire group is systematized into subdivisions of two or three lights each, the larger mullions enclosing each subdivision.

MULLITE (named from the Island of Mull, Inner Hebrides, Scot., where it was first recognized as a mineral) is an aluminum silicate with ideal composition $3Al_2O_3.2SiO_2$.

Rarely found in nature, mullite is formed from firing aluminosilicate raw materials, as andalusite, sillimanite or kyanite (*qq.v.*), and is the most important constituent of ceramic whiteware, porcelains and high-temperature insulating and refractory materials. For highest thermal stability, mullite is desirable to keep the alumina content of ceramic and refractory materials high since compositions having the alumina/silica ratio at least as high as 3:2 will not melt below 1,810° C., while compositions higher in silica undergo partial melting as low as 1,545° C.

Natural mullite is found as elongated orthorhombic prisms or needles, white or faintly coloured. It has so far been recognized only in buchites or fused argillaceous enclosures in intrusive igneous rocks, suggesting very high temperatures of formation. It occurs together with cordierite, corundum, spinel and anorthite in the Island of Mull. In normal contact aureoles and regionally metamorphosed sediments the place of mullite is taken by andalusite, sillimanite or kyanite. Synthetic conditions of formation of these minerals suggest that mullite is stable under conditions of moderately low to atmospheric pressure at moderate to very high temperatures; whereas sillimanite. andalusite and kyanite require higher pressures for their formation. Synthetic mullite is manufactured by sintering or fusing mixtures of alumina and siliceous materials (as kaolin or silica).

Synthetic mullite admits Al_2O_3 into solid solution up to the composition $2Al_2O_3.SiO_2$ and most mullite grown from fused mixtures has this composition. It also commonly has Fe_2O_3 and TiO_2 in solid solution.

Mullite is difficult to distinguish from sillimanite, which has the composition $Al_2O_3.SiO_2$ and forms similar-appearing orthorhombic crystals. Refractive indices of pure mullite are lower than those of sillimanite, but Fe_2O_3 and TiO_2 present in solid solution in mullite increase the refractive index and make distinction difficult by this method. Unequivocal identification of the two minerals may be made by their infrared absorption spectra and detailed examination of accurate X-ray diffraction spectra. Two or three subvarieties of mullite having slightly different crystallographic properties may be distinguished by the latter method.

(Ru. R.; DA. R.)

MULOCK, SIR WILLIAM (1843–1944), Canadian statesman and jurist. was born at Bond Head, Ont., on Jan. *19, 1843.* From 1882 to 1905 he was a prominent member of the Liberal party in the federal house; postmaster general from *1896* to 1905, and minister of labour from 1900 to 1905. He introduced many improvements into the Canadian postal service, and in *1898* induced the Inter-Imperial Postal conference to adopt the principle

of penny postage within the British empire.

In 1905 Mulock resigned office, and was appointed chief justice of the exchequer division of the high court of the province of Ontario (1905–23). He was chief justice of Ontario from 1923 to 1936. From 1881 to 1900 he was vice-chancellor of the University of Toronto, and chancellor from 1924, and mas largely responsible for the federation between that body and Victoria university (Methodist). He was appointed privy councilor in 1925, and became a knight commander of St. Michael and St. George in 1902. He died Oct. 1, 1944.

MULREADY, WILLIAM (1786–1863), British painter, who excelled in the genre of the cottage door, the schoolhouse and young love. was born at Ennis, County Clare, Ire., on April 1, 1786, entering the Royal Academy schools in London in 1800. In 1804 he began a long series of successful exhibits. and in 1816 he was made an academician. Meanwhile. in 1805, David Wilkie began in London a vogue for highly wrought narrative pictures which had strong links in the field of naturalistic and sentimental literature. This vogue. backed by the prince' of Wales's taste for Dutch masters, inspired a reaction against the strict academism taught by Sir Joshua Reynolds. Mulready was quick to follow this. At first. like his Dutch exemplars, he painted opaquely and directly. mainly in earth colours, but later. and especially after 1830, he turned to rich glazes. Among Mulready's best-known works are his "Interior of an English Cottage" (1838, royal collection), and those given by his friend John Sheepshanks to the Victoria and Albert museum, London.

Mulready is also noted for his academic studies: children's book illustrations and his design (1840) for the first penny postage envelope. He died in Bayswater, London, on July 7, 1863.

See F. G. Stephens, *Masterpieces of Mulready* (1867).

(D. C. T. T.)

MULTAN, a municipality and cantonment, district and division of West Pakistan. The city is 4 mi. from the left bank of the Chenab and 190 mi. S.W. of Lahore. Pop. (1951) 190,122, including 14,693 in the cantonment. It is enclosed on three sides by a wall, but large suburbs have grown up outside. The fort contains the shrines of two Mohammedan saints and an ancient Hindu temple. Multan manufactures carpets, silk and cotton goods, shoes, glazed pottery and enamel work, and has an annual horse fair. It is one of the important trade centres in the Punjab region.

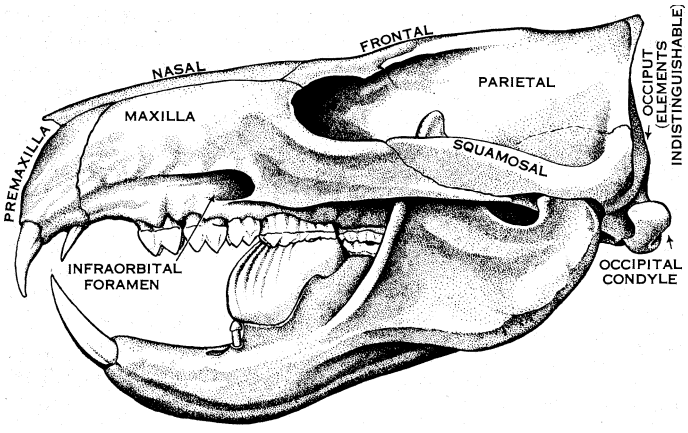
MULTAN DISTRICT occupies the southwestern angle of the Bari Doab, or tract between the Sutlej and the Ravi and Chenab, with an extension northward across the Ravi. Area, j.619 sq.mi. The population in 1951 was 2,107,603. The principal crops are wheat, millet, pulses; oilseeds, cotton and indigo. There are factories for ginning and pressing cotton. A large area is irrigated from the lower Bari Doab permanent canal. The heat is notoriously unbearable.

The early Arab geographers mention Multan as part of the kingdom of Sind, which was conquered for the caliphate by &Tohammed bin Kasim in 712 A.D. In the 10th century it became a centre of the Karmathian heretics. In 1006 it was occupied by Mahmud of Ghazni. From 1526 it was subject to the Delhi emperors. On the dismemberment of the Mogul empire in the middle of the 18th century. Multan fell to the Afghans (1779), who held it with difficulty against the Sikhs. At length. in 1818, Ranjit Singh, after a long siege, carried the capital by storm; and in 1821 he made over the administration of Rlultan with five neighbouring districts to Sawan Mal, who raised the province to prosperity by excavating canals and inducing new inhabitants to settle. After the establishment of the council of regency of Lahore, difficulties arose between Mulraj, son and successor of Sawan Mal. and the British officials.which led to his rebellion, the second Sikh war and the annexation of the whole of the Punjab. The city of Multan, after a stubborn defense, was captured in Jan. 1849.

MULTAN DIVISION was the southwesternmost of the commissioner's divisions of the former Punjab province. Area 16,761 sq.mi.; pop. (1951) 6,953,347. On Oct. 14, 1955, it was reduced to the districts of Multan, Jhang. Lyallpur and Montgomery.

MULTIPLE SHOPS: see CHAIN STORE.

MULTITUBERCULATE, an extinct, small, superficially



BY COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY

LEFT LATERAL VIEW OF COMPOSITE RESTORATION OF THE SKULL AND JAWS OF A MULTITUBERCULATE (PTILODUS MONTANUS)

rodentlike mammal belonging to the order Multituberculata, which constitutes the subclass Allotheria. They existed from the Jurassic period (about 160,000,000 years ago) of the Mesozoic era through the early part of the Cenozoic era. During most of this span (about 100,000,000 years) they were by far the most abundant mammals. There are three subfamilies, but relatively little evolutionary diversification occurred throughout their long history. These small herbivores were characterized by molar teeth with 2 or 3 longitudinal rows of cusps, 5 or 6 cusps in primitive forms and up to 30 in advanced genera. There was a single large lower incisor and three upper incisors, with one enlarged. In most genera the lower premolars were large, compressed, shearing teeth. The multituberculates are not closely related to any other mammals. They apparently arose from the mammallike reptiles independently of other groups of mammals and did not give rise to any other types.

(E. C. O.)

MUMMERS, bands of masked persons who, during European winter festivals, paraded the streets and entered houses to dance or dice in silence. The name has been connected with words such as mumble, mute: etc., with German *mumme* ("mask," "masker") and with Greek *mommo, mormo* ("a child's bugbear," "frightening mask," "ogress"). Mormo was probably an underworld goddess, resembling the ogress who gave her name to the Perchten runners, German masked mummers who paraded on Twelfthnight.

From the 13th to the 16th century the mumming or momerie was a popular (and frequently prohibited) and sophisticated amusement. John Lydgate composed the earliest extant libretti, but these were probably not intended for recital by the mummers themselves. In 1454 mummers representing 12 virtues were introduced t~ Philip of Burgundy by their presenter, Grace-Dieu, who handed him a letter explaining their disguises. During the 16th century the elaborate momerie was absorbed into the Italian masquerade and mumming became a purely popular amusement. In Great Britain from at least the 18th century mummers have presented a play, usually at Christmas. There are many variants, but it always contains a fight in which a champion is killed and revived by a doctor. The performers are male, with a fool and man in woman's clothes as stock characters. It is introduced by a presenter and concluded by a collection. Western European and Balkan analogues suggest a ritual origin.

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(E. E. H. W.)

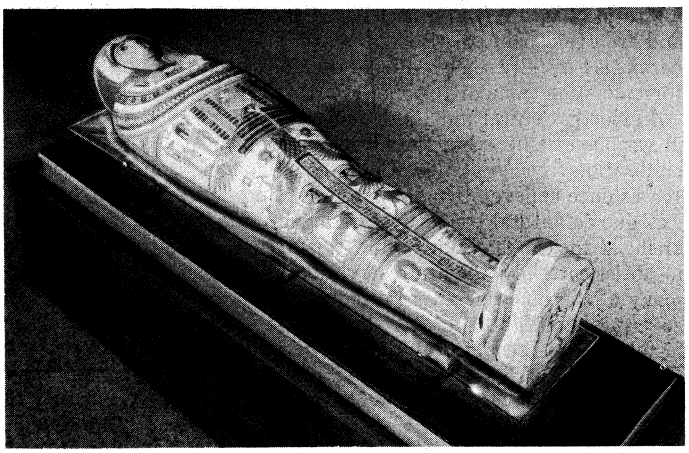
MUMMIUS, LUCIUS (2nd century B.C.), surnamed Achaïcus, Roman statesman and general. Consul in 146 B.C. Mummius was appointed to take command of the Achaean War. On capturing Corinth he massacred the inhabitants, removed all the works of art to Rome and destroyed the city. This is explained by Mommsen as due to the interference of the commercial party in the senate. In 142 he was censor with the younger Scipio Afri-

canus. Mummius was the first *novus homo* of plebeian origin who received a distinctive cognomen for military services. His indifference to works of art and ignorance of their value is shown by his well-known remark to those who contracted for the shipment of the treasures of Corinth to Rome, that "if they lost or damaged them, they would have to replace them."

MUMMY, a dead body preserved by the ancient Egyptian or other method of embalming (Persian *mumiai,* "wax"; later meaning pitch or asphalt).

EGYPTIAN MUMMIFICATION

In Egypt, in prehistoric times, the dead were buried, sometimes loosely wrapped in mats or skins, in shallow graves. the body being placed in a flexed position. The hot, dry, desert sand came into direct contact with the skin and often so completely arrested the process of decay that the hair, skin and soft parts are entirely preserved. This phenomenon of natural preservation was probably made known to the Egyptians through the ravages of grave robbers, whose depredations exposed the bodies to view. The discovery that the corpses of the dead did not suffer corruption undoubtedly strengthened, perhaps originated! the belief in the physical survival of the dead. which underlies the practice of mummification throughout the historic period, and prompted the ampler provision of food, utensils and other objects necessary to physical life which were buried with the dead. As the number of objects placed in the grave increased, the grave itself had to be more spacious. But the burial of the dead in roomier graves or in constructed tombs in which the corpse, no longer embedded in desiccating sand, was in a space filled with air which assisted decomposition, defeated the very object that had inspired the more lavish equipment. The body decayed, and the dead man did not survive to enjoy the objects with which he was surrounded. Thus arose the attempt to achieve by art the preservation of the body which unaided nature could no longer accomplish in the larger tombs.



BY COURTESY OF THE ORIENTAL INSTITUTE, THE UNIVERSITY OF CHICAGO

COFFIN OF THE LADY MERESAMON, 10TH CENTURY B.C., THEBES, EGYPT

Development and Methods. — It is probable that attempts at mummification were being made at the time of the 1st dynasty, but the earliest evidence of such attempts is afforded by a mummy of the and dynasty, which was lying in a coffin in a flexed position, and was wrapped in a complex series of bandages, the innermost of which were corroded by the action of some preservative [probably crude natron) that had been applied to the skin. Similarly treated bodies belonging to the 3rd and 4th dynasties have been discovered. By the time of the jth dynasty considerable advances had been made. The body was then laid in the extended position and the internal organs were removed through an incision in the left flank, the vacant cavity being filled with linen and resin. The outer wrappings were saturated with resin and the form of the body was then molded into shape, the details of the features being carefully modeled and emphasized by means of paint. During the Middle Kingdom, the art of embalming deteriorated somewhat; owing to the less lavish use of resin and to imperfect desiccation, the mummies of this period are usually very fragile and ill-preserved. There is definite evidence that at this period the custom of macerating the body in a salt bath had been introduced, but no attempt had as yet been made to remove the brain.

In the New Kingdom (18th–20th dynasties) numerous improvements in method nere introduced. The brain nas removed by forcing a passage into the skull, a better method of desiccation was used which preserved the tissues, and greater skill had been acquired in the preparation and application of the resinous preservative material with which the body was treated. Mummies of many of the kings and other members of the royal family of this period have survived. and although they have all been mutilated by tomb robbers, many of them are excellent specimens of the embalmer's art.

The order of events in the process of making a mummy was as follows: The corpse was taken to a specially erected tent or kiosk, where the operator first extracted the brain and then opened the body by an incision in the left flank. Through this incision all the viscera were removed with the exception of the heart, which was carefully left in *situ.* The body cavity having been washed out, the corpse was doubled into the smallest possible compass and placed in a large jar filled with a solution of salt or natron that reached to the level of the neck. In this jar the body remained for several weeks, during which time the fatty matter was dissolved away, and the whole of the epidermis peeled off, except from the head which was not immersed, and from the fingers and toes where the skin had been previously cut so as to form natural fingerstalls or thimbles of skin in order to retain the nails. Threads or wires were wound round the digits or metal sheaths were placed upon them in order to prevent the nails from becoming detached and lost. The body was then taken out of the jar, washed, straightened and desiccated. The final stages in the process involved the packing of the body cavity and skull with preservatives. plastering the body all over with a paste made of resin and fat, and wrapping it in a complex series of bandages. The internal organs were separately treated and placed in four vases known as canopic jars. The whole process occupied 70 days.

During the 21st and 22nd dynasties the art of mummification reached its highest pitch of perfection. In order to make the body more lifelike. an elaborate system of introducing packing material under the skin was devised. A schematic series of incisions was made in various parts of the body, and through these sand, mud or other material was forced into the space between the skin and the underlying muscular tissue. The material was distributed and molded into shape, and the shrunken contours of the body were thus plumped out into the form they had assumed during life. The use of canopic jars was discontinued, and the viscera were made into linen parcels and replaced in the body. The mummy was painted all over with red ochre: the lips and cheeks were rouged, artificial eyes were inserted, and, in short, every care was taken not only to preserve the body but to make it complete and lifelike. This distinctive method of embalming was first described in 1906 by G. E. Smith from the examination of 44 mummies of the period. Since then numerous other specimens of the same kind have been examined.

After this period the art declined and, although well-made mummies of the later periods are occasionally found, the embalmer's craft had become superficial and slipshod, and less care was devoted to the body than to the arrangement of the superficial bandages so as to give the mummy a presentable exterior. In the Ptolemaic period, the body was usually merely treated with molten resin, nhich destroyed the tissues; the resulting mummy was a mere cast of the contours of the body. During the 26th dynasty and after, mummies were sometimes eviscerated per *anum* instead of by the usual flank incision. Mummification survived the advent of Christianity by several centuries. The bodies of this period were not eviscerated or treated nith resin but packed in large quantities of common salt, and are usually well preserved.

Purposes of Mummification. — Throughout the period of more than 30 centuries during which mummification was practised in Egypt, the embalmers had two definite objects in view: first, the

preservation of the body from decay; and. second, the perpetuation of the personal identity of the deceased. During the Pyramid age the features of the mummy were painted on the outer wrappings. and in some cases a thin layer of plaster was applied to the head and the features painted upon it. In the 11th dynasty, the face and aig were modeled in cartonage, and this headpiece was placed upon the head of the mummy. The use of cartonage masks lasted until Ptolemaic times, but out of it mas early evolved the anthropoid coffin, on which the features, dress and ornaments of the mumrny were elaborately detailed. In Roman times, painted portrait panels were employed. All these measures had one object —the preservation of the dead man's personal identity. That the idea underlying mummification was physical survival is further indicated by the magical ceremonies to which the finished mummy was subjected. These ceremonies, which are usually known as "Opening the Mouth," had for their object the reanimation of the mummy by restoring to it the faculties of which death had deprived it. By means of magical instruments and the recitation of formulas, the eyes, mouth and ears of the dead man were opened in order that he might once more see, speak, eat and hear. The use of his limbs was restored that he might move and walk, and amulets were used to stimulate the functions of the heart, the spine and the blood Moisture and warmth were restored to the mummy by the ceremonial use of incense and libations. The funerary banquet which followed was envisaged not as spiritual food for the soul but materialistically as physical sustenance to be consumed by the mummy with its restored faculties. (See EGYPT: Religion.)

Just as many of the drugs used in ancient Egyptian medicine, even when therapeutic, were originally introduced into the pharmacopoeia for purely magical reasons, so natron, salt and resin, all of which are excellent preservatives, probably were first employed in mummification because these substances were credited with life-giving or life-preserving properties. Natron was used in the daily ceremonies for the rebirth of the sun-god, the life-giving power of salt was a tradition which survived until classical times (cf. Plutarch, Symposiacs, v, 10) and resin was believed to be the blood or some other bodily emanation of Osiris. When therefore the necessity for artificial preservation of the dead first became apparent, it was natural that the attempt to confer or prolong life should have taken the form of applying to the corpse substances which were believed to possess divine or magical potency to that end. Bitumen was not used by the Egyptians for embalming. The staple material in all periods was resin, and the fact that resin often has a lustrous pitchlike appearance probably gave rise to the assertion expressed by Strabo (xvi, ii, 45) and repeated by modern writers that the Egyptians used bitumen for their mummies. Modern chemical analysis has failed to discover any trace of bitumen in hundreds of samples of various periods. Neither Herodotus (ii, 85–88) nor Diodorus Siculus (i, 91), in their well-known accounts of Egyptian embalming, makes any reference to bitumen. Their accounts of mummification are on the whole correct although seriously wrong in certain details.

Mummified Animals.— In relatively late periods the Egyptians mummified various sacred animals. Large numbers of mummified cats and dogs have been found, but especially elaborate was the ritual employed in embalming the Apis bulls, and their tombs and gigantic sarcophagi are familiar to visitors to Egypt. Among the birds, the ibis, falcon, owl and others have been found, in addition to the preserved remains of various reptiles (especially crocodilesj and fishes. Joints of meat and trussed poultry were mummified and provided with wooden coffins shaped to fit them. The systematic study of the technique of animal mummification has yet to be made.

MUMMIFICATION IN OTHER REGIONS

Mummification in various forms has had a wide geographical distribution. In some areas, the custom has long been extinct and only tradition remains to attest its former practice, but in others it survived until more recent times, or still persists in a debased form. In studying the technique of mummification in countries from which actual mummies have been obtained, it is interesting to find that many of the arbitrary details of Egyptian procedure are repeated. In the Canary Islands, for instance, the Guanches employed certain methods which are distinctive of the Egyptian technique of the 21st dynasty. They made incisions for packing material under the skin. the sites of these incisions closely corresponding with those of the 21st dynasty Egyptian mummies, and there is a similar distribution of sandy mud in the tissues. In some cases at least, the viscera, which were always removed through a flank incision, were made into parcels and returned to the body. The epidermis was removed from the whole body but carefully retained on the fingers and toes, the nails being tied on in the characteristic Egyptian fashion. Again, in the islands of Torres straits. mummification was practised until modern times. The viscera were removed through a flank incision, or by the perineum, the brain was extracted, the body painted nith red ochre and provided with artificial eyes. The thimbles of skin on the fingers and toes mere cut, but they were pulled off. and thus stultified the object for which the Egyptians devised them. In Australia, mummification has survived in a debased form. The bodies are flexed and are often painted with red ochre, and in some cases the epidermis is carefully removed from the body even when it is destined for cremation immediately afterward.

In North, Central and South America mummies have been found in various localities, but the most numerous are those of the Inca civilization from Venezuela, Colombia, Ecuador, Bolivia and Peru. It was once believed that the preservation of these Inca mummies was due to natural properties of the soil and climate, and not to artificial measures. But, while the natural conditions in many localities certainly favour preservation, the circumstances in uhich many of the mummies mere discovered, closely wrapped in dense coverings and tightly corded, show that they must have been artificially desiccated before burial. The wrappings prevent contact of the body with the desiccating influence of the soil. and the coverings moreover closely embrace the shrunken contours of the corpse. In many instances mummies have been found which prove to have been eviscerated per *anum* or by an incision in the trunk, and others again are thickly coated with preservative material. Inca mummies are often painted red, and specimens have been examined in which the epidermis had been removed from the whole body except the fingers and toes.

Mummy as a Drug.— The belief that Egyptian mummies were prepared with bitumen or asphalt led to the virtues of that substance being transferred to bodies that had been mummified. Throughout the middle ages, and until the 18th century, mummies were exported to Europe for sale in the apothecaries' shops, and the material obtained by pounding them was reputed to have great medicinal virtue. In course of time it was forgotten that the supposed value of mummy was due to asphalt, and the virtue was transferred to bodies themselves. This led to the manufacture of spurious "mummy" from the bodies of felons and suicides, and the term was finally applied to medicated flesh in general. In spite of the denunciation of such eminent physicians as A. Paré in the 16th century, the traffic in mummy was continued until the 18th century, and the substance is frequently mentioned in the "dispensatories" of the period. In the orient, mummy is still sold in the drug bazaars. See also EMBALMING.

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MUMPS (syn. CYNANCHE PAROTIDAEA, PAROTITIS; also, "THE BRANKS"), a specific infectious disease caused by a filterable virus, characterized by inflammatory swelling of the parotid and other salivary glands, frequently occurring as an epidemic and affecting mostly young persons. The incubation period is about 17–21 days after contact; danger of transfer begins one week before the affected person feels sick and lasts about two weeks. The disease generally sets in with symptoms of a slightly febrile cold, soon followed by swelling and stitiening in the region of the parotid gland in front of the ear. The swelling speedily increases and spreads toward the neck and under the jaw, involving the numer-

ous glands in that locality. The condition is often bilateral. Pain is seldom severe, nor is there much redness or any tendency to suppuration. There is, however, great interference with mastication and swallowing. After four or five days the parts return to their normal condition. During convalescence there occasionally occur swelling and tenderness in other glands, such as the testicles in males (orchitis), and the mammae or ovaries (oophritis) in females, and rarely involvement of the pancreas, but these are of short duration and usually of no serious significance. Mumps is in general a mild disease, and requires no special treatment. The use of convalescent serum, especially in adult patients, has tended to reduce the incidence of complications.

MUN, ADRIEN ALBERT MARIE DE, COUNT (1841–1914), French politician, was born at Lumigny, Seine-et-Marne, on Feb. 28, 1841. He entered the army, saw much service in Algeria (1862) and took part in the fighting around Metz in 1870. A fervent Roman Catholic, he advocated a type of Christian socialism. His eloquence made him the most prominent member of the Cercles Catholiques d'Ouvriers. He resigned his commission (Nov. 1875), and in the following February stood as Royalist and Catholic candidate for Pontivy, which he represented from 1876 to 1910. He was for many years the most conspicuous leader of the anti-Republican party. "We form," he said on one occasion, "the irreconcilable Counter-Revolution." It was chiefly through his influence that the support of the Royalist party was given to General Boulanger. But as a faithful Catholic he obeyed the encyclical of 1892, and declared his readiness to rally to a Republican government, provided that it respected religion. He died at Bordeaux on Oct. 6, 1914.

MUN, THOMAS (1571–1641), English writer on economics, who gave the first clear and vigorous statement of the theory of the balance of trade, was baptized on June 17, 1571; he was the son of a London mercer. As a member of the committee of the East India company, and of the standing commission on trade, appointed in 1622, he was a prominent figure in mercantile circles, and well qualified to discuss current economic problems. In *A Discourse of Trade, from England unto the East Indies* (1621), he defended the East India company from the recurring early mercantilistic notion that the export of bullion was harmful to English trade. Mun argued that so long as exports exceeded imports overall, a specific drain of specie from a country had no significance. In his most important work, *Discourse on England's Treasure by Forraigne Trade,* published posthumously in 1664, Mun further developed this idea. He was buried on July 21, 1641.

(D. F. DD.)

MUNCH, EDVARD (1863–1944), Norwegian painter and an outstanding artist of extraordinary sensitiveness, was born on Dec. 12. 1863, at Löten. He was brought up in Christiania (Oslo), where he went to the school of design and was, for a short time, a pupil of the important naturalistic painter Christian Krohg. The principal works of his early period were "The Sick Child" (1886) and "Spring" (1889), both in the National gallery at Oslo, which has an excellent collection of his paintings. Already, from the end of the 1880s, Munch occupied himself with psychological and symbolical themes dealing with the problems of love and death, which were given in the 1890s an expressionistic form and colour of great strength. An important part of his work in these and later years are his woodcuts, etchings and lithographs. From about 1900, and especially after his ultimate return from abroad to Norway in 1909, the symbolic trend is less dominant in his art and the direct contact with nature, which always was of importance to him. is expressed in a very free, vigorous and broad way of painting in bright and rich colours. Fevertheless, the undercurrent of mental agitation, due to his extreme sensitivity. often breaks through. His principal works are the decorations in oil in the Oslo university festival hall (1913; inaugurated 1916). His subjects are mostly Norwegian landscape, figure compositions in interior and in landscape (sometimes alluding to Ibsen), nudes and portraits. Munch has had great influence. especially in central Europe (German expressionism) and in Scandinavia. From 1916 he lived on his estate near Oslo, where he died on Jan. 24, 1944.

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MUNCHAUSEN, BARON. This name is famous in literary history on account of the amusingly mendacious stories known as the *Adventures of Baron Munchausen.* In 1785 a shilling book of 49 pages was published in London, called *Baron Munchausen's Narrative of His Marvellous Travels and Campaigns in Russia.* No copy is known to exist, but a second edition (apparently identical) was printed at Oxford early in 1786. The publisher was a certain Smith, and he then sold it to another bookseller named Kearsley, who brought out in 1786 an enlarged edition: with illustrations under the title of *Gulliver Reviv'd: the Singular Travels, Campaigns, Voyages and Sporting Adventures of Baron Munnikhouson, Commonly Pronounced Munchausen; as He Relates Them Over a Bottle When Surrounded by His Friends.* Four editions rapidly succeeded, and a free German translation by the poet Gottfried August Biirger, from the fifth edition, was printed at Göttingen in 1786. The seventh English edition (1793) is the usual text. In 1792 a *Sequel* appeared, dedicated to James Bruce, the African traveler, whose *Travels to Discover the Nile* (1790) had led to incredulity and ridicule. Munchausen increased in popularity and was translated into many languages.

The original author was Rudolf Erich Raspe (*q.v.*). Raspe had apparently become acquainted at Gottingen with Hieronymus Karl Friedrich, Freiherr von Münchausen, of Bodenwerder in Hanover. This Freiherr von Munchausen (1720–97) had been in the Russian service and served against the Turks, and on retiring in 1760 to his estates used to amuse himself by relating extraordinary instances of his prowess as soldier and sportsman. His stories became a byword among his circle, and Raspe, when hard up in London, utilized the suggestion ior his little brochure. Raspe can only be held responsible for the nucleus of the book; additions were made by bookseller's hacks, suggestions being taken from Baron de Tott's Memoirs (Eng. trans., 1785), the aeronautical feats of Montgolfier and Blanchard and topical "sensations" of the time, such as Bruce's explorations in Africa.

MÜNCH-BELLINGHAUSEN, ELIGIUS FRANZ JOSEPH, FREIHERR VON (pseudonym FRIEDRICH HALM) (1806–1871), once Grillparzer's envied rival for popularity as a dramatist in Austria, now remembered for his stories. Born at Cracow on April 2, 1806, he studied at Vienna and rose to high rank in the Austrian civil service. In 1845 he was appointed custodian of the Kaiserliche Hofbibliothek and by 1869 was in charge of the two court theatres in Vienna. He died at Hiitteldorf near Vienna on May 22, 1871. His dramas are now forgotten because the characters lack life and their behaviour is poorly motivated; the most celebrated in their day were *Griseldis* (1835), *Der Sohn der Wildnis* (1842; Eng. trans., *Son of the Wilderness,* 1852) and *Der Fechter von Ravenna* (1854; Eng. trans., *The Gladiator of Ravenna,* 1861). His most effective stories were *Die Marzipan-Lise* (1856) and *Das Haus an der Veronabriicke* (written 1862–64). In all his tales he shows both an understanding of psychology and a skill in handling dramatic situations.

See intro. and bibliography in *Die Marzipan-Lise,* ed. by L. H. C. Thomas (1957). (L. H. C. T.)

MUNCIE, an industrial city of eastern Indiana, U.S., on the White river, 54 mi. N.E. of Indianapolis, is the seat of Delaware county. Its name (originally Munseytown, but changed by the state legislature in 1845) commemorates the Munsee clan of Delaware Indians who had a village near the present centre of the city. After Indians sold the land to the U.S. government and moved west in 1820, white settlers began to arrive. Among them were Goldsmith C. Gilbert, of New York state. the city's founder. In 1825 Gilbert bought 1 sq.mi. of land and built a cabin and store. When Delaware county was instituted in 1827 he and two other landowners donated land for county purposes and Muncie became the county seat. Muncie was founded in 1827 and was incorporated as a town in 1854 and as a city in 1865.

The first railroad (1852) and the discovery of natural gas (1886) contributed to the city's industrial growth. When gas failed in the late 1890s, the city was economically strong and continued to grow. The population was 68,603 in 1960.

Muncie has numerous and varied industries producing batteries, transmissions and castings, glass fruit jars, insulators, blocks for building, bottles, steel wire, metal card tables, chairs and lawn furniture. It is a trading centre for 22 counties in eastern Indiana

and western Ohio.

Ball State Teachers college, founded in 1918. is named for the Ball family of Sluncie. manufacturers. It became a fully accredited state institution in 1958.

Muncie nas the locale for the field work of Robert S. Lynd and Helen Merrell Lynd, on which they based their sociological studies *Middletown* (1929) and *Middletown in Transition* (1937).

(R. A. G.)

MUNDA, BATTLE OF, was fought in 45 B.C., at a site in southern Spain not precisely locatable. between the forces of Gnaeus Pompeius, son of the triumvir, and Julius Caesar.

The town was situated on a hill. and under its walls Pompey camped on March 15, 45 B.C. The next day, Caesar arrived and camped about five miles away. The two camps mere separated by an undulating plain traversed by a stream.

Caesar's army numbered about 40.000, and as Pompey refused to come down from the hill he advanced toward him. On reaching the stream Caesar halted his line. and pointed out to his officers the disadvantage of attacking uphill. This halt induced Pompey to believe that Caesar had hesitated through fear. and he moved his line down the hill. When the lines met the greatest enthusiasm was shown on both sides and little by little Caesar's cohorts were pushed back. Seizing a sword and a shield Caesar rushed forward and stimulated his men.

As evening approached both sides had exhausted their reserves. Then Caesar's 10th legion once again charged forward. driving back Pompey's left and compelling him to draw on his right to reinforce it. Caesar's cavalry then fell upon the weakened right wing, which was badly shaken, and his Numidian cavalry moved round Pompey's right wing toward his camp. Five cohorts were dispatched to head the cavalry off, and this rearward movement was mistaken by the Pompeian army as a general withdrawal. The line broke and fell back on blunda in confusion.

See PHARSALUS, BATTLE OF. (J. F. C. F.; X.)

MUNDA LANGUAGES are the languages spoken by the Mundas. tribal inhabitants of north and central India. This is the smallest (about 4,000,000 speakers) of the three major linguistic families of India. the others being the Indo-Aryan languages (*q.v.*) and the Dravidian languages (*q.v.*). There are several geographical groups: a northern one, which includes Santali! Mundari, Bhumij. Ho. Birhar. Koda. Turi, Asuri, Korwa and Kharia spoken in the Chota Nagpur plateaus of Bihar. Bengal and Orissa. South of this. Juang is spoken in central Orissa and Sora (or Savara) and Gadaba along the Andhra-Orissa border. To the west. Korku is found in the Mahadeo hills of Madhya Pradesh.

The northern group, which includes about 88% of all Munda speakers is the most important. Except for Kharia. all member languages of the group are closely related and are referred to by the single name of Kherwari. Santali is the chief language in the group. Its speakers, the Santals. are largely settled agriculturalists. Literacy among them is high. The language is written in Roman. Devanagari, Bengali and Oriya scripts. It is used as a medium of instruction in primary schools in Bihar, and there are also several Santali language periodicals. Mundari and Ho are next to Santali in number of speakers, followed by Sora and Korku. The remaining languages are spoken by relatively small isolated groups of forest dwellers and are little known.

In the past, Munda languages were more widespread than at present. They have been receding into hills and remote forest areas under the impact of Aryan and Dravidian speech. This process of recession is being accelerated as communications improve. Among the Bhumij of Southern Bengal, for example, many have adopted the local Aryan dialect while others retain their language. Intermarriage among the two groups continues.

Historically, the closest relative of the Kherwari languages is Korku. The position of other languages is not certain. Sora and Gadaba seem to form a single group. although their relationship is not as close as that of Korku and Kherwari. Kharia and Juang seem closer to Kherwari than to Sora and Gadaba. The family as a whole is said to be part of the larger family of Austro-asiatic languages (*q.v.*) comprising Khasi, Nicobarese, Mon Khmer and several tribal tongues of Malaya and Burma. The relationship has, however. not been confirmed by systematic study. All Munda languages have been greatly influenced by the surrounding Indo-Aryan and Dravidian tongues. Present vocabularies show a high percentage of loan words. The influence has also extended to phonology and morphology. The retroflex *ṭ* and d in Kherwari. for example, seem to be borrowings since they do not occur in either Sora or Korku.

The chief dialect of Santali has nine vowels: unrounded front *i, e, ẹ;* unrounded central *ï, ë, a;* rounded back *u, o,* o. The Santali of Orissa has six: *i, e, ë, a, u, o.* Mundari and Korku have five: *i, e, a, o, u.* Sora seems similar to Santali with nine vowels. There are no significant distinctions between long and short vowels in any of the languages.

The consonant systems distinguish between voiced and voiceless and aspirate and nonaspirate stops and affricates. Santali has the following: *p, ph,* b, *bh, t, th, d, dh, ṭ, ṭh, d, dh, c, ch,* j, *jh, k, kh, g, gh.* Korku and Sora lack retroflex *t, d, ṭh, dh,* but they have significant glottal stop *?*. At the end of a word, stops in all languages have unreleased and glottalized variants (sometimes referred to as checked consonants). *?* is the word final variant of k in Mundari and Santali. Santali and Mundari have three nasal consonants: a labial m, a dental *n,* a velar *ṅ*. Korku and Sora show an additional palatal *ñ*. In Mundari and Santali *ñ* is a nonsignificant variant of *ṅ*. Other consonants are: spirants v (confined to Santali'), *s* and *h;* a lateral *l;* a trill *r* and a retroflex *ṛ* with varying pronunciation. Santali, Sora and Korku have the semivowel *y;* Korku also has *w*.

Accent is predictable everywhere except in Korku, where syllables show two tonal distinctions, high tone and low tone (reflections of an old voiceless velar stop'). All languages show a large number of diphthongs. Consonant sequences are rare, except in the middle of a word.

Munda grammar distinguishes two main classes of words: nouns and verbs. Both are formed from roots by addition of affixes (*i.e.*, suffixes, infixes, prefixes). The same root may function as a verb or a noun, depending on the affix. *e.g., kombyo,* "thief," *kombyo-ket-a-e,* "he stole." Derivatives can also be formed from each root by means of affixes, *e.g., dal,* "strike." *daṗal,* "strike each other:" *bur,* "two," *banar,* "both.!'

Nouns fall into two gender classes, animate and inanimate (except in Juang and Kharia). They show three numbers (Sora has two): singular, dual and plural. Number, time. possession and other relationships that are expressed by case forms in other languages. are indicated by suffixes or by particles following the noun. *e.g., hoṛ,* "man." *hoṛ-ko,* "men.!' *hoṛ-kin,* "two men." *hoṛ-ak,* "of the man," *hoṛ seṛeṭ,* "together with the man." Personal pronouns have special forms in the dual and plural indicating whether or not the speaker is included.

The typical Santali verb construction consists of a base plus. a suffix, indicating tense and voice: follow-ed by *a,* the finite verb affix. The verbal base may consist of a single word or of two or more words, *e.g., dak-et-a,* "(it) is raining," *nël-ok-a,* "(it) will be seen." *dal oco-et-a,* '((it) is causing to see." "(it) is showing." Additional tense distinctions are expressed by means of auxiliaries: *dak-et tahekan-a,* "(it) was raining." Animate subjects and objects are shown in the verb construction. The subject indicator is inserted either after the a affix or after the word immediately preceding the verbal base. The object is shown by an infix following the base. *e.g., ako idi-e-a-ko* or *ako-ko idi-e-a,* "they take away-him-finite verb affix-they" ("they take him away"). Verbal systems in other languages are similar. Korku does not have subject suffixes; Kharia and Juang show neither subject nor object in the verb.

See G. A. Grierson, ***Linguistic*** *Survey of* ***India,*** vol. vi, (1906); P. O. Bodding, *Materials for a Santali Grammar* (1929); G. V. Ramamurti, *Manual of the Sora Language* (1931). (J. J. G.)

MUNDAY, ANTHONY (1560–1633), English poet. dramatist, pamphleteer and translator. whose importance as a predecessor of Shakespeare was only understood in the 20th century. was born near St. Paul's cathedral. London, probably in the autumn of 1560. His father, a London stationer and draper, and his

mother were both dead by Dec. 1570. Munday had some experience as an actor before he was 16, when he was apprenticed to a well-known printer. Soon afterward he commenced to write, but no copy has survived of his first publications. which included the romance of *Galien of France,* probably a translation, in 1578. After 1579 his writings streamed from the press; they included popular ballads, some original lyrics of great charm, much tedious moralizing in verse, translations of many volumes of French and Spanish romances. prose pamphlets some of which are still of historical interest, a number of edifying or moral works, but only two of his many plays. His writings were apparently the product of his leisure, at least until about the year 1600. In 1578 he was abroad, evidently as a secret agent sent to discover the plans of English Catholic refugees in France and Italy. Under a false name he obtained admission to the English college at Rome, remaining for several months as one of "the pope's scholars" in training for the reconversion of England. On his return he renewed his connection with the stage. In 1581–82 he was prominent in the capture and trials of the Jesuit emissaries who followed Edmund Campion to England, many of whom he had known at Rome. He also wrote several pamphlets, apparently with official approval, justifying the prosecution of the Jesuits and incidentally giving valuable autobiographical information. His *English Romayne Lyfe* (1582) is of permanent interest as a detailed and entertaining description of life and study in the English college at Rome; although his account is hostile, its authenticity is confirmed by numerous Catholic reports of the same events. By 1586 he had been appointed one of the "messengers of her majesty's chamber," a post he seems to have held for the rest of Elizabeth I's reign.

Little is known about Munday's career as actor and playwright, the chief focus of modern interest in him. After his journey to Rome he made some attempts to act extempore like the Italian players. He was writing for the theatre, and with success, before any of the "university wits" except John Lyly and George Peele. His *Fedele and Fortunio* (1584 at latest) is a clever adaptation of Luigi Pasqualigo's *Il Fedele;* it was played at court and was printed in 1585. *John a Kent and John a Cumber,* his earliest surviving original play. was written not later than 1590 and very probably before the middle of 1589. He was apparently the only early Elizabethan dramatist who continued to write successfully for the theatre after Shakespeare's rise in the mid-1590s. Francis Mere's *Palladis Tamia* mentions him as a busy and popular dramatist in 1598, and he was still receiving commissions from Philip Henslowe in 1602. It is difficult to tell whether his four extant plays show him at his best. but he was clearly a playwright with whom no contemporary need have disdained to collaborate. Thus special interest attaches to the fact that he was the scribe of the original version of *Sir Thomas More,* one of the alterations to which is widely believed to be in Shakespeare's handwriting. From the late 1590s until at least 1623, he wrote many of the pageants with which lord mayors of London celebrated their entry into office. His connection with the City became closer still after he undertook to revise his friend John Stow's *Survey* of *London* (1598), of which he published an expansion in 1618, and completed a further enlargement just before his death. He was buried in St. Stephen's. Coleman street, on hug. 9, 1633.

See Celeste Turner, *Anthony Mundy* (1928), the fullest account, it collects much useful material, especially bibliographical, but its conjectures need correcting. *See* also I. *A.* Shapiro, "Mundy's Birthdate," in *Notes and Queries,* new series, 201 (1956), "The Significance of a Date," *Shakespeare Survey,* 8 (1955). (I. **A.** S.)

MUNDELEIN, GEORGE WILLIAM (1872–1939), U.S. cardinal and archbishop of Chicago, was born in New York city on July 2, 1872. He received his education at Manhattan college and St. Vincent seminary, Beatty, Pa., subsequently proceeding to Rome and studying theology at the Urban College of the Propaganda in that city. He was ordained priest on June 8, 1895, at Rome, and became secretary to the bishop of Brooklyn, N.Y., and pastor of the Lithuanian church, being made chancellor of the diocese in 1897. He was appointed auxiliary bishop of Brooklyn, with the titular see of Loryma, in 1909 and became archbishop of Chicago on Nov. 30, 1915. He was created a cardinal by Pope Pius XI on March 24. 1924. Mundelein was a prominent figure at the Eucharistic congress held in Chicago in June 1926. He died Oct. 2, 1939, at his home adjoining the Seminary of St. Mary's of the Lake, founded by him at Mundelein, Ill., a town near Chicago named in his honour.

MUNICH (MÜNCHEN), the capital of the *Land* of Bavaria in Germany, and the third largest town in Germany (after Berlin and Hamburg), lies on the gravel banks of the Isar river, which flows through the middle of the town. It is 25–37 mi. from the edge of the Alps and 1,700 ft. above sea level. The average annual temperature is about 45.5° F. Pop. (1950) 830,795.

History. — The oldest form of the name Munich is Munichen, *i.e.,* the home of the monks; the town traces its origin to the Benedictine foundation at Tegernsee. Henry the' Lion granted it the right to hold a market in 1157–58 and he therefore may be held to be Munich's real founder. In 1255 Munich became the home of the Wittelsbach family, and for 700 years, until the 1918 revolution, the Wittelsbachs remained closely connected with the to n's destiny. The emperor Louis IV, called the Bavarian, in the 14th century; blaximilian I, elector of Bavaria, in the 17th; and Louis I, king of Bavaria, in the 19th, played particularly important parts in the history of the town. Louis the Bavarian expanded the town to a size at which it remained up to the end of the 18th century. The economic advance and prosperity of Munich lasted until the beginning of the Thirty Years' War, which brought a short occupation by Gustavus Adolphus in 1632 and a plague epidemic in 1634–35. During this time the population was reduced by one-third. In 1791 the gradual demolition of the fortifications was begun. In 1808 Friedrich von Sckell and Karl von Fischer produced a magnificent building plan for the Max and Ludwig suburbs. In 1800 the population was 40,000, and a year later the first Protestant was admitted to citizenship in what had been until then a purely Roman Catholic town. Since 1821 Munich has been the seat of the archbishop of Munich-Freising.

In 1854 Munich became a "city" with a population of 100,000 and in 1900 it passed the 500.000 mark. The city was the scene of Hitler's political activity in the 1920s. It was there that he joined the Nationalsozialistische (Nazi) Deutsche Arbeiter Partei and became its leader, held vast mass meetings in the square. and organized his first party army. The beer cellar can still be seen where he held meetings which led to the *Putsch* against the Bavarian authorities on Nov. 8, 1923. In this cellar too, an attempt was made on Hitler's life with a bomb in 1939 on the anniversary of the *Putsch,* the explosion occurring shortly after he had left the cellar. In World War II nearly 50% of Munich's buildings were destroyed but most of the damage was subsequently repaired.

The Town. — The old town is clustered round the ancient crossroads formed by Tal. Kaufinger- and Neuhausstrasse, running east and west. and by Theatiner-, Wein- (or Residenz-). Diener- and Sendlingerstrasse. running north and south. The old town has become more and more of a business centre and has lost much of its ancient character. Some of the old buildings still stand, though damaged in World War II, and among them are three of the seven town gates — Karlstor. Sendlingertor and Isartor, all dating from the 14th century — and medieval buildings such as the cathedral (1468–88), the centre of the city's religious life. and the old town hall (1470–80), in the Marienplatz, with its beautiful wooden barrel vault. The Peterskirche. the oldest church in the town, was completely destroyed in World War II but has been rebuilt almost in its original form; the Salvatorkirche, a medieval building, is now a Greek Orthodox church; the Heiliggeistkirche, the former arsenal of the town in Jakobsplatz, is now the municipal museum and in it are the ten original Maruska (morris) dancers carved in wood by Erasmus Grasser for the town hall; and the house at Burgstrasse no. 3 is the only remaining Gothic private house. The oldest of the Wittelsbach residences, the 15th-century Alte Hof. has retained its medieval appearance to a great extent. A later residence, the Neue Veste, lies between the Hofgarten and Max-Josef-Platz. The original building dates from 1385, but the style of every period up to the 19th century was tried out on it with superb effect; it was destroyed in World War II but it was planned to rebuild it as far as possible in its original form. Of the

Maxburg, built in 1590 by Duke William V, only one tower remains; a modern steel and concrete building now stands in its place. The Renaissance left behind it the Münzhof, at one time the duke's art gallery and stables (1563–67). The Michaelkirche (1583–97) is considered to be the most important Renaissance church in Germany.

The old town is predominantly baroque and rococo. Italian models inspired the Theatinerkirche, the Dreifaltigkeitskirche and the Bürgersaal (all built around the beginning of the 18th century). St. Michael in Berg am Laim, the Johann-Nepomuk-Kirche and the Residenztheater were built in the first half of the 18th century. This theatre, in the Neue Veste, mas destroyed in World War II but the costly interior decorations were saved and it was rebuilt in its original form and reopened in 1958. Outside the town walls were built summer castles: Nymphenburg. with the little rococo jewel Amalienburg. and Schleissheim. The Bavarian landed gentry and court nobility built their houses round the court at the same time early in the 18th century. Of these the Peysing-Palais. the Portia-Palais and the Palais Holnstein still remain.

Munich received the first great impetus to expand beyond the old town through the magnificent building and artistic development under King Louis I. He had the monumental Ludwigstrasse built, between Siegestor and Feldherrnhalle. and in it were the state library. the Ludwigskirche and the university. Other work commissioned by Louis I were the Konigsplatz with the Glyptothek. which houses a collection of ancient and modern sculpture. the Propylaen, the Staatsgalerie. the Alte Pinakothek, containing one of' the great European collections of paintings, the Bonifazius-Basilika, the king's apartments and the court banqueting hall. Louis' son. Maximilian II (1848–64), built the Maximilianstrasse with the Maximilianeum, today the seat of the Bavarian *Landtag* (diet). In addition to the university, which was moved from Landshut to Munich in *1826,* there are a technical college and academies of art and music.

Since the middle of the 19th century Munich has become, to an ever increasing degree, a town for exhibitions and congresses. It is also an important industrial city, manufacturing precision instruments, optical and electrical appliances. vehicles. chemicals, cigarettes and beer. Munich is a trade centre, connected by rail to all the main towns of Germany and Austria. There are three *Autobahnen,* one to France at Karlsruhe, one to Austria at Salzburg and one to Berlin, and there is the important waterway down the Isar river to the Danube. Munich is a seat of great banking houses, a wholesale market that has one of the biggest turnovers for fruit and vegetables from south and southeast Europe and a vast slaughterhouse and stockyards. (ML. S.)

MUNICIPAL ENTERPRISE: *see* PUBLIC ENTERPRISE.

MUNICIPALITY. In the United States a municipality is an urban unit of local government. It is one of five basic types of local government: the other types are counties. townships. school districts and special districts. A municipality. according to the U.S. bureau of the census, is a political subdivision of a state within which a municipal corporation has been established to provide general local government for a specific population concentration in a defined area. A municipality may be designated as a city, borough, village or tom-n. except in New England states: New York and Wisconsin where "town" relates to an area subdivision of the county or state.

Municipal corporations are organized under the applicable state constitution and laws. with powers of government expressly or implicitly conferred by state constitution. state laws or charter. These powers are exercised by a governing body elected by the people. Each state sets its own legal requirements for incorporation. The states have set up restrictions designed to prevent the incorporation of territory not truly urban in nature. A municipality therefore is the response of the state government to the need for certain public services in addition to what is available from the other local governments in the area.

Europe. — The law in many European countries provides for one type of local government unit to which the term municipality may be applied. The same legal provisions usually apply to all municipalities. but in a fen. cases a special charter may be given to one or two of the largest cities. The system of the uniform type of municipality exists in France (*commune*), Italy (*comune*), the Lon Countries (*Gemeente*) and in most of the Scandinavian countries. Several other European countries, the most important of which are Great Britain and Germany. have a diversified system of local government in which several different categories of local government units exist.

In Great Britain the term "municipality" is in general used only for the large boroughs (municipal corporations). *See* also CITY; CITY GOVERNMENT; CITY MANAGER; COMMUNE (OF PARIS, 1871); COMMUNE (MEDIEVAL); BOROUGH; LOCAL GOVERNMENT; HOME RULE (MUNICIPAL). (0. F. N.)

MUNICIPAL OWNERSHIP: *see* PCBLIC ENTERPRISE.

MUNICIPIUM, the term applied primarily to a status, a certain relation between individuals or communities and the Roman state (Lat, *munus,* a "duty" or "privilege"); subsequently to a community standing in such a relation to Rome.

Early History. — The status had its origin in the conferment of citizenship upon Tusculum in 381 B.C., and was widely extended in the settlement made by Rome at the close of the Latin War in *338* B.C. *(see* ROME: *Ancient History).* Italian towns were then divided into three classes: (1) *Coloniae civium Romanorum,* the members of which had all the rights of citizenship; (2) *municipia,* which received partial citizenship; *(3) foederatae civitates,* separate from Rome. and in relations with it separately arranged for each state by treaty (*foedus*). The *municipia* stood in very different degrees of dependence on Rome. Some, such as Fundi. enjoyed a local self-government only limited in the matter of jurisdiction; others. such as Anagnia, were governed directly from Rome. But all had certain features in common. Their citizens were called upon to pay the same dues and perform the same service in the legions as full Roman citizens. but had not the right of voting in the comitia (*ius suffragii*) or of holding Roman magistracies (*ius honorum*). Jurisdiction mas entrusted in every *municipium* to *praefecti iuri dicundo* sent out from Rome to represent the praetor urbanus. *Municipium* must therefore have been more a burden than a privilege. But after the Second Punic War, when Rome had become the chief power in the Mediterranean. we can trace a tendency among the Italian cities to regard citizenship of this great state as a privilege and to clsim complete citizenship as a reward of their services in helping to build up the Roman power. During the 2nd century B.C. the *ius suffragii* and *ius honorum* were conferred upon numerous *municipia.* They can have exercised their public rights but seldom, because of their distance from Rome.

Later Republic and Empire. — The result of the Social War *(see* ROME: *Ancient History)* was the establishment of a new uniform municipality throughout Italy. By the Lex Iulia of 90 B.C. and the Lex Plautia Papiria of 89 B.C., every town in Italy which made application in due form received the complete citizenship. The term *municipium* was no longer confined to a particular class of Italian towns but included all urban communities of Roman citizens in Italy. The organization of a municipal system. which should regulate the governments of all these towns on a uniform basis and define their relation to the Roman government, was probably the work of Sulla. Julius Caesar extended the sphere of the system by his enfranchisement of Cisalpine Gaul and the inclusion of all the towns of that region in the category of *municipia.* Xugustus and his successors granted to existing towns in the provinces either the full citizenship or a partial *civitas* known as the *ius Latii,* and the distinction survived for some time in the provinces between *coloniae, municipia iuris Romani* and *municipia iuris Latini.* But the uniform administration gradually adopted in all three classes rendered the distinction unimportant, and the general term *municipium* is used of all alike.

Internal Constitution. — Of the internal life of the *municipia* very little is known before the empire. when a series of municipal laws gives us a detailed knowledge of the constitution imposed on the *municipia,* and a host of private inscriptions gives particulars of their social life.

The municipal constitution of the 1st century is based upon a type common to Greece and Rome from earliest times. The

government of each town consists of magistrates. senate and assembly. and is independent of the Roman government except in cases of higher civil jurisdiction, which come under the cognizance of the praetor urbanus at Rome (*see* PRAETOR). Each community is bound to perform certain services to the imperial government, such as the contribution of men and horses for military service, the maintenance of the imperial post and the entertainment of Roman officials or billeting of soldiers. The citizens were of two classes: (1) *cives*, whether by birth. naturalization or emancipation; (2) *incolae*, who enjoyed a partial citizenship based on domicile for a certain period. Both classes were liable to civic burdens, but the *incolae* had a limited right of voting. The citizens were grouped in tribes or *curiae*, and accordingly the *comitia* sometimes bore the name of *tributa*, sometimes that of *comitia curiata*. The theoretical powers of these *comitia* were extensive. but the growing influence of the municipal senates gradually made popular election a mere form.

Social Organization Under the Empire.—The *municipia* of the empire may be treated under three heads: (1) as centres of local self-government; (2) as religious centres; (3) as industrial centres.

1. The chief feature of the local government is the activity of the authorities in improving the conditions of life in the town. Provision was made out of the public funds for feeding the poor and providing corn which could be bought by ordinary citizens at a moderate price. In Pliny's time there existed in many towns schools controlled by the municipal authorities. Pliny promoted another kind of school at Como, where the leading townspeople subscribed for the maintenance of the school and the control remained in the hands of the subscribers. Physicians seem to have been maintained at the public expense. The water supply was provided out of the municipal budget and controlled by magistrates. To enable it to bear the expense involved in all these undertakings, the local treasury was assisted by benefactions from individual citizens; but direct taxation was hardly ever resorted to. The treasury was filled out of the proceeds of the landed possessions of the community, especially mines and quarries, and out of import and export duties.

2. The chief feature in the religious life of the towns was the position they occupied as centres for the cult of the emperor. Caesar worship developed spontaneously in many provincial towns during the reign of Augustus. and was fostered by him and his successors as a means of promoting a strong loyalty to Rome and the emperor, which was one of the firmest supports of the latter's power.

3. The development of this free industrial class is the chief feature of the *municipia* considered as centres of industry and handicraft. The rise of the equestrian order had to some extent modified the old Roman principle that commerce was beneath the dignity of the governing class; but the aristocratic notion survived in Rome that industry and handicrafts were fitted only for slaves. In the provincial towns, however, this idea rapidly disappeared, and even in Italy the inscriptions give evidence of the existence of a flourishing free industrial class. The members of this class show a strong tendency to bind themselves together in guilds *(collegia, sodalitates)*. These societies were viewed with suspicion by the emperors as politically dangerous; but in spite of opposition the guilds in the provincial towns grew and flourished. The ostensible objects of such *collegia* were the worship of some god and provision for the funerary rites of their members.

The policy of encouraging the independence and civic patriotism of the towns was superseded in the 3rd and 4th centuries A.D. by a deliberate effort to use the towns as instruments of the imperial government. under the control of representatives of the emperor in the provinces. This policy was accompanied by a decay of civic feeling and municipal enterprise, which showed itself in the unwillingness of the townsmen to become candidates for local magistracies. Popular control of the towns was ceasing to be a reality by the end of the 1st century.. Two centuries later local government was a mere form.

MUNK, KAJ HARALD LEININGER (1898–1944), Danish playwright, priest and patriot who was a rare exponent of religious drama with a strong sense of the theatre and a passionate quality in his writing not often found among his fellow countrymen. He was born at Maribo on Jan. 13. 1898, and studied at Copenhagen university, where he began his first produced play, *En Idealist* (1928; Eng. trans., *Herod the King*, 1955). This was originally misunderstood by the critics, although ten years later it was received with acclamation.

In 1931 he achieved success with *Cant* (on the rise and fall of Anne Boleyn), and the impression made by *Ordet* (1932; *The Word*, a miracle play set among Jutland peasants) established him as Denmark's leading dramatist. For his principal character he often chose a dictator or "strong" man whom he showed struggling, in vain, against God. This gave Munk opportunity to preach, and to show that he could do this as effectively from the stage as from the pulpit.

En Idealist, Ordet and *Han sidder ved Smeltediglen* (1938; Eng. trans., *He Sits at the Melting-Pot*, 1944; a drama of Hitler's Germany) are his three best plays, though several others, such as *Cant, Kaerlighed* (1926) and *I Braendingen* (1929) remain popular. Kaj Munk was a conscientious and much-loved parish priest, and during World War II his bold, outspoken sermons, many of which were printed, drew masses to the ranks of the Resistance and led to his murder near Silkeborg by the Nazis on Jan. 4, 1944.

See R. P. Keigwin (ed and trans.), *Kaj Munk, Some Examples of His Work* (1944), *Five Plays by Raj Munk*, with preface and translations (1955). (R. P. KN.)

MUNKACSY, MIHALY VON (MIHÁLY VON MUNKÁCSY; originally MICHAEL LIEB) (1844–1900), Hungarian painter, was born at Munkács on Feb. 20, 1844. He was apprenticed to a carpenter in 1855, but shortly afterward made the acquaintance of the painters Fischer and Szamossy, whom he accompanied to Arad in 1858. About the end of 1867 he was working at Düsseldorf. where he painted (1868–69) "The Last Day of a Condemned Prisoner," exhibited in the Paris Salon in 1870. He had already paid a short visit to Paris in 1867, but in 1872 he settled there permanently. Munkacsy's other chief pictures are "Milton, Blind, Dictating *Paradise Lost* to His Daughters" (Paris exhibition, 1878; now in the New York Public library), "Christ Before Pilate" (1881), "Golgotha" (1883), "The Last Moments of Mozart" (1885), "Arpad, Chief of the Magyars, Taking Possession of Hungary," exhibited at the Salon in 1893. His style was semi-realist. semiacademic. He died on April 30, 1900.

MUNNICH, BURKHARD CHRISTOPH, COUNT (1683–1767), Russian soldier and statesman, was born at Neuenhuntorf, in Oldenburg, in 1683, and was in the French, Hesse-Darmstadt and the Saxon services before, and was the rank of general in chief and the title of count, he joined the army of Peter II of Russia. In 1732 he became field marshal and president of the council of war. In 1734 he took Danzig, and with 1736 began the Turkish campaigns which made Miinnich's reputation as a soldier. Working along the shores of the Black sea from the Crimea, he took Ochakov in 1737, and in 1739 won the battle of Stavutschina, took Khotin (or Choczim) and established himself firmly in Moldavia. Marshal Münnich then entered on political rivalry with Biron, duke of Courland. During the revolution of 1741 he was condemned to death, reprieved, and sent to Siberia, where he remained until 1762. when he was released. Catherine II employed the old field marshal as director-general of the Baltic ports.

He wrote an *Ebauche pour donner une idée de la forme de l'empire de Russie* (1774), and voluminous diaries, of value for the history of the period, have appeared in various publications—Herrmann, *Beiträge zur Geschichte des russischen Reichs* (1843).

See Hempel, *Leben Münnichs* (1742); Halem, *Geschichte des F. M. Grafen Munnich* (1803; 2nd ed., 1838); Kostomarov, *Feldmarschall Munnich* (*Russische Geschichte in Biographien*, v. 2).

MUÑOZ-RIVERA, LUIS (1859–1916), Puerto Rican commissioner at Washington (1910–16), was born at Barranquitas, Puerto Rico. in 1859. In 1889 he founded the newspaper *La Democracia*, the purpose of which was to obtain Puerto Rican autonomy from Spain, and he soon became a leader in the autonomist parties In 1897 Puerto Rico was given home rule, and Muñoz-Rivera nas first secretary of state and later president of

the first Autonomist cabinet. He resigned in 1899 and spent most of the rest of his life in the United States, urging measures to help his country. He died in 1916, just before successful completion of his campaign for passage of the Jones bill, which gave Puerto Rico a large measure of self-government.

MUNSEY, FRANK ANDREW (1854–1925), U.S. publisher and newspaper proprietor, was born in Mercer. Me., on Aug. 21, 1854. He was one of the largest accumulators of magazines and newspapers of his day and a dominant figure in the growing trend toward journalistic consolidation. Beginning business in a country store, he became manager of the Western Union office in Augusta, Me. In 1882 he established, in New York city. the *Golden Argosy,* later the *Argosy.* Among other periodicals founded by Munsey were *Munsey's Weekly* (1889), *Munsey's Magazine* (1891), the *All-Story Weekly* (1904) and the *Railroad Man's Magazine* (1906). His outstanding newspaper purchases were the *New York Star* (1891), the *Baltimore News* (1908), the *New York Press* (1912), the *New York Sun* (1916), the *New York Evening Telegram* (1920), and the *New York Herald* (1920). He died Dec. 22, 192j, leaving most of his estate, estimated at $20,-000,000, to the Metropolitan Museum of Art, New York city.

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MÜNSTER, SEBASTIAN (1489–1552), German Hebraist, mathematician, cartographer and cosmographer. whose *Cosmograplzia* is the earliest German description of the world, was born in 1489 at Ingelheim in the Palatinate. He studied at Heidelberg and Tiibingen. He entered the Franciscan order, but later adopted Lutheranism. In 1527 Miinster was appointed professor of Hebrew at Basel and he was the first German to edit the Hebrew Bible (2 vol., 1534–35); his edition was accompanied by a new Latin translation and a number of annotations. In 1531 he contributed to *Novus Orbis,* published by J. Herwagen of Basel (1532). In 1540 he published a Latin edition of Ptolemy's *Geographia Universalis* which included 48 woodcut maps (27 after Ptolemy and 21 designed by Miinster himself), but his most important work was his *Cosmographia* which appeared first in 1544. It attracted the educated world of his day and was warmly received by Catholic and Protestant alike because of bliinster's impartial tone. About 40 editions were printed in Germany alone, and copies were handed down in families as a kind of secular bible. The most valued edition is the revision of 1 jjo which is especially prized for its portraits and its city and costume pictures. He died of the plague at Basel on May 23, 1552.

Munster's other books include: *Chaldaica Grammatica* (1527); *Dictionarium trilingue* in Latin, Greek and Hebrew (1530); *Germania descriptio* (1530); *Mappa Europae* (1536); *Rlzaetia* (1538); *Organum Uranicum* (1536).

See V. Hantzsch, "Sebastian Miinster," *Publications of the Royal Society of Sciences of Saxony,* vol. xviii (1898). (E. M. J. C.)

MÜNSTER, a town in North Rhine-Westphalia, Ger., lying in a sandy plain on the Dortmund-Ems canal. 107 mi. S.W. of Bremen. Pop. (1950) 118,496. Münster is first mentioned about the year 800, when Charlemagne made it the residence of Ludger, bishop of the Saxons. Because of its distance from any available river or important highway, the growth of the settlement round the *monasterium* was slow, and it was not until after 1186 that it received a charter, the name Münster having supplanted the original name of Mimegardevoord about a century earlier.

During the 13th and 14th centuries the town was one of the most prominent members of the Hanseatic league. At the time of the Reformation, the armed intervention of the bishop suppressed all divergence from the older faith. The authority of the bishops, who usually resided at Ahans, was limited, but in 1661 the bishop built a citadel, and deprived the citizens of many privileges. The bishopric was secularized in 1803. During World War II part of the city was destroyed by air raids.

The town preserves its medieval character, especially in the "Prinzipal-Markt" and other squares, with their gabled houses and arcades. The fortifications were dismantled during the 18th century. The cathedral was rebuilt in the 13th and 14th centuries, and combines Romanesque and Gothic forms; its chapter house is specially fine. The Gothic church of St. Lambert (14th century) was largely rebuilt after 1868; on its tower hang three iron cages in which the bodies of John of Leiden and two of his followers were exposed in 1536 The church of St. Ludger, erected in the Romanesque style about 1170, was extended in the Gothic style about 200 years later. The church of St. Maurice, founded about 1070, was rebuilt during the 19th century, and the Gothic church of Our Lady dates from the 14th century.

Other noteworthy buildings are the town hall. a Gothic building of the 14th century, and the Stadtkeller, mhich contains a collection of early German paintings. The room in the town hall called the Friedens Saal, in which the peace of Westphalia was signed in Oct. 1648, contains portraits of many ambassadors and princes who were present at the ceremony. The Schloss, built in 1767, was formerly the residence of bishops of Munster. The private houses are admirable examples of German domestic architecture in the 16th, 17th and 18th centuries. The University of Miinster, founded after the Seven Years' War and closed at the beginning of the 19th century, was reopened as an academy in 1818 and again attained the rank of a university in 1902. Industries include weaving, dyeing, brewing and printing and the manufacture of furniture, pianos, chocolates, surgical instruments, ropes, soap, cement and machines.

MUNSTER (MUMHA), the southwesternmost of the traditional five provinces or "fifths" of Ireland *(see* IRELAND: *History).* The counties of Munster are Clare, Cork, Kerry, Limerick, Tipperary and Waterford and its land area is 9,315 sq.mi., which is 29.3% of the total area of Ireland. The Shannon estuary, at the top of mhich stands Limerick, is the deepest indentation in the irregular western coast line with its many offshore islands. hlunster contains Ireland's highest hill, Carrantuohill (3,414 ft.) in Kerry, and is specially rich in archaeological remains. The political and economic capital in modern times has been Cork (*q.v.*), but Cashel (*q.v.*), with an archbishop, remained the ecclesiastical capital for the Roman Catholic Church. The population of Munster increased rapidly after the 18th century and rose from approximately 2,227,000 in 1831 to 2,396,000 in 1841, but it had dropped to 1,858,000 in 1851, after the great famine of 1845–47. From that time it decreased steadily and had fallen to 877.238 in 1956. The decline has been caused chiefly by a general movement from the agricultural to the industrial areas (Munster is predominantly agricultural) and by emigration overseas.

MÜNSTERBERG, HUGO (1863–1916). German-U.S. philosopher, psychologist, pioneer in juristic and industrial psychology and psychotherapeutics, was born in Danzig, Prussia, on June 1, 1863. Münsterberg received his early education at the *Gymnasien* in Danzig and Geneva, his Ph.D. at Leipzig (1885) with Wilhelm Wundt (*q.v.*) and his M.D. at Heidelberg (1887). He habilitated (1887) as an instructor in psychology at Freiburg, established a psychological laboratory there, and was soon publishing significant researches in his *Beiträge zur experimentellen Psyclzologie* (1889–92). In 1892 he went to Harvard as a visiting professor on leave of absence from Freiburg, and in 1897 he returned to Harvard, where he remained the rest of his life; to direct the psychological laboratory. He died suddenly, while lecturing to a class at Radcliffe college, on Dec. 16, 1916.

Munsterberg did not long confine himself to his laboratory; he soon was extending psychology into neighbouring and allied fields—law, business, industry, teaching, medicine, sociology. By many scientific historians he is credited with being the founder of applied psychology *(see* PSYCHOLOGY, APPLIED).

His chief books are: *Psychology and Life* (1899); *Grundzüge der Psyclzologie* (1900); *Die Amerikaner* (1904); *Philosophie der Werte* (1908); *Psychology and the Teacher* (1909); *On the Witness Stand* (1910); *Psychology and Industrial Efficiency* (1913); *Psychology: General and Applied* (1914); and *Grundzüge der*

Psychotechnik (1914).

His biography. *Hugo Münsterberg: His Life and Work* (1922). written by his daughter. Margaret Münsterberg, is personal. No evaluation of his contributions to psychology and philosophy is attempted. The book gives his complete bibliography in an appendix. (K. M. D.)

MUNTHE, AXEL MARTIN FREDRIK (1857–1949), Swedish physician and author. wrote several books of reminiscences, most notable of which was *The Story of San Michele* (1929), first published in the United States in English and translated later into many languages. Born at Oskarshamn on Oct. 31, 1857, he received his M.D. degree at Paris and was in private practice there after 1881 and in Rome after 1890. Physician-in-ordinary to Gustav V after 1903 and to his queen (1908–1930). Munthe died on Feb. 11, 1949, in the royal palace at Stockholm, where he had been a house guest for 10 years.

MUNTJAC, a small deer. of the genus *Muntiacus*, found only in southeastern Asia (*see* DEER'). Muntjacs have long bodies and short limbs and necks. The antlers of the buck are short, simple and supported on long processes of the frontal bones. the front edges of which are continued downward as ridges on to the face. The upper canine teeth of the male form long tusks. loosely implanted in their sockets. The presence of both tusks and antlers in the same species is unusual. Solitary in habit. the muntjacs haunt hilly forests, living in the dense thickets, emerging at dawn and dusk to graze. They are remarkable for the facility with which they creep through tangled undergrowth. Their alarm cry is a short, shrill bark. The Indian muntjac is *M. muntjak;* other races occur from Tibet and southeastern China to Borneo.

MUNTZ METAL, a variety of brass. invented by G. F. Muntz in 1832. is also known as yellow metal because the large zinc content gives it a yellow colour. The alloy is composed of 60% copper and 40% zinc. It can be forged, and is employed for machine parts exposed to corrosion. (*See* ALLOYS; BRASS.)

MÜNZER, THOMAS (*c.* 1489–1525), German anabaptist. was born at Stolberg in the Harz. and educated at Leipzig and Frankfort. graduating in theology. In 1520 he became a preacher at the Church of St. Mary, Zwickau, and his rude eloquence. together with his attacks on the monks. soon raised him to influence. Aided by Nicholas Storch. he formed a society on principles akin to those or' the Taborites, and clainied that he was under the direct influence of the Holy Spirit. Driven out of Zwickau, he went to Prague. where he won numerous adherents. but his violent language brought about his expulsion from that city also. At Easter 1523 Münzer came to Xllstedt and began to preach at the Church of St. John. His preaching and his denunciation of Martin Luther's teaching soon produced an uproar in Allstedt. and he left the town for Lliihlhausen. where Heinrich Pfeiffer was already preaching doctrines similar to his own. The union of Münzer and Pfeiffer caused a disturbance in that city and both were expelled. Münzer went to Nuremberg, where he issued a writing against Luther. He now denounced established governments. and advocated community of goods. After a tour in south Germany he returried to Mühlhausen. overthrew the governing body of the city and established a communistic theocracy. The Peasants' War had already broken out in various parts of Germany; and Münzer collected a body of men. and established his camp at Frankenhausen. On May 15. 1525, the peasants were dispersed by Philip. landgrave of Hesse. Münzer was executed on May 27, at Mühlhausen.

His *Aussgetrückte Emplössung des falschen Glaubens* was edited by R. Jordan (Mühlhausen, 1901), and the liie of Münzer, *Die Histori von Thome Müntzer dcs Anfengers der döringischen Uffrur,* has been attributed to Philip Melanchthon (Hagenau, 1525). *See* also O. Merx, *Thomas Münzer und Heinrich Pfeiffer* (Gottinnen. 1889); J. Zimmermann. *Thomas Münzer* (1925). The Saxon Historical Commission had (1928) in hand an edition of his letters.

MURAD (AMURATH) I (1326–1389), surnamed Khudavendigyar !"sovereign"). Ottoman sultan. the son of Orkhan and the Greek princess Nilufer, succeeded his father in 1362. His main object was to extend the Turkish dominions in Europe and in token of this purpose he transferred his capital from Brusa to Adrianople (1365). At the same time, however. he had to face in Anatolia a coalition of princes who were apprehensive of the growing power of the Ottomans. This coalition. headed by the bey of Karaman. was not effectively broken until the battle of Konia (1387).

The Balkan states. divided by jealousies. could do little to stem Jlurad's advance into Europe. By 1373 most of Jlacedonia had been annexed. and in 1375 the despot of Serbia agreed to pay a yearly tribute in men and money. whereupon the Greek emperor. despairing of aid from the Catholic pon-ers. came to terms with Murad. Murad used the ensuing years of peace to extend the feudal system of *timars* and *zeamets* to the newly conquered territories. A renewal of hostilities in 1380 led to the capture by the Turks of Monastir, Nish and Sofia. The armies of the alliance created by Lazar of Serbia were, after an initial success, crushed by Murad at the hattle of Kossovo (1389), but at the cost of his own life. The manner of his death is not clear.

Some historians have called Jlurad cruel because of his treatment of his son Savji. who in 1385 made an attempt on the throne. But he showed no less fatherly affection in putting down the insurrection than Savji had shown filial piety in beginning it.

Murad was not only a stern and courageous soldier. but also a clever and patient diplomat. It was through his diplomacy that he turned the principality that he had inherited from his father into the makings of an empire. (G. L. L.)

MURAD (AMURATH) II (1403–1451), Ottoman sultan, succeeded his father. Mohammed I. in 1421. Murad set himself to complete his father's work of restoring the unity of the Ottoman state. dismembered among the sons of Bayezid. Having sustained many reverses in the Balkans at the hands of János Hunyadi, he concluded a ten years' peace with Hungary at Szegedin (1444). Shortly afterward he abdicated in favour of his 14-year-old son Alohammed, but soon returned from his retirement at Manisa upon a resumption of hostilities by the Christian pon-ers in violation of the treaty. After his victory at the battle of Varna he again withdrew to Manisa. but a revolt of the janissaries in the following year induced him to return to power. He spent the remaining six years of his life in warfare in Europe. defeating Hunyadi at Kossovo (1448). He died at Adrianople in 1451.

Murad was the first Ottoman to maintain a circle of distinguished poets and scholars at his court.

During his reign. prominence was given to the legend. later accepted as history, of the descent of the Ottomans from the tribe of Qayi. the most distinguished branch of the Oghuz Turks. This fact points to the beginnings of the belief in the Ottoman's imperial destiny.

See P. Wittek, *Rise of the Ottoman Empire* (1938). (G. L. L.)

MURAD (AMURATH) III (1546–1595). Ottoman sultan, the eldest son of Selim II. succeeded his father in 1574. His accession marked the beginning of the decline of the Ottoman power, which had been maintained under Selim only by the genius of the grand vizier Mohammed Sokollu. For though Sokollu remained in office until his assassination in 1579, his authority was undermined by the sultan's \-enetian wife Safiye, his mother. Nur Banu, snd his courtiers.

Jlurad was far from being the strong ruler the times demanded. He had a taste for mysticism and was the author of a work entitled *The Victories of Fasting.* Yet he not only permitted the corrupt sale of offices but also profited by it.

Ey the end of the 1jth century. the janissaries had realized how dependent the sultans were on them. Murad's policy was to weaken the unruly corps by adding large bodies of untrained recruits to their humber. In order to pay this inflated army the coinage was debased. a measure which led to a mutiny of janissaries in 1589 and of spahis three years later. The basis of the army was further undermined by the conversion of military fiefs into civil fiefs and even into private holdings. The process of decay n-as hastened b>- victories in Georgia. the Crimea, Daghistan and Persia. which by weakening the Moslem states facilitated the advance oi Russia to the Black sea and the Caspian.

Murad died in 1595, leaving to his successor a legacy of war and anarchy.

It was in Murad's reign that England's relations with the Porte began. (G. L. L.)

MURAD (AMURATH) IV (1612–1640), Ottoman sultan, the son of Ahmed I. succeeded his uncle Mustafa I in 1623, at a time when the news from all quarters of the empire was of rebellions and defeats. The first ten years of the reign saw seven grand viziers. The effective control of affairs was in the hands of the turbulent janissaries and spahis nho had forced Mustafa to abdicate; and more than once they had to be placated with the blood of high officials. The last such occasion was in 1632, when the spahis invaded the palace, demanding the heads of the grand vizier Hafiz Pasha and 16 other notables. The young sultan could not save them, but soon he felt himself strong enough to put an end to the prevailing lawlessness. Rallying some loyal men, he exacted a terrible vengeance on the mutineers. Thereafter he repressed the anarchy and licentiousness of the troops with a bloody ferocity and riveted a strong yoke on every department of the state. Coffeehouses and wineshops everywhere were closed, no doubt as being breeding places for sedition (it was for this reason that Mahmud II, two centuries later, closed the coffeehouses of Constantinople when he destroyed the janissaries); but the security of the state seems an inadequate justification for the numerous executions of people guilty or merely suspected of defying the ban on the use of tobacco. Under his heavy hand the empire enjoyed a reign of law unknown since the time of Suleiman.

Order once restored. Murad assumed personal command in the war against Persia, undertaken to win back the lands lost to the shah by the peace of 1619. Baghdad was reconquered after a siege that ended in a pitiless massacre of garrison and citizens alike (1638). Peace was concluded the following year on the basis of Suleiman's treaty of 155j. In 1640 the last warrior sultan of the house of Osman died at the age of 28, his great physique sapped by habitual intemperance. (G. L. L.)

MURAD (AMURATH) V (1840–1904), Ottoman sultan, eldest son of Sultan Abdul-Mejid, was born on Sept. 21, 1840. On the accession of his uncle Abdul-Aziz, Prince Mohammed Murad Effendi—as he was then called—was deprived of all share in public affairs and imprisoned because of his opposition to the sultan's plan for altering the order of succession. On the deposition of Abdul-Aziz May 30. 1876, Murad was haled from his prison by theological students and soldiers of the Young Turkey party and proclaimed "emperor by the grace of God and the will of the people."

Three months later, his sanity, undermined by his long confinement, gave way; and on Aug. 31 he was deposed to make room for his younger brother, Abdul-Hamid II. Confined in the Chiraghan palace, he died on Aug. 29. 1904.

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MURAENA, name of an eel common in the Mediterranean, and sometimes applied to the whole group of morays. About 90 species are known from tropical and subtropical seas, especially in rocky parts or on coral reefs. The skin is scaleless and smooth, in many species ornamented with varied and bright colours, so that they are frequently mistaken for snakes. The mouth is wide, the jaws strong and armed with formidable teeth. which enable the *Muraenn* not only to seize its prey (which consists chiefly of other fishes) but also to inflict serious wounds on its enemies, including man. Some of the tropical *Muraenas* exceed a length of 6 ft., but most of the species attain to only half that length. M. *helena* of the Mediterranean was a great delicacy of the ancient Romans. Some are said to have thrown slaves into their fish ponds to feed the *Muraenas*. Some forms range through the Indian ocean to Hawaii.

MURAL CROWN, in heraldry (*q.v.*), a crown taking the form of an embattled tower given to the man who first set up his standard in a captured city.

MURAL PAINTING is that branch of painting which has to do with the decoration of the walls and ceilings of buildings. It may properly include painting on fired ceramic tiles. and is sometimes loosely, although incorrectly, used to include mosaic decorations. Mural painting is inherently different from all other forms of pictorial art in being organically connected with architecture. The use of colour, design and thematic treatment can radically alter the sensation of spatial proportions of the building. In this sense it is the only form of painting which is truly three-dimensional, since it modifies and partakes of a given space. Byzantine mosaic decoration evinced the greatest respect for organic architectural form. The great artists of the Renaissance on the other hand attempted to create an illusionistic feeling for space; and the masters of the subsequent Baroque period obtained such radical effects as to dissolve almost entirely the walls or ceilings.

Apart from its organic relation to architecture, a second characteristic of mural painting is its broad public significance. The mural artist must conceive pictorially a social, religious or patriotic theme on the appropriate scale in reference both to the structural exigencies of the wall and to the idea expressed. For back of all great mural art is faith: either religious as in the 13th century, national as in the 17th or socially-minded as in the 20th. Like great architecture. mural art can flower only in those periods where national culture has found an expression understood and shared by the people.

Throughout history many mural techniques have been used: encaustics, tempora. fresco. ceramics, oil paint on canvas and more recently liquid silicate and fired porcelain enamel. Primitive man decorated the caves of Altamira in Spain with drawings of bison and elk during the Old Stone Age perhaps 100,000 years ago. Encaustics was the commonest medium used among the ancients. Colours were ground in a beeswax binder and applied by means of heat. Tempera painting was also practised from the earliest known times. The binder was an albuminous medium such as egg yolk or egg white diluted in water. After the decline of the great period of mural art in the 17th century, oil paint on canvas came into general use. Its malleability was well-suited to the realistic treatment imposed by official academic standards. The fact that it could be completed in the artist's studio and later transported to its destination and attached to the wall was of practical convenience. Yet oil paint is the least satisfactory medium for murals. It lacks both brilliance of colour and surface texture. Many pigments are yellowed by the binder or are affected by atmospheric conditions, and the canvas itself is subject to rapid deterioration.

Egypt.—The world's first great national expression in mural art—and by far the longest—began in Egypt in the 4th millenium B.C., and continued uninterrupted and relatively unchanged either in formal style or religious content until the conquest of the country by Alexander the Great. Yet Egyptian painting over a span of 30 centuries had little influence on the art of other civilizations. We must judge it solely by the tomb painting, since none of the murals on the buildings remain. Its purpose was to insure the survival of the dead by a highly literal, narrative, symbolized and ritualistic representation of the life of the deceased and his physical needs in the world hereafter.

Egyptian art was primarily utilitarian. Its realism, although charged with symbolic intent, showed great clarity of statement. It was flat and linear! without spatial illusion or perspective. People and animals were represented without any suggestion of movement. Human beings were drawn with the head, torso, legs and feet in profile and the eyes from the front view. Yet it must not be thought that these decorations are without aesthetic sensibility. The conscious emphasis on the horizontal and perpendicular and the bold use of symmetry create a feeling of monumental stability never surpassed. The literal presentation of the narrative is always accompanied by highly abstracted and stylized ideographic writing, used with a sensitive feeling for decorative pattern.

Egyptian painting is static and monumental like the sphinx, the architecture and the pyramids of this archconservative and hierarchic civilization.

Greece.—Comparatively little is known and nothing has survived of Greek mural painting. Like all Greek culture, however, its influence was of paramount importance on Roman and Byzantine art, which became the two main sources of western European mural decoration. What knowledge there is of Greek murals comes from inadequate literary descriptions, the doubtful evidence of their vase painting and late Roman frescoes, derived from Greek

originals.. The enormous and unique contribution of Greek painting was the development in the jth and the 4th centuries B.C. of that particular realism which thereafter characterized most periods of western art: the attempt to suggest a three-dimensional world, perspective, foreshortening. atmospheric effects. chiaroscuro and modelling through light and shade.

Greek realism, however. was tempered by a nobility of conception corresponding to the idealism of Attic sculpture. The human figure became the expression of an ordered and rational ethic. Among the foremost Greek muralists were Zeuxis (late jth century B.C.), Polygnotus (middle of the 5th century B.C.), who painted large narrative scenes in the four-colour system of the times. and Apelles (second half of the 4th century B.C.). who worked for Philip and Alexander at the Macedonian court.

Rome. — From the earliest times Roman painting was dominated by the influence of Greece. The mural decorations of the tombs and temples are completely lost. But much of the painting in the houses has survived through the excavation in 1748 of Pompeii and Herculaneum. which were destroyed by eruptions from Vesuvius in A.D. 79. Such murals were conceived of as interior decoration through the use of flat areas of colour, imitation marble slabs. stylized festoons. grotesques and other abstract embellishments. Effects of architectural illusion were resorted to, *trompe-l'oeil* ("optical illusion") and sequences of receding vistas. There was, however, a wide range of subject matter in a realistic vein: landscapes. portraits. still lifes and allegorical themes.

From the 3rd century the realism of Roman art was subjected to the influence of abstract and symbolic decoration from the east. It rapidly deteriorated. Nevertheless the Graeco-Roman realistic tradition along with Byzantine mosaic decoration became the source of early Christian painting, and thus an important link in the long line of the western European mural tradition.

Etruscan Painting. — The tomb paintings of the Etruscans from central Italy. from the 7th to the 4th centuries B.c., are another important source of information on lost Hellenic mural art. They were executed as frescoes in sunken tombs on smooth and polished rock. Their ritualistic purpose was to recreate for the dead an earthly environment.

India, China and Japan. — Although the art of these and other oriental cultures often rivalled and sometimes surpassed that of contemporary European countries. its importance in the mural field is limited. The early Buddhist fresco paintings on the walls of the Ahanta cave temples of western India (300 B.C.–A.D. 700) are among the world's greatest works of art. Indian painting is highly symbolic, decorative, rhythmic and delicate in detail, deriving from Greece and Persia. After the Gupta dynasty (A.D. 320–470) Indian genius turned to other art forms, spreading to Afghanistan, Central Asia and China.

Already by the 1st century A.D. fragments of Chinese mural painting on brick show a highly developed art. When Buddhism became a powerful force in the 4th century, temple walls and ceilings were covered with murals. From the 5th to the 13th centuries hundreds of frescoes were painted in Tun-huang in the province of Kansu, showing a growing preoccupation with form and spatial unity and an incomparable mastery of line and silhouette. Chinese art is essentially philosophic and symbolic, expressive rather than realistic, linear and technically disciplined. The importance of the brush-stroke is highly personal so that painting and calligraphy become inseparable. Beginning with the Ming period (1368–1644) mural decoration was confined largely to screens and hanging scrolls. The great era in Chinese art ended with the Manchu conquest in 1644.

Following the introduction of Buddhism the arts penetrated into Japan in the 6th century by way of Korea. In iconography the images stemmed from India but in style and technique China was the source of inspiration. As in China folding screens and hanging scrolls served as wall decorations. The famous frescoes of the golden hall of the Horyuji temple at Nara are a unique Japanese example of true mural painting.

Byzantine and Early Christian **Art.**—With the decline of Roman civilization European painting suffered a long eclipse and did not fully emerge until the dawn of Gothic art in the 13th century. Byzantium. chosen by the emperor Constantine I in 326 as his capital and renamed Constantinople. became for 1.000 years the repository of Graeco-Roman culture. Before the 9th century the terms Early Christian and Early Byzantine art are interchangeable: the former generally referring to the primitive. exclusively sepulchral frescoes of the catacombs, painted in cryptic symbols. From the beginning of the 5th century. when catacomb burials ceased, until the decline of Byzantine culture with the sack of Constantinaple by the crusaders in 1204, the art of the eastern empire was dominant in the Jlediterranean. The classical tradition of realism and a feeling for space occasionally lingered on, however. as in the mosaic murals of S. Pudenziana in Rome (c. 400). The actual work, however, was probably executed by Byzantine craftsmen.

Byzantine art fused the humanistic and realistic heritage of the west with the introverted mysticism and technical stylizations of the east. Their art was highly symbolic, hieratic. imperial, iconographic and sumptuous in its lavish decoration. Its fullest expression was the mosaic murals, which can still be seen in their dazzling splendour in St. Sophia, Constantinople; St. Marks. Venice; Monreale. in Sicily; and in the many churches of Ravenna. Rome and Salonika. In monumental architectonic feeling, in the surface brilliance achieved by their craftsmen and in the emotional passion conveyed. Byzantine mosaic murals are a sublime expression of early Christian mysticism and religious faith. Their influence directly afiected the dawn of Renaissance mural painting in Italy and spread to the Balkans. Crete. Poland and Russia.

The Renaissance. — From the long twilight millenium after the fall of the Roman empire, various regional adaptations in different parts of Europe mingled with the two dominant artistic traditions, the Graeco-Roman and the Byzantine. This fusion produced two great periods of architecture, the Romanesque in Italy (11th–13th century) and the Gothic. which originating in France in the 13th century spread throughout Europe. But it was not until the 14th century in Italy that these same merging currents from west and east culminated in Renaissance painting. As is the case with individuals the historian can study but never adequately explain the generating sources of national genius. During the 14th century the modern world was slowly emerging from mediaeval civilization. In Italy in every field of art and science there occurred a sudden burst of creative activity, unrivalled since the age of Pericles.

Cimabue (c. 1240–*c.* 1302) was the last exponent of Byzantine formalism. Giotto (*c.* 1266–1337), born only about 26 years later than his fellow Florentine. was by tradition his pupil. Yet in his murals are seen all the characteristics of Renaissance painting. Man is no longer conceived as a mere symbol in a mystic hierarchy but is portrayed in flesh and blood, with human dignity and human frailty against the background of a visual and spatial world. In comparison with the achievements of the High Renaissance his technical resources seem crude. yet in his murals he introduced every artistic aim that was to govern painting for the next 600 years. Giotto remains one of the undying masters in mural painting. As in all great art his work shows that essential balance between the expressive content and a preoccupation with the visual world. formally expressed in line. colour and design.

The innovations of the succeeding Renaissance artists from Giotto to Titian influenced both easel and mural painting in Europe until the advent of Modernism in the 20th century. In order to understand the scope of this major art cycle it is necessary briefly to review the specific contributions of certain of these artists.

Masaccio (1401–*c.* 1428) carried forward Giotto's aim of setting his figures in a spatial environment. He introduced the use of a consistent light source and cast shadows rather than the over-all brightness of mediaeval painting.

Fra Xngelico (1387–1455) and Benozzo Gozzoli (1420–97) clothed the lingering Gothic content of mediaeval piety and sweetness in the new Renaissance styles. Their influence. with that of Sandro Botticelli, is noticeable in the English Pre-raphaelite school.

Piero della Francesca (c. 1418–92), one of the towering figures of mural art. was a pioneer in the new theory of perspective. He was among the first to use spatial illusion to mitigate or destroy architectural feeling.

Sandro Botticelli (1444–1510) introduced the humanistic tendency toward poetic and philosophic allusion, and the recurrence to classical mythology. Such subject matter would characterize many schools of academic painting up to and including the 20th century.

Luca Signorelli (*c.* 1450–1523) was a master of anatomy and movement in space. The seething masses of his skilfully drawn figures in the Orvieto cathedral blazed a trail which Michelangelo followed.

Leonardo da Vinci (1452–1519) was the first Renaissance artist to anticipate the modern psychological approach in his subtle and objective analysis of human character.

Raphael Sanzio (1483–1520) represents the culmination of High Renaissance mural art. In his idealized types, his classic feeling and monumentality. and his technical brilliance in the use of line, colour and form. he has had a lasting and often pernicious influence on subsequent academic schools of mural painting.

Michelangelo (1475–1564) is the most personal. awesome and overpowering genius of the Renaissance. His murals in the Sistine chapel in Rome had an incalculable influence on all those attempting a heroic expression through the use of the human figure. He was perhaps the major source of Mannerist painting and a precursor of the Baroque.

Titian (c. 1477–1576) was the first modern muralist in his broad treatment of oil paint and in his unifying use of grays as a brilliant colourist. His opulent and secular treatment of classical and religious themes strongly influenced Peter Paul Rubens.

Jacopo Tintoretto (1518–94) expressed the synthesis of the Florentine tradition in drawing and the Venetian school of colour. Through his Mannerist influence on El Greco he can be spoken of as the first subjective Expressionist.

Renaissance mural art early in the 1 jth century had clearly established those aesthetic and philosophic aims which would remain unchallenged until the 20th century. These conceptions, so basically different from those of the Byzantine tradition, conceived of man as a human being in the realistic setting of a spatial world. Experimental studies from nature supplanted the frozen conventions of early Christian and mediaeval art. Western scientific curiosity and a realistic approach replaced the introverted mysticism of the middle ages. The preoccupation with space and linear perspective tended. however, to mitigate or destroy the feeling for architectural unity. There 'is, then, no question that Renaissance mural art lacked the organic monumentality of Byzantine mosaic murals.

Mannerism. Baroaue and **Rococo.**—Earlv in the 16th century a reaction took place against the ordered rationality of Renaissance classicism. Distortions of form and proportions and exaggerations of movement are already noticeable in Michelangelo's late work and in Tintoretto's murals. They reach a climax with El Greco (Domenico Theotocopuli) (c. 1542–1614). In the late 16th and 17th centuries this style was followed by the Baroque. The Counter Reformation had induced a return to realism from the Gothic mysticism and intellectual aestheticism of the Mannerist painters. But the dramatic compositions, infinitely extended spatial effects and emotional violence of Mannerism remained. Michelangelo da Caravaggio in Italy (1573–1610) and Rubens in Flanders (1577–1640) were the outstanding geniuses of Baroque painting. During this period, however. wall decorations evidenced a steady decline in monumental feeling and architectural understanding. Murals for the most part were enormous easel paintings hanging like tapestries on church or palace walls.

Rome, the seat of the papacy, was logically the birthplace of the Baroque. The illusionistic effects of the painting became an integral element of Baroque architecture. Pietro da Cortona (1596–1669) was the most famous of the Roman school. It was largely. however, through Fra Andrea dal Pozzo (1642–1709), active in Vienna after 1702, that Baroque art spread to Germany and Austria. which became in the late 17th and 18th centuries the centres of mural art.

In the 18th century Rococo art. which personified the aristocratic and princely tastes of court life, spread from France throughout Europe. Light, sentimental, theatrical. witty and gay, the cupids, lovers, boudoir scenes and artificially rustic garden landscapes pictured a make-believe world that was blown to bits by the French Revolution. François Boucher (1703–70) and Jean-Honoré Fragonard (1732–1806) were the reigning salon decorators at the courts of Louis XV and Louis XVI. Giovanni Tiepolo (1696–1770) in Venice was the greatest genius of this period style, as also the last of a joo-pear cycle of great Italian muralists.

19th Century.— The rapid decline of mural art in the 19th century is difficult to explain. for it is accompanied in easel painting by the genius of Joseph Turner in England, and in France by the creative achievement of the painters of the Romantic movement, the Barbizon school, Impressionism and Postimpressionism. Yet mural art, which is essentially a social expression, calls for a social consciousness and cultural awareness. which had been destroyed by the Industrial Revolution as much as by the French Commune. In those official circles in Europe and the United States which were responsible for public decorations, there reigned a sterility of taste and aesthetic discrimination which were in marked contrast to the creative genius of individual easel painters, now more and more isolated from a cultivated mass audience. The mere mention of the principal muralists of this period indicates the rapid decline of this noblest pictorial art form.

In Germany Peter von Cornelius (1783–1867) was the leading muralist of the Romantic movement, while Wilhelm von Kaulbach (1805–74) carried on the Italian classical tradition. Arnold Böcklin (1827–1901) and Ferdinand Hodler (1853–1918) in Switzerland were essentially literary muralists. In England Lord Leighton (1830–96) upheld an academic classicism. Dante Gabriel Rossetti (1828–82) and Sir Edward Burne-Jones (1833–98). members of the Pre-Raphaelite Brotherhood. turned to a sentimental mediaevalism in vain protest against the materialism of the machine age. In the United States John Trumbull (1; 56–1843) and John La Farge (1835–1910) were traditionalists in the Renaissance manner. In France Eugene Delacroix (1798–1863) and Pierre Puvis de Chavannes (1824–98) were the outstanding muralists.

20th Century.— The Modern movement, originating in Paris just before World War I, created the most significant idiom of design since the Renaissance. Modern painting was a conscious protest against many of the aims which had controlled western art for 600 years. In its revolt against realism in representation, the study of anatomy, perspective and a spatial world, and in its preoccupation with abstraction: Modernism reintroduced many of the characteristics of Gothic and Byzantine styles. Yet there have been no significant mural paintings in the abstract or radically modern idiom by European artists. The isolated wall decorations of Fernand Léger, Henri Matisse and Joan Miró. all pioneers of abstract or Modern design, are without understanding of organic architectural scale and are totally lacking in emotional content. Pablo Picasso's "Guernica," perhaps the master's most important single painting, can hardly be considered a mural.

Curiously, the only significant national school of mural art since the 18th century occurred in Mexico in the 1920s, when the country was still culturally backward, outside the main currents of contemporary art, impoverished and torn by civil war. Inspired by social ideals of the revolution and fired by a wave of nationalism, half a dozen Mexican painters, all of them intellectuals and most of them educated in Europe, created in a decade the most expressive, national, individual and genuinely mural school of painting since the High Renaissance in Italy. José Clemente Orozco, Diego Rivera and David Siqueiros were the acknowledged leaders of the movement.

About a decade later, inspired by the example of the Mexican artists and under the urgency of the depression, a significant mural program was organized in the United States under the various New Deal art projects. The importance of the movement depended less on the 2.000 murals painted during the following decade in every section of the country than on the growing awareness among young painters of the potential nobility of this art form. Among the outstanding muralists of the period were: Thomas Hart Benton, Henry Varnum Poor. III, Mitchell Siporin, Ben Shahn, Maurice Sterne, Boardman Robinson and George Biddle. The movement, however, was short-lived. During World War II the art projects were liquidated by congress. Fifteen years later there seemed little

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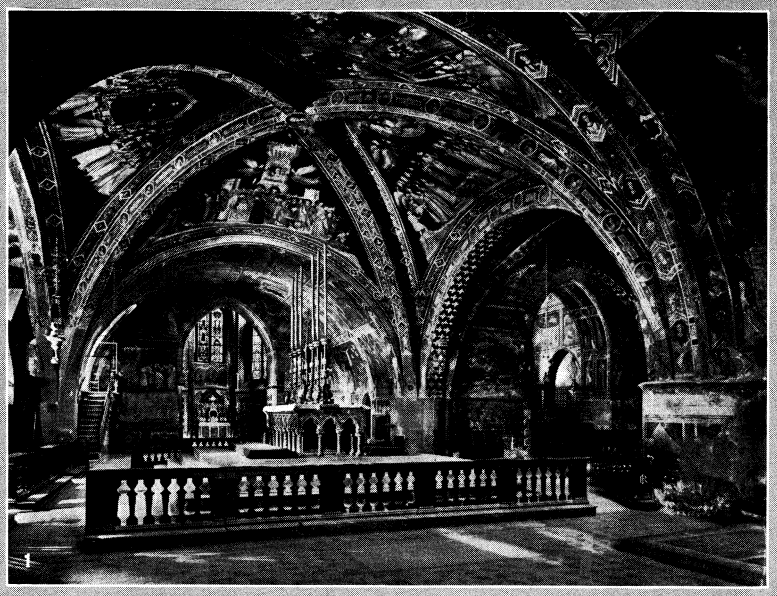
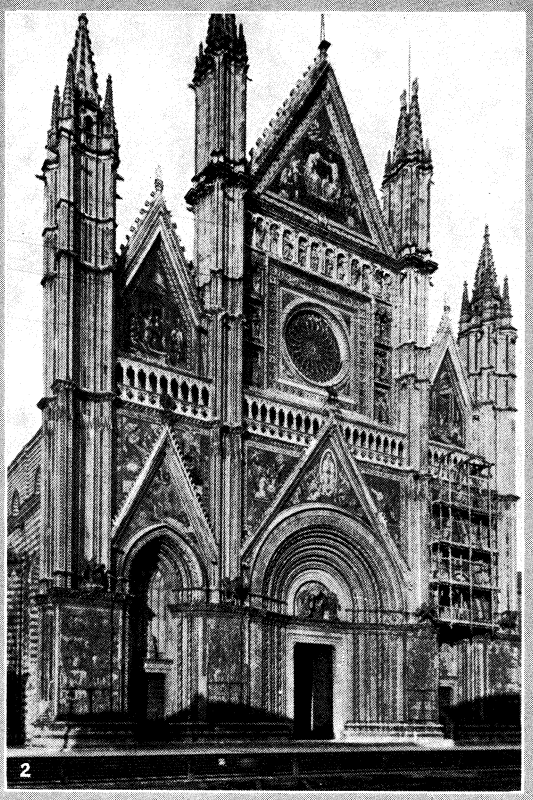
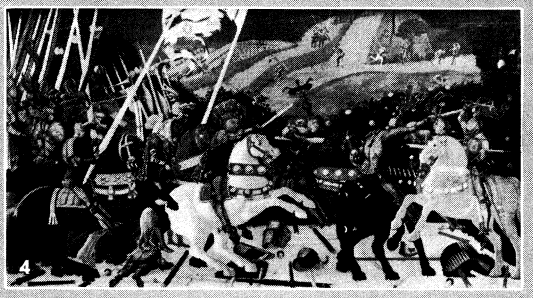
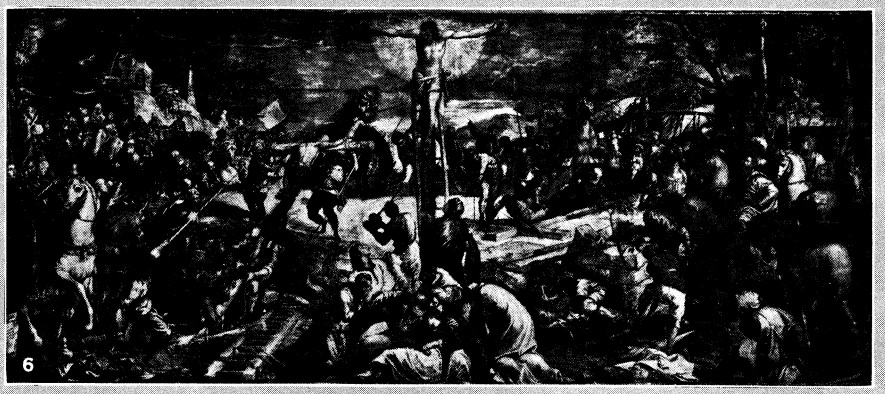
Above: Mural depicting a country political rally, by Thomas Hart Benton (1889–), American; in the Missouri state capitol, Jefferson City, Mo. Below: Mural panels from a series on U.S. history at Unity House, Forest Park, Pa., by Diego Rivera (1886–1957), Mexican. The centre panel is entitled "The American Revolution"

MURAL PAINTING









BY COURTESY OF (4) THE NATIONAL GALLERY, LONDON; PHOTOGRAPHS (1, 6) ANDERSON, (2) BURTON HOLMES FROM EWING GALLOWAY, (3) PUBLISHERS PHOTO SERVICE, (5) ALINARI

MOSAICS AND FRESCOES

1. Interior of the Lower Church of St. Francis, at Assisi, Italy. Frescoes (*c.* 1300) in the vaulting above the high altar, representing the Mystic Marriage of St. Francis with Holy Poverty, Chastity, Obedience, and St. Francis in glory, are ascribed to Giotto or to one of his pupils
2. Façade of Orvieto Cathedral (begun in 1310), showing the use of mosaics for exterior wall decoration
3. Interior of the Basilica of St. Paul's Outside the Wails, Rome, founded in 386. The space above the triumphal arch is filled with a mosaic decoration executed under Galla Placidia; portraits in mosaic of all the popes from St. Peter to Benedict XV. form a frieze around the nave walls below the olerestorey windows
4. "The Rout of San Romano," one of a group of three frescoes painted by Paolo Uccello (15th century) for decoration of the Palazzo Medici, Florence. Now in the National Gallery, London
5. Interior of the Sistine Chapel of the Vatican, showing above the altar "The Last Judgment," by Michelangelo (1475–1564). The ceiling also is entirely covered with frescoes by Michelangelo, arranged in a symmetrical architectural grouping. The frescoes on the side walls are by Botticelli, Ghiriandaio, Perugino, Pinturicchio and other painters of the Renaissance
6. "The Crucifixion," by Tintoretto (Jacopo Robusti, 1518–94), in the Scuoia di San Rocco, Venice

BY COURTESY OF (5) THE METROPOLITAN MUSEUM OF ART, KENNEDY FUND, 1913; PHOTOGRAPHS (1, 3, 4) PUBLISHERS PHOTO SERVICE, (2) ANDERSON

MURAL PAINTINGS AND TAPESTRIES

1. "The Last Supper," by Andrea del Sarto (1486–1530), Florentine, on the refectory wall in the Abbazia di San Salvi, near Rovezzano, Tuscany
2. "The School of Athens," by Raphael (Raffaello Sanzio, 1483–1520), in the Stanza della Signatura, the Vatican. The scene represents the triumph of Philosophy with Plato and Aristotle as the centre of a gathering of philosophers and scholars of all the ages
3. Sala del Maggior Consiglio, Doges Palace, Venice. The walls are decorated with large canvases by the brothers Tintoretto, and other 16th century painters. On the entrance wall is "Paradise," by Jacopo and Domenico Tintoretto. It is 72 by 22 ft., and is said to be the largest oil painting in the world
4. Gobelin tapestries used as wall decoration in the Palace of Versailles, France. In the 17th century such tapestries replaced mural paintings, but were designed in the manner of paintings, with borders imitating the carved and gilt frames of the period
5. "The Glorification of Jacopo Giustiniani." by Giovanni Domenico Tiepolo (1727–1804), Venetian

MURAL PAINTING

BY COURTESY OF (1) THE DIRECTOR OF THE VICTORIA AND ALBERT MUSEUM, (5) THE BOSTON PUBLIC LIBRARY EMPLOYEE BENEFIT ASSOCIATION; PHOTOGRAPHS, (2) MONGER AND MARCHANT, (3) EDWIN A. ABBEY FROM A COPLEY PRINT (COPR. CURTIS AND CAMERON), (6) DE COU FROM EWING GALLOWAY

EXAMPLES OF MODERN MURAL PAINTING BY ENGLISH, FRENCH AND AMERICAN ARTISTS

1. "The Arts of War," one of two lunettes by Lord Leighton (Frederick Leighton, 1830-96). In the Victoria and Albert Museum
2. "Moses and the Tablets of the Law" by Gerald Moira, English. In the Central Criminal Court, London
3. "The Golden Tree and the Achievement of the Grail" by Edwin Austin Abbey (1852-1911). The last panel of the series of the Holy Grail, a frieze decoration in the Boston Public Library
4. "Sylvie" by Jean Dupas, French. In the salon of the S.S. "Ile de France"
5. "Astarte" by John Singer Sargent (1856–1925), U.S. One of the panels of the series The Pageant of Religion in the Boston Public Library
6. "History of Mexico," by Diego Rivera, Mexican. One of the panels in the National Palace, Mexico City
7. "L'Après-midi d'un Faune" by Louise Janin, U.S.

evidence that among the architects and those circles that dispense with commissions there existed that cultural understanding that is necessary to promote a great school of mural art.

About 1930 under the direction of two Americans, a painter and a critic, an impulse was given to native Negro art in the Republic of Haiti. One of the results of this movement was the decoration of the walls of the cathedral in Porte-au-Prince. Unlike the Mexican experiment the work was done by unschooled native artists who had never been outside the country. Though technically crude these decorations, brilliant in colour, achieve a dignity and emotional sincerity which characterize successful mural art.

Through the most cursory review of the 20th-century European art it becomes evident that a great creative period in allied art forms is not in itself the necessary climate to foster mural painting. At the same time an individual aptitude for decorative design offers no proof of talent in the mural field. Nor does a national expression in mural art depend on economic prosperity. Mural art is a public expression, no matter whether it reflects a priestly caste as in ancient Egypt, religious faith as in early Christian and Gothic times, a princely aristocracy as in the High Renaissance or a social faith as in Mexico and a few of the New Deal murals. The great cultural cycle, born in Italy in the Renaissance, ended with two world wars. Modern art is indubitably an intuitive expression of a changing civilization. Not until this expression is consciously crystalized into a faith on a national level, can we look forward to a great mural movement in the modern idiom. (See also FRESCO PAINTING; GREEK ART; MOSAIC; ROMAN ART.)

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(GE. B.)

MURANO, an island of Venezia Italy, in the Venetian lagoon about 1 mi. N. of Venice. Pop. (1951) 7,595—in the 16th century about 30,000. It was a favourite resort of the Venetian nobility before they began to build their villas on the mainland; and in the 15th and 16th centuries its gardens were famous.

The town (7,576), is built upon one broad main canal, where the tidal current runs with great force, and upon several smaller ones. The cathedral, SS. Maria e Donato, is a fine basilica, of the 9th–12th century. The pavement (of 1111) is richly inlaid, and the mosaics of the tribune are remarkable. The beautiful exterior of the tribune has been well restored. The church of St. Peter the Martyr contains a fine picture by Gentile Bellini and other works. Murano has from ancient times been celebrated for its glass manufactories. See GLASS.

MURASAKI SHIKIBU (978?–1026?) was the author of The Tale *of* Genji, the greatest work of Japanese literature. Her real name is unknown, and it is conjectured that she acquired the sobriquet of Murasaki from the name of the heroine of her novel. The main source of knowledge about Lady Murasaki's life is the diary kept by her between 1007 and 1010. This work possesses considerable interest not only for its biographical information but also for the delightful glimpses it affords of life at the court of the empress Akiko, whom Lady Murasaki served.

Some critics believe that she wrote the entire Tale *of* Genji between 1001 (the year her husband Fujiwara no Nobutaka died) and 1005, when she began serving at court. More probably, however, the composition of this long and complex novel extended over a much greater number of years. The theory has been advanced, indeed, that the last 14 of the 54 chapters of the book were by another and later hand.

The Tale *of* Genji (*Genji* monogatari) is the oldest full novel written anywhere in the world and one of the finest. Much of it is concerned with the loves of Prince Genji and the different women in his life, all of whom are exquisitely delineated. If the novel is lacking in scenes of powerful action or violence, it is permeated with a sensitivity to human emotions and to the beauties of nature hardly paralleled elsewhere. The tone of the novel darkens as it progresses, indicating perhaps a deepening of Lady Murasaki's Buddhist conviction in the vanity of this world.

The translation of The Tale of Genji (1935) by Arthur Waley is a classic of English.

Lady Murasaki's Diaries *of Court* Ladies *of Old* Japan was translated by Omori and Doi (1935). (DD. K.)

MURAT, JOACHIM (1767–1815), king of Naples, younger son of an innkeeper at La Bastide-Fortunière (Lot), was born on March 25, 1767. He studied canon law at Toulouse, but enlisted in a cavalry regiment, from which he was dismissed in 1790 for insubordination. Through the good offices of J. B. Cavaignac, he was enrolled in the New Constitutional Guard of Louis XVI.

In 1795 he met Napoleon Bonaparte, whom he assisted on the 13th Vendémiaire, and to whom he acted as first aide-de-camp in Italy. He distinguished himself in the campaign of 1796 and '97, became commandant at Rome in 1798 and in the same year accompanied Bonaparte to Egypt. At the battle of the Pyramids he led his first famous cavalry charge, and for his exploits in Syria was made general of division (Oct. 1799). Returning to France with Bonaparte, he led into the orangery of Saint Cloud the 60 grenadiers whose appearance broke up the Council of Five Hundred (18th Brumaire), and for his success was made commandant of the consular guard. On Jan. 20, 1800, he married Caroline Bonaparte, youngest sister of the first consul. He commanded the French cavalry at the battle of Marengo, was made governor of the Cisalpine Republic, and in 1801, he forced the Neapolitans to evacuate the Papal States and to accept the Treaty of Florence. As governor of Paris (1804) he appointed the commission by which the duc d'Enghien was tried and shot; in May he was made marshal of the empire; in Feb. 1805 he was made grand admiral, with the title of prince, and invested with the grand eagle of the Legion of Honour. For his prowess as commander of the Grand Army in the German campaign of 1805, Napoleon made him grand duke of Berg and Cleves (March 15, 1806). He subsequently commanded the cavalry at Jena, Eylau and Friedland, and in 1808 was made general-in-chief of the French armies in Spain. Though disappointed of the throne of Spain, he was made king of Naples on Aug. 1, in succession to Joseph Bonaparte.

King Joachim Napoleon, as he styled himself, entered Naples in September, and soon after wrested Capri from the British. At Naples he set up a sumptuous court, created a new nobility, nominated marshals, swept away the last relics of the effete feudal system, and effectively suppressed brigandage. From the first his relations with Napoleon were strained. The emperor upbraided him sarcastically for his "monkey tricks" (*singeries*); Murat ascribed to the deliberate ill-will of the French generals who served with him, and even to Napoleon, the failure of his attack on Sicily in 1810. A breach was averted by Napoleon's invitation to Murat to command the cavalry of the Grand Army in the Russian Campaign of 1812; but although Murat displayed his usual intrepidity in the disastrous retreat, his suspicions of Napoleon, and his wife, Caroline, led him to throw up his command and return to Naples in December. The battle of Leipzig found him again at Napoleon's side, but on Oct. 16, Metternich opened a separate negotiation with him, and feeling that on his acceptance of Austrian advances depended his chance of continuing a king, Murat agreed to withdraw his support from Napoleon if his throne were guaranteed by England and Austria. Having obtained the emperor's leave to return to Naples, he entered that city on Nov. 4, and immediately made overtures to the allies through the Austrian envoy. On Jan. 11, 1814, a treaty was signed by which Austria guaranteed to Murat the throne of Naples, and promised her good offices to secure the assent of the other Allies. Secret articles further stipulated that Austria would endeavour to secure the renunciation by Ferdinand of his rights to Naples, in return for an indemnity to hasten the conclusion of peace between Naples and Great Britain, and to augment the Neapolitan kingdom at the expense of the States of the Church.

Meanwhile Murat had formally broken with Napoleon and on Jan. 16, the French envoy left Naples. But he now became the cat's-paw of the Allies, who, with the exception of Austria, refused to recognize his title. At the opening of the Congress of Vienna, Talleyrand affected not to know "the man" who was referred to as "the King of Naples," and his attitude was representative of the other congressistes who wished for the restoration of the Bourbons. The tortuous diplomatic proceedings which ensued roused Murat's suspicions, and, breaking with Austria as he had formerly broken with Napoleon, he determined to secure his throne by proclaiming the cause of united Italy. Already popular with the Neapolitans, his chances of success were enhanced by the escape from Elba of Napoleon, with whom he had been corresponding, but as soon as he mobilized his troops, the Allies commissioned Austria to deal with him. Ferdinand IV. was to be restored to Naples, on promising a general amnesty and giving guarantees for a "reasonable" system of government. Meanwhile Murat's popularity in Naples had waned, and his troops were routed at Tolentino on May 2; Austrians advanced on Naples, Ferdinand IV. was restored, while Queen Caroline and her children were deported to Trieste.

Murat himself escaped to France, where his offer of service was contemptuously refused by Napoleon. He hid for a while near Toulon, with a price upon his head, then, after Waterloo, refusing an asylum in England, he sailed for Corsica, where he was joined by a few rash spirits who urged him to attempt to recover his kingdom. Refusing Metternich's offer to allow him to join his wife at Trieste and to secure him a position and a pension, Murat sailed for Calabria on Sept. 28, with a flotilla of six vessels and about 250 men. Four of his ships were scattered by storm, one deserted him, and on Oct. 8, he landed at Pizzo with only 30 men. Captured almost immediately, he was imprisoned at Pizzo, and on Oct. 13 was court-martialled and shot.

He was the most dashing cavalry leader of the age. Rash, hot-tempered and brave, he was adored by the troops, who followed him against the most terrible odds. Napoleon lived to regret his refusal to accept his services during the Hundred Days, declaring that Murat's presence at Waterloo would have inspired the cavalry charges and might have changed defeat into victory.

By his wife Maria Annunciata Carolina, Murat had two sons. The elder, NAPOLEON ACHILLE MURAT (1801–1847), during his father's reign prince royal of the Two Sicilies, emigrated about 1821 to America, and settled in Florida, being postmaster at Lipona, Jefferson county, 1828–31. In 1826 he married a great-niece of Washington. He died in Florida, April 15, 1847.

The second son, NAPOLEON LUCIEN CHARLES MURAT (1803–1878), created prince of Ponte Corvo in 1813, lived with his mother in Austria after 1815, and in 1824 started to join his brother in America. but was shipwrecked on the coast of Spain and held for a while a prisoner. Arriving in 1825, two years later he married in Baltimore a rich American, Georgina Frazer. After several abortive attempts to return to France, the revolution of 1848 at last gave him his opportunity. He was elected a member of the constituent assembly and of the legislative assembly (1849), was minister plenipotentiary at Turin, 1849–50, and after the *coup d'état* of Dec. 2, 1851, was made a member of the consultative commission. On the proclamation of the empire, he was recognized by Napoleon III as a prince of the blood royal, with the title of Prince Murat. He died on April 10, 1878, leaving three sons and two daughters.

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MURATORI, LUDOVICO ANTONIO (1672–1750), Italian scholar, historian and antiquary, was born of poor parents at Vignola in the duchy of Modena on Oct. 21, 1672. Having taken minor orders in 1688, Muratori took his doctorate in law before 1694, was ordained priest in 1695, and appointed by Count Carlo Borromeo one of the doctors of the Ambrosian library at Milan. From manuscripts now placed under his charge he made a selection of materials for several volumes (*Anecdota*), which he published with notes. He returned to Modena in 1700, on the invitation of the duke, as keeper of the archives. The preparation of numerous valuable tracts on the history of Italy during the middle ages, and of dissertations and discussions on obscure points of historical and antiquarian interest, as well as the publication of his various philosophical, theological, legal, poetical and other works absorbed the greater part of his time. These brought him into communication with the most distinguished scholars of Italy, France and Germany. But they also exposed him in his later years to envy. His enemies spread abroad the rumour that the pope, Benedict XIV., had discovered in his writings passages savouring of heresy, even of atheism. Muratori appealed to the pope, and was assured of his protection. Muratori died on Jan. 23, 1750.

Muratori is rightly regarded as the "father of Italian history." This is due to his great collection, *Rerum italicarum scriptores,* to which he devoted about 15 years' work (28 vols., 1723–38). This was followed by a series of 75 dissertations on mediaeval Italy (*Antiquitates italicae medii aevi,* 6 vols., 1738–42). To these he added a *Novus thesaurus inscriptionum* (4 vols., 1739–43), which was of great importance in the development of epigraphy. He then set about a popular treatment of the historical sources he had published. These *Annuli d'Italia* (1744–49) reached 12 volumes, but were imperfect and are of little value. In addition to this national enterprise (the *Scriptores* were published by the aid of the Società palatina of Milan) Muratori published *Anecdota ex ambrosianae bibliothecae codd.* (2 vols., Milan, 1697, 1698; Padua, 1713); *Anecdota graeca* (3 vols., Padua, 1709); *Antichita Estens* (2 vols., Modena, 1717); *Vita e rime di F. Petrarca* (1711), and *Vita ed opere di L. Castelvetro* (1727). *In* biblical scholarship Muratori is famous as the discoverer of the so-called *Muratorian Canon,* the name given to a fragment (85 lines) of early Christian literature, which he found in 1740, embedded in an 8th-century codex which forms a compendium of theological tracts followed by the five early Christian creeds. The document contains a list of the books of the New Testament, a similar list concerning the Old Testament having apparently preceded it. There is little doubt that it was composed in Rome, and we may date it about the year 190. It is the earliest document known which enumerates the books in order. It is interesting to notice the coincidence of the compiler's list with the evidence gained from Tertullian for Africa and from Irenaeus for Gaul and indirectly for Asia Minor.

Muratori's *Letters,* with a *Life* prefixed, were published by Lazzari (2 vols., Venice, 1783). His nephew, F. G. Muratori, also wrote a *Vita del celebre Ludov. Ant. Muratori* (Venice, 1756). *See* also *A. G.* Spinelli, "Bibliographia delle lettere e stampa di L. *A.* Muratori," in *Bolletino dell' instituto storico italiano* (1888), and Carducci's preface to the new *Scriptores.* The *Muratorian Canon* is given in full with a translation in H. M. Gwatkin's *Selections from Early Christian Writers.* It is also published as No. 1 of H. Lietzmann's *Kleine Texte fur theologische Vorlesungen* (Bonn, 1902). *See* also *Journal* of *Theological Studies,* viii. 537.

MURAVIEV, MICHAEL NIKOLAIEVICH, COUNT (1845–1900), Russian statesman, was born on April 19, 1845. He was the son of General Count Nicholas Muraviev (governor of Grodno), and grandson of the Count Michael Muraviev, who became notorious for his drastic measures in stamping out the Polish insurrection of 1863 in the Lithuanian provinces. He was educated at a secondary school at Poltava, and was for a short time at Heidelberg university. In 1864 he entered the chancellery of the minister for foreign affairs at St. Petersburg, and was soon afterwards attached to the Russian legation at Stuttgart. He served in various European capitals, and finally became minister at Copenhagen. In Denmark he was brought much into contact with the imperial family, and on the death of Prince Lobánov in 1897 he was appointed by the Tsar Nicholas II. to be his minister of foreign affairs. As regards Crete, Count Muraviev's policy was vacillating; in China his hands were forced by Germany's action at Kiaochow. But he acted with singular *légèreté* with regard *at*

all events to his assurances to Great Britain respecting the leases of Port Arthur and Talienwan from China; he told the British ambassador that these would be "open ports," and afterward essentially modified this pledge. When Tsar Nicholas inaugurated the peace conference at The Hague, Count Muraviev extricated his country from a situation of some embarrassment. When Russian agents in Manchuria and at Peking connived at the agitation which culminated in the Boxer rising of 1900, the relations of the responsible foreign minister with the tsar became strained. Muraviev died suddenly on June 21, 1900.

MURCHISON, SIR RODERICK IMPEY (1792–1871), British geologist, was born at Tarradale, Scot., on Feb. 19, 1792. Educated at Durham and the military college, Great Marlow, he landed (1808) with Wellesley in Galicia and was present at the acticns of Roriça and Vimiera. Under Sir John Moore he took part in the retreat to Corunna.

In 1818 he sold his paternal property in Ross-shire and settled in England, where he took to field sports. He soon became one of the greatest fox hunters in the midland counties. Sir Humphry Davy persuaded him to attend lectures at the Royal institution. He joined the Geological Society of London and, with the help of W. H. Fitton, prepared his first scientific paper, read to the society in 1825. In three years he had explored large parts of England and Scotland, had obtained materials for three important memoirs as well as for two more written in conjunction with Adam Sedgwick (*q.v.*) and had risen to be a prominent member of the Geological society and one of its two secretaries. He then explored with Sir Charles Lyell the volcanic region of Auvergne, parts of southern France, northern Italy, Tirol and Switzerland. Later, with Sedgwick as his companion, he attacked the difficult problem of the geological structure of the Alps, and their joint paper giving the results of their study is one of the classics in the literature of Alpine geology.

In 1831, at the suggestion of William Buckland, he visited the Welsh border, to discover whether the graywacke rocks underlying the Old Red Sandstone could be grouped into a definite order of succession, as the secondary rocks of England had been made to tell their story by William Smith. For several years he worked in that region. The result was the establishment of the Silurian system, under which were grouped for the first time a remarkable series of formations, each containing distinctive organic remains older than and very different from those of the other rocks of England. These researches, together with descriptions of the coal fields and overlying formations in south Wales and the English border counties, were embodied in *The Silurian System* (1839), illustrated with map, sections, pictorial views and plates of fossils. As years passed on the types of existence brought to light by him from the rocks of the border counties of England and Wales were ascertained to belong to a geological period of which there are recognizable traces in almost all parts of the globe. Thus the term "Silurian," derived from the name of the old British tribe Silures, soon passed into the international vocabulary.

The establishment of the Silurian system was followed by that of the Devonian system, an investigation in which, with the palaeoniological assistance of W. Lonsdale, Sedgwick and Murchison were fellow labourers, both in the southwest of England and in the Rhineland. Murchison then projected an important geological campaign in Russia. He was accompanied by P. E. P. de Verneuil (1805–73) and Count A. F. M. L. A. von Keyserling (1815–91), in conjunction with whom he produced a magnificent work on *Kussia and the Ural Mountains* (1845). In 1846 he was knighted, and in the same year he presided over the meeting of the British association at Southampton. During the later years of his life a large part of his time was devoted to the affairs of the Royal Geographical society, of which he was in 1830 one of the founders; he was president 1843–45, 1851–53, 1856–59 and 1862–71. He was interested in the work of Livingstone. He devoted his last year to the Scottish Highlands, where he believed, erroneously, he had succeeded in showing that the vast masses of crystalline schists, then supposed to be part of what was termed the Primitive formations, were really not older than the Silurian period, because underneath them lay beds of limestone and quartzite containing Lower Silurian (Cambrian) fossils.

In 1855 Murchison was appointed director-general of the geological survey and director of the Royal School of Mines and the Museum of Practical Geology in Jermyn street, London. He prepared successive editions of his work *Siluria* (1854; 5th ed., 1872), which presented the main features of the original *Silurian System* together with a digest of subsequent discoveries, particularly of those which showed the extension of the Silurian classification into other countries. In 1863 he was made a K.C.B., and three years later was raised to the dignity of a baronet. The learned societies of his own country bestowed their highest rewards upon him, and he received many foreign honours.

Murchison founded a chair of geology and mineralogy in the University of Edinburgh. He died on Oct. 22, 1871. Under his will there was established the Murchison medal and geological fund to be awarded annually by the Geological society.

See Sir **A. Geikie,** ***Life of Sir Roderick I. Murchison (1875).***

MURCIA, a maritime province of southeastern Spain. Pop. (1950) 755,850; area, 4,369 sq.mi. It was the first Spanish possession of the Carthaginians, and the Romans included it in Hispania Tarraconensis. Under the Moors the province was known as Todmir, which included, according to Edrisi, the cities Murcia, Orihuela, Cartagena, Lorca, Mula and Chinchilla. The kingdom of Murcia, which came into independent existence after the fall of the Omayyads *(see* SPAIN: *History)* included the modern Albacete as well as Murcia. It became subject to the crown of Castile in the 13th century. Murcia remained loyalist throughout the civil war of 1936–39.

The extent of coast is about 75 mi., and the mountains reach their highest point (5,199 ft.) on the Sierra de Espuña, between the Mula and Sangonera valleys. They are rich in iron, copper, argentiferous lead, alum, sulphur and saltpetre. Mineral springs occur at Mula, Archena (hot sulphur) and Alhama (hot chalybeate). The climate is hot and dry, and agriculture is largely dependent on irrigation, which, where practicable, has been carried on since the time of the Moors. Wheat, barley, maize, hemp, oil and wine (the latter somewhat rough in quality) are produced; fruit, especially the orange, is abundant along the course of the Segura; mulberries for sericulture are extensively grown around the capital; and the number of bees kept is exceptionally large. Esparto grass is gathered on the sandy tracts. Large quantities of lead and esparto, as well as of zinc, iron and copper ores and sulphur, are produced. The province is traversed by railways which connect Murcia with Albacete, Valencia, Alicante and southwest to Granada; branches lead to Cartagena and Torrevieja. The chief towns are Murcia, the capital, Cartagena, Lorca, La Unión, Mazarrón, Yecla, Jumilla, Águilas, Caravaca, Totana, Cieza, Mula, Moratalla and Cehegin.

MURCIA, the capital of the Spanish province of Murcia; on the river Segura, 25 mi. W. of the Mediterranean sea. Pop. (1950) 84.757 (mun., 217,934). Murcia was a town before the Punic Wars, but its name then, under Roman rule, is not known, though some have tried to identify it with the Roman Vergilia. To the Moors it was known as Medinat Mursiya. After the fall of the caliphate of Cordova it passed successively under the rule of Almeria, Toledo and Seville. In 1172 it was taken by the Almohades, and from 1223 to 1243 it became the capital of an independent kingdom. After its recapture by the Christians, Moorish princes continued to rule in name over a mixed population, but in 1269 a rising against the suzerain, Alphonso the Wise, led to the final incorporation of Murcia (which then included the present province of Albacete) into the kingdom of Castile.

Murcia became an episcopal see in 1291. It is built nearly in the centre of a low-lying fertile plain, known as the *huerta* or garden of Murcia, which includes the valleys of the Segura and its right-hand tributary the Sangonera, and is surrounded by mountains. Despite the proximity of the sea, the climate is subject to great variations, the summer heat being severe, while frosts are common in winter. The streets are broad, straight and planted with avenues of trees, but the Calle de Platería and Calle de la Traperia are lined with old-fashioned balconied houses, and so

narrow that wheeled traffic is not easy The cathedral, dating from 1388–1467, is in the main late Gothic, but a Renaissance dome and a tower 480 ft high were added in 1521, while a Corinthian façade was erected in the 18th century. After 1875 the industrial importance of Murcia steadily increased. Mulberries (for silkworms), oranges and other fruits are largely cultivated in the *huerta,* and the silk industry, which dates from the period of Moorish rule, is still carried on. Manufactures of woolen, linen and cotton goods, of saltpetre, flour, leather and hats, have been established.

MURDER, in law, the unlawful killing of a person with malice aforethought *(see* HOMICIDE). It is defined by Lord Coke in his *Institutes* as "where a person of sound memory and discretion unlawfully killeth any reasonable creature in being and under the King's Peace, with malice aforethought, either express or implied."

MURDOCH, JAMES EDWARD (1811–1893), U S. actor, highly regarded during the 19th century as both tragedian and comedian, was born in Philadelphia. Pa., on Jan. 25, 1811. After performing with amateur groups in Philadelphia, Murdoch persuaded his father, a bookbinder who was opposed to his son's theatrical ambitions, to hire a theatre and an acting company for him. His debut, in Kotzebue's *Lover's Vows,* was considered a success, and after a season with the company (at no salary) Murdoch traveled about the U.S. and Canada, playing with various companies. In 1832, when he was emerging as an important actor Murdoch mistakenly took arsenic, thinking it medicine, and was a semi-invalid thereafter. For the next 60 years he was on the stage irregularly, yet he managed to establish a reputation as one of the United States' foremost actors. His most popular successes were in *Conrad* (1832), *Velasco* (1837), *Calynos* (1851) and *De Soto* (1852). Murdoch died on Rlay 19, 1893. (S W. H)

MURDOCK, WILLIAM (1754–1839), British inventor, who made fundamental contributions to the development of steam pouer and gas lighting, was born near Auchinleck. Scot.. on Aug. 21, 1754. In 1777 he entered the employment of Boulton & Watt in the Soho works at Birmingham, and about two years afterward he was sent to Cornwall to superintend the fitting of Watt's engines. At Redruth he is said to have carried a series of experiments in the distillation of coal so far that in 1792 he was able to light his cottage and offices with gas. After his return to Birmingham about 1799, he made such progress in the discovery of practical methods for making, storing and purifying gas that in 1802 a portion of the exterior of the Soho factory nas lighted with it in celebration of the peace of Amiens, and in the following year it was brought into use for the interior.

Murdock was also the inventor of important improvements in the steam engine. He was the first to devise an oscillating engine, of which he made a model about 1784; in 1786 he was busy—somewhat to the annoyance of both Boulton and Watt—with a steam carriage or road locomotive; and in 1799 he invented the long D slide valve. He is also believed to have been the real deviser of the sun and planet motion patented by Watt in 1781. In addition, Murdock's ingenuity was directed to the utilization of compressed air, and in 1803 he constructed a steam gun. He retired from business in 1830, and died at Soho on Nov. 15, 1839.

MURE, SIR WILLIAM (1594–1657), Scottist poet, whose works combine classical learning with staunch Presbyterianism, was born at Romallan, Ayrshire. After a quiet life, he became M.P for Ayrshire in the Scottish parliament in 1643, and, taking up arms for the Covenanters. was wounded at Marston moor in 1644. His best work is *Dido and Aeneas,* a verse paraphrase of book iv of Virgil's *Aeneid.* Religious zeal inspired. among other poems, *Tlze True Crucifixe for True Catlzolikes* (1629) and *The Cry of Blood and of a Broken Covenant* (1650). He wrote much miscellaneous verse, including paraphrases of the psalms; his *Lute-Book,* in the Laing collection of manuscripts in Edinburgh university library, is of considerable interest. His *Works* were edited in two volumes by W Tough for the Scottish Text society (1898).

MURETUS, the Latinized name of MARC ANTOINE MURET (1526–1585), French humanist, who was born at Muret near Limoges on April 12. 1526 Some time before 1552 he delivered a course of lectures in the college of Cardinal Lemoine at Paris, which was largely attended, Henry II and his queen being among his hearers. His success made him many enemies! and he was thrown into prison on a disgraceful charge, but released by the intervention of powerful friends. After a wandering and insecure life of several years in Italy. he accepted the invitation of Cardinal Ippolyte d'Este to settle in Rome in 1559. In 1561 he revisited France, at the conference at Poissy. He returned to Rome in 1563.

In 1578 the king of Poland invited Muretus to teach jurisprudence at his new college at Cracow, but Gregory XIII induced him to stay in Rome, where he died on June 4, 158j.

Complete editions of his works: *editio princeps,* Verona (1727–30); by D. Ruhnken (1789), by C. H. Frotscher (1834–41); two volumes of *Scripta selecta, by* J. Frey (1871); *Variae lectiones,* by F. A. Wolf and J. H. Fasi (1791–1828). His other works include *Juvenilia et poernata varia, orationes and epistolae.*

MURFREE, MARY NOAILLES: *see* CRADDOCK, CHARLES EGBERT.

MURGER, (LOUIS) HENRI (1822–1861), French novelist who first depicted Bohemian life. He was born in Paris, March 27, 1822. the son of a concierge and tailor. Leaving school at 13, he went into a lawyer's office, but later through the influence of the academician Étienne de Jouy, who lived in the house where his father was concierge. became a secretary to Count Aleksei Tolstoi, then representative in Paris of the Russian ministry of education. He was thus enabled to improve his education and publish some poems in periodicals: he also entered Bohemian society. He was often destitute: his health deteriorated and he was frequently in hospital. These experiences give verisimilitude to his books, in which he himself figures as Rodolphe. He began to make friends, however, and to have work published. From 1845 to 1849 *Le Corsaire* published his *Scènes de la vie de Bohème* in separate episodes. Theodore Barrière dramatized it as *La Vie de Bohème* (1849) and it was highly praised. Thanks to this success, Murger was able to live more comfortably. *Le Pays latin* (1851). *Scènes de campagne* (1854) and *Les Buveurs d'eau* (1855) were first published in the *Revue des Deux Mondes;* in 1852 the Comédie Française produced *Le Bonhomme Jadis,* which remains part of the repertory.

In 1855 Murger bought a house near Melun and there wrote *Le Sabot rouge* (1860) and *Nuits d'Hiver* (1861). He died in the Maison-Dubois hospital. Paris, Jan. 28, 1861. Ruggiero Leoncavallo and Giacomo Puccini both used *La Vie de Bohème* as the basis of operas.

See P. Martino, *Le Roman réaliste sous le Second Empire* (1913); C. Beuchat, *Histoire du Naturalisme français,* vol. i (1949). (R DL.)

MURGHAB, a river of Afghanistan, which flows into the U S S R. It rises in the Firozkhoi highlands, the northern scarp of which is defined by the Band-i-Turkestan, and after traversing that plateau from east to west it turns north through deep defiles to Bala Murghab. Beyond this, in the neighbourhood of Maruchak, it forms for a space the boundary line between Afghan and Turkestan; then joining the Kushk river at Pul-i-Khishti (Tash Kupri) it runs north to Merv, losing itself in the sands of the hlerv desert after a course of about 450 mi.

MURIATIC ACID: *see* HYDROCHLORIC ACID.

MURILLO, BARTOLOME ESTEBAN (1617–1682), the most popular Spanish religious artist of his time, was baptized in Seville on Jan. 1. 1618. After studying painting in Seville under Juan del Castillo (d. 1640), according to his first Spanish biographer, Palomino de Castro y Velasco (El *Museo Pictdrico,* iii, 1724), he made sufficient money from a consignment of pictures for the Spanish Indies to go to Madrid. There, under the protection of Velázquez, he saw the famous paintings in the royal palaces and private collections. He copied many works by Titian, Rubens and Van Dyck, much to the improvement of his colouring, drew from statues and other models and was influenced by the "grand manner" of Velázquez. Palomino places this journey to Madrid before Murillo's paintings for the monastery of San Francisco in Seville, one of which is dated 1646. However, in Feb. 1645, on the occasion of his marriage, Murillo declared that he had never been away from Seville, and, since there is no documentary evidence to confirm the story of his Madrid visit, some

critics have denied that it was ever made. It is, nevertheless, probable that Palomino, who had his information from close associates of Murillo. was mistaken only in the date of the visit. This is more likely to have taken place after he made the paintings for San Francisco. possibly in 1648–49, when there is apparently no record of his presence in Seville: for the San Francisco paintings are still in the naturalistic tradition of the school of Seville, whereas Murillo's mature style after about 1650 seems to be directly dependent on those masters whom he is said to have studied in Madrid. The rest of his life appears to have been spent in Seville, where he died on April 3. 1682.

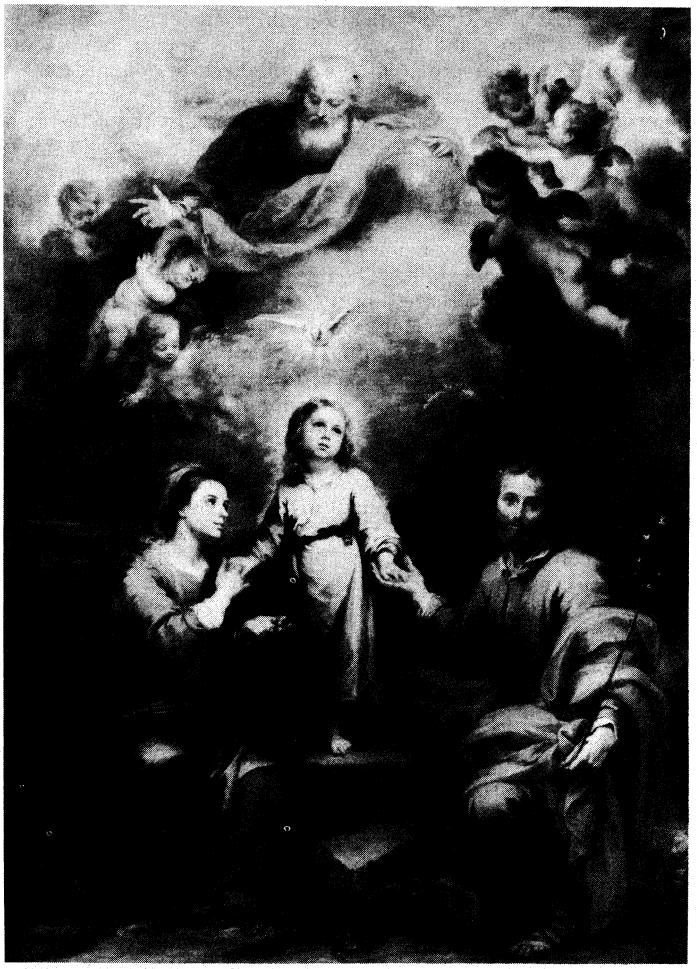
Murillo. like all Spanish painters of his time outside the court, devoted himself mainly to religious subjects. Among his chief patrons mere the Franciscans and he worked for many lay confraternities. Most of his paintings were made for the cathedral and churches of Seville. His small religious compositions were doubtless usually designed for private houses.

The "Vision of Fray Lauterio" (Fitzwilliam museum. Cambridge) and the "Virgin of the Rosary" (Archbishop's palace, Seville), considered to be hlurillo's earliest known works. are in the retardative style of his master Juan del Castillo, a combination of mannerism and realism. The 11 paintings for the *claustro chico* of San Francisco (now dispersed), of which the "Ecstasy of St. Diego of Alcalá," popularly called the "Angels' Kitchen" (Louvre museum, Paris), is dated 1646. are in the more "modern." naturalistic style established in Seville by Velázquez and continued by Zurbarán. In the "Charity of St. Diego" (Academia de San Fernando, Madrid). realism and tenebrism, commonplace models and emphasis on genre are directly inspired by the *bodegones* of Velázquez.

In Murillo's paintings of the 1650s, there appears the striking transformation of style which is hardly to be explained except by a visit to Madrid. The further stages of his evolution are, however, not clearly defined. and no satisfactory chronology of his work has yet been established. Throughout his life, he absorbed influences from a variety of sources. and many of his compositions are adapted from paintings and engravings of Flemish and other masters. He seldom signed or dated his paintings and only some of his official commissions are documented. But the chief characteristics of his later norks are already present in those which mark the creation of his personal manner and his break with provincial naturalism.

In the large "Immaculate Conception" of 1652 (museum, Seville), Murillo's softly modeled forms, rich colours, general system of lighting and broad technique reflect the change which had taken place in Velázquez' own style after his move to Madrid. through contact with Venetian and Flemish paintings in the royal collection. hlurillo's "Conception" is also strongly influenced by J. de Ribera, and may even be based on the latter's painting of this subject at Salamanca. The "St Leandro" and "St. Isidoro." which caused Murillo to be described as the best painter in Seville when they were placed in the cathedral sacristy in 1655, are still further removed from the simple naturalism of his earlier Franciscan saints. These seated figures of holy bishops, over life size. are in the grand manner of baroque portraiture. which had become fashionable at the Spanish court through Rubens and Van Dyck. The "Vision of St. Anthony." one of Murillo's most celebrated pictures. painted for the baptistery of Seville cathedral and completed in 1656, is an early example of his so-called "vaporous" style. which derives from Venetian rather than Flemish sources. In this enormous and elaborate composition, Murillo may also have been influenced by a reflection of Roman baroque paintings nhich was introduced into Seville at about this time by Francisco Herrera the Younger. But. unlike Herrera and his other Sevillian contemporary Juan de Valdés Leal, Murillo never adopted the more exaggerated elements of this style. crowded space, violent movement and excited gesture. The isolated kneeling figure of St. Anthony turns nith outstretched arms toward the vision of the Infant Christ. who descends in an aura of light encircled by angels and cherubs floating among clouds, and the whole glory is enveloped in a misty veil.

Nebulous apparitions of angels hovering in the sky occur in many of Murillo's later biblical compositions, as well as in representations of mystical visions, to suggest the mystery of heaven. At the same time he retained throughout his life his early interest in genre and narrative. His images of the Virgin. of Christ and the saints, though idealized and often sentimental, are based on popular local types. and the prominence which he gives to homely accessory figures, particularly of children, and to familiar details



BY COURTESY OF NATIONAL GALLERY, LONDON

"THE HEAVENLY AND EARTHLY TRINITIES" BY BARTOLOMÉ ESTEBAN MURILLO. IN THE NATIONAL GALLERY, LONDON

of everyday life give an intimate character to most of his religious scenes.

The enormous success which Murillo must have enjoyed in Seville is indicated by the increasing range of his official activities. He was one of the founders and first president of the Academy of Painting established in Seville in 1660. The "Invention of Painting," a subject derived from Pliny. is the only classical legend that he is known to have represented; it is one of several uorks executed for the confraternity of the Guild of Painters. to which he belonged. In 1665 he completed a series of paintings for the church of Santa María la Blanca, Seville, illustrating the foundation of Sta. Maria Maggiore. Rome (partly preserved in the Prado museum, Madrid), and began work on 22 pictures for the Capuchins (mostly preserved in the Seville museum), which he interrupted in order to decorate the chapter house of the cathedral. In 1671 he played a major role in the decoration of the cathedral for the celebration of the new cult of St. Fernando (recorded by Fernando de la Torre Farfán, *Fiestas de la S. Iglesia . . . de Sevilla* [1672], with engravings after Murillo and others). In 1665 he had been admitted to the confraternity which owned the church and hospital of San Jorge, known as La Caridad, having been recommended as a person who would be of service to God and the poor as well as for the adornment of the church. Murillo's paintings for La Caridad include the famous series of eight compositions representing works

of mercy, completed in 1674 (partially dispersed in 1810)—very different from the macabre "Hieroglyphs of Our Last Days" made by Valdés Leal for the same church but themselves varied in character. "Moses Striking the Rock" and the "Feeding of the Five Thousand" (La Caridad, Seville) have romantic landscape backgrounds, like many other later works of Murillo, and numerous genre details; "Christ Healing the Paralytic" (National gallery, London) is a more monumental composition with grandiose figures and architectural setting; "St. Elizabeth of Hungary Healing the Sick" (La Caridad) and the "Return of the Prodigal Son" (National gallery, Washington, D.C.) are, in effect, dramatized genre. From 1678 onward Murillo was working on paintings for the Hospital de los Venerables Sacerdotes, which included the celebrated "Soult Conception" (one of the many paintings by Murillo taken to France by Marshal Soult; now in the Prado, Madrid). His last works for the Capuchin church at Cádiz were left unfinished at his death; but the "Heavenly and Earthly Trinities" (National gallery, London), probably painted for a private patron in Cádiz, is an example of his late style. The mystical symbolical significance of the subject is emphasized by the characteristic vaporous glow which radiates from the Holy Ghost, illuminating the figures of the "Earthly Trinity" below. But these figures, based on familiar human archetypes, with natural gestures and tender and devout expressions, create an effect of intimate rather than exalted religious sentiment, which has led to the picture being generally known as a "Holy Family."

Murillo's religious art, with its manifest appeal to popular piety, illustrates the popular teaching of the Counter-Reformation church, as opposed to its militant activities. He represented the joys rather than the sufferings of spiritual life. His paintings for the Franciscans depict the acts of faith and charity, the mystical visions of their saints, while the subjects that he painted most frequently were those relating to the Virgin, above all the "Immaculate Conception," a cult which from the early 17th century had enjoyed enormous popularity in Spain, particularly in Seville. He also painted many versions of the Infant Christ and of the infant St. John the Baptist. These idealized "portraits" of beautiful children, in landscape settings, have their secular counterpart in his numerous rustic scenes with picturesque beggar children, though the latter have the features and expressions of individual models. His few portraits give an impress-ion of unaffected likeness. The "Self-Portrait" (National gallery. London), copied frequently in paintings and engravings, shows him in middle age, with an aspect as gentle and tranquil as is the character of his art.

Murillo had many pupils and innumerable followers, and his paintings were copied and imitated in Seville throughout the 18th century. He was the first important Spanish painter to achieve European fame, and up until the 19th century he was the only one whose works were widely known abroad. In England, his paintings were enormously popular throughout the 18th and 19th centuries; they were admired and imitated by Reynolds and Gainsborough and so highly prized by collectors that Curtis' catalogue of his works, published in 1883, shows more in England than in Spain. But many of the paintings now attributed to Murillo are by other hands, and though authentic works are distributed all over the world, the bulk of his original work is still preserved in Madrid and Seville.

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MURMANSK, a port on the Kola inlet of the Murmansk coast of the Barents sea in the Russian Soviet Federated Socialist Republic, U.S.S.R., in 69° 10′ N., 33° 30′ E. Pop. (1959) 226,000. In 1916 it was merely a few log huts, but the completion of a railway line linking it with Leningrad led to a rapid development as the only northerly port of the U.S.S.R. ice-free all year. Its industries are mainly dependent on fishing, and cod liver oil, fish guano, and shagreen from shark skin are produced. Murmansk took on great strategic importance in World War II as the destination for U.S. and British war supplies shipped to the U.S.S.R. by the arctic route.

The Murmansk coast extends from the Russian frontier to Cape Svyatoi Nos. It is a region of granitic cliffs 1,000 ft. in the west and 300 ft. at Svyatoi Nos, indented by deep gulfs and inlets with tundra and stunted bushes, and has many excellent harbours. The Atlantic drift warms the coast and west of Litski point there is little pack ice and, though a thin ice crust may form, it does not impede navigation, and thus this coast, lying within the Arctic circle, is open all the year round. Ice-breakers are rarely needed. The fishing season lasts from March to August. The fish come from Norway and so the fishing moves from west to east. Not only are the local inhabitants employed, but men from the Kem and Onega district ordinarily come for the season, and need no longer endure a long sledge journey. The chief fish caught are cod (treska), turbot, haddock, coal fish or saith, wolf fish, flat fish, comber or sea perch, eel and pout. Herrings are common but are not in much demand. Sharks are caught and oil extracted from their liver is used for medicinal purposes, and their skin is dressed. Deficiency of salt gave Murmansk fish a bad name, but government salt depots were established and the fish thereafter were satisfactorily cured. The Murmansk oblast includes the Kola peninsula and had a population in 1959 estimated at 567,000, of whom 524,000 were urban.

MURNER, THOMAS (1475?–1537). German satirist. born on Dec. 24, 1475 (?), at Oberehnheim, Alsace, became a Franciscan in 1490, studied in Freiburg, Paris, Cracow, Basel and elsewhere, and later held teaching and administrative offices in his order. In 1j23 he visited England. After the peasants' revolt he fled from Alsace to Lucerne. At his death (in Aug. 1537) he was priest of Oberehnheim.

Murner translated Virgil's *Aeneid* (1515) and Justinian's *Institutiones* (1519) and wrote the *Chartiludium logicae* (1507) and numerous pamphlets; his fame, however, rests on his satirical poems, chiefly *Die Narrenbeschworung* (1512), *Die Schelmenzunft* (1512), *Die Mühle von Schwindelsheim und Gredt Müllerin Jarzeit* (1515) and *Die Geurhmatt* (1519), in which the corruption of his age is attacked unmercifully but with broad humour and in racy, popular language. Murner became a bitter opponent of the Reformation; his *Von dem grossen lutherisehen Narren* (1522) is one of the fiercest and ablest contemporary satires on Luther.

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MUROM, a town of the U.S.S.R. in the Vladimir oblast, R.S.F.S.R., in 55° 32′ N.. 42° 2′ E., on the Oka, near its confluence with the Tesha. Founded toward the end of the 10th century, Murom played a considerable role in the 11th–13th centuries as one of the centres of Russian expansion toward the northeast. It is on the railway from Moscow to the east, and has a branch going north to Kovrov. It has iron smelting works, a railway repairing yard, leather, oil pressing, cotton and flax spinning and brandy factories. Grain is unloaded from the lower Oka. The district is noted for its kitchen gardens and cucumbers. Pop. (1959) 73,000.

MURORAN, Japanese city, largest industrial centre and one of the chief ports of Hokkaido. located on the northeastern coast of Uchiura bay in southeastern Hokkaido. Pop. (1955) 123,533. It is noted for its iron and steel production, based on both local and imported raw materials. Muroran's port. sheltered within a large curved sandspit, handles large amounts of coal from the interior Ishikari fields, wood and wood pulp and marine products. Railways link it with principal Hokkaido cities. (J. D. EE.)

MURPHY, FRANK (1890–1949), an associate justice of the U.S. supreme court from 1940 to 1949, was born April 13. 1890, at Harbor Beach, Mich. He took his bachelor's degree in law at the University of Michigan in 1914 and pursued graduate study in London and Dublin. During World War I he was a captain of infantry in France. From 1923 to 1930 he was a judge in Detroit and from 1930 to 1933 mayor of that city. He was appointed governor general of the Philippines in 1933. Elected governor of Michigan in 1936, he came into national prominence during the sit-down strikes in that state. Defeated for re-election, he became U.S. attorney general Jan. 2, 1939. Pres. Franklin D. Roosevelt named him to the supreme court, Jan. 4, 1940. He died

July 19, 1949.

MURPHY, JOHN BENJAMIN (1857–1916), U.S. surgeon, eminent as a teacher, was born in Appleton, Wis.. on Dec. 21. 1857. He graduated at Rush Medical college, Chicago, Ill.. in 1879. practised in Chicago for three years and then studied in Europe from 1882 to 1884. Murphy was the inventor of the anastomosis button (1892), which simplified the technique of certain intestinal operations and so reduced their danger. He taught successively at Rush Medical college, at the College of Physicians and Surgeons of Columbia university and at Northwestern university medical school. In 1911 he was president of the American Medical association. He was author of *General Surgery,* vol. ii of the "Practical Medical Series," and of numerous articles. He died Aug. 11, 1916.

MURPHY, JOHN FRANCIS (1853–1921), U.S. landscape painter, was born at Oswego, N.Y., on Dec. 11, 1853 He was self-taught. He ,first exhibited at the National Academy of Design in 1876 and was made an associate in 1885 and a full academician two years later. He died in New York city on Jan. 10, 1921.

Landscapes by Murphy are exhibited at public galleries in Pittsburgh. St. Louis, Detroit. Chicago and other cities.

MURPHY, WILLIAM PARRY (1892–), U.S. physician, co-winner of the Nobel prize in medicine was born in Stoughton, Wis., on Feb. 6, 1892. He received his A.B. degree from the University of Oregon in 1914 and his M.D. degree from Harvard university in 1920. Before entering medical school he taught physics and mathematics for two years in Oregon high schools. From 1920 to 1922 Murphy served as house officer at Rhode Island hospital, Providence, R. I. He entered the practice of medicine at Boston in 1923 and subsequently was appointed successively assistant resident, junior associate, associate and senior associate in medicine at the Peter Bent Brigham hospital, Boston, Mass. At Harvard he was successively assistant in medicine (1923), instructor (1928), associate (1935) and lecturer (1948).

In 1926 Murphy and George Richards Minot (*q.v.*) reported their successful results in the treatment of pernicious anemia with a liver diet. This discovery, and the developments which arose from it, converted a previously inevitably fatal disorder into one readily amenable to treatment. It was for this work that he and Minot (with G. H. Whipple) were awarded jointly the 1934 Nobel prize. In 1939 Murphy's textbook *Anemia in Practice* was published. (F. H. BL.)

MURRAY (MORAY), EARLS OF. The earldom of Moray was one of the seven original earldoms of Scotland, its lands corresponding roughly to the modern counties of Inverness and Ross. Little is known of the earls until about 1314, when Sir Thomas Randolph, nephew of King Robert Bruce, was created earl of Moray (*q.v.*). When the childless John Randolph, 3rd earl, was killed at the battle of Neville's Cross in 1346, it is not certain who held the earldom until 1359 when Henry Plantagenet, duke of Lancaster (d. 1361), was made earl of Moray by King David II. In 1372. however, John Dunbar (d. 1391), a grandson of Sir Thomas Randolph and a son-in-law of Robert II, obtained the earldom.

The last of the Dunbar earls was James Dunbar, who was murdered in August 1429, and after this date his daughter Elizabeth and her husband, Archibald Douglas (d. 1455), called themselves earl and countess of Moray.

James IV created his natural son, James Stuart (*c.* 1499–1544), earl of Moray, and after the title had been borne for a short time by George Gordon, 4th earl of Huntly (c. 1514–1562), it was bestowed in 1562 by Mary Queen of Scots upon her half-brother, an illegitimate son of James V. This was the famous regent, James Stuart, earl of Moray, or Murray (*q.v.*), who was murdered in Jan. 1570.

See vol. vi of R. Douglas's *Peerage of Scotland,* new ed. *by* J. B. Paul (1909).

MURRAY, LORD GEORGE (1694–1760), Jacobite general, fifth son of John, 1st duke of Atholl, was born at Huntingtower near Perth, on Oct. 4, 1694. He joined the army in Flanders in 1712 and in 1715 the Jacobite rebels under the earl of Mar. Wounded at the battle of Glenshiel in 1719, he escaped to Rotterdam some months later. In 1724 he returned to Scotland, and on being granted a pardon, settled at Tullibardine until 1745, when on the eve of the Jacobite rising the duke of Perth approached him on behalf of the Pretender; but his attitude was doubtful. He paid his respects to Sir John Cope, the commander of the government troops. and permitted his brother, the duke of Crieff, to appoint him deputy-sheriff of Perthshire. He received a commission in the Jacobite army and the victory at Prestonpans, on Sept. 21, was practically due to his able generalship. After opposing the invasion of England, he prevailed on the prince to march into Cumberland. When Carlisle was lost, he resigned his command, but the dissatisfaction of the army with his successor, the duke of Perth, compelled Charles to reinstate Murray. Obliged to retreat from Derby, his army reached Carlisle safely and in January 1746 entered Stirling.

The prince laid siege to Stirling Castle, while Murray defeated General Hawley near Falkirk; but the losses of the Jacobites by sickness and desertion, and the approach of Cumberland, made retreat to the Highlands an immediate necessity. The battle of Culloden, where the Stuart cause was ruined, was fought on the 16th of April 1746. On the following day the duke of Cumberland intimated to his troops that "the public orders of the rebels yesterday was to give us no quarter"; and Hanoverian newssheets printed what purported to be copies of such an order. The original copies of Lord George Murray's "orders at Culloden" which are in existence, contain no injunction to refuse quarter. After the defeat Murray conducted a remnant of the Jacobite army to Ruthven, but Prince Charles had determined to abandon the enterprise, and dismissed Murray from his service. Charles's belief in the general's treachery was shared by several leading Jacobites, but there appears no ground for the suspicion. Murray escaped abroad and died in Holland on Oct. 11, 1760.

See *A Military History of Perthshire,* ed. *by* the marchioness of Tullibardine (2 vols., 1908); *The Atholl Chronicles,* ed *by* the duke of Atholl (privately printed); The Chevalier James de Johnstone, *Memoirs of the Rebellion in 1745* (3rd ed., 1822); J. Ray, *Complete History of the Rebellion, 1745–1746* (1754); R Patten, *History of the late Rebellion* (and ed., 1717); *Memoirs of Sir John Murray of Broughton,* ed. by *R* F. Bell (Edinburgh, 1898); A. Henderson, *History of the Rebellion, 1745–1746* (2nd ed., London, 1748); W. Duke, *Lord George Murray and the Forty-five* (1927).

MURRAY, (GEORGE) GILBERT (AIMÉ) (1866–1957), British classical scholar, whose liberal humanism was shown both in his verse translations from Greek tragedy and in his work for international co-operation, was born in Sydney, Austr., Jan. 2, 1866. At 11 he was sent to England and was educated at Merchant Taylors' school, London, and St. John's college, Oxford. He was elected a fellow of New college in 1888 and in the following year became professor of Greek at Glasgow. There he soon showed, in his *Hirtory of Ancient Greek Literature* (1897) and in his lectures and classes, his distinctive blend of erudition and power to reanimate the classics. In 1899 he returned to Oxford, where from 1908 until he retired in 1936 he was regius professor of Greek. He had married in 1889 Lady Mary Howard, eldest daughter of the 9th earl of Carlisle, and their home became a centre of inspiration to all who shared their varied interests.

Critical editions of Euripides (1901, 1904 and 1910) laid the foundations of the inspired series of verse translations uhich for the first time made Greek drama real to modern audiences. The most famous — Euripides' *Electra, The Trojan Women, Iphigenia* and *Alcestis* — *were* performed in London (notably at the Court theatre, 1902–27) and elsewhere, as were later translations from Aeschylus, Sophocles and Aristophanes. Another aspect of his interpretative work was shown in *The Rise of the Greek Epic* (1907) and *Four Stages of Greek Religion* (1913, revised as *Five Stages* of *Greek Religion,* 1925) which examined Greek religion and society in the light of anthropology.

The outbreak of World War I moved Gilbert Murray deeply, and he became passionately concerned in the setting up of the League of Nations union. He served as chairman, 1923–38, and co-president from 1938 onward, and was tireless as a writer and speaker, in settings as varied as the assembly at Geneva and the local village hall. He stood three times as Liberal candidate for

parliament for Oxford university, but without success. After World War II he became known as a broadcaster, and continued to write on classical and political subjects, and in support of the United Nations. He received the order of merit in 1941. He died at Oxford, May 20, 1957.

His other works included: *Stoic Philosophy* (1915); *Religio Grammatici* (1918); *The Ordeal of This Generation* (1929); *Liberality and Civilization* (1938); *Greek Studies* (1947); *Hellenism and the Modern World* (1953); and many editions and translations of classical texts.

MURRAY, JAMES (*c.* 1719–1794), British governor of Canada! was a younger son of Alexander Murray, 4th Lord Elibank (d. 1736).

He commanded a brigade at the siege of Louisburg, was one of Wolfe's three brigadiers in the expedition against Quebec, and commanded the left wing of the army in the famous battle in Sept. 1759. After the British victory and the capture of the city, Murray was left in command of Quebec, which he defended in April and May 1760 against the attacks of the French, forcing them to raise the siege.

In Oct. 1760 Murray was appointed governor of Quebec, and he became governor of Canada after its formal cession to Great Britain in 1763. In this year he quelled a dangerous mutiny. In 1766 he retired owing to charges of partiality to the French Canadians but was exonerated in the House of Lords. In 1774 Murray was sent to Minorca as governor, where he was besieged in Fort St. Philip by a large force of French and Spaniards in 1781, and was obliged to surrender after seven months' resistance. On his return to England he was tried by a court-martial, at the instance of Sir William Draper, who had served under him in Minorca as lieutenant-governor. He was acquitted and he became a general in 1783. He died on June 18, 1794.

MURRAY, SIR JAMES AUGUSTUS HENRY (1837–1915), British lexicographer, was born at Denholm, near Hawick, on Feb. 7, 1837. After a local elementary education he proceeded to Edinburgh, and thence to the University of London, where he graduated in 1873. Sir James Murray, who received honorary degrees from several universities, both British and foreign, was engaged in teaching for 30 years, from 1855 to 1885, chiefly at Hawick and Mill Hill. During this time his reputation as a philologist was increasing; in 1878 he wrote his famous article on English Language for the *Encyclopædia Britannica,* and he was president of the Philological Society of London from 1878 to 1880, and again from 1882 to 1884. It was in connection with this society that he undertook the chief work of his life, the editing of the *New English Dictionary,* based on materials collected by the society (*see* DICTIONARY). These materials, which had accumulated since 1857, when the society first projected the publication of a dictionary on philological principles, amounted to an enormous quantity, of which an idea may be formed from the fact that Dr. Furnivall sent in "some ton and three-quarters of materials which had accumulated under his roof." The contracts between the society, the delegates of the Clarendon Press, and the editor, were signed on March 1, 1879, and Murray began the examination and arrangement of the raw material, and the still more troublesome work of re-animating and maintaining the enthusiasm of "readers." In 1885 he removed from Mill Hill to Oxford, where his *Scriptorium* came to rank among the institutions of the university city The first volume of the dictionary was printed at the Clarendon Press, Oxford, in 1884. Murray himself was personally responsible only for about one-half of the dictionary, covering A–D, H–K, O, P, T. But he created the organization which made the undertaking possible, and inspired both hiscolleagues and successors. In 1885 Murray received the honorary degree of M.A. from Balliol college; he was an original fellow of the British Academy, and in 1908 he was knighted. He died at Oxford on July 26, 1915.

See a memoir by Henry Bradley in *Proceedings of the Brit. Acad.* (vol. viii., 1917–18).

MURRAY or **MORAY, JAMES STUART, EARL OF** (*c.* 1531–1570), regent of Scotland, was an illegitimate son of James V of Scotland by Margaret Erskine, daughter of the earl of Mar. In 1538 he was appointed prior of the abbey of St. Andrews in order that James V. might secure its funds, and later, he also received those of Pittenweem and Mâcon in France, but manifested no vocation for a monastic life. In fact, shortly after the return of Knox to Scotland in 1559, he joined the lords of the congregation, who resolved to abolish forcibly the Roman service. In 1562 he was created earl of Murray, a dignity also held by George Gordon, earl of Huntly, who, however, had lost the queen's favour. Only a few days later he was made earl of Mar, but as this title was claimed by John, Lord Erskine, Stuart resigned it.

Murray displeased the queen, his half-sister, by his efforts in behalf of Knox now accused of high treason; and as he was also opposed to her marriage with Darnley, he was after that event declared an outlaw and took refuge in England. Returning to Scotland after the murder of Rizzio, he was pardoned by the queen. After her abdication in 1567, he was appointed regent of Scotland, and defeated the queen's forces at Langside, near Glasgow (May 13, 1568). He baffled Mary's schemes, suppressed the border thieves, and ruled firmly, resisting the temptation to place the crown on his own head while Mary remained a captive under suspicion of complicity in the murder of Darnley.

Several events occurred for which Murray has been censured, but which were necessary for his security: the betrayal to Elizabeth of the duke of Korfolk and of the secret plot for the liberation of Mary; the imprisonment of the earl of Northumberland, who after the failure of his rising in the north of England had taken refuge in Scotland; and the charge brought against Maitland of Lethington of complicity in Darnley's murder. Lethington was committed to custody, but was rescued by Kirkaldy of Grange, who held the castle of Edinburgh. Murray was afraid to proceed with the charge on the day of trial, while Kirkaldy and Maitland held the castle; which became the stronghold of the deposed queen's party. It has been suspected that Maitland and Kirkaldy were cognizant of the design of Hamilton of Bothwellhaugh to murder Murray, for he had been with them in the castle. As he rode through Linlithgow Murray was shot on Jan. 21, 1570, from a window by Hamilton.

See the various *Calendars of State Papers* and the general bibliography for Mary, Queen of Scots given in *Camb. Mediaeval Hist.* (vol. 3, chap. 8, 1904).

MURRAY, SIR JOHN (1841–1914), British naturalist and a founder of oceanography, was born at Coburg, Ont., on March 3, 1841. In 1868 he visited Jan Mayen Island and explored part of Spitsbergen.

In 1872 he was appointed a naturalist to the "Challenger" expedition and on the death of Wyville Thomson in 1882 became editor of the *Reports* of the expedition. He was also part author of the *Narrative of the Cruise,* and of the *Report on Deep-Sea Deposits.*

In 1880 and 1882 Murray explored the Faeroe channel and between 1882 and 1894 inspired various biological investigations in Scottish waters, establishing marine biological laboratories at Granton and Millport (later to develop into the Scottish Marine Biological association). With financial and technical assistance from Frederick and Laurence Pullar, he completed in 1906 a bathymetric survey of the fresh-water lochs of Scotland, and in 1910 he joined Johan Hjort in an oceanographical expedition to the North Atlantic ocean and was coauthor, with Hjort, of *Depths of the Ocean* (1912). Murray was accidentally killed near Kirkliston, in Scotland, on March 16, 1914. (H. F. P. H.)

MURRAY, JOHN, the name for several generations of a great firm of London publishers, founded by John McMurray (1745–1793), a native of Edinburgh and a retired lieutenant of marines, who in 1768 bought the book business of William Sandby in Fleet Street, and, dropping the Scottish prefix, called himself John Murray. He was one of the twenty original proprietors of the *Morning Chronicle,* and started the monthly *English Review* (1783–1796). Among his publications were Mitford's *Greece,* Langhorne's *Plutarch's Lives,* and the first part of Isaac D'Israeli's *Curiosities of Literature.* He died on Nov. 6, 1793.

JOHN MURRAY (2) (1778–1843), his son, was then fifteen. During his minority the business was conducted by Samuel Highley, who was admitted a partner, but in 1803 the partner-

ship was dissolved. Byron called him "the Anak of publishers." In 1807 he took a share with Constable in publishing *Marmion,* and became part owner of the *Edinburgh Review,* although with the help of Canning he launched in opposition the *Quarterly Review'* (Feb. 1809), with William Gifford as its editor and Scott, Canning. Southey, Hookham Frere and John Wilson Croker among its earliest contributors. Murray was closely connected with Constable, but, to his distress, was compelled in 1813 to break this association on account of Constable's business methods, which, as he foresaw, led to disaster. In 1811 the first two cantos of *Childe Harold* were brought to Murray by R. C. Dallas. to whom Byron had presented them. Murray paid Dallas 500 guineas for the copyright. In 1812 he bought the publishing business of William Miller (1769–1844) and migrated to 50 Albemarle street. Literary London flocked to his house, and Murray became the centre of the publishing world. It was in his drawing room that Scott and Byron first met. and here, in 1824, after the death of Lord Byron, his memoirs manuscript, considered by Gifford unfit for publication, was destroyed. A close friendship existed between Byron and his publisher, and their correspondence is a chief literary document of the period. Murray died on June 27, 1843.

His son, JOHN MURRAY (3) (1808–1892), began the famous series "Murray's Handbooks" for travelers; he himself wrote several volumes. (*See* his article on the "Handbooks" in *Murray's Magazine,* Nov. 1889.) He published many books of travel; also Campbell's *Lives of the Chancellors, The Speaker's Commentary,* Smith's *Dictionaries,* and works by Hallam, Gladstone, Lyell, Layard, Dean Stanley, Borrow, Darwin, Livingstone and Samuel Smiles. He died on April 2, 1892, and was succeeded by his eldest son. SIR JOHN MURRAY (4) (1851–1928), under whom, in association with his brother, A. H. Hallam Murray, the firm was continued. Sir John Murray edited Gibbon's *Autobiography* and Byron's *Correspondence.* He died Nov. 30, 1928.

MURRE, the common U.S. name for the guillemot (*q.v.*).

MÜRREN (5,415 ft.), a village in the Bernese Oberland in Switzerland, with magnificent mountain views. The place is a famous health resort and winter sport centre.

MURSA, BATTLE OF (A.D. 351). In Jan. 350 Magnentius the usurper deposed the emperor Constans, and a little while after was opposed by Constantius, who decisively defeated him near Mursa in Pannonia on Sept. 28, 351, and finally destroyed him two years later. The battle is of interest because the Romans adopted new tactics.

Behind Constantius flowed the Danube, and on his right lay the Drave; consequently flight was out of the question. On both wings he posted his mounted archers, and in the forefront his mailed cavalry organized after the Persian model. In the centre he drew up his heavy armed infantry, and in rear of them deployed his bowmen and slingers. His attack was made against the enemy's right wing, the whole of his left wing cavalry advancing in oblique order. When well on the outer flank of the enemy's right wing the cavalry wheeled inward and charged with great effect, for the whole of Magnentius' line was thrown into confusion. The action now became general, and, though Magnentius fled, Marcellinus continued the fight, the Gauls of the western Roman army refusing to surrender. It has been estimated that Magnentius lost 24,000 and Constantius 30,000. So great was the loss of the victor in veteran troops that after this battle it was not possible to find a sufficiency of trained men to defend the frontiers, let alone add new triumphs to Rome. (J. F. C. F.)

MURSHIDABAD, a town and district in West Bengal, India. The administrative headquarters of the district are at Berhampore. Murshidabad is on the left bank of the Bhagirathi, an old and sacred channel of the Ganges. Pop. (1951) 10,756. It was the last Moslem capital of Bengal. In 1704 the nawab Murshid Kuli Khan changed the seat of government from Dacca to Maksudabad, which he called after his own name. Even after the conquest of Bengal by the British, Murshidabad remained for some time the seat of administration. The town is still the seat of the descendant of the nawab nazim of Bengal, who ranks as the first nobleman of West Bengal, with the style of nawab bahadur of Murshidabad. Murshidabad still has such industries as ivory carving, gold and silver embroidery and silk weaving.

MURSHIDABAD DISTRICT has an area of 2.095 sq.mi. and a population (1951) of 1,715.759. The Padma, the main channel of the Ganges, separates it from East Pakistan. The Bhagirathi divides it into two almost equal parts. The tract to the west, known as the Rarh, is high and undulating, with a hard clayey soil and a dry climate; the majority of the inhabitants are Hindus. The Bagri, or eastern half, is a low-lying alluvial plain liable to annual flooding and has a humid climate; there is a Moslem majority. The district is well wooded and has large mango orchards. The principal industry, silk, is now declining. (S. GL.)

MURUT, a tribe living in Borneo and the southern part of British North Borneo. They numbered an estimated 250,000 in the early 1960s. The Muruts formerly built their villages on lofty escarpments in the undeveloped and heavily forested mountain country. hut they are increasingly moving down into the valleys and also abandoning their communal houses in favour of private dwellings. Their life and customs are broadly similar to those of the other inland tribes of Borneo (*q.v.*). They plant hill rice. sweet potatoes, manioc and maize in jungle clearings on the shifting cultivation system. They also gather jungle fruits, fish in the rivers and hunt wild pig, deer and other animals. Many of their long houses are equipped with a remarkable springing dance floor, mounted on curved saplings. which may hold as many as 30 dancers jumping rhythmically and singing. The outer walls of the houses are of bark; and the roofs are covered with palm leaves. *See* also BORNEO: *Anthropology.*

See M. C. Clark, "The Murut Home," Man, vol. lii, **art.** 21 and 51 (1952). (W. B. FG.)

MUS, the name of a Roman family of the plebeian Decian gens. (1) PUBLIUS DECIUS MUS in 343 B.C. rescued the Roman army from a difficulty in the Samnite War (Livy, vii, 34). In 340, as consul with T. Manlius Torquatus as colleague, he commanded in the Latin War. The decisive battle was fought near Mt. Vesuvius. The consuls, in consequence of a dream, had agreed that the general whose troops first gave way should devote himself to destruction, and so ensure victory. The left wing under Decius became disordered, uhereupon, repeating after the chief pontiff the solemn formula of self-devotion he dashed into the ranks of the Latins and met his death (Livy, viii. g) (2) His son, also called PUBLIUS, consul for the fourth time in 295, followed the example of his father at the battle of Sentinum. when the left wing which he commanded was shaken by the Gauls (Livy. x, 28).

MUSACEAE, the banana family, monocotyledonous plants divided into 5 genera and about 150 species, all tropical and mostly gigantic herbs. *Ravenala madagascariensis* is called the traveler's tree, as water accumulates in the sheathing bases of its leaf stalks and can be used for drinking. *Musa* includes the banana and plantain and also abaci (*qq.v.*).

MUSAEUS, the name of three Greek poets. (1) The first was a mythical seer and priest, the pupil or son of Orpheus, who was said to have been the founder of priestly poetry in Attica. He composed hymns and prose treatises, and oracular responses. which were collected in the time of Peisistratus by Onomacritus. The mystic and oracular verses and customs of Attica, especially of Eleusis, are connected with his name. A *Titanomachia* and *Tlzeogonia* are also attributed to him. (2) The second was an Ephesian attached to the court of the kings of Pergamum, who wrote a *Perseis,* and poems on Eumenes and Attalus. (3) The third (called Grammaticus in all the manuscripts) is of uncertain date, but probably belongs to the beginning of the 6th century A.D., as his style and metre are evidently modeled after Nonnus. He is possibly identified with the friend of Procopius who wrote a poem on Hero and Leander (editions by F. Passow [1810]; G. H. Schäfer [1825]; C. Dilthey [1874]; vl. by E. Sikes [London, 1920]). It was imitated by Marlowe. among others. and has been translated into many languages. The little love poem *Alpheus and Arethusa* is also ascribed to Musaeus.

MUSÄUS, JOHANN KARL AUGUST (1735–1787), German author, was born at Jena. His first work, *Grandison der Zweite* (1760–62), afterward rewritten (1781–82) and issued

with a new title, *Der deutsche Grandison*, is a satire on Samuel Richardson's hero. In 1769 Musäus became a master at the Weimar gymnasium. His second book, *Physiognomische Reisen* (1778–79), was directed against Johann Kaspar Lavater. From 1782–86 he published his best work, *Volksmärchen der Deutschen*. Even in this series of tales, the substance of which Musäus collected among the people. he could not refrain from satire. The stories, therefore, lack the simplicity of genuine folklore. In 1785 was issued *Freund Heins Erscheinungen in Holbeins Manier* by J. R. Schellcnberg, with explanations in prose and verse by Musäus. A collection of stories entitled *Straussfedern* (1787) was left unfinished at his death on Oct. 28, 1787.

See M. Müller, J. K. A. *Musäus* (1867), and an essay by A. Stern in *Beiträge zur Literaturgeschichte des 18. Jahrhunderts* (1893).

MUSCAT (MASQAT), a town on the southeast coat of Arabia, capital of the Sultanate of Muscat and Oman. It commands the entrance to the Persian gulf. In geographical position it is isolated from the interior of the peninsula as the mountains rise behind it in a rugged wall. Only from Matrah. to the north, can land communication with the rest of Arabia be maintained.

The early history of Muscat is the history of Portuguese ascendancy in the Persian gulf. When Albuquerque burned the place after destroying Quryat in 1508, Kalhat was the chief port of the coast and Muscat was comparatively unimportant. Kalhat was subsequently sacked and burned. For 114 years Muscat was held as a naval station and factory during a period of local revolts, Arab incursions and Turkish invasion by sea; but it was not till 1622, when the Portuguese lost Hormuz, that Muscat became the headquarters of their fleet and the most important place held by them on the Arabian coast. In 1650 the Portuguese were finally expelled from Oman. Muscat had been reduced after a siege in 1648. The Persians next occupied Oman. but left it in 1741. Under the great ruler of Oman. Sa'id ibn Sultan (1804–1856), the fortunes of Muscat attained their zenith; but on his death, when his kingdom was divided and the African possessions were parted from western Arabia, Muscat declined. In 1883–84, when Turki was sultan, the town was unsuccessfully besieged by the Indabayin and Rehbayin tribes, led by 'Abd al-'Aziz, the brother of Turki.

The sultan's palace is near the centre of the town.

The towns of Muscat (1954 est.. 3,500) and Matrah (8,500) have a very small Arab population. Baluchis and Negroes being by far the most numerous. Muscat, which lost most of its inland trade to Matrah. imports rice, coffee and cotton goods and exports dates, pomegranates and dried fish.

MUSCATINE, the seat of Muscatine county, Iowa, U.S., on the Mississippi river, 29 mi. W. of Davenport. Manufactured products include buttons and button machinery, woodwork, industrial alcohol, cellulose products, soybean products, livestock feeds, sand and gravel. canned foods, meats, butter, poultry, centrifugal pumps, motorized wheelbarrows, steel cabinets and other metal products. Muscatine's most distinctive industry is the making of pearl buttons from fresh-water mussel shells found in the tributaries of the Mississippi river; its factories produce more than 95% of all fresh-water pearl buttons manufactured in the U.S. The city was founded as a trading post in 1833 and incorporated in 1851. The name came from the Mascoutin Indian word meaning "Burning Island." For comparative population figures *see* table in *Iowa: Population.* (O. F. TA.)

MUSCICAPIDAE, the old world flycatchers, a large family of mostly tropical perching birds that feed on insects. They are found only in the eastern hemisphere. Some of these small songbirds catch insects on the wing; others pick their prey off leaves and twigs. *See* FLYCATCHER.

MUSCLE AND MUSCULAR SYSTEM. In all except the simplest organisms, specialized muscle cells perform the function of converting chemical energy into mechanical energy. The muscle cells may be combined in large, organized groups that act together as a single muscle. In like manner, individual muscles may work together as part of a muscle system. In higher animals two kinds of muscle tissue—that is, aggregations of muscle cells—are found: (1) Striated or striped muscle; this includes all the voluntary muscles used for active movements, as well as the involuntary cardiac muscle. (2) Smooth muscle; all are involuntary muscles and include those of the viscera, lungs. etc.

Nerves lead from the brain and spinal cord to the muscles, and impulses sent down these nerves control the action of the muscles.

This article on the muscles and muscular system is organized as follows:

I. Functions of Muscles
  A. Muscular Activity
  B. Chemical Changes
  C Muscular Exercise
  D. Muscular Systems
II. Microscopic Structure and Function
  A. Organization
  B. Sarcolemma and Muscular Excitation
  C. Sarcoplasm
  D. Myofilaments
  E. Smooth and Striated Muscle
III. Anatomy
  A. Gross Anatomy of the Human Muscular System
  B. Embryology
  C. Comparative Anatomy (X.)

I. FUNCTIONS OF MUSCLES

A. MUSCULAR ACTIVITY

Fundamental Nature.—A11 muscles exercise their function by shortening or by exerting tension along some linear axis. Nuscular contraction resembles a change in the elastic constants of a spring. Although muscle does not behave like an ideal spring, contraction is characterized by a reversible increase in the elastic properties or modulus of elasticity of the muscle.

To shorten a spring or a muscle and thus to lift a weight is equivalent to the accomplishment of work, and this requires energy. The energy sources of muscle contraction are derived ultimately from the oxidation of sugars and fats or from the splitting of sugars to form lactic acid. The oxidation can be compared to the industrial or domestic burning of fuels such as wood or oil, which resemble chemically the sugars and fats used by the muscle. Efficientuse of fuels in industry requires high temperatures. Muscles use their fuels with efficiencies comparable with those of well-engineered industrial power plants. hut achieve these efficiencies at ordinary temperatures found naturally at the surface of the earth. (H. S. BT.)

Control.—The method of control of muscular activity employed in the body is suited to the particular function of the muscle. Thus some slowly acting muscles such as the uterus are controlled in part at least by hormones circulating in the blood stream. Where quicker control is required it is provided by nerve endings which come into close contact with the muscle membrane. Activity in the nerve fibre may then cause merely a local depolarization and contraction of graded strength, as in certain postural muscles and muscles of crustaceans. or it may set off a self-propagating disturbance. the action potential, which passes over the whole of the muscle cell, depolarizing each part of the membrane in turn. This is the type of control employed in skeletal muscles used for ordinary voluntary movement. Fibres of these muscles exhibit all-or-nothing properties—any stimulus which is strong enough to activate them at all will activate them completely. (*See* ALL-OR-NONE LAW.)

Although the electrical changes associated with muscular activity are quite small: they can be easily detected by a sensitive amplifier connected to electrodes in contact with the skin over the muscle. A recording of these changes, called an electromyogram (or EMG), is useful for assessing the degree of activity of the underlying muscle. An electrocardiogram (ECG or ERG) is a recording of the electrical changes produced by the heart. Clinically an ECG is of great value, since it gives important information about the conduction of the cardiac impulse and the state of the heart muscle. It is particularly useful in diagnosing coronary thrombosis, a disease in which the blood vessels of the heart become blocked by blood clots.

Muscular Contraction.—Muscles are primarily mechanical

organs, able to exert forces and lift weights; so their mechanical properties are of primary physiological interest. In mammals and birds the muscles have a secondary function: they are the most important source of the heat which enables these creatures to maintain their raised, constant body temperature.

The mechanical properties of muscle are most conveniently studied on muscles which have been excised from the body. These can be kept alive for a long time if they are supplied with oxygen and bathed in a solution containing the same inorganic ions as blood. Most of the experimental results described here were obtained on striated muscles. Smooth muscles are less well understood, but they seem to be similar in many ways.

Resting muscle is soft and extensible, like very soft rubber. If it is stimulated by applying an electric shock of a few volts, there is a sudden and radical change in its properties; it becomes hard, develops tension, resists stretching and can shorten and lift a weight, thus performing mechanical work. The change in state persists for only a short time after the stimulus—from a hundredth to a few tenths of a second in the case of most striated muscles—then the muscle returns to its original condition. This sequence of contraction and relaxation is called a twitch. If the stimulus is repeated at a high enough frequency there is not enough time for the contracted state to decline between one shock and the next. The muscle therefore remains in a state of maintained contraction called a tetanus. Most of our bodily movements are of tetanic type. Cardiac muscle cannot be tetanized because each stimulus gives rise to a long refractory period during which additional stimuli are ineffective. This type of muscle is therefore very resistant to fatigue.

When a muscle is held at a fixed length and tetanized it develops a large force of 1–3 kg. per square centimetre, depending on the type of muscle. The force varies with the length at which the muscle is held, being reduced to zero when the muscle is very short or very long and passing through a maximum in between. The graph of tension developed against length therefore looks something like a parabola. Voluntary muscles in the body are usually attached to the skeleton in such a way that they are working near their optimal length and at a considerable mechanical disadvantage, so that even in a large movement such as flection of a limb the actual variation in muscle length is less than 10%; in consequence, tension development is about the same in all positions of the limb. Cardiac muscle, on the other hand, normally works below its optimal length. This provides the heart with a large functional reserve, since extra blood flow can cause it to dilate. This stretches its muscle fibres and increases their tension development. Dilatation of the heart is an important clinical sign that the heart is calling up its functional reserves.

The mechanical state of an active, tetanized muscle also can be examined by letting it lift various weights. It is best not to hang the weight directly on the muscle, but to let it act through a lever system which gives the muscle a large mechanical advantage. since this reduces complications due to inertia. The larger the weight applied, the shorter is the distance through which the muscle can lift it. The relation between weight and distance is the same as the tension-length graph described above. As the load is increased, not only is the amount of shortening reduced, but the speed of shortening also is reduced; *i.e.,* the muscle can lift a light load more quickly than a heavy one. The graph relating load and speed is part of a rectangular hyperbola. It has roughly the same shape for all muscles, and even for contracting actomyosin threads; however, the speed against a given load varies widely from the slow smooth muscles to the fast striated ones. The rate of working (= load × speed) can be calculated directly from the load-speed graph. The maximum power output is surprisingly high; for example, by bending an elbow one can produce work at the rate of a quarter of a horsepower, though only for a few seconds.

Until about 1935 theories about the mechanical behaviour of muscle were based on the idea that stimulation transformed the muscle into a new, stretched, elastic body, which then shortened passively toward its new equilibrium length. The relation between load and speed could then be attributed to the presence of an internal viscosity. This idea can explain many of the mechanical properties of muscle, but it later seemed more probable that the mechanical energy of contraction is generated continuously by chemical reactions all the time the muscle is active, and that the extent and speed of these reactions is linked to the tension on the muscle.

Heat Changes in Muscle.—These have been carefully studied because they are an index to the underlying chemical and physical processes of contraction. The total heat production has a number of separate components. Even at rest metabolic processes are going on in muscle, as they must in every living tissue. These processes produce a small amount of heat which is called the resting heat. In addition, resting muscle shows thermoelastic properties which do not depend on metabolic processes but on a passive rearrangement of molecules when the muscle is stretched. Muscle behaves like rubber, giving out heat when stretched and reabsorbing the heat on release.

When a muscle becomes active its heat production increases enormously. as we all know from our experience of muscular exercise. A single muscle twitch raises the temperature by a few thousandths of a degree centigrade in a few tenths of a second. These changes can be accurately measured and analyzed by modern techniques. Some of the heat, the "activation heat" or "maintenance heat," is found to accompany the state of activity; it seems that a continual flux of energy is needed to maintain the contractile machinery in being. "Shortening heat" is produced in addition whenever the muscle shortens and the amount of heat is proportional to the amount of shortening. Note that heat is produced only during the phase of contraction. Heat appears during relaxation only if mechanical energy is dissipated in the muscle. For example, if a weight is lifted during contraction it will fall during relaxation, and the energy of the falling weight will appear as heat in the muscle.

Following activity, production of "recovery heat" begins. This is the outward sign of chemical processes which are recharging the energy stores of the contractile proteins. Most of the heat comes from the oxidation of carbohydrates. The total amount of recovery heat is about equal to the total maintenance plus shortening heat.

The heat produced by muscles does not appear to play any useful part in their mechanism—almost all of it represents mere waste of energy; though, of course, mammals and birds make good use of this waste heat to maintain a constant and raised body temperature, which trahsforms them into more effective and adaptable creatures. A good deal of the waste of energy arises from the fact that maintenance heat must be produced all the time that the contractile machinery is held active. This means that a muscle consumes energy even when it is doing no mechanical work—for example, when it is supporting a weight. A spring can do this indefinitely without using up any energy. Some muscles (for example, the one that holds together the two halves of the shell of the common mussel) are much more efficient than others at holding tension for long periods. They relax very slowly, so they can be tetanized by very slow rates of stimulation.

Muscular *Efficiency*.—Measurement of heat production makes it possible to estimate the efficiency of muscular contraction, for efficiency = (work done)/(energy consumed) = (work done)/(work done + total heat produced). Isolated muscles under optimal conditions have an efficiency of 20% to 25%, and in the intact body work is performed with about the same maximum efficiency. For measurements on whole animals or men it is convenient to estimate energy consumed from the oxygen used rather than from heat measurements, though large calorimeters have been constructed in which a man could take exercise. It is quite easy to measure a man's oxygen consumption even during such exercise as swimming or skiing by collecting the air that he breathes out in a gastight bag and analyzing it for oxygen and carbon dioxide. Each litre of oxygen used generates about 5,000 cal. of energy. Since it is difficult to estimate the mechanical work performed during many kinds of exercise, measurements of human muscular efficiency are usually made by getting the subject to pedal a stationary bicycle or climb a treadmill, when the work done can be

easily calculated.

Muscle has sometimes been compared with a heat engine. It is true that both systems produce work by oxidizing combustible materials, but the parallel ends there. Muscle works at constant temperature and resembles an electric motor driven by a battery. The chemical energy of the battery is converted into mechanical work without prior conversion into heat. The consumption of zinc in the battery is analogous to the consumption of foodstuff5 in the muscle. This is potentially a far more efficient system, though in muscle efficiency is limited by the extreme complexity of the chemical reactions which take place; for at each step some free energy is degraded into heat and wasted.

B. Chemical Changes

Muscular energy is derived from the combination of carbohydrate food stores with atmospheric oxygen to form carbon dioxide and water. Carbohydrate is stored in the muscle as glycogen. which the body can form from fat and protein in the diet as well as from other carbohydrates; and oxygen is brought to the muscle by the circulating blood. This oxidation is a very complex process involving many different enzyme systems. It can take place only slowly, and the energy liberated is not in a form that can be directly used by the contractile proteins. The energy derived from these oxygen-using (or aerobic) processes is therefore used to drive forward a complex system of anaerobic chemical reactions which lead eventually to the synthesis of creatine phosphate (CP) and of adenosine triphosphate, or ATP. ATP is readily hydrolyzed in the presence of the appropriate enzyme: ATP + adenosine diphosphate (ADP) + energy. and the energy is handed on to the contractile proteins. The store of ATP is quickly regenerated by driving the above reaction backward. the energy required being derived from the hydrolysis of CP. ATP and CP are present in quite appreciable quantities, and since the hydrolysis of either of them yields about **7,000** cal. per mole. they constitute an important local store of energy. It is this that permits muscles to work at such a high rate for a few seconds until the local store is used up.

All muscles can outstrip their oxidative processes during severe exercise and the local blood supply may not be able to transport enough oxygen for current needs. Under these conditions energy can be obtained from glycogen not only by oxidizing it but also by splitting it anaerobically into lactic acid. Surplus lactic acid is carried by the blood stream to the liver and to other inactive muscles where about 20% of it is oxidized to carbon dioxide and water. The energy thus obtained is used to rebuild the remaining 80% into glycogen. In this fashion the metabolic load is spread over the whole body instead of being confined to the active muscles.

Many animals rely almost exclusively on anaerobic processes to get them out of danger. They are the animals with white meat—rabbits, poultry, etc.—which after a burst at high speed soon become exhausted. The red colour of the muscles of hares, game birds and carnivores is due to the presence of iron-containing pigments, which act as catalysts in a highly developed oxidative system. This gives these animals their capacity for sustained effort

In order to study these complicated chemical processes in detail it is necessary to break up the cells and extract their contents. Some important structural elements, such as the mitochondria, may be preserved in the extract, and it seems fairly safe to infer that the chemical processes going on in the extract are similar to those in living muscle; though the latter are more highly organized and co-ordinated.

Actomyosin, the system of actin and myosin proteins that constitute muscle fibres (see *Microscopic Structure and Function: Myofilaments,* below). will dissolve in strong salt solutions. If such a protein solution is squirted through a fine jet into water, the salt is rapidly diluted and the protein precipitates as a fine thread. or filament. If ATP is added, the thread undergoes a remarkable change in properties—it develops tension and will shorten and lift a weight. At the same time the ATP is hydrolyzed to ADP under the influence of the ATP-ase groups attached to the myosin. These changes can be produced only by ATP and a few very closely related substances.

If the actomyosin threads are made in such a way that the protein molecules are oriented along the length of the thread. the tension developed per unit area is almost as great as in a living muscle. An easier way to obtain a highly oriented structure is to treat a living muscle fibre with glycerol. This kills the fibre, breaks its cell membrane and extracts many enzymes; but it leaves the skeleton of protein filaments intact. The contraction which occurs when ATP is added is similar in many ways to that of a living muscle. Indeed, the evidence is strong, though circumstantial, that actomyosin and ATP form the basic contractile system of muscle.

C. Muscular Exercise

When a muscle becomes active it needs extra oxygen. The blood vessels in the muscle therefore open up so that more of the total blood flow is diverted into the active region. If the exercise is at all severe there will have to be compensating changes in other parts of the cardiovascular system. Blood vessels in the skin and viscera close down and the heart beats faster and more forcefully in order to circulate the blood more rapidly. The active muscles produce extra carbon dioxide, which stimulates sensitive chemoreceptor cells in the brain; this causes the breathing to become deeper and quicker so that carbon dioxide is more effectively washed out of the blood and more oxygen is absorbed.

These compensating mechanisms make it possible to transport a much larger quantity of oxygen than usual, though, of course, they have their limits. Even the most athletic man breathing air cannot absorb more than about 4.**j** l. of oxygen per minute (this is about 20 times the resting value), and in order to distribute this oxygen to the tissues each half of the heart must pump about **30** l. of blood per minute. Since each litre of oxygen consumed yields about 5,000 cal. of energy, the maximum human rate of continuous energy production is about 1. j kw. Assuming an efficiency of **2j**% this corresponds to production of mechanical work at the rate of 0.5 h.p. This is about equal to the value obtained by direct measurement in man during strenuous rowing. Notice that this limit is set by considerations of oxygen transport, not by intrinsic limitation in the muscles. If a high concentration of oxygen is breathed instead of air, the oxygen is more effectively absorbed into the blood stream, and by this means it is possible to work at higher rates without discomfort. The beneficial effect of breathing oxygen only appears when the physiological mechanisms are under strain, during hard exercise or at high altitude; under normal conditions there is no detectable benefit.

Even a small group of muscles, the flexors of one arm, can work for a short period at 0.25 h.p. while they are generating energy anaerobically. In a similar way the whole body can work at a much higher rate than 0.5 h.p. for a short time. The metabolic products that accumulate during anaerobic work must ultimately be disposed of by oxidation. so the body will have accumulated an "oxygen debt" that can be paid off later during recovery.

After severe exercise there may be as much as 100 g. of lactic acid in the tissues corresponding to an oxygen debt of 15–20 l. It is not surprising, therefore, that it may take an hour or more to recover from a strenuous bout of exercise, though persons who are physically fit tend to recover more quickly. Indeed, in a trained athlete all the physiological mechanisms involved in exercise appear to function more effectively. The details of this process of adaptation are not yet understood, so athletic training methods continue to be largely empirical.

The steady improvement in athletic performance from year to year results partly from the success of these empirical training methods. partly from improvements in the technique of performance. Knowledge of physiology has certainly transformed mountaineering and it may have played a helpful role in other sports. Runners in particular have developed great skill in setting a high steady pace which utilizes their maximal oxygen income, and in so timing the final sprint that it completely uses up the remaining stores of anaerobic energy. It is not understood what makes a great athlete different from a mediocre one of similar physique;

skill, economy of movement and tenacity must all play a part. It is difficult enough to find out how any muscle works; subtle differences between individuals are still beyond our methods.

(D. R. W.)

D. Muscular Systems

Individual muscle fibres usually act in concert with other fibres and with nerves. and often with sense organs and glands as well. The activity of the whole system may produce a movement benefiting the animal. Thus in the smooth muscle system of the intestine, the circular and longitudinal muscle fibres act in a coordinated manner to produce the action known as peristalsis. By means of these rhythmic contractions the contents of the intestine are mixed with digestive juices and slowly impelled down the canal. A much less conspicuous and more delicate component of the intestinal muscular system resides in the intestinal villi. The villi are tiny fingerlike projections that form a naplike surface on the inner lining of the intestine. Each individual villus or projection contains in its core a slender strand of smooth muscle. These act during digestion under the regulation of the nerves that govern the whole system. Contraction of the muscle fibres in the cores retracts the tips of the villi and facilitates mixing and contact with intestinal contents ready for absorption.

The cardiac muscular system is comprised of typical cardiac striped muscle and a modified fibre specialized to conduct rapidly the electrical impulse exciting contraction of the muscle itself. These specialized conducting fibres are called Purkinje fibres, after the great 19th-century anatomist J. E. Purkinje of Prague. The regular contracting cardiac muscle fibres are also capable of transmitting an excitatory impulse to neighbouring regions of the heart musculature, but at a rate slower than that of the Purkinje fibres. The mammalian heart muscle system is composed of a large number of individual cellular domains containing one to ten or more nuclei. Until 1 9 j j it was thought that the heart musculature constituted one vast syncytium. The electron microscope, however, showed that this is not so. One cell is joined to another at specialized attachment areas called intercalated disks. The fibres are wound around the atria and ventricles in spirally disposed layers. The excitatory impulse triggering each heart beat is initiated in the atrial region near the point at which much of the venous blood enters the heart. From this point it is conducted over the atria and into the ventricles. whence it spreads through the Purkinje fibres and the muscle fibres themseives to all parts of the ventricles. The excitatory impulse is followed quickly by contraction. The cardiac muscle system is nicely regulated as to rate and force of contraction by nerves, by hormones such as epinephrine and by the degree of stretching of the heart muscle fibres imposed by the filling of the heart with blood during the period of relaxation between beats.

Skeletal or striated muscle systems of vertebrates are elaborately organized. The performance of a simple movement such as the raising of the arm or the swimming of a fish requires elaborate control, regulation and participation of many muscles, nerves and sense organs. Each individual muscle in the system is usually described as having an origin and an insertion. Upon contraction. it exerts a force tending to draw origin and insertion closer together. The origin is usually defined as that attachment of the muscle that is affixed to the less movable or more central or proximal part of the animal, whereas the insertion is taken to be the attachment to the more movable or distal object. Most skeletal muscles originate and insert in bones. but some may attach to other objects, as to skin, mucous membrane, cartilage or connective tissue strands of one sort or another. In many muscular systems it is convenient to speak of two groups of muscles acting antagonistically to each other. Thus one may speak of flexors and extensors of the elbow, or of pronators and supinators of the forearm.

Skeletal muscle systems include nervous control mechanisms that initiate and regulate action and that, as they stimulate contraction of one group of muscles in a set. may inhibit the contraction of antagonistic muscles. The individual muscles and tendons are fitted with special sensory organs that monitor the tension generated by the muscle. The tendon organs are characterized by fairly simple sensory nerve endings intertuined with the tendon fibres. More elaborate sense organs are found in the muscle itself. These intramuscular sense organs are called muscle spindles. They consist of special, short. slender muscle fibres enclosed in a cellular and connective tissue capsule. The tendons of these intracapsular fibres attach to the connective tissue strands within the main mass of muscle. The special slender fibre of the muscle spindle receives a complex sensory and motor nerve supply. Sensory endings spiral around the middle section of the spindle fibre. which is here nearly devoid of contractile elements. This middle portion of the spindle fibre functions as the sensing element of the strain gauge. The two ends of the spindle fibre are well endowed with striated myofibrils and receive a special motor innervation. As the large muscle fibres around the spindle contract. the two muscular ends of the spindle fibre are activated so as to keep the central sensory region taut. This acts to maintain the elastic bias of the strain gauge.

Information sensed by vertebrate tendon organs and spindles is coded and carried by nerves to the central nervous system. where it is processed as in a computer and fed into the output of the motor nerves governing the main fibres of the muscle. This completes a feed-back loop which has an important role in regulating the activity of the muscle system.

Invertebrates also may have elaborate muscle systems. The squid has an extensive smooth muscle system surrounding its mantle cavity. All the muscle of this system is innervated from a single giant nerve fibre. which can conduct an impulse with considerable rapidity When the squid is alarmed this nerve activates the mantle muscle, which, on contraction. ejects a quantity of water from under the mantle through a narrow orifice. The resulting jet of nater squirting through the orifice propels the squid in the opposite direction At the same moment a quantity of sepia or squid "ink" is expelled by the animal, and its skin pigment cells are contracted so the animal becomes pale and less conspicuous A predator is thus tempted to pay momentary attention to the prominent cloud of ink deposited where the squid was at the moment danger was appreciated. while the inconspicuous pale squid may be able to retire rapidly unnoticed.

II. MICROSCOPIC STRUCTURE AND FUNCTION

A. Organization

Fundamental Organization of Muscle and of Muscle Systems.—The actual contractile machinery of muscle resides in long threadlike filaments of molecular dimensions. These are called myofilaments, which means "muscle filaments." The myofilaments are very small units of structure and are too slender and too closely packed to be resolved with a light microscope, though they can be studied conveniently with an electron microscope.

In many muscles the myofilaments are arranged in more or less well-organized units of structure called myofibrils, which means "little muscle threads." Myofibrils are bundles of many hundreds or thousands of myofilaments arranged parallel to each other. Each myofibril is separated from its neighbour or from the outer surface of the muscle fibre by intervening material called sarcoplasm Sarcoplasm. which means "muscle juice." contains a complex array of molecular devices that have a role in supporting. controlling. fueling and sustaining the contractile process executed by the myofilaments themselves Sarcoplasm is also found betueen and around myofilaments in muscles in which the myofilaments are not organized in well-defined myofibrils.

In all instances the sarcoplasm and the contractile machinery are part of a cell. In most cases these components comprise the main part of the cell, in which case the cell is termed a muscle cell Most muscle cells are elongated considerably in a direction parallel to that assumed by their constituent filaments and fibrils. Such elongated cells are endowed with a threadlike appearance and are called muscle fibres. Some of the larger muscle fibres are about o 1 mm. in diameter and hence are large enough to be seen individually with the naked eye. Others are smaller, perhaps

0.04 mm. in diameter, but can be distinguished with a low-power microscope. Short muscle fibres might be less than 1 mm. long. Some fibres are very much longer, achieving lengths of several centimetres or inches. Some types of muscle fibres are branched.

In some instances muscular contractile filaments are present in only part of a cell. portions of which may be specialized to serve physiological functions other than contractility. For example, cells lining the cavity of the fresh-water coelenterate *Hydra* are called endodermal epithelial cells and serve the important function of absorbing food materials ingested by the animal. A portion of these epithelial cells, however, is fitted with contractile filaments that actuate some of the movements of which the animal is capable. Similarly, in the fresh-water one-celled protozoan called *Stentor,* a thin stalklike projection by which the animal can attach itself to some solid object contains a well-defined bundle of contractile filaments that, when exercised, can shorten the stalk and withdraw the main portion of the animal from an exposed position. Such a contractile organelle is called a myoneme; it is really a tiny muscle resident in a single-celled animal that is capable of many varied functions besides that of contractility. As a rule, however, muscle filaments are arranged not in dual or multipurpose cells such as those in *Hydra* or *Stentor* but in specialized muscle cells whose primary physiological function appears to be that of contractility. Such muscle cells or fibres may be combined in large organized groups that act together as a single muscle. In like manner, individual muscles may work together or in a co-ordinated manner as part of a muscle system.

Muscle cells, muscles and muscle systems may be fitted with various auxiliary devices that control, monitor, regulate. supplement and adjust the activity of the muscle and transmit the tension generated upon contraction. These devices vary in complexity and in organizational features throughout the animal kingdom. The control mechanism may be very simple. Some are capable of merely initiating a single muscle twitch, which cannot be regulated as to strength. In contrast, there are also very elaborate control systems involving complex nervous connections and computerlike circuits in a central nervous system. These receive signals from sensory devices — some with variable bias — which act like strain gauges monitoring the tension generated in the muscle or in a tendon. These signals are processed in a nerve centre, whence correcting nerve impulses can be sent to the muscle once more. Chemical substances such as hormones also can participate in the regulation of muscle activity. In many animals nerve circuits are present that permit visual, auditory, tactile or other stimuli to generate signals that can be fed into the regulating mechanism. Thus muscle cells may be part of a complex and elaborately instrumented system involving muscle, tendon. nerve, hormones, blood vessels. sense organs and nerve centres.

General Features of Muscle Cells.—M. J. Schleiden (in 1838) and Theodor Schwann (in 1839) advanced the general hypothesis that all plants and animals contain or are made up of one or more units of structure known as cells. This cell theory has been very useful in biology. In general, each cell is a unit capable of self-duplication. It is surrounded by a thin delicate membrane, the plasma or cell membrane, which encloses a complement of complex materials and organelles, often highly ordered structurally. These comprise the cytoplasm or juice of the cell. The vast majority of cells possess, in addition, one or more nuclei, which contain genetic material important to the cell. Substances in the nucleus appear to be capable of directing or influencing profoundly the activities of the cytoplasm. Certain cells, such as mammalian red blood cells or nerve cells, may lack one or another of the above features, but these exceptions need not be considered here.

Muscle cells fall within the general pattern. All muscle cells are surrounded by a very thin membrane, called the sarcolemma, which represents the plasma or cell membrane of the muscle cell. Surrounding the sarcolemma is a thin associated accumulation of extracellular material rich in sugars of high molecular weight (polysaccharides). The sarcolemma encloses the entire muscle cell, whatever its shape, and demarcates the inner living intracellular material from the nonliving extra- or intercellular substance. The cytoplasm of the muscle cells is called sarcoplasm. It encloses the nuclear material and the contractile myofilaments, whether or not the latter are organized in myofibrils. Each muscle cell contains one or more nuclei, each of which has a complement of chromosomes embodying genes characteristic for the species. Many muscle cells contain only a single nucleus. Others, such as the great muscle fibres of human skeletal muscle, may contain many nuclei — often hundreds of them — scattered along the length of the fibre. Such units are multinucleate cells, often called syncytia (joined cells). A syncytium is a mass of cytoplasm containing several or many nuclei but surrounded by a single cell or plasma membrane. As is the case in other cells, the genes in the nuclei of muscle cells have important directing influences on the activity and properties of the fibre. These influences are subject to regulating and triggering signals imposed from sources outside the muscle cell.

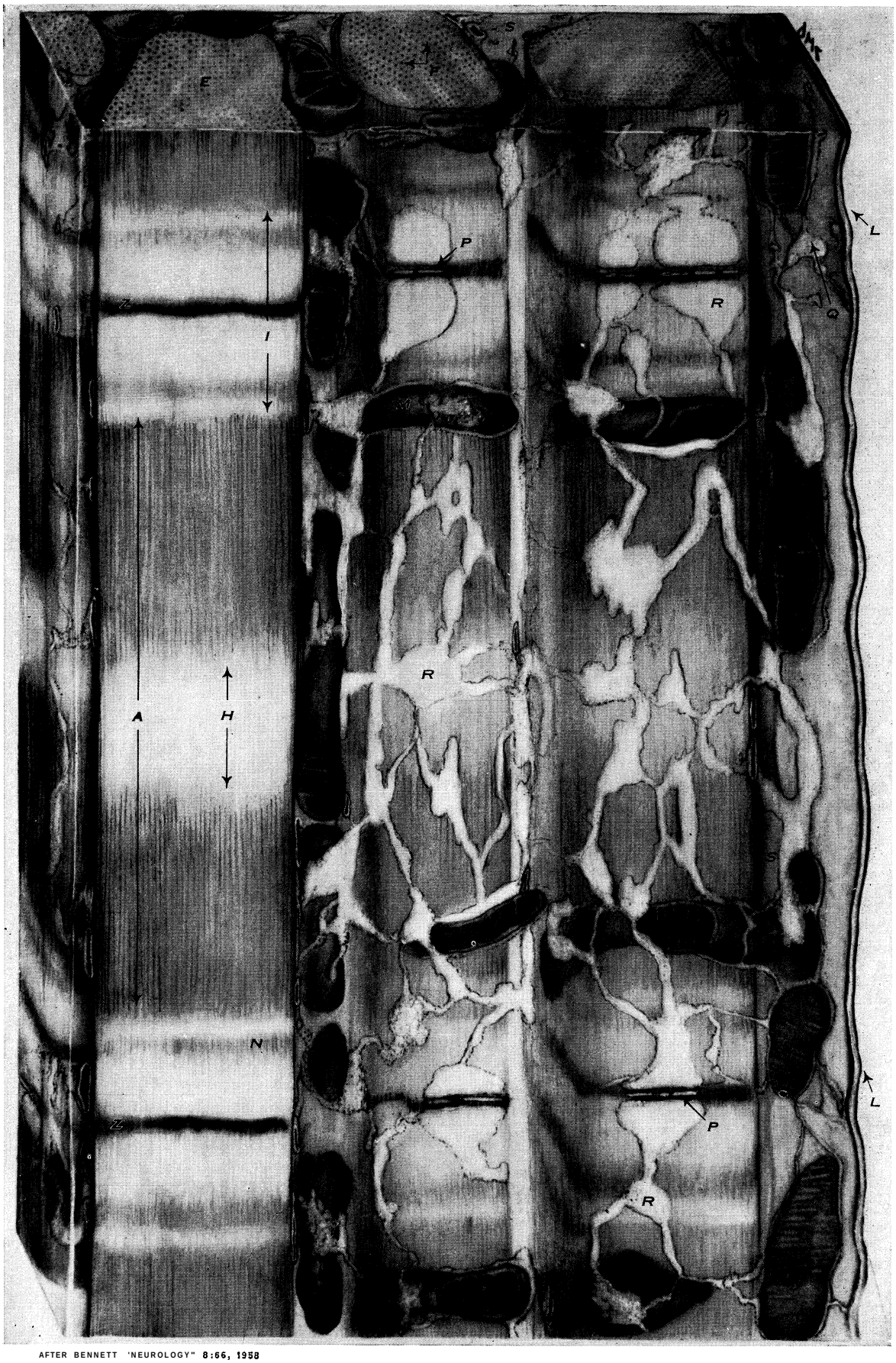
Muscle cells embody molecular machinery capable of many functions besides those of contractility. If provided with suitable raw materials from their environment, muscle cells can synthesize and organize their important sarcoplasmatic, sarcolemmatic and contractile components. They are capable of repairing damage by use. wear or injury. They can respond to increased use by synthesizing and organizing more contractile material (hypertrophy). Conversely, they respond to prolonged inactivity or disuse by disassembling part of their machinery and undergoing hypotrophy, characterized by a loss of contractile material. Muscle cells can store fuel in the form of fat or high-molecular-weight sugar and convert the fuel to a form of chemical energy convenient for immediate exploitation by the contractile protein filaments. They possess molecular coupling mechanisms whereby this chemical energy can be converted to mechanical energy by the filaments, thus changing their elastic parameters. Muscle cells can regulate the concentrations of salts or ions and other substances within them to fairly close tolerances. They are fitted with instruments for receiving signals from nerves or other information-transmitting devices and for responding to specific signals with contraction or with inhibition as directed by the signal. They can discharge some of their spent chemicals derived from fuels, oxidants, intermediates and component parts, and can reprocess some of the spent intermediate chemical carriers of energy exploited during activity.

Units Used in Describing Muscle Structure.— The dimensions of many of the components of muscle are so small that they cannot be expressed conveniently in the units of measurement of length or of mass customarily used in daily life, any more than the dimensions of this page could be expressed conveniently in miles or kilometres or light-years. For example. the dimensions of the filaments are expressed most conveniently in terms of Angstrom units, abbreviated Å. One Angstrom unit is one ten-millionth of a millimetre, or 10^{-8} cm., or about $\frac{1}{250,000,000}$ in., or about 4×10^{-9} in. (four-billionths of an inch). One Å is about one five-thousandth of the wave length of ordinary visible green light, or about two-thirds of the distance between successive carbon atoms in simple carbon chains such as occur in polyethylene, butter or petroleum oil. For somewhat larger structures found in muscle, it is convenient to use the unit of length called the micron, abbreviated μ. One micron is equal to 10,000 Å, or to $\frac{1}{1,000}$ mm., or to 10^{-4} cm.. or to about $\frac{1}{25,000}$ in., or to about 4×10^{-5} in. A micron is equal to about twice the wave length of green light, or to about one-eighth of the diameter of a human red blood cell.

B. Sarcolemma and Muscle Excitation

The sarcolemma is a strong but delicate membrane with remarkable mechanical, chemical and electrical properties. It is about 75 Å thick and is composed of one or more sheets of proteins to which are applied lipid or fatty molecules arranged very regularly with their long carbon chains packed close together in parallel array, all perpendicular to the plane of the sheet of the sarcolemma. This membrane is mechanically strong and withstands considerable tension without tearing. It is resistant to the passage of ions, glucose (a type of sugar) and many other

MUSCLE AND MUSCULAR SYSTEM

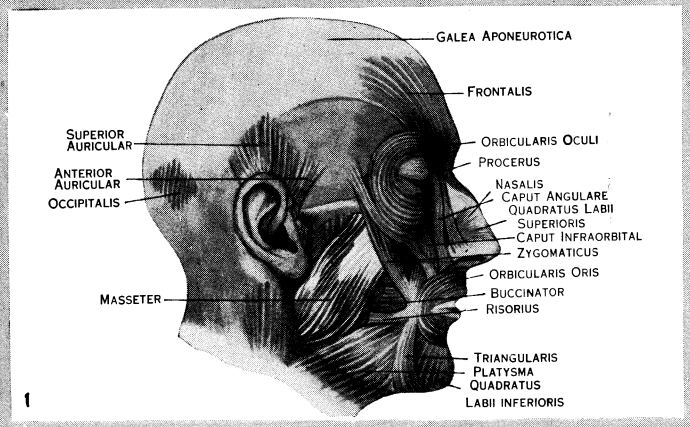


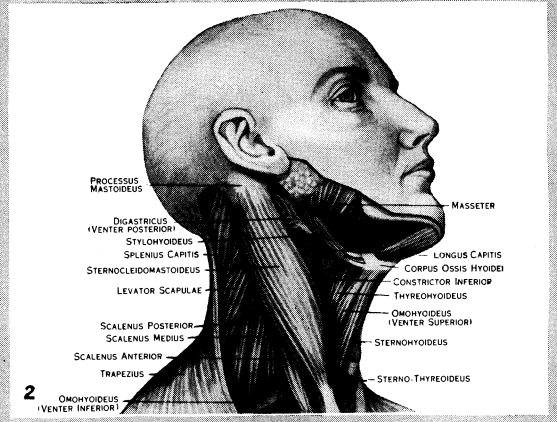
AFTER BENNETT 'NEUROLOGY" 8:66, 1958

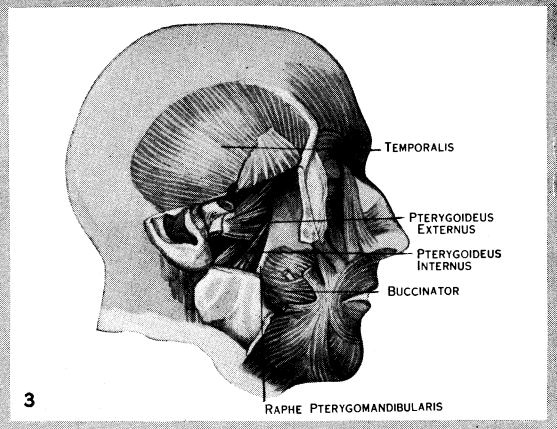
BLOCK OF STRIATED MUSCLE MAGNIFIED 70,000 TIMES

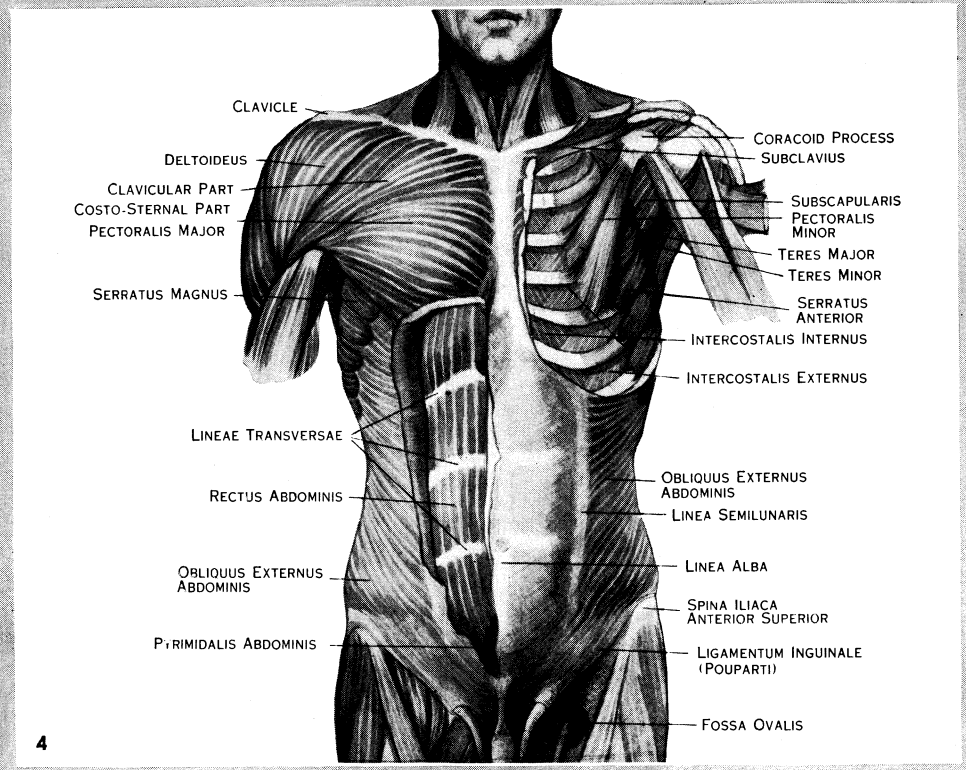
Cross bands of muscle are designated by the letters A, H, I, Z and N; other identification as follows: S, sarcoplasm; L, sarcolemma; M, mitochondria (or sarcosomes); R, sarcoplasmatic reticulum; P, attachment of reticulum to myofibrils; Q, attachment of reticulum to sarcolemma; E, myofibril; F, myofilaments

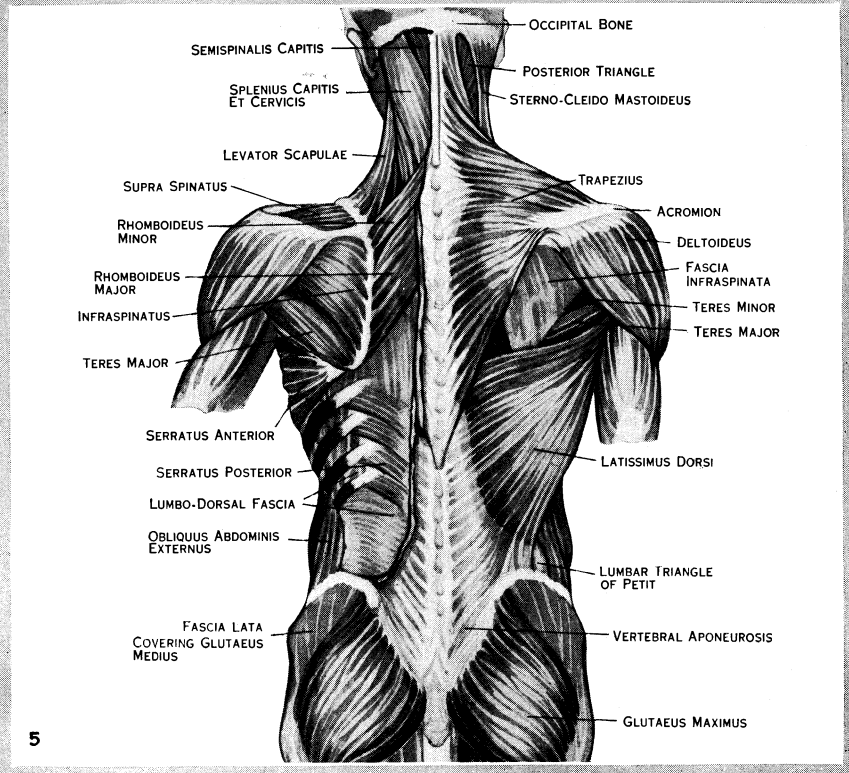
MUSCLE AND MUSCULAR SYSTEM





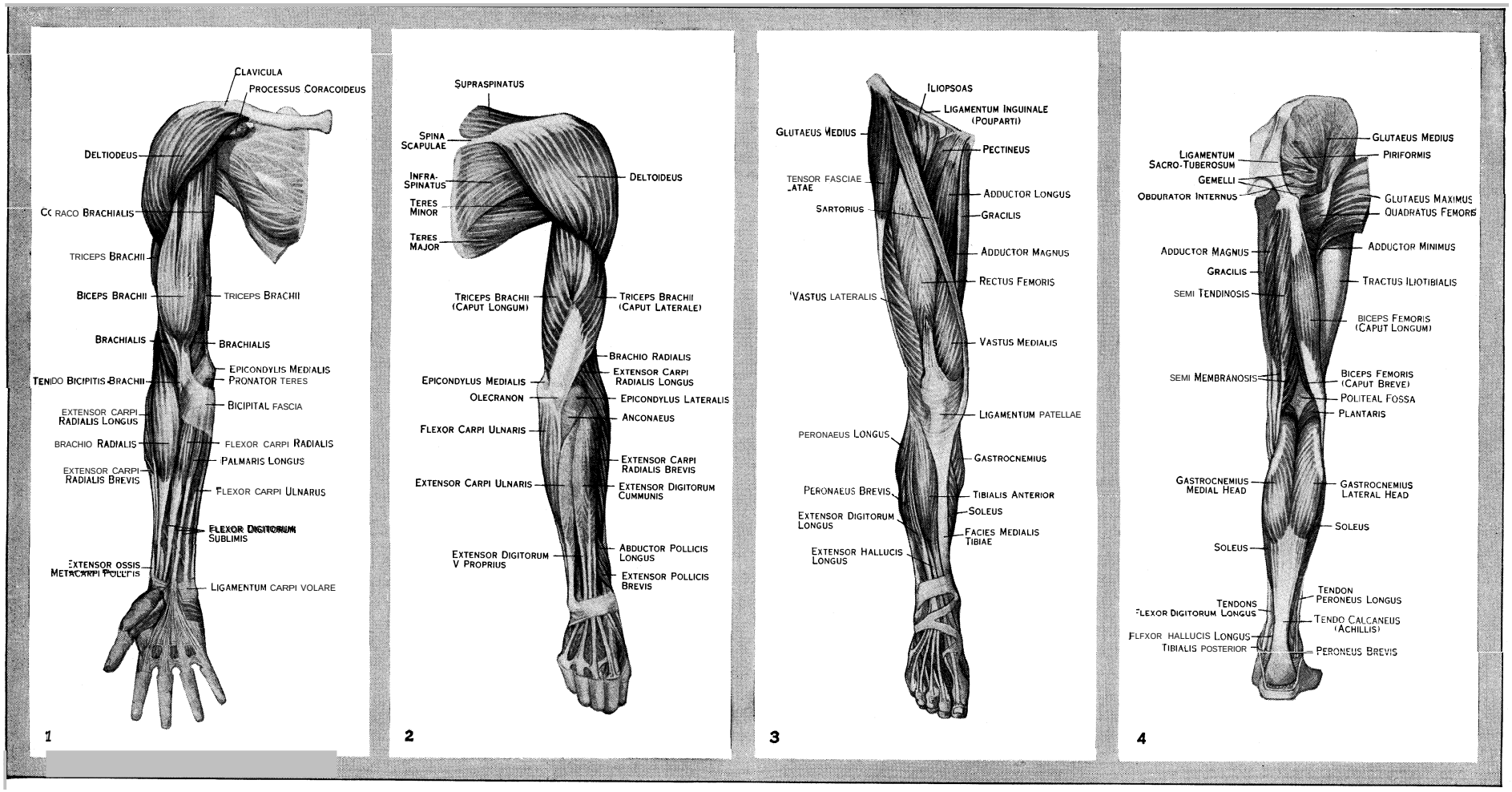






MUSCULAR CONSTRUCTION OF HEAD, NECK AND TRUNK

1. Muscles of the face and scalp (muscles of expression)
2. The triangles of the neck
3. Pterygoid region (base of skull)
4. Anterior muscles of the trunk
5. Posterior muscles of the trunk



MUSCULAR CONSTRUCTION OF THE **ARMS AND LEGS**

1. Muscles of the arm and forearm (front)
2. Muscles of the arm and forearm (back)
3. Muscles of the thigh and leg (front)
4. Muscles of the thigh and leg (back)

substances, but permits more ready passage of water and is quite freely permeable to oxygen and carbon dioxide. Simple ions such as sodium or potassium applied to the outside of the sarcolemma gain access to the sarcoplasm inside rather slowly, but once inside they diffuse quickly through many portions of the muscle cell. A considerable ionic concentration gradient exists across the sarcolemma. Thus the potassium ion is concentrated inside the cell, where it may reach, in the sarcoplasm, a concentration of potassium of about 0.55%; outside the cell much lower concentrations exist. In many animals sodium and chloride ions are present outside the muscle cell in concentrations substantially above those inside. For example, in mammalian skeletal muscle the sodium concentration outside the cell may be 0.35%, whereas that inside the cell would be 0.03%. Phosphate and inorganic anions are more concentrated inside the muscle cell than outside. These concentration gradients are maintained in spite of a slow but continuous leakage or exchange of these ions between the outside and the inside of the cell. The maintenance of the gradient is accomplished by means of molecular ion pumps, which bail out sodium ions as they enter and thus maintain the difference in concentration. Potassium ions are correspondingly selectively pumped into the cell and thus concentrated within it.

Accompanying, and apparently as a consequence of, the differences in concentration of ions across the sarcolemma, a voltage or electrical potential gradient exists across the sarcolemma. In a typical muscle the sarcoplasm may be at a potential of −0.050 to −0.10 v. with respect to the fluid outside the cell. That is to say, if a millivoltmeter is connected to two fine wires or salt electrodes, and the end of one wire is placed inside the sarcoplasm (piercing the sarcolemma) and the end of the other wire inserted in the fluid outside, the meter will indicate a potential of 50 to 100 mv. between the ends of the two wires. If the circuit is closed, a feeble current will flow. The voltage across the sarcolemma measured under these conditions with the muscle inactive is called the resting potential of the cell. It is maintained by and depends on the ion pumps mentioned above.

As a consequence of this resting potential, there exists an electrostatic field that tends to drive electrons or anions from the interior of the cell across the sarcolemma to the surrounding fluid, or to draw protons or cations into the cell. The sarcolemma resists this current, permitting only a small leakage that the ion pumps can handle without difficulty. Thus with respect to direct current, the sarcolemma behaves as an insulator with quite respectable specifications, being able to stand up without breakdown in the face of direct current voltage gradients of the order of 100,000 v. per centimetre. In this specification it is superior to many insulating materials used in industry and commerce. It is also an effective capacitor or electrical condenser, which property has important physiological connotations. Its dielectric constant is about 5.4, and this endows it with capacity to transmit high-frequency alternating current.

In many muscles the sarcolemma shows specially modified structure and properties at certain restricted areas. One type of specialized portion of the sarcolemma is usually found at or near the end of the fibre, where the contractile filaments transmit the tension they generate to a tendon or other structure outside the cell. Such a specialized region is called a myotendinal junction. Here the sarcolemma is thickened and receives inserted in it the ends of intracellular filaments continuous with the myofilaments, or even the ends of myofilaments themselves. These appear to anchor themselves in the thickened sarcolemma. Opposite this anchorage, on the other side of the sarcolemma, are the ends of extracellular tendinous fibres or, in some cases, another cell on which tension can be exerted directly. These structures are bound to the external surface of the sarcolemma by linkages capable of transmitting the tension.

A second important specialized area of the sarcolemma is found in some muscle cells where motor nerves terminate in close relation to the cell, forming a relationship whereby a nerve impulse reaching the terminus can convey a signal to which the muscle fibre responds by contraction. The complex of motor nerve terminus and specialized muscle receptor area constitutes a motor end plate. These are not found in all muscle, but are of physiological importance where present. Biochemical abnormalities of the motor end plates may have severe consequences, as in the disease myasthenia gravis.

The sarcolemma in the region of the motor end plate is normally thickened and folded and lies very close to the plasma membrane of the nerve terminal. In many types of motor end plates, when the motor nerve is activated a simple chemical substance such as acetylcholine is liberated by the nerve terminal. This liberation confronts the adjacent sarcolemma with a sudden bath of acetylcholine. which is sensed by this portion of the sarcolemma as a specific signal. This is ordinarily followed by a series of events culminating in a contraction. Usually the motor end plate is characterized by high concentrations of an enzyme such as cholinesterase. capable of rapidly destroying the chemical mediator to which the constituent portion of the sarcolemma is sensitive. This quickly clears the area for a new signal. It is noteworthy that in many muscles only this specialized portion of the sarcolemma is sensitive to the chemical mediator liberated by the nerve terminal. In such muscles, all portions of sarcolemma outside the motor end plate are insensitive to the mediator substance, even if it is applied in high concentration. Moreover, in the motor end plate itself the sarcolemma is sensitive to acetylcholine or other specific mediator only if the chemical is applied to the outer surface of the sarcolemma, where the nerve terminal normally delivers it. If it is applied experimentally by injection to the inner or sarcoplasmatic surface of the sarcolemma at the motor end plate, no response is produced.

The electrical and ionic barrier properties of the sarcolemma are subject to rapid and reversible transient changes associated with excitation of the muscle fibre. The triggering mechanisms involved in natural physiological activity vary from muscle to muscle but generally resemble in some respects the example provided in the paragraph above. The introduction of a specific chemical mediator (such as acetylcholine, succinylcholine, epinephrine, 5-hydroxytryptamine or norepinephrine) to the outer surface of the sarcolemma is usually involved. Some muscles are fitted with specialized sarcolemmatic receptor sites such as those characterizing the motor end plate. In other muscles wide areas of the sarcolemma are sensitive to the activating chemical agent. Experimentally, excitatory transients in the sarcolemma can be induced in most muscles by any stimulus that "depolarizes" the electrical conditions existing across the sarcolemma. This depolarization can be induced conveniently by appropriate application of an electrical pulse to the sarcolemma. Various arrangements of electrodes and of pulsing circuits can be used. By depolarization is meant a reversal of, or sufficient reduction of, the voltage difference maintained across the sarcolemma by the ionic concentration gradients mentioned above. If at any point along the sarcolemma the normal negative potential of the interior of the fibre is caused to assume a sufficiently low value, a sudden breakdown of the sarcolemmatic ionic barrier can be produced at that point. In a muscle with a resting potential of about −90 mv., these events might be brought to pass by reducing the potential electrically to about −50 mv. The resulting excitatory wave is called an action potential. Sodium ions flow into the muscle cell, electric currents flow between resting and excited portions of the cell, and neighbouring portions of the sarcolemma may in turn be excited. During these ionic surges the inside of the muscle fibre reverses in polarity and may reach a value of +40 mv. with respect to the fluid outside. These action potentials are transient, however. In fast muscles they may last only a few thousandths of a second before the original resting potential is restored. In slower muscles each such transient change may be characterized by a pulse lasting a number of seconds. In many muscles depolarization of one segment of the sarcolemma excites and depolarizes a neighbouring area so that a wave of excitation sweeps over the fibre at speeds up to two metres per second. In others, the electrical disturbance remains localized and does not spread over unstimulated portions of the fibre. In either case the filaments inside the muscle normally sense the depolarization in some way and respond by contracting. The amount of ionic

exchange between the outside and inside of the fibre occurring at each impulse is minute, and the original balance can be restored quickly by the pumping mechanisms of the cell. Many muscles can be depolarized and stimulated to contract by measures other than electrical pulses. Application of heat. cold or various mechanical or thermal stimuli may initiate a response.

Electrical pulses associated with muscle excitation can be recorded nith suitable amplification from electrodes placed in the muscle or. if considerable distortion and loss of spatial resolution can be tolerated. from electrodes outside the body. The electrolytes of the body fluids are capable of conducting the transient currents from the sarcolemma to the skin. Electrical impulses originating from the heart and recorded in this nay constitute the electrocardiogram. Similar electrical impulses can be recorded from skeletal muscle.

In aquatic animals these electrical currents originating from muscle can be transmitted into the surrounding water and give rise to transient pulses that may be detected some distance away. Some fishes have sense organs capable of receiving such impulses and thus of transmitting to the fish's nervous system information about the environment based on electrical signals. Such electrical sense organs are highly developed in electric fish.

These fish also have specialized electric organs comprised of large cells derived from muscle cells. These cells have developed very highly the capability of generating the electrical pulses characteristic of muscle cell membrane excitation. The cells are further developed and arranged so as to give a directional component to the ionic surge. The cell membrane, corresponding to the sarcolemma. of these electric organ cells is very elaborately developed morphologically and physiologically and forms a highly effective ion pump. In the electric fish *Electrophorus electricus,* often called the electric eel, many thousands of these units are arranged in series and in parallel so that on simultaneous activation the whole assembly can deliver about half an ampere at 300 or 400 v. In the electric ray *Torpedo,* currents of *60* amp. can be delivered at 80 v. by a similar electric organ. Thus, although ordinary muscle cells are feeble sources of electric current. these electric cells derived from muscle are capable of quite a respectable performance as pulse generators. This is accomplished by special development of the sarcolemma at the expense of the contractile units.

The sarcolemma also influences and regulates uptake and excretion of substances other than ions. For example, many vertebrate muscle cells take up glucose at an adequate rate only in the presence of the pancreatic hormone insulin.

C. Sarcoplasm

The sarcoplasm consists of the contents of the sarcolemma exclusive of nuclei and of the contractile filaments themselves. The sarcoplasm contains a continuous phase of proteinaceous fluid in which are dissolved and suspended various ions. sugars. nitrogenous compounds, proteins. lipids. gases and waste products. Within this poorly organized liquid are suspended more highly ordered structural elements. The most important of these are (1) the glycogen granules or particles. (2) the fat or lipid droplets, (3) the mitochondria or sarcosomes and (4) the membrane system comprising the sarcoplasmatic reticulum. These components are present in varying amounts and in varying geometrical distribution in muscles of different types.

Glycogen. — Glycogen is a type of animal starch. It is a substance characterized by polymers or macromolecules comprised of many glucose units bound together in very large molecular units. These form granules, about 200–400 Å across, which can be seen in the electron microscope. Glycogen granules can be regarded as a storage form of glucose, a simple sugar capable of serving as one of the fuels used for energizing muscle contraction. Large amounts of sugar present as monomeric glucose within a cell would make the fluid contents of the cell sirupy and would increase the osmotic pressure of the intracellular fluid so that water would tend to pass into the cell. thus upsetting the ionic and fluid balance of the cell. By stocking glucose in the form of the polymer glycogen. large amounts can be stored with very little influence on the osmotic pressure. The individual glucose units in a glycogen molecule can be processed and detached one by one as they are oxidized by the molecular machinery of the cell. Glycogen is found in variable amounts in muscle. It is frequently abundant in embryonic heart muscle and may be present only in meagre quantities in other muscles. It may become depleted in starvation.

Fat. — Fat can also serve as a source of fuel, and may be found in muscle cells in the form of droplets 0.5 to 2 μ in diameter, as well as in states of finer dispersion. Such fat droplets may be distributed among the contractile elements, but they vary much in size, abundance and distribution according to the species, type of muscle and physiological state of the animal. For example, in migrating fish such as the salmon. large amounts of fat may be laid anay in muscle cells during the feeding in salt water prior to entering the river for the spawning run. Much of this stored fat is used as fuel during the ascent of the rivers. The amount of fat accumulated in the fuel bunkers determines to some extent the length of the upstream migration of which the fish is capable. In a similar manner migratory water fowl may stock large amounts of fat in their muscles during a feeding phase prior to a long migratory flight. The distance the birds can cover in a single flight depends on the fuel they can load at take-off, and an important part of their fuel is the fat in the muscle.

The fuel function served by the fat and glycogen in the muscle fibres themselves is supplemented importantly by reserves elsewhere in the body. Fat cells may be found between the muscle fibres, and stores of fat and glycogen in such organs as liver, fat body or connective tissue can be mobilized and transferred quickly to the muscle cells upon need.

Mitochondria.—Glycogen or fat from a suitable storage site is not used directly by the contractile filaments but is processed in special intracellular organelles called mitochondria. Mitochondria are present in almost all cells and appear to perform much the same functions wherever found. This function is to oxidize a primary fuel such as fat or glucose in a controlled manner, converting much of the energy rendered available by this burning or oxidation to chemical bond energy resident in esters or amides of phosphoric acid. Certain compounds containing phosphoric acid. such as creatine phosphate. adenosine triphosphate or arginine phosphate. can be utilized directly as energy sources. Enzymes associated with the filaments can split off a phosphate group from such a compound, coupling the energy thus rendered available to the contractile process. Phosphoric acid compounds capable of yielding energy in this way are said to contain high-energy phosphate bonds The mitochondria can be thought of as little boilers or furnaces in which fat or sugar is burned in such a way as to convert part of the heat of combustion into high-energy phosphate bonds. Such phosphate bonds provide the immediate energy for contraction, and, indeed, for many other reactions in the cell.

Most muscle fibres contain many hundreds or thousands of mitochondria distributed widely throughout the fibre. They are often especially abundant close to the motor nerve ending or end plate. If they are placed close to the sites of utilization of the energy-rich compounds they produce, the problem of transport of such compounds within the cell is simplified. Muscle capable of prolonged sustained activity, such as hummingbird, pigeon or fly flight muscle or human cardiac muscle, contains very large numbers of mitochondria. Flight muscles of domestic fowls contain few mitochondria and are capable only of short bursts of activity before available stores of energy are exhausted.

The mitochondria of muscle resemble those of other cells in that they contain lipo-protein membranes that are to some extent like those of the sarcolemma but that differ in geometrical organization and in biochemical properties. Each mitochondrion is a separate sausagelike unit perhaps 0.5 μ in diameter. Some are greatly elongated. reaching lengths of several microns. Some are branched. In all cases they are surrounded by a membrane resembling structurally that comprising the sarcolemma. Inside this delicate sausage-skin-like covering is a second membrane that differs from the outer one in that it is folded extensively, forming crests or brackets or shelves extending into the interior of the

mitochondrion. These are called the mitochondrial cristae. The inner mitochondrial membrane encloses a fluid matrix into which the cristae project

The oxidation and coupling reactions executed by the mitochondria are mediated by organic catalysts called enzymes These are large protein molecules capable of expediting greatly the chemical processes to which fuels and phosphate compounds and intermediates are subjected. The oxidation of glucose or of fat is accomplished through a definite series of reactions. each catalyzed by a specific enzyme The enzymes are associated in some manner nith the framework of the mitochondria and are probably incorporated in or bound to the constituent membranes forming cristae or inner or outer investment

These enzymes are exceedingly efficient and speedy in action; they can disassemble or oxidize a sugar or fat so rapidly that it is thought that the enzyme units may be arranged structurally in order like rows of machines in assembly lines at a factory. The substrate, or molecule acted upon by the enzyme, is then passed in regular order from enzyme to enzyme arranged in an array corresponding to the sequence of chemical reactions to which the substrate is subjected.

Reticulum. — The last important component of the sarcoplasm is a netlike system of intracellular membranes that has come to be known as the sarcoplasmatic reticulum. This network can be impregnated nith gold salts and its grosser disposition rendered visible with the light microscope. It then appears as a three-dimensional plexus intertwining with the myofibrils, often showing regular transverse and longitudinal strands repeating geometrically at fairly regular intervals. When examined with the electron microscope, the individual strands of the sarcoplasmatic reticulum are seen to be comprised of slender tubules and enclosed channels, the walls of uhich are made up of membranes resembling in fundamental structure the lipo-protein membranes of the sarcolemma and of the mitochondria. These membranes wall off a complex maze of channels from the surrounding sarcoplasm and neighbouring myofibrils.

In 1871 the great Swedish anatomist G. M. Retzius suggested that the sarcoplasmatic reticulum might serve to conduct an excitatory impulse from the sarcolemma to the myofibrils within the fibre. In many muscles it seems to be ideally distributed to serve such a function, for it sends members that make connection with the sarcolemma from place to place, and it sends other connections to myofibrils and myofilaments within the muscle fibre.

D. Myofilaments

The contractile mechanism itself resides in slender molecular filaments arrayed parallel to each other and to the direction of tension, spaced laterally from their fellows by distances of 300–500 A. In some muscles interdigitating thick and thin myofilaments have been described, the thick ones exceeding 110 Å in diameter, the thin ones about half as thick. Even thicker ones. up to 500 Å in diameter, are found in some unusual cases. Myofilaments may range in length from one or two microns to many microns. They contain the important contractile proteins actin and myosin. In most striated muscles the myofilaments, when cut across, appear as arranged in a hexagonal pattern, as cylindrical rods would pack together with minimal interstices. Molecular cross filaments connecting the filaments transversely can be seen with the electron microscope. In some muscles these repeat regularly every 400 Å along considerable stretches of the muscle.

The cross filaments themselves are about 50 Å in diameter and may represent sites of interaction between neighbouring filaments.

E. Smooth and Striated Muscle

Muscle cells of all animals can be classified as belonging to either of two broad classes. One of these is called smooth or plain muscle, and the other is called striped or striated muscle.

Each class of muscle is distributed widely throughout the animal kingdom. Striped or striated muscle fibres are characterized by the presence of regularly repeating transverse markings on the muscle fibre. Smooth muscle fibres lack such markings.

Striated Muscle. — The cross markings that characterize striated or striped muscle are too fine to be seen with the unaided eye. but they can be studied readily with the light or electron microscope. The cross stripes repeat at regular intervals of two to five microns along the lengths of the fibre. In certain unusual invertebrate striped muscles the pattern repeats at longer intervals, up to 10 or even 50 μ or more in some exceptional cases.

The cross bandings of striated muscle are manifestations of regularly repeating variations in structure and molecular content along the lengths of the contractile material. The bands are characteristic of each constituent myofibril. which tends to line up parallel to its neighbours with its cross bands in phase with or in register with those adjacent to it. The result is an array of cross bands aligned across the fibre, though imperfections in the lateral alignment are often apparent.

Each set of repeating cross bands along a myofibril is called a sarcomere. which means "flesh part." Thus a myofibril represents many sarcomeres repeating end on end one after another, and the striated muscle fibre contains many such myofibrils side by side. Within each sarcomere are represented examples of each important component of the contractile mechanism of the muscle, and the sarcomere itself is the smallest unit showing the characteristics of the contracting mechanism of the striped muscle.

The various cross bands comprising a sarcomere have names, to which letters have been assigned. The most conspicuous band is the anisotropic band or A band, sometimes called the Q band, from the German word *Querscheibe* or "cross disk." **A** lighter portion of this in the centre of the sarcomere is called the H band, from the German *Hellscheibe*, "bright disk." Separating the **A** bands are the isotropic or I bands, each of which is bisected by a so-called Z band, from the German *Zwischenscheibe*, "between disk." By convention. the Z band is regarded as marking the boundary between one sarcomere and its neighbour.

Each of these bands differs from the others in the sarcomere with respect to chemical composition. optical properties, density and staining reactions. Thus the A bands contain most of the myosin. which is one of the important contractile proteins of striated muscle. A second important contractile protein, actin, is found in the I band and in most of the A band. but not in the H. Very rapid interactions between actin and myosin are triggered off when the muscle is excited. These interactions change the elastic constants of the muscle and appear to be important molecular features of the contractile process. Actin, myosin and other important proteins are resident in the myofilaments comprising the myofibrils.

From this description it becomes apparent that the characteristic cross stripes of striated muscle discernible with the light and electron microscopes represent a regular geometric pattern of arrangement of the molecular units responsible for contraction. These units repeat themselves at periodic intervals of two to five or more microns along the course of the fibre. This is in contrast to the situation in smooth muscle, where, as shown below, the contractile molecular units are more randomly disposed along the length of the fibre.

Striped muscle fibres are found in a great variety of vertebrate and invertebrate animals. They are found in some jellyfish (Coelenterata), where they actuate the contractions of the umbrella by which the creature swims. They are seen in some rotifers (wheel animalcules). Striped muscle is rare among worms and mollusks. hut is found in the heart of snails. in the swimming muscles of arrow-worms (Sagitta) and in the fast shell adductor muscles of the scallop *Pecten*. All the muscles of arthropods (insects; spiders and other arachnids; crustaceans, including lobsters, crabs. etc.; and isopods, including centipedes and millipedes) are of the striped variety. Here the striped fibres function as visceral and as skeletal muscles. In vertebrates, striped muscle is found in the heart and in the entire skeletal or voluntary muscular system.

Striped muscle is capable of rapid motions. The flight muscles of an insect or a hummingbird can contract and relax more than

100 times a second. Heart muscle is slower, contracting two or three times a second in large mammals, rather faster in small birds and more slowly in turtles and fishes. Most striped muscle lies between these extremes in capability for fast contraction.

Smooth Muscle.—As indicated in the discussion of striped muscle, smooth muscle lacks cross striations, and its constituent filaments and molecular contractile components are disposed without periodically repeating geometric patterns. Smooth muscles vary widely in structure from animal to animal. Some—for example, those of the tentacles of the squid and octopus—display definitive myofibrils arranged in spirals within the fibre. In the smooth muscle of earthworms the myofibrils are ribbon-shaped. In many smooth muscles no well-defined myofibrils are recognizable, and the myofilaments lie embedded in sarcoplasm without forming recognizable structural units smaller than the fibre itself.

Smooth muscle forms the greater part of the visceral musculature of vertebrates. It forms coats surrounding the alimentary canal, bile ducts, ureters and bladder. Activity of these fibres propels the contents of the viscera and provides for essential housekeeping needs in the body. Smooth muscle coats are also found around arteries and veins and can regulate the calibre of these vessels, though most of the force that propels the blood is provided by the striated muscle of the heart.

In many animals, however, the entire muscular system is comprised of smooth muscle. In most worms the body and visceral movements alike are dependent on smooth muscle. Smooth muscle is found in the feet of snails, slugs, clams and other mollusks and is used when the animal crawls on a surface. Smooth muscle is found in all phyla of animals except the arthropods.

In general, smooth muscle fibres are slower in their action than striated muscle, though there is a considerable overlap and some smooth muscles are capable of very fast response. Thus the cuttlefish, squid and octopus can execute rapid darting movements and can catch fish or crabs, yet this is accomplished with smooth muscle. A worm can retract and pull itself into its burrow very quickly, and does this with smooth muscle. Examples of slow smooth muscles are to be found in snails, where complete contraction may occupy several seconds. The smooth muscle of human viscera is intermediate in speed of reaction. (H. S. Bt.)

III. ANATOMY

A. Gross Anatomy of the Human Muscular System

In this discussion, only the voluntary muscles, under the control of the will, are considered.

The voluntary muscles form the red flesh of an animal, and are the structures by which one part of the body is moved at will upon another. Each muscle is said to have an origin and an insertion, the former being that attachment which is usually more fixed, the latter that which is more movable. This distinction, though convenient, is arbitrary, as an example will show. The pectoralis major being attached to the front of the chest and to the upper part of the arm bone, its contraction draws the arm toward the chest, whereas when, in climbing a tree, the hand grasps a branch above, contraction will draw the chest toward the arm. Generally, a muscle is partly fleshy and partly tendinous; the fleshy contractile part is attached at one or both ends to cords or sheets of white fibrous tissue, which in some cases pass round pulleys and so change the direction of the muscle's action. The other end of these cords or tendons is usually attached to the periosteum of bones, with which it blends. In some cases, when a tendon passes round a bony pulley, a sesamoid bone is developed in it which diminishes the effects of friction. A good example of this is the patella in the tendon of the rectus femoris.

Every muscle is supplied with blood vessels and lymphatics, and with one or more nerves. The nerve supply is very important both from a medical and a morphological point of view. The attachments are also important, as determining the action of the muscle. This action cannot be understood by reference to the dead body alone, for every movement expresses the balanced contractions of numerous muscles.

Muscles may be fusiform, conical, ribbonlike or flattened into triangular or quadrilateral sheets. They may also be attached to skin, cartilage or fascia instead of to bone, while certain muscles surround openings which they constrict and are called sphincters. As there are about 400 muscles on each side of the body it will be impossible here to attempt more than a mere sketch; for details, anatomy textbooks must be consulted.

Head and Face.—The scalp is moved by a large flat muscle called the occipitofrontalis, which has two muscular bellies, the occipitalis and frontalis, and an intervening epicranial aponeurosis; this muscle moves the scalp and causes the transverse wrinkles in the forehead. The anterior, posterior and superior auricular muscles are present but are almost functionless in man. The orbicularis palpebrarum forms a sphincter round the eyelids, which it closes, though there is little doubt that parts of the muscle can act separately and cause various expressions. The side of the nose has several muscles, the actions of which are indicated by their names; they are the compressor, two dilators and the depressor alae nasi, while the levator labii superioris alae que nasi sometimes goes to the nose. Raising the upper lip, in addition to the last named, are the levator labii superioris proprius and the levator anguli oris, while the zygomaticus major draws the angle of the mouth outward. The lower lip is depressed by the depressor labii inferioris and depressor anguli oris, while the orbicularis oris acts as a sphincter to the mouth. The buccinator muscle in the substance of the cheeks rises from the upper and lower jaws and runs forward to blend with the orbicularis oris. All the foregoing are known as muscles of expression and all are supplied by the seventh or facial nerve.

The temporal muscle at the side of the cranium and the masseter, which rises from the zygoma, close the mouth, since both are inserted into the ramus of the mandible; while, rising from the pterygoid plates, are the external and internal pterygoid muscles, the former of which pulls forward the condyle, and so the whole mandible, while the latter helps to close the mouth by acting on the angle of the lower jaw. This group of muscles forms the masticatory set, all of which are supplied by the third division of the fifth nerve.

For the muscles of the orbit, *see* Eye, Human; for those of the soft palate and throat, *see* Throat; and for those of the tongue, *see* Tongue.

Neck.—Just below the mandible is the digastric, which, as its name shows, has two bellies and a central tendon. The anterior belly, supplied by the fifth cranial (trigeminal) nerve, is attached to the mandible near the symphysis; the posterior belly, supplied by the seventh cranial nerve, is attached to the hyoid bone; the central tendon also is bound to the hyoid bone. Stretching across from one side of the lower jaw to the other and forming a floor to the mouth is the mylohyoid muscle; posteriorly this reaches the hyoid bone, and in the midline has a tendinous raphe separating the two halves of the muscle. Rising from the manubrium sterni and inner part of the clavicle is the sternocleidomastoid, which is inserted into the mastoid process and superior curved lines of the occipital bone; when it contracts it makes the face look over the opposite shoulder, and it is supplied by the spinal accessory nerve as well as by branches from the cervical plexus. It is an important surgical landmark, and forms a diagonal across the quadrilateral outline of the side of the neck, dividing it into an anterior triangle with its apex downward and a posterior with its apex upward.

In the anterior triangle the relative positions of the hyoid bone. thyroid cartilage and sternum should be realized, and then the hyoglossus, thyrohyoid, sternohyoid and sternothyroid muscles are explained by their names. The omohyoid muscle rises from the upper border of the scapula and runs across both triangles to the hyoid bone. Where it passes deep to the sternomastoid it has a central tendon which is bound to the first rib by a loop of cervical fascia. Rising from the styloid process are three muscles, the styloglossus, stylohyoid and stylopharyngeus, the names of which indicate their attachments. Covering these muscles of the anterior triangle is a thin sheet, close to the skin, called the platysma, the upper fibres of which run back from the mouth over the cheek and are named the risorius; this sheet is one of the few remnants

in man of the skin musculature or panniculus carnosus of lower mammals. With regard to the nerve supply of the anterior triangle muscles, all those that go to the tongue are supplied by the hypoglossal or 12th cranial nerve, while the muscles below the hyoid bone are apparently supplied from this nerve but really from the upper cervical nerves.

The posterior triangle is formed by the sternomastoid in front, the trapezius behind and the clavicle below; in its floor from above downward part of the following muscles are seen: complexus, splenius, levator anguli scapulae, scalenus medius and scalenus anticus. Sometimes a small piece of the scalenus posticus is caught sight of behind the scalenus medius. The splenius rotates the head to its own side, the levator anguli scapulae raises the upper angle of the scapula, while the three scalenes run from the transverse processes of the cervical vertebrae and fix or raise the upper ribs. The trapezius arises from the spines of the thoracic vertebrae and the ligamentum nuchae, and is inserted into the outer third of the clavicle and the spine of the scapula; it is used in shrugging the shoulders and in drawing the upper part of the scapula toward the middorsal line. Its nerve supply is the spinal accessory and third and fourth cervical nerves.

When the superficial muscles and complexus are removed from the back of the neck, the suboccipital triangle is seen beneath the occipital bone. Externally it is bounded by the superior oblique, running from the transverse process of the atlas to the lateral part of the occipital bone, internally by the rectus capitis posticus major, passing from the spine of the axis to the lateral part of the occipital bone, and inferiorly by the inferior oblique joining the spine of the axis to the transverse process of the atlas. These muscles move the head on the atlas and the atlas on the axis. They are supplied by the posterior branch of the first cervical nerve.

Trunk. — The trapezius has already been described as a superficial muscle of the upper part of the back; in the loin region the latissimus dorsi is the superficial muscle, its origin being from the lower thoracic spines, lower ribs and lumbar fascia, and it is inserted into the upper part of the arm bone. When the trapezius is cut, the rhomboid muscles (major and minor) passing from the upper thoracic spines to the vertebral border of the scapula are seen, and deep to these is the serratus posticus superior passing from nearly the same spines to the upper ribs. On reflecting the latissimus dorsi the serratus posticus inferior is seen running from the lower thoracic spines to the lower ribs. When these muscles are removed the great mass of the erector spinae is exposed; it runs all the way up the dorsal side of the vertebral column from the pelvis to the occiput, the complexus already mentioned being its extension to the head. It is longitudinally segmented into many different bundles to which special names are given, and it is attached to the various vertebrae and ribs as it goes up, thus straightening the spinal column. Deep to the erector spinae are found shorter bundles passing from one vertebra to another and forming the semispinalis and multifidus spinae muscles. The latissimus dorsi and rhomboids are supplied by branches of the brachial plexus of nerves, while the deeper muscles get their nerves from the posterior primary divisions of the spinal nerves.

On the anterior part of the thoracic region the pectoralis major runs from the clavicle, sternum and ribs to the humerus; deep to this is the pectoralis minor, passing from the upper ribs to the coracoid process. The serratus magnus is a large muscle rising by serrations from the upper eight ribs and running back to the vertebral border of the scapula, which it draws forward as in the fencer's lunge. Between the ribs are the external and internal intercostal muscles. The former begin at the tubercle and end at the junctions of the ribs with their cartilages; the latter only begin at the angle of the ribs but are prolonged onto the sternum, so that an interchondral as well as an intercostal part of each muscle is recognized. The fibres of the external intercostals run downward and forward, those of the internal downward and backward (see RESPIRATION).

The abdominal walls are formed of three sheets of muscle, of which the most superficial or external oblique is attached to the outer surfaces of the lower ribs; its fibres run downward and forward to the pelvis and midline of the abdomen. The middle sheet, the internal oblique, is on the same plane as the ribs, and its fibres run downward and backward. The transversalis is attached to the deep surfaces of the ribs, and its fibres run horizontally forward. Below, all these muscles are attached to the crest of the ilium and to Poupart's ligament, which is really the lower free edge of the external oblique; behind, the two deeper ones, at all events, blend with the fascia lumborum. As they approach the midventral line they become aponeurotic and form the sheath of the rectus. The rectus abdominis is a flat muscular band that runs up on each side of the linea alba or midventral line of the abdomen from the pubis to the ribs and sternum. This muscle has certain tendinous intersections or lineae transversae, the morphology of which is referred to below. In front of the lowest part of the rectus is sometimes a small triangular muscle called the pyramidalis. The quadratus lumborum is a muscle at the back of the abdominal wall that runs between the last rib and the crest of the ilium. In front of the bodies of the vertebrae is a prevertebral or hypaxial musculature, of which the rectus capitis anticus major and minor muscles and longus colli in the neck and the psoas in the loins form the chief parts. The pelvis is closed below by a muscular floor formed by the levator ani and coccygeus muscles. The diaphragm is explained in a separate article.

Upper Extremity. — The deltoid is the muscle that forms the shoulder cap and is used in abducting the arm to a right angle with the trunk; it runs from the clavicle, acromial process and spine of the scapula to the middle of the humerus, and is supplied by the circumflex nerve. Several short rotating muscles pass from the scapula to the upper end of the humerus. These are the subscapularis, passing in front of the shoulder joint; the supraspinatus above the joint; and the infraspinatus and teres minor behind. The teres major comes from near the lower angle of the scapula, and is inserted with the latissimus dorsi into the front of the surgical neck of the humerus. The coracobrachialis passes from the coracoid process to the middle of the humerus in front of the shoulder joint, while the brachialis anticus passes in front of the elbow from the humerus to the coronoid process of the ulna.

Passing in front of both shoulder and elbow is the biceps, the long head of which rises from the top of the glenoid cavity inside the joint, while the short head comes from the coracoid process. The insertion is into the tubercle of the radius. These three muscles are all supplied by the same (musculocutaneous) nerve.

At the back of the arm is the triceps, which passes behind both shoulder and elbow joints and is the great extensor muscle of them; its long head rises from just below the glenoid cavity of the scapula, while the inner and outer heads come from the back of the humerus. It is inserted into the olecranon process of the ulna and is supplied by the musculospinal nerve.

The muscles of the front of the forearm form superficial and deep sets. Most of the superficial muscles come from the internal condyle of the humerus. From without inward they are the pronator radii teres going to the radius, the flexor carpi radialis to the base of the index metacarpal bone, the palmaris longus to the palmar fascia, the flexor sublimis digitorum to the middle phalanges of the fingers and the flexor carpi ulnaris to the pisiform bone. In addition to these, the brachioradialis is a flexor of the forearm, though it arises from the outer supracondylar ridge of the humerus. It is supplied by the musculospiral nerve, the flexor carpi ulnaris by the ulnar, the rest by the median.

The deep muscles of the front of the forearm consist of the flexor longus pollicis, running from the radius to the terminal phalanx of the thumb; the flexor profundus digitorum from the ulna to the terminal phalanges of the fingers; and the pronator quadratus passing across from the lower third of the ulna to the same amount of the radius. These three muscles are supplied by the anterior interosseous branch of the median nerve, but the flexor profundus digitorum has an extra twig from the ulnar.

The extensor muscles at the back of the forearm are also divided into superficial and deep sets. The former rise from the region of the external condyle of the humerus, and consist of the extensor carpi radialis longior and brevior inserted into the index

and medius metacarpal bones; the extensor communis digitorum to the middle and distal phalanges of the fingers; the extensor minimi digiti; the extensor carpi ulnaris passing to the metatarsal bone of the minimus; and the supinator brevis wrapping round the neck of the radius to which it is inserted. The aconeus. which runs from the external condyle to the olecranon process, is really a part of the triceps. The deep muscles rise from the posterior surfaces of the radius and ulna, and are the extensor ossis metacarpi pollicis, the name of which gives its insertion; the extensor brevis pollicis to the proximal phalanx; and the extensor longus pollicis to the distal phalanx of the thumb; while the extensor indicis joins the extensor communis slip to the index finger. All these posterior muscles are supplied by the posterior interosseous nerve.

In front of and behind the wrist the tendons are bound down by the anterior and posterior annular ligaments, while on the flexor surface of each finger is a strong fibrous sheath or theca for the flexor tendons. The ball of the thumb is occupied by short muscles called the thenar group, while hypothenar muscles are found in the ball of the little finger. The four lumbrical muscles run.from the flexor profundus digitorum tendons to those of the extensor communis between the heads of the metacarpal bones, while. rising from the shafts of these bones. are the three palmar and four dorsal interosseous muscles. which also are inserted into the extensor tendons. The two outer lumbricals and the thenar muscles are supplied by the median nerve: all the other hand muscles are supplied by the ulnar.

Lower Extremity. — On the front of the thigh the quadriceps extensor muscles are the most important. There are four of these: the rectus femoris, with its straight and reflected heads rising from just above the acetabulum; the crureus. deep to this, from the front of the femur; and the vastus externus and internus wrapping round the femur on each side from the linea aspera. All these are inserted into the patella. or rather the patella is a sesamoid bone developed where their common tendon passes round the lower end of the femur when the knee is bent. The distal part of this tendon. which passes from the patella to the tubercle of the tibia. is the ligamentum patellae.

The sartorius is a long, ribbonlike muscle running from the anterior superior spine of the ilium to the inner surface of the tibia. obliquely across the front of the thigh. It forms the outer boundary of Scarpa's triangle, the inner limit of which is the adductor longus and the base Poupart's ligament. The floor is formed by the iliacus from the iliac fossa of the pelvis. which joins the psoas. to be inserted with it into the lesser trochanter, and by the pectineus running from the upper ramus of the pubis to just below the insertion of the last muscles.

The adductor muscles, longus, brevis and magnus, all rise from the subpubic arch, and are inserted into the linea aspera of the femur so that they draw the femur toward the middle line. The gracilis is part of the adductor mass, though its insertion is into the upper part of the tibia. The extensor muscles of the front of the thigh are supplied by the anterior crural nerve, but the adductor group on the inner side are supplied by the obturator nerve. The pectineus is often supplied from both sources.

On the back of the thigh the gluteus maximus plays a great part in determining man's outline. It rises from the sacral region. and is inserted into the upper part of the femur and the deep fascia of the thigh, which is very thick and is known as the fascia lata; the muscle is a great extensor of the hip and raises the body from the stooping position. The gluteus medius rises from the ilium, above the hip joint. and passes to the great trochanter; it abducts the hip and enables the body to be balanced on one leg. as in taking a step forward. The gluteus minimus is covered by the last muscle. and passes from the ilium to the front of the great trochanter, thus rotating the hip joint inward. Some of its anterior fibres are sometimes separate from the rest, and are then called the scansorius.

When the gluteus maximus is removed, a number of short externally rotating muscles are seen. rising from the pelvis and inserted into the great trochanter; these are, from above downward, the piriformis, gemellus superior, obturator internus, gemellus inferior and quadratus femoris. They are all supplied by special branches of the sacral plexus. On cutting the quadratus femoris a good deal of the obturator externus can be seen, coming from the outer surface of the obturat or membrane and passing to the digital fossa of the great trochanter. Unlike the rest of this group, it is supplied by the obturator nerve. Coming from the anterior part of the crest of the ilium is the tensor fasciae femoris, which is inserted into the fascia lata, as is part of the gluteus maximus, and the thickened band of fascia which runs down the outer side of the thigh from these to the head of the tibia is known as the ilio tibial band. The tensor fasciae femoris, gluteus medius and minimus, are supplied by the superior gluteal nerve, the gluteus maximus by the inferior gluteal.

At the back of the thigh are the hamstrings, rising from the tuberosity of the ischium; these are the semimembranosus and semitendinosus, passing to the inner part of the upper end of the tibia and forming the internal hamstrings, and the biceps femoris or external hamstring, which has an extra head from the shaft of the femur and is inserted into the head of the fibula. These muscles are supplied by the great sciatic nerve and extend the hip joint while they flex the knee.

In the leg, as distinguished from the thigh, are three groups of muscles, anterior, external and posterior. The anterior group all come from the front of the tibia and fibula, and consist of the extensor longus digitorum. extending the middle and distal phalanges of the four outer toes, the extensor proprius hallucis, extending the big toe, and the peroneus tertius, a purely human muscle inserted into the base of the fifth metatarsal bone. All these are supplied by the anterior tibial nerve.

The external group comprises the peroneus longus and brevis, rising from the outer surface of the fibula and inserted into the tarsus, the longus tendon passing across the sole to the base of the first metatarsal bone, the brevis to the base of the fifth metatarsal. These are supplied by the musculocutaneous nerve.

The posterior group is divided into a superficial and a deep set. The superficial is composed of the gastrocnemius. the two heads of which rise from the two condyles of the femur; the soleus, which rises from the upper parts of the back of the tibia and fibula: the plantaris, which comes from just above the external condyle of the femur; and the popliteus. which, although on a deeper plane, really belongs to this group and rises by a tendon from the outer condyle while its fleshy part is inserted into the upper part of the back of the tibia. The gastrocnemius and soleus unite to form the tendo Achillis, which is attached to the posterior part of the calcaneum. while the plantaris runs separately as a very thin tendon to the same place. These muscles are supplied by the internal popliteal nerve.

The deep set of the posterior group of leg muscles is formed by three muscles that rise from the posterior surfaces of the tibia and fibula. The flexor longus digitorum, the tibialis posticus and the flexor longus hallucis. from within outward. Their tendons all pass into the sole. that of the flexor longus digitorum being inserted into the terminal phalanges of the four outer toes, the flexor longus hallucis into the terminal phalanx of the big toe. while the tibialis posticus sends expansions to most of the tarsal bones. The nerve supply of this group is the posterior tibial.

On the dorsum of the foot is the extensor brevis digitorum, which helps to extend the four inner toes. In the sole are four layers of short muscles. the most superficial of which consists of the adductor hallucis, the flexor brevis digitorum and the adductor minimu digiti. the names of which indicate their attachments. The second layer is formed by muscles that are attached to the flexor longus digitorum tendon; they are the accessorius, running forward to the tendon from the lower surface of the calcaneum, and the four lumbricales. which rise from the tendon after it has split for the four toes and pass between the toes to be inserted into the tendons of the extensor longus digitorum on the dorsum. The third layer comprises the flexor brevis hallucis. adductor obliquus and adductor transversus hallucis and the flexor brevis minimi digiti. The fourth layer contains the three plantar and four dorsal interosseous muscles, rising from the metatarsal

bones and inserted into the proximal phalanges and extensor tendons in such a way that the plantar muscles draw the toes toward the line of the second toe while the dorsal draw them away from that line. Of these sole muscles the flexor brevis digitorum, flexor brevis hallucis, adductor hallucis and the innermost lumbrical are supplied by the internal plantar nerve, while all the rest are supplied by the external plantar.

B. Embryology

The development of the muscular system is partly known from the results of direct observation and partly inferred from the study of the part of the nervous system whence the innervation is derived. The smooth muscle is formed from the mesenchyme cells of the somatic and splanchnic layers of the mesoderm (see Vertebrate Embryology), but never, so far as is known, from the mesodermal somites. The heart muscle is also developed from mesenchymal cells, though the changes producing its feebly striped fibres are more complicated. The skeletal or real striped muscles are derived either from the mesodermic somites or from the branchial arches.

As the mesodermal somites are placed on each side of the neural canal in the early embryo, it is obvious that the greater part of the trunk musculature spreads gradually round the body from the dorsal to the ventral side and consists of a series of plates called myotomes. The muscle fibres in these plates run in the long axis of the embryo. and are at first separated from those of the two neighbouring plates by thin fibrous intervals called myocommata. In some cases these myocommata persist and even become ossified, as in the ribs, but more usually they disappear early, and the myotomes then unite with one another to form a great muscular sheet.

In the whole length of the trunk a longitudinal cleavage at right angles to the surface occurs, splitting the musculature into a dorsal and ventral part, supplied respectively by the dorsal and ventral primary divisions of the spinal nerves. From the dorsal part the various muscles of the erector spinae series are derived by further longitudinal cleavages either tangential or at right angles to the surface, while the ventral part is again longitudinally split into mesial and lateral portions.

A transverse section of the trunk at this stage, therefore, would show the cut ends of three longitudinal strips of muscle: (1) a mesial ventral, from which the rectus. pyramidalis sternohyoid omohyoid and sternothyroid muscles are derived; (2) a lateral ventral, forming the flat muscles of the abdomen. intercostals and part of the sternomastoid and trapezius; and (3) the dorsal portion already noticed. The mesial ventral part is remarkable for the persistence of remnants of myocommata in it, forming the linae transversae of the rectus and the central tendon of the omohyoid. The lateral part in the abdominal region splits tangentially into three layers, the external and internal oblique and the transversalis. the fibres of which become differently directed. In the thoracic region the intercostals probably indicate a further tangential splitting of the middle or internal oblique layer, because the external oblique is continued headward superficially to the ribs and the transversalis deeply to them. The mole cephalic part of the external oblique layer probably disappears by a process of pressure or crowding out as a result of the encroachment of the serratus magnus, a muscle ahich, as its nerve supply indicates, is derived from the lower cervical myotomes. The deeper parts of the lateral mass of muscles spread to the ventral surface of the bodies of the vertebrae, and form the hypaxial muscles—such as the psoas, longus colli and recti capitis antici.

The nerve supply indicates that the lowest myotomes taking part in the formation of the abdominal walls are those supplied by the first and second lumbar nerves, and are represented by the cremaster muscle in the scrotum. In the perineum, hoaever. the third and fourth sacral myotomes are represented. and these muscles are differentiated largely from the primitive sphincter that surrounds the cloacal orifice, though partly from vestigial tail muscles. In the head no distinct myotomes have been demonstrated in the mammalian embryo, but as they are present in more lowly vertebrates, it is probable that their development has been slurred over, a process often found in the embryology of the higher forms. Probably nine cephalic myotomes originally existed, of which the first gives rise to the eye muscle supplied by the third nerve, the second to the superior oblique muscle supplied by the fourth nerve and the third to the external rectus supplied by the sixth nerve. The fourth, fifth and sixth myotomes are suppressed, but the seventh, eighth and ninth possibly form the muscles of the tongue supplied by the 12th cranial nerve.

Turning now to the branchial arches, the first branchiomere is innervated by the fifth cranial nerve, and to it belong the masseter, temporal, pterygoids, anterior belly of the digastric, mylohyoid. tensor tympani and tensor palati, while from the second branchiomere, supplied by the seventh or facial nerve, all the facial muscles of expression and the stylohyoid and posterior belly of the digastric are derived, as well as the platysma, which is one of the few remnants of the panniculus carnosus or skin musculature of the lower mammals. From the third branchiomere, the nerve of which is the ninth or glossopharyngeal, the stylopharyngeus and upper part of the pharyngeal constrictors are formed, while the fourth and fifth gill arches give rise to the muscles of the larynx and the lower part of the constrictors supplied by the vagus or tenth nerve. It is possible that parts of the sternomastoid and trapezius are also branchial in their origin, since they are supplied by the spinal accessory or 11th nerve, but this is unsettled.

The limb musculature is usually regarded as a sleevelike outpushing of the external oblique stratum of the lateral ventral musculature of the trunk. and it is believed that parts of several myotomes are in this way pushed out in the growth of the limb bud. This process actually occurs in the lower vertebrates, and the nerve supplies provide strong presumptive evidence that this is the real phylogenetic history of the higher forms, though direct observation shows that the limb muscles of mammals are formed from the central mesoderm of the limb and at first are quite distinct from the myotomes of the trunk. A possible explanation of the difficulty is that this is another example of the slurring over of stages in phylogeny, but this is one of many obscure morphological points. The muscles of each limb are divided into a dorsal and ventral series, supplied by dorsal and ventral secondary divisions of the nerves in the limb plexuses, and these correspond to the original position of the limbs as they grow out from the embryo, so that in the upper extremity the back of the arm, forearm and dorsum of the hand are dorsal, while in the lower the dorsal surface is the front of the thigh and leg and the dorsum of the foot.

C. Comparative Anatomy

In the Acrania (*e.g.*, the lancelet) the simple arrangement of myotomes and myocommata seen in the early human embryo is permanent. The myotomes or muscle plates are < shaped. with their apexes pointing toward the head end, each being supplied by its own spinal nerve. In the fishes this arrangement is largely persistent, but each limb of the < is bent on itself, so that the myotomes have now the shape of a $\lessgtr$, the central angle of which corresponds to the lateral line of the fish. In the abdominal region, however, the myotomes fuse and rudiments of the recti and obliqui abdominis muscles of higher types are seen. In other regions too, such as the fins of fish and the tongue of the lamprey, specialized muscular bundles are separated off and are coincident with the acquirement of movements of these parts in different directions. In the amphibia the limb musculature becomes much more complex as the joints are formed. and many of the muscles can be homologized with those of mammals, though this is by no means always the case, while, in the abdominal region, a superficial delamination occurs, so that in many forms a superficial and deep rectus abdominis occurs as well as a cutaneus abdominis delaminated from the external oblique. It is probable that this delamination is the precursor of the panniculus carnosus or skin musculature of mammals. The branchial musculature also becomes much more complex and the mylohyoid muscle, derived from the first branchial arch and lying beneath the floor of the

mouth, is very noticeable and of great importance in breathing.

In the reptiles further differentiation of the muscles is seen, and with the acquirement of costal respiration the external and internal intercostals are formed by a delamination of the internal oblique stratum. In the dorsal region several of the longitudinal muscles which together make up the erector spinae are distinct, and a definite sphincter cloacae is formed round a cloacal aperture. In mammals certain muscles vary in their attachments or presence and absence in different orders, suborders and families, so that. were it not for the large amount of technical knowledge required in recognizing them, they might be useful from a classificatory point of view. There is, however, a greater gap between the musculature of man and that of the other primates than there is between many different orders. and this is usually traceable either directly or indirectly to the assumption of the erect position.

The chief causes that produce changes of musculature are: (1) splitting; (2) fusion; (3) suppression, either partial or complete; **(3)** shifting of origin; (5) shifting of insertion; (6) new formation: (7) transference of part of one muscle to another. In many of these cases the nerve supply gives an important clue to the change that has been effected.

Splitting of a muscular mass is often the result of one part of a muscle being used separately, and a good example of this is the deep flexor mass of the forearm. In the lower mammals this mass rises from the flexor surface of the radius and ulna, and supplies tendons to the terminal phalanges of all five digits; but in man the thumb is used separately and. in response to this, that part of the mass that goes to the thumb is completely split off into a separate muscle. the flexor longus pollicis. The process, however, is going farther, for man has acquired the habit of using his index finger alone for many purposes, and the index slip of the flexor profundus digitorum is in man almost as distinct a muscle as the flexor longus pollicis.

Fusion may be either collateral or longitudinal. The former is seen in the case of the flexor carpi ulnaris. In many mammals (*e.g.*, the dog) there are two muscles inserted separately. into the pisiform bone, one rising from the internal condyle of the humerus. the other from the olecranon process, but in many others (*e.g.*, man) the two muscles have fused. Longitudinal fusion is seen in the digastric, where the anterior belly is part of the first (mandibular) branchial arch and the posterior of the second or hyoid arch; in this case, as might be expected. the anterior belly is supplied by the fifth nerve and the posterior by the seventh.

Partial suppression of a muscle is seen in the rhomboid sheet; in the lower mammals this rises from the head. neck and anterior (cephalic) thoracic spines. but in man the head and most of the neck part is completely suppressed. Complete suppression of a muscle is exemplified in the omotrachelian. a muscle that runs from the cervical vertebrae to the acromian process and fixes the scapula for the strong action of the triceps in pronograde mammals; in man this strong action of the triceps is no longer needed for progression. and the fixing muscle has disappeared.

Shifting of origin is seen in the short head of the biceps femoris. This in many lower mammals (*e.g.*, rabbit) is a muscle running from the tail to the lower leg; in many others (*e.g.*, monkeys and man) the origin has slipped down to the femur. and in the great anteater it is evident that the agitator caudae has been used as a muscle slide, because the short head of the biceps or tenuissimus has once been found rising from the surface of this muscle.

Shifting of an insertion is not nearly so common as shifting of an origin: it is seen. however, in the peroneus tertius of man. in which part of the extensor longus digitorum has acquired a new attachment to the base of the fifth metatarsal bone.

New formation of a muscle is seen in the stylohyoideus alter, an occasional human muscle; in this the stylohyoid ligament has been converted into a muscle.

Transference of part of one muscle to another is well shown by the human adductor magnus; here the fibres that pass from the tuber ischii to the condyle of the femur have a nerve supply from the great sciatic instead of the obturator. and in most lower mammals are a separate part of the hamstrings known as the presemimembranosus.

See also CONNECTIVE *AND* SUPPORTING TISSUES; JOINTS AND LIGAMENTS; SKELETON, VERTEBRATE. (F. G. P.)

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MUSCLES, DISEASES OF. Each of the three types of muscle tissue of the human body is subject to a variety of diseases. The term diseases of muscles, however, generally refers to affections of the striated (skeletal) muscle, which comprises about 40% of the weight of the human adult male body and is disposed in more than 400 separate muscles. (For the anatomy, *see* MUSCLE AND MUSCULAR SYSTEM.) This article is confined, therefore, to diseases of the skeletal muscles. Diseases of smooth muscle (the contractile tissue in the wall of stomach and intestinal tract, bronchi, ureters, uterus, etc.) are discussed in separate articles relating to diseases of those organs. Disorders of the cardiac muscle, a special form of striated muscle, are dealt with in HEART, DISEASES OF.

An orderly conception of these muscle disorders is provided by the following classification.

1. Muscle atrophies resulting from denervation. These include progressive muscular atrophy, amyotrophic lateral sclerosis (*q.v.*), progressive bulbar palsy. infantile muscular atrophy and various forms of diseases of the spinal cord and peripheral nerves.

2. Muscle disorders caused by abnormalities of neuromuscular transmission and of muscular membrane irritability. Under this may be considered myasthenia gravis, familial periodic paralysis and congenital myotonia.

3. Primary myopathies. These include progressive muscular dystrophies, polymyositis and dermatomyositis and other metabolic diseases such as glycogen storage diseases.

The muscle tissue, the etiector apparatus of the body, is also deranged in its function by diseases of the brain, manifesting themselves as paralysis, spasm. convulsion. tremor, athetosis, chorea. myoclonus and dystonia; but these are not generally regarded as diseases of the muscle.

Denervation.—In denervation atrophy, the muscle or muscles are deprived of all nervous control. Weakness (paresis) or paralysis of all movement. reflex as well as voluntary, is the immediate result. The muscle fibres gradually become atrophied, losing 1/20 of their bulk within three months. The atrophied fibres sur-

vive for long periods, months or years; exhibit a "spontaneous" individual contraction (shown as a small brief action potential, also called fibrillation) which can be detected by inserting electrodes into the muscle and amplifying them by means of a cathode-ray oscilloscope (electromyogram); and are capable of regaining organized function if new fibres regenerate and effect junction with them (reinnervation).

Abnormality of **Neuromuscular** Transmission.— In disorders of neuromuscular transmission the main effect is paralysis or spasm, depending on whether the transmitting apparatus is subnormally irritable or excessively excitable. The disturbance is chiefly one of function and can be demonstrated by measurement of biochemical changes in the blood. by the finding of altered electrical excitability and by the clinical test of reduced power of contraction. The muscles do not atrophy to any significant degree and there are no unequivocal changes to be seen under the light microscope. Correction of the chemical aberration restores power.

Primary **Myopathies.**—The primary myopathies include all morbid conditions in which a disease process destroys the muscle fibres or their sheaths. There are many forms of myopathic disease; only the commonest and most serious ones are mentioned here.

Muscular Dystrophy.—Muscular dystrophy is a relatively rare disease characterized by wasting and enfeeblement of the muscles of trunk and limbs. It usually begins in childhood or adolescence and progresses over a period of 5 to 20 or more years. The first muscles to be affected are those of the pelvis and thighs or the shoulders. upper arms and face. Attention is usually attracted to the person who is developing the disease by delay in beginning to walk, if its onset is early in life, or by frequent falls, a waddling gait. failure to arise from a recumbent position without the use of the hands, clumsiness in walking and running or inability to lift the arms above the head. In some cases, especially those beginning in childhood, the muscles first become large and firm. a condition known as pseudohypertrophy. In the late stages of the disease extreme wasting occurs. and power of movement and even the tendon reflexes are abolished. Mental function and the senses remain normal.

The cause of the disease is unknomn. Presumably it is based on an inherited abnormality in the chemistry of the body which results in a primary degeneration of the muscle cells. Microscopic examination reveals a loss of many muscle fibres, atrophy, degenerative changes and hypertrophy in some of those which remain and an increase in connective tissue and fat cells. There are no important changes in the nervous system.

On the basis of the type of inheritance, the distribution of muscle involvement and associated findings, four subtypes of the disease have been delineated. These are the pseudohypertrophic muscular dystrophy of Duchenne; the facioscapulohumeral dystrophy of Landouzy-Dejerine; the limb-girdle dystrophy of Erb; and the myotonic dystrophy of Steinert. The latter is remarkable because of unusual persistence and slow relaxation of strong muscle contractions (myotonia) and an association of cataracts and atrophy of the testes.

There is no specific treatment, but corrective and remedial measures are helpful.

Polymyositis and Dermatomyositis.—Polymyositis is an inflammatory disease of unknown cause which involves the connective tissue and leads to destruction of the muscle fibres. Affection of the skin (dermatitis) may be conjoined. in which case the term dermatomyositis is applied. The proximal limb (upper arm and thigh) and trunk muscles bear the brunt of the disease, but the small muscles of larynx and pharynx also may be involved. The principal symptoms are weakness and atrophy with reflex impairment, in direct proportion to the degree of paralysis, difficulty in swallowing (dysphagia) and change in voice (dysphonia). The condition is painless. In approximately one-half of the cases polymyositis or dermatomyositis is only part of a more general noninfective inflammation of the connective tissues of the body presented as rheumatic fever, rheumatoid arthritis, scleroderma or lupus erythematosis. (See also CONNECTIVE TISSUE, DISEASES OF.)

Diagnosis is substantiated by two biochemical tests, by characteristic changes in the electromyogram and by muscle biopsy (excision of a small piece of muscle for microscopic examination). The latter test reveals the destruction of muscle fibres and the inflammatory reaction.

Treatment consists of adrenal steroids and aspirin. Physiotherapy, to prevent stiffness and contracture, is also helpful: however, the condition may subside spontaneously. Since muscle can regenerate to some extent, partial or complete recovery is the rule.

(R. D. A.)

MUSCLE SHOALS, the name of: (1) a stretch of the Tennessee river, originally 37 mi. long, that constituted a barrier to navigation from Knoxville to the Ohio and ultimately to the Mississippi river, the Tennessee falling 132 ft. in the 37-mi. stretch; (2) a power and flood control project which ultimately became part of the Tennessee Valley authority (see TENNESSEE RIVER); and (3) a town in Alabama that became headquarters for the authority. The name has been variously but uncertainly attributed to the mussels growing in the shoals and to a fancied resemblance of the river on a map in this stretch to a man's biceps.

With the introduction of the steamboat on the Tennessee in 1828, navigation through Muscle shoals became a major problem. the rapids and pools making navigation dangerous when the river was high and impossible when it was low. The first unsuccessful attempt to remedy this situation was made by the state of Tennessee. which began a canal in 1823 and completed it in 1836. A portage railroad was later built around the shoals. The river was never navigable year round in this stretch, however, until the construction of two federal canals, begun in 1875 and completed in 1890, which operated until 1918.

During World War I the National Defense act of 1916 provided for construction of two dams and two nitrate plants to meet a feared shortage of materials for high explosives. Work began in 1918 and one nitrate plant was completed, but the end of the war brought suspension of appropriations except for Wilson dam. completed in 1925. The Muscle shoals project was put up for sale to private interests and became the hopeful symbol of public power to its advocates, but an anathema to its opponents. Sen. George Norris (Rep., Neb.) initiated a bill in congress in 1922 to operate the project publicly: the bill passed twice in congress but was vetoed by Pres. Calvin Coolidge and Pres. Herbert Hoover. The project sold power to private companies until, in 1933, Norris' plan was included in legislation establishing the Tennessee Valley authority. Further dam construction on the Tennessee and its tributary. the Clinch, finally provided a year-round nine-foot channel and adequate flood control. The old nitrate plant no. 2 produced phosphate fertilizer.

MUSCOVITE, a common rock-forming mineral belonging to the mica group. As the mica is obtainable in thin, transparent sheets it was used in Russia for window panes and known as Muscovy glass; hence its name. It is an aluminosilicate with potassium and hydrogen and with some substitution of sodium, magnesium, iron, lithium and silicon. Muscovite, most common of the micas, is a principal constituent of the fine-grained sediments, many of the metamorphic rocks and some classes of siliceous igneous rocks. It is especially common in the granites although absent in the extrusive equivalents. Muscovite is important in gneisses and schists and persists to the higher grades of metamorphism. Large crystals are often found in veins and pegmatites. One crystal measured $9\frac{1}{2}$ ft. by 7 ft. and nearly 3 ft. thick. Muscovite develops secondarily after feldspar, nepheline, topaz. corundum, kyanite and other aluminosilicates.

Muscovite and its fluorine analogue, fluoromuscovite, have been synthesized. Large sheets and ground natural material are used in the electrical and electronics industry, paper and paint manufacturing and as a lubricant, dusting powder and filler and in special decoration effects.

Muscovite is usually colourless; however, it may be gray, brown, pale green, lavender or ruby in colour. The lustre is vitreous to pearly. Crystals are tabular with a hexagonal or pseudohexagonal outline; commonly lamellar and in aggregates. Muscovite is known to occur in at least three polymorphic forms. The single-

layer polymorph forms mixed-layer structures with montmorillonite and is then called illite. When fine grained, muscovite is generally referred to as sericite or white mica. The basal cleavage is perfect and yields thin elastic laminas; two secondary partings are known. The hardness is 2.5 to 3; the specific gravity ranges from 2.76 to 3.00; and the index of refraction is between 1.55 and 1.59, although it may be as high as 1.66 in iron-rich varieties. Birefringence (double refraction) is very strong and the dispersion distinct. Muscovite is not decomposed by acids. It alters to kaolinite or gibbsite with quartz. On weathering the mica is leached of its potassium and hydrated. Addition of fertilizers will reverse this process in some soils.

The chemical composition is close to $KAl_2(AlSi_3)O_{10}(OH)_2$ with some Na substituting for K; Mg, Fe^{+3} and Li for the first Al; and Si for the second Al. For further discussion of composition and the relation of structure to cleavage *see* MICA.

(H. S. Y.)

MUSCULAR DYSTROPHY: *see* MUSCLES, DISEASES OF.

MUSES (Gr. *Mousai, Moisai*), a group of goddesses of obscure but ancient origin, the chief centre of whose cult was Mount Helicon in Boeotia. Greece. Allegedly they came from Pieria in Macedonia. but it is doubtful if this statement. first made by Euripides, is not a misunderstanding. the real Pieria being somewhere in Greece. Very little is known of their cult, but they had a festival every four years at Thespiae, near Helicon. and a contest (*Museia*), presumably — or at least at first — in singing and playing. There can be little doubt that they n-ere originally the patron goddesses of poets (who in early times were also musicians. providing their own accompaniments). although later their range was extended to include all liberal arts and sciences; hence, their connection with such institutions as the museum (*Mouseion,* seat of the muses) at Alexandria. and occasionally with the *gymnasia,* since physical training was part of a liberal education. There n-ere nine muses as early as the *Odyssey,* and Hoiner invokes either a muse or the muses collectively: *e.g.,* in the *Iliad* on one occasion he calls on simply "a goddess" and on another asks all the muses to prompt him, because they know everything and men do not. while in the *Odyssey* he uses the name *Mousa* and adds that she is a daughter of Zeus. It would appear that to begin with they were one of those vague collections of deities) undifferentiated within the group. which are characteristic of certain, probably early, strata of Greek religion *(see* H. J. Rose in *Harvard Theological Review,* li, pp. 22 ff., 1958).

Differentiation is a matter rather of mythological systematization than of cult and begins with Hesiod. who mentions the names of Clio. Euterpe. Thalia. Melpomene, Terpsichore. Erato. Polymnia. Urania and Calliope, n-ho was their chief. Their mother was Mnemosyne (Memory), a patent bit of allegorizing not uncommon in Hesiod, and a not unplausible etymology of the name *Mousa* would connect it with the root which appears in the Latin *monere* (to warn) and make it mean "reminder"; but this is quite uncertain. Although Hesiod's list became canonical in later times. it was not the only one; at both Delphi and Sicyon there were but three muses: one of whom in the latter place bore the fanciful name Polymatheia ("much learning"). All the Hesiodic names are significant; thus Clio is approximately "the proclaimer." Calliope "she of the beautiful voice." Erato "the lovely," Urania "the heavenly" and so on. Since dancing was a regular accompaniment of song, it is not remarkable that Hesiod calls one of his nine "the whirler of the dance," Terpsichore. This again is characteristic of him: compare for instance the names of the Nereids, all of which have some relation to travel by sea, weather conditions, the seashore or trade and its results.

The muses are often spoken of as virgins or at least unmarried, but are repeatedly referred to as the mothers of more or less famous sons: such as Orpheus, Khesus. Eumolpus and others connected somehow either with poetry and song or with Thrace and its neighbourhood or both. In other words, all their myths are secondary. attached for one reason or another to the original vague and nameless group. Hence there is no consistency in these minor tales — Terpsichore for example being named as the mother oi several different men in various authors, and Orpheus generally being called the son of Calliope but occasionally of Polymnia.

Statues of the muses were a popular decoration in long galleries and similar places: naturally. sculptors did not make them all alike but gave each a different attribute, such as a lyre. scroll, etc. This may have contributed to the fanciful distribution of the individual muses among the different arts and sciences; *e.g.,* Clio as muse of history, Erato of love poetry, Urania of astronomy. The lists which have come down are all late and disagree widely with one another; that they are without authority is clear from the way the names of individual muses are employed by classical authors. For instance. Xpollonius Rhodius and Virgil called on Erato to inspire an epic poem, while Horace mentioned Clio. Calliope. Euterpe, Melpomene and Polymnia all in connection with lyrics. In Latin. when the name is not simply transliterated. the equivalent of *Musa* is *Camena.* As the functions of the *Camenae* are obscure. so also is the reason for the equation.

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MUSETTE, the name of a musical composition in the 18th century. deriving from the instrument of the same name, a small French bagpipe (*q.v.*), favoured in court circles during the reigns of Louis XIV and Louis XV. The musette was a slow dance, pastoral in character, performed on a pedal bass or drone over which delicate figurations n-ere played. It was originally played on the musette accompanied by the vielle, and later on other instruments. Early examples were the *Oeuvre de Musette* by Jean Baptiste Anet (*c.* 1661–1755) and *Loisirs du Bercail* by J. B. Boismortier 1691–1755). The name was adopted by J. S. Bach for movements in his English suites, no. 3 and 6; by Handel; and by N. Dalayrac in his *Nina ou La Folle par amour* (1786) as the title of an operatic aria.

MUSEUM ARCHITECTURE. While there are many differing types of museums ranging from modest places for the display of curios to imposing shrines for the housing of great arrays of treasures, the majority falls under two categories: art museums and science museums.. Both have the primary function to assemble and care for material worthy of exhibition and to present it to the public for education and enjoyment. Specialization in diverse types of exhibits and services brought further definitions within these categories. such as civic museums. historical museums. museums of modern art, museums of archaeology, museums of decorative arts, college museums, children's museums: zoological museums, marine museums. planetariums. etc., each presenting special demands for architectural treatment.

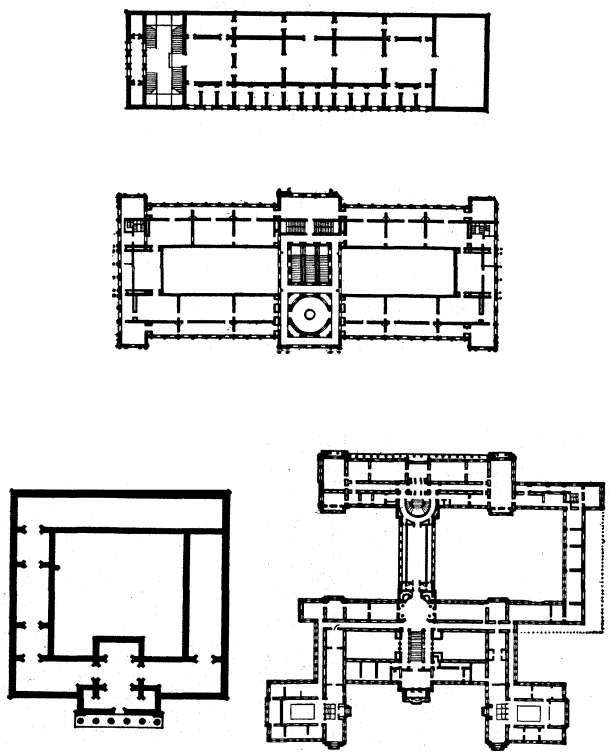
Art museums. being dedicated to the fine arts, serve to display and store collections of paintings. sculpture, architecture, craftsmanship and related works. Initially, imposing old palaces. mansions or historically significant buildings were converted to this use—a convenient practice that has been continued. An identifiable museum architecture developed when buildings were erected especially to house the collections of art treasures that had accumulated in the capitals and centres of European culture and wealth in the early 19th century. As a consequence of the role museums played in national prestige and civic pride, the character of these edifices was monumental and imposing. They were located in prominent positions on major avenues or in parks, and the architectural treatment of sites and buildings strove for a grandiose effect. Architects relied on colonnades and arches, high vaulted interiors, vast flights of stairs outside and inside. and rich decoration in sculpture and carving to achieve the desired quality of impressiveness. The monumental character of these edifices and their classic or historic styles were imitated in the design of the U.S. civic museums that were built to house the collections of wealthy donors and to serve as memorials to them. This approach to museum design, which gave pre-eminence to architectural embellishment commonly at the expense of the impressiveness of the exhibits, prevailed into the early 20th century and continued in evidence in Nazi Germany and the C.S.S.R.

Science museum:: serve as storehouses of a vast variety of exhibits from the fields of natural history, ethnology and discovery.

The objects displayed are highly diverse in nature. appearance, size, rarity and monetary value. Lacking the imposing prototypes and demand for expression of wealth associated with the housing of art treasures, science museums are more modest in architectural character.

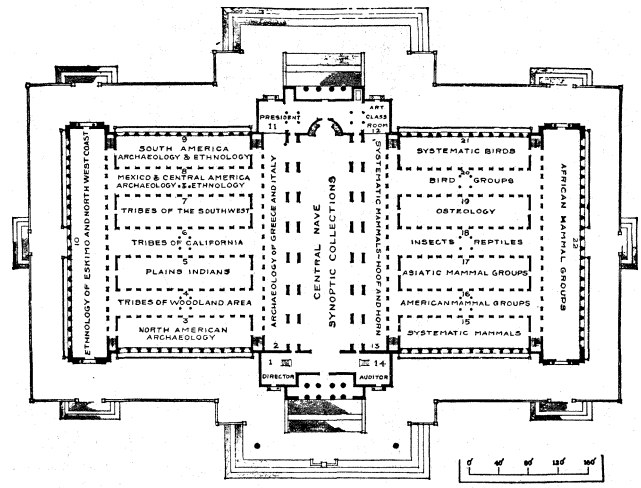
With the beginning of the 20th century in Europe, and a few decades later in the United States. an awareness arose of the functional inadequacies of traditional museum architecture. A growing consciousness of the deficiencies in buildings that in their design followed the dictates of styles rather than the needs of exhibitions brought architectural changes. However. the liberation from the dogmas of historic styles progressing in all fields of architecture affected museums much later than most other types of buildings. With the need for stricter obedience to functional demands. galleries were shaped and illuminated to improve the display of exhibits. varied in size and form in keeping with the effect of intimacy or grandeur demanded by the displays, and arranged for a less tiring and boring effect on the visitors. The appearance of museums became less pompous and formal. Distracting and meaningless architectural embellishment gave way to the simpler treatment and plain surfaces associated with modern architecture. The inventiveness and individuality of modern architects led to projects based on complete departures from traditional planning. such as the stepped pyramid proposed by the architect Le Corbusier for the Musée Mondial (1929'1and a flattened version of it suggested for a "Growing museum" (1938); Paul Nelson's design for a circular museum with a roof suspended by cables conceived for the 1937 Paris exposition; and Frank Lloyd Wright's galleries of spiral ramps for the Guggenheim Museum of Son-Objective Painting in New York city.

Development **of** Art Museums.--When collections were first opened to public view. existing buildings that no longer served their original purposes were remodeled to meet the new requirements. Of this type were museums such as the Louvre, Luxembourg. Cluny and Carnavalet in Paris, most of the Italian museums. the Belvedere in Vienna and others. In the United States:



BY COURTESY OF WALTER F. BOGNER

TOP: NEW PINAKOTHEK OF MUNICH (1846–53), AUGUST VON VOIT, ARCHITECT: CENTRE: ART-HISTORY MUSEUM OF VIENNA (1872–91). KARL FREIHERRN VON HASENAUER. ARCHITECT: LOWER LEFT: GLYPTOTHEK OF MUNICH (1816–301, LEO VON KLENZE. ARCHITECT; LOWER RIGHT: BOSTON MUSEUM OF FINE ARTS (1907–28), GUY LOWELL, ARCHITECT; EDMUND M. WHEELWRIGHT, D. DESPRADELLE AND R. CLIPSTON STURGIS. ADVISORY ARCHITECTS



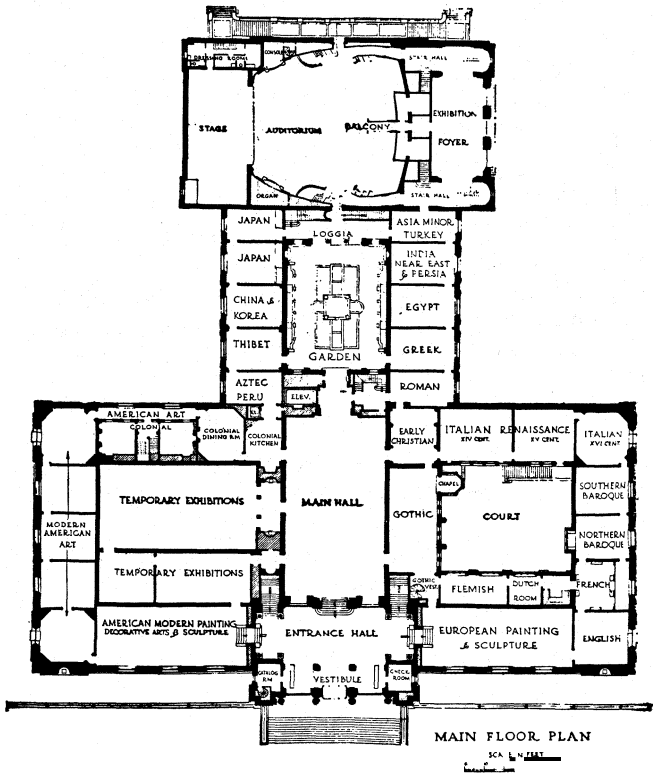
FIRST FLOOR PLAN OF THE CHICAGO NATURAL HISTORY MUSEUM (1911–19)

similar conversions on a more modest scale were carried out: *e.g.,* for the Isabella Stewart Gardner museum in Boston. Mass.

Museums built during the 19th century were usually two stories high. with services in the basement, and with an imposing entrance hall leading to a central monumental stairway. On the entrance floor were the collections of sculpture (though occasionally placed in a courtyard covered by a glass roof) and other galleries of lesser importance. all lighted by windows. The upper and principal floor was devoted to the picture galleries lighted by skylights. The circulation flowed usually from room to room, with an opportunity to make a circuit tour of the galleries. Representative museums of this type were: the Altes museum **of** Berlin. by K. F. Schinkel (1822–30), the Glyptothek at Munich. by Leo von Klenze (1830), the British museum. by Sir Robert Smirke (1825–27). the National gallery in London (1838). the Dresden museum (1850), the museums at Vienna and Marseilles and many others. Their architecture along with many of the features of other great museums of Europe. such as the Louvre in Paris. the Prado in Madrid. the Vatican gallery in Rome and the Uffizi in Florence. influenced the design of the older art museums in the United States — the Metropolitan Museum of Art in New York city. the Brooklyn (N.Y.) Institute of Arts and Sciences, the Toledo (O.) Museum of Art. the Corcoran Gallery of Art, Washington. D.C., and many others of less prominence.

20th-Century **Developments.**—Many innovations appeared in 20th-century museum planning. Galleries became more varied in size and character, some smaller spaces were included for a better display of intimate works of art. and rooms were designed to hârmonize with exhibits representative of historic periods. Such features were exemplified in the museums of Germany in Munich and Darmstadt (Alfred Messel. architect) and in the United States at the Detroit (Mich.) Institute of Arts (Paul Cret and Zantzinger. Borie and Medary, architects). The formality of the design of the façade deemed desirable for public buildings was combined with some informality in the treatment of certain portions to allow for the varied fenestrations demanded by smaller and period rooms. Courtyards served for outdoor displays and as gardens for the relaxation of spectators. Such are found in the Cleveland (O.) Museum of Art, the Detroit Institute of Arts and the Freer Gallery of Art. Washington. D.C.

Two Dutch buildings illustrate further progress in museum design — the Gemeente museum at The Hague. with its unusual lighting features. and Museum Boymans at Rotterdam. for its harmony in the size of the rooms and the exhibits. Also significant for their contributions to museum architecture of the second quarter of the 20th century were two museums built in Paris in 1937, one on the site of the Trocadéro (Carlu. Boileau and Xzema. architects') and the other a double structure flanking an imposing courtyard embellished by neoclassic colonnades. known as the Musée des Arts Modernes (Donel. Xubert. Viard. Dastugue. architects). The Museum of Modern Art of New York (Good-



MAIN FLOOR PLAN OF DETROIT INSTITUTE OF ARTS (1927), SHOWING THE WINDOW LIGHTING OF ROOMS AND THE GEOGRAPHIC AND CHRONOLOGICAL DISTRIBUTION OF EXHIBITS

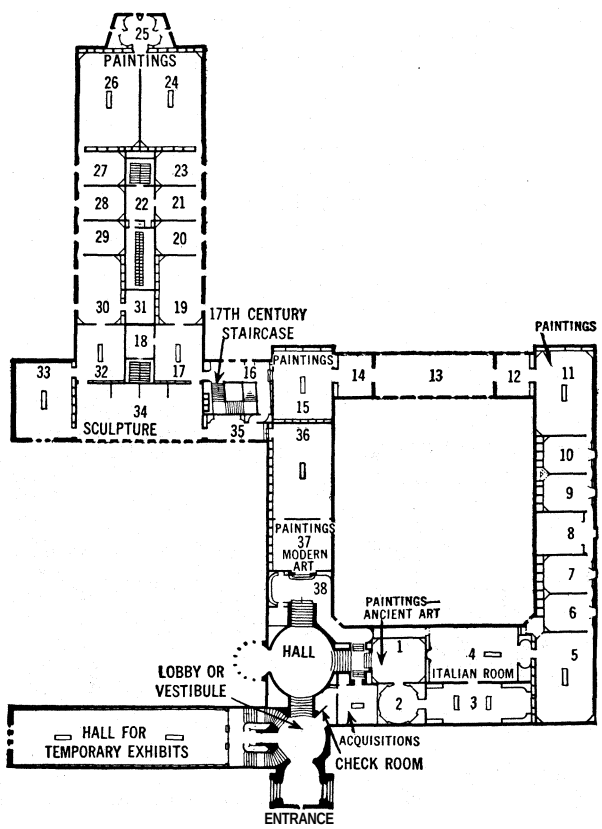
win and Stone, architects, 1939) indicated significant departures from established patterns. Fixed partitions between exhibition spaces were almost completely absent in the original plan. but permanent fireproof walls were added after a fire in 1958. Also the winning design presented in a competition for a new Smithsonian Gallery of Art in Washington, D.C.. 1938 (Eliel and Eero Saarinen, Robert Swanson associates), illustrated the trends in the development of a new museum architecture. Classic motives had been abandoned in the façade treatments, symmetry of plan and the succession of fixed galleries placed on an axis had disappeared, and unbroken interior spaces were substituted to allow for an infinite variety of divisions by temporary partitions.

As museums progressed from mere storehouses of treasures to active cultural forces in communities, galleries for temporary exhibitions, study galleries, reserves. loan departments, lecture rooms and classrooms, etc., were added. The consequent growth of buildings combined with the increasing amount of material on display forced the attack on the problem of museum fatigue. Avoidance of monotony in the arrangement of displays, aided by variations in the space forms, the treatment and colour of backgrounds. the creation of special settings for important pieces, the improved design of showcases and the insertion of gardens or planted courts served to make a museum visit less tiring. Excellent installations for sculpture were made in the garden court of the Museum of Modern Art and in the Whitney museum in New York (remodeled 1958–59). Additions made to the Cleveland Museum of Art in 1954 (Byers Hayes, architect) and proposed for the Detroit Institute of Arts in 1959 (Minoru Yamasaki, architect) ingeniously expanded old galleries. At Wellesley college, Paul Rudolph designed the Jewett Arts centre (1958) with fine spaces. The great progress in display techniques furthered by the many international expositions held in most European countries and the United States helped to enliven exhibits and benefited museums in general and the science and industry museums in particular.

Science Museums.—Because of special demands arising in the showing of exhibits from the fields of natural history, mineralogy, ethnology, technology, inventions and a miscellany of subjects of public interest, many departures from the routine patterns of galleries occurred. Installations with realistic settings for exhibits known as habitat groups became major attractions. An interesting arrangement of zoological galleries was made by Messel in the rear galleries of the Darmstadt museum. The Deutsches museum of Munich (G. and E. Seidl, architects, 1908) incorporated many new features that furnished inspiration to science and industry museums throughout the world. There, the displays were given a live character through great realism, and through the opportunity for manipulation of exhibits by the public. The U.S. National museum (Hornblower and Marshall, architects) in Washington, D.C., must be mentioned, and for sheer size the Chicago Natural History museum (Graham, Anderson, Probst and White, architects, 1927) was outstanding; an area 350 by 700 ft. was filled by exhibits representative of many fields, with a quantity of specimens presented realistically by means of accurate and artfully contrived habitat groups.

Museum Planning.—Circulation of visitors demands that the galleries be easily accessible from the main entrance and that an orderly tour of the building or of individual sections is possible. Offices are placed so the public can readily find them. Storage rooms and repair shops usually occupy the ground floor or basement and allow for the transfer of bulky objects from the shipping platform to any of the exhibition halls with a minimum of effort and danger to the exhibits. Preparation departments are near mechanical shops and accessible from the curatorial offices without traversing exhibition halls. Lecture halls and auditoriums often have separate entrances from the street, permitting their use when other parts of the museum are closed.

With the exception of small museums, most institutions are divided into departments, each with its own exhibition space, curatorial offices, study rooms, workrooms, storage space and mechanical shops if needed. A central library or a series of departmental libraries is accessible to both visitors and the museum staff. For the issuing of publications and illustrations often required as *a* museum service, printing plants are installed and photographic workshops are set up. Large museums find it economical to build their own exhibition cases and furniture and therefore require workshops. Art museums have facilities for restoring paintings, casting and cleaning sculpture and renovating other objects.



UPPER FLOOR PLAN. MUSEUM BOYMANS, ROTTERDAM (1935); A. VAN DER STEUR. ARCHITECT. IN COLLABORATION WITH D. HANNEMA

Science museums require shops for taxidermist, modelmaking and similar functions incidental to the installation and care of exhibits.

The size, shape and character of the galleries depend on the exhibits and their installation. They are designed to give free rein to the showmanship demanded of museum directors and curators for the creation of displays that stir the interest and imagination of the spectators. Since many exhibits require special treatment and frequent rearrangement. a great amount of flexibility is provided for in the planning and construction of museum buildings. Most museums are built with a definite program of expansion in view.

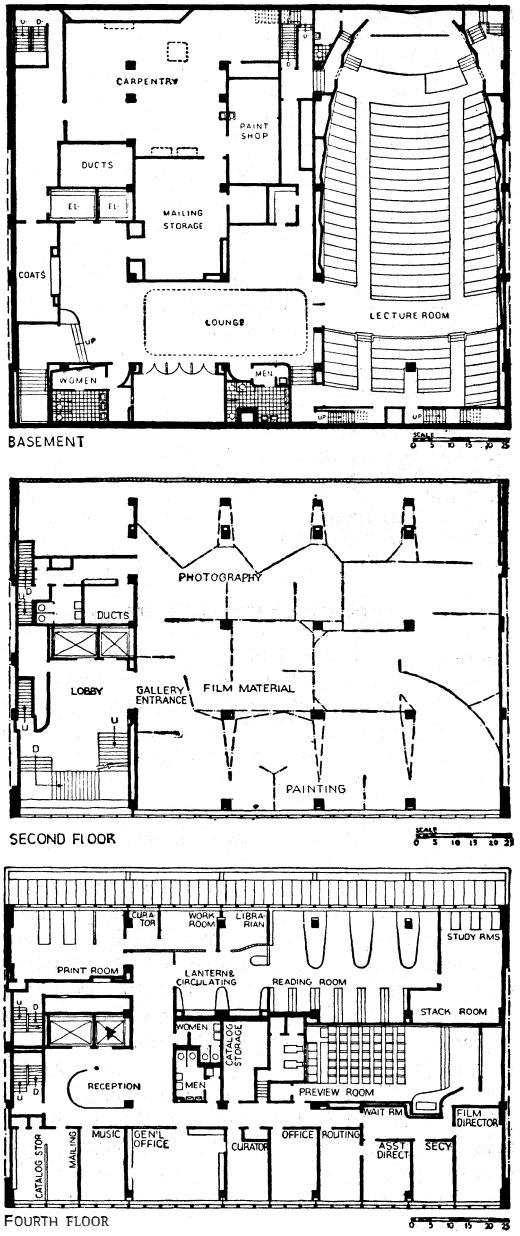
The interrelation of the galleries is determined by the established sequence for the treatment of subjects; by the successive steps necessary to convey a message through the exhibits; or by architectural considerations, such as the placing of picture galleries where they can be skylighted and the grouping together of objects of similar size or type. Crowding of galleries with a profusion of exhibits of little interest to the spectators is avoided, and excess material is relegated to well-organized study or reserve collections, where it may be examined on request.

The modern museum no longer restricts its activities to interesting the casual visitor who comes to its doors but organizes constructive educational programs extending to the schools and many types of civic organizations. It supplies loan exhibitions. sends out lecturers. furnishes motion pictures and lecture material for outside use and spreads its educational message by radio and television. Within its building it maintains an efficient guide service to the collections, appointing certain hours for children and young persons. Its lecture halls and auditoriums furnish opportunities for talks illustrated by the surrounding museum material. Chamber music! organ recitals and theatrical productions are common features of museum activity. Organizations working along similar lines are encouraged to use museum facilities, and many types of nature, art and hobby clubs are promoted by museums.

College or school museums; of which there are several types, require relatively little exhibition space but may have a number of classrooms and laboratories and a more complete library service. If the museum is engaged chiefly in supplying material for use in the schools its building may consist almost entirely of workshops in which collections are prepared, packed and shipped.

Outdoor exhibitions and outdoor museums provide for a variety of activities, from the display of collections in a museum courtyard to completely detached shows in the open air. For example, the outdoor collection of growing plants maintained by the Agricultural and Commercial museum in Rio de Janeiro augments the exhibits inside the galleries. The garden of the Museum of Modern Art in New York serves the display of sculpture. The Cloisters in New York. a branch of the Metropolitan Museum of Art, with an herb garden and medieval courtyards, gives through the architecture of the building, the treatment of the landscape and planting, the exhibits in painting, sculpture and craftsmanship a complete portrayal of the art and culture of the middle ages.

Museum Lighting. — The design of windows and skylights as well as the type of artificial illumination chosen affects the effectiveness of the displays and the architectural quality of the interiors. A great amount of research has been carried out for the purpose of preventing reflections on showcases and paintings and to determine the kind of light best suited to bring out the colour, form and detail of the exhibits. Overhead natural light requires skylights, an attic as mixing chamber for the light, and galleries with glass ceilings. Since natural light varies with the movement of clouds and the sun, there are considerable advantages in artificial illumination, allowing walls of galleries and exhibits to be lighted constantly with even intensities. However, some kinds of exhibits, notably relief sculpture, do not always appear to best advantage under artificial light; moreover, the constancy of this type of illumination may produce an effect of monotony. Hence, in spite of tremendous technological developments offering infinite possibilities for the lighting of galleries or exhibits directly or indirectly by incandescent or fluorescent lights, natural illumination is still desirable in certain places. Both types of lighting are used by architects to make the interiors of buildings pleasant and the exhibits stimulating. The advance in artificial illumination was perhaps the most important influence the technological progress of the first half of the 20th century brought to museum architecture. (See also MUSEUMS AND GALLERIES.)



BY COURTESY OF "THE ARCHITECTURAL FORUM"

BASEMENT, SECOND AND FOURTH FLOORS OF THE MUSEUM OF MODERN ART, NEW YORK CITY (1939); PHILIP L. GOODWIN AND EDWARD D. STONE, ARCHITECTS

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MUSEUMS AND GALLERIES are places in which collections of objects are exhibited for their particular interest. Some deal with one or several general subjects, such as art, history, science and industry; some are limited to special material, such as a particular industrial object (Glass museum, Corning, N.Y.)

or the work of one artist (Rodin museum, Paris). However diverse the aims of present-day museums and however old the habit of mankind of collecting objects, the museum as it is now known originated in Italy during the Renaissance.

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I. PURPOSES AND ACTIVITIES

Three elements are involved in any museum at any time: the owner. the object and the public. But just as basic philosophies of life have evolved through the centuries, so have the purposes of the museum and the relationship between the three elements continually changed. In any case, the most important fact to be determined about a museum is its purpose.

The way in which it fulfills that purpose may be a result of its history, both general and specialized, rather than its present stewardship.

Education may be considered the foremost purpose of the museum. The museum cannot accomplish this purpose without research work by its staff on its own collections, as well as on material it wishes to acquire. The extent of this task varies according to the size and means of the museum. but even the smallest museum must have individual and independent thinking by a curator trained in museum practice and scholarly work. The educational purpose is by no means the only requirement for a collection. There must also be an appeal, particularly an aesthetic appeal. This requirement is not confined to the art museum alone; it is essential in any museum. A museum must also serve as an archive for objects that must be protected from destruction or loss because they are precious, rare, significant or indispensible for research. Although these three objectives may conflict. each is important; it is the responsibility of the curator, in the selection of a new object and in the arrangement of display, to reconcile them.

In addition to the selection and exhibition of objects, the curator must engage in a number of activities designed to acquaint the public with the museum and its collection. These activities vary with the size and contents of the museum. Printed material published by the museum ranges irom mimeographed sheets to bulletins and expensive catalogues. In general, European museums, more than museums elsenhere, tend to publish complete catalogues of their collections, even at a financial loss.

Special exhibitions are helpful in stimulating interest in the museum; they also provide a service to the public. In most of these exhibitions, loans from private onners or dealers are essential for success. After World War II, nhen many European museums were suffering from war damage and objects were stored for safekeeping, it was comparatively easy to secure loans. This tendency received further impetus from publicity agencies of European tourist centres, which considered exhibitions a means of attracting tourists. A drawback was the fact that tourists were often disappointed to find a masterpiece away on loan More important. old paintings and other norks of art should not be exposed to the rigours of travel. Experts no longer favour international loan exhibitions unless scholarly interests are furthered, either by a one-man show or an exhibition which stimulates special studies.

1. Educational Function. — Every museum must develop an appropriate program for the education of the community it serves. Educational efforts are directed at two groups—student and adult—and each must be treated in a different way. In educating students, museums can follow classroom methods as long as the student groups have the same educational background, the same urge to increase their knowledge and the same desire for promotion. If the museum can provide teachers irom its own staff, or train schoolteachers to introduce the museum to students. and if it keeps in close touch nith local school authorities student education does not offer difficult problems. In regard to adult education the situation is somewhat different. The adult audience is elusive; adults are not required to visit a museum. Diligent effort is required to attract them, and far more effort is required to hold them. Here the time element is important, since the museum faces tremendous competition for the visitor's time. One of the accepted methods to attract and hold the visitor's interest is to make him feel that acquiring knowledge is a pleasant experience and that the museum has made every effort to convey ideas and information in the fastest and most attractive nay. Visitor behaviour must be taken into consideration. Museums have recognized that the visitor will not inspect a large museum if it is unattractively arranged and if no opportunity is afforded for him to rest his eyes and feet. On the other hand, in a time when more and more people seem to be reluctant to nork for an intellectual goal and are often satisfied with answers at second hand, museums sometimes may be guilty of coddling visitors. The visitor to the museum. to make his visit worth while, must learn not to accept every label he reads without devoting any thought of his own to the subject.

The use of the best exhibition techniques available is obviously most important in making museums attractive. But first it is necessary to make a wise selection of which objects are to be exhibited and nhich are better suited for a study collection. This decision must be made in a small as well as in a large museum. The educational duties of the art museum are especially difficult because art objects, nhen separated from their context. *e.g.*, the church, the public building. the house. lose some of their effect and may become more difficult to understand, though they may be enhanced aesthetically. Lengthy labels will not help the casual visitor, since lack of time may prevent his reading or, more important, digesting them. Some museums have offered a room of art interpretation, with temporary exhibitions treating various topics. Undoubtedly this is a stimulating method, but it is open to question nhether the advantages are not offset by the disadvantages. Since such educational displays must be presented in an oversimplified way, they tend to offer solutions that are too easy. The art museum. more than the other types, must rely on adult visitors nhose knowledge is based on their own studies in classes, in seminars or perhaps in conducted gallery tours.

Since museums are not always conveniently reached from all parts of a city, a number of practices have been instituted to overcome the problem of inaccessibility. Branch museums have been established, and loan exhibitions have been held in suitable civic centres, in suburbs or in industrial settlements. Exhibits have been prepared for regular circulation at schools. The presentation of original objects is, honever, fraught with danger, so protective measures must be taken. Films, for television or other purposes, are an effective and lasting means of attracting visitors. They may be especially valuable for outdoor museums at historical sites to inform visitors about the general scope of the project. Colonial Williamsburg, Va., uses such a film to give visitors a general orientation in the area. A convenient device for the interpretation of museum objects to visitors is the recorded message or lecture. relayed to listeners by portable earphones furnished by the museum; *e.g.*, National Gallery of Art, Washington, D.C.

Museum objectives can be advanced by the maintenance of regular and harmonious relations with the press and other public communication media. Some newspapers will feature museum nens: others are reluctant to do so, often because the museum does not provide suitable material. It is the responsibility of the museum to see that material for the press is interesting, in good taste and dignified. It is also important that a museum be aware of activities throughout the museum field; one means of doing so is to have staff members attend annual meetings of museum organizations. In the U S.. for example. there are the American Association of Museums, the College Art association and others. Published reports of these meetings, as well as annual sales reports. directories of dealers and other reference material. should be included in all museum libraries. A specialized library is necessary to every museum. nhatever its size.

2. Museum Staff.—The staff of a museum may vary in number from 3 to 300. While in the smaller museums staff members may be required to fulfill a variety of duties certain offices require specialized training : the business manager nho is in charge of museum finances: the registrar. whose office keeps full and complete records of all museum objects; the curator, whose duty it is to care for, study and interpret objects under his jurisdiction The director of the museum must carry out museum policies and direct all its activities He is usually responsible to a board of trustees, who. with the director, determine the policies of the museum. Trustees are, for the most part, interested persons of wealth, who are frequently expected to take an interest in the financial situation of the museum. The president of the museum must be a man sufficiently interested to assume the sometimes precarious task of keeping the institution on an even keel as regards finance as well as policy.

In Europe most museums are governed by public authorities; in the U.S. they are usually privately administered.

To qualify for museum work in most countries on the continent an applicant either should have a university degree and credit in additional special courses or must have served an apprenticeship. Neither in England nor in the U.S. is there any prescribed method of education for museum work; but the British Museums association sponsors a training program leading to a diploma or certificate. In the U.S. the American Association of Museums has worked toward the development of a similar project. Special courses are offered by some museums in conjunction with universities. Since the number of museums in the U.S. is constantly increasing, a museum career offers excellent opportunities, though salaries tend to be lower than in other educational institutions.

In addition to technical workers, such as painters, cabinetmakers and the many kinds of engineers required by all public institutions, museums employ photographers and conservators. The museum photographer photographs all objects for the archives; there are also many requests from outside the museum for photographs. The conservator and his assistants are responsible for the constant care of objects in the collection and the restoration and repair of damaged or neglected works. There is probably no museum which has kept abreast of the work necessary in preservation. biuseums of science require special workshops, staffed with artists, taxidermists and others, to prepare exhibits and to create dioramas: charts, etc. Museums of industry need even more equipinent to deal with the ever-increasing number and size of exhibits. Often these museums receive help from the industry or agency to be represented in the exhibit.

II. COLLECTIONS

1. Acquisitions.— Collections in most European museums have grown through the centuries; the U.S. museum collection usually owes its existence to the munificence of one or several individuals. The most important element of a gift to a museum is the provision of adequate funds, not only to enlarge or improve the collection but to operate it effectively. Donors anxious to perpetuate their names on museum labels are not always willing to donate funds for a purpose as inconspicuous as maintenance.

Although most U.S. museums are younger than their counterparts in Europe, their growth has been phenomenal, and a number of them can be compared to old established European museums. The foremost example is the National gallery in Washington. D.C. The original nucleus of *30* pictures given by Andrew Mellon inspired other donors. such as J. E. Widener, Samuel H. Kress and Chester Dale, to give their collections, thus confirming the rule that an important collection, once started, will attract donors. The fact that such bequests to nonprofit institutions can be deducted from taxes has undoubtedly been a contributing factor.

The museum must constantly watch for suitable purchases. An important source for European museums is the auction, but U.S. museums rarely buy at auction, since purchases must usually be approved by committees of trustees and it is difficult to secure the approval of a purchase before the auction. Most U S. museums buy through dealers and watch the markets throughout the world. All dealers will send objects to a museum on approval; and if a price cannot be met. the dealer will sometimes agree to a trade, but in the long run this practice is not profitable for the museum. Objects from collections willed to the museum may duplicate objects already in the museum collection or may not be quite up to the standard required. The best means of disposing of such objects is a more or less public sale. It is neither customary nor practical for a museum to dispose of works of art created by living artists or given by donors nho are still living.

In considering objects for purchase, certificates of authenticity are not sufficient guarantees of merit. Laboratory tests may have to be made, but even these must be considered with stylistic, historical or other factors to establish a conclusive opinion. It is unfortunate that so often the public is misled by reports of great art finds which later, after thorough examination, turn out to be of little or no value.

2. Care.—A11 museum acquisitions are inspected by the registrar, the curator and the conservator. The registrar, noting the condition of the object on arrival, assigns it a number and records the object in his files. The conservator and curator, after careful examination of the object. plan any necessary treatment. The object, before exhibition will be given to the photographer and then to the restorer or craftsman required for its care. After the object is placed on exhibition, precautions, *e.g.,* controlled atmosphere and cleaning, must be taken to safeguard it.

The extent to which a museum can and will adhere to all these requirements varies greatly, but its responsibility to do so is implicit in the acquisition of important objects. If its maintenance funds do not allow proper protection of objects, the museum is seriously neglecting its duty.

It is obvious that museums need elaborate protection against burglary, theft and unexpected attacks on objects by fanatics. Less obvious, and not always duly considered, is the need for protection against the deterioration of objects through neglect or decay. It is not easy to hold to a middle line between overprotection and wrong or careless treatment. In any case, before normal housekeeping can begin, it is necessary to restore objects to the point at which cleaning, dusting or other routine measures cannot hurt them.

After World War II the protection of museums in wartime became a major consideration. The policy during World War II was to take safety measures for immovable objects and to evacuate certain collections from cities in the danger zones. Caves and dry obsolete mines were proved to be safe storage places for those treasures. Skeleton collections were left in museums for the benefit of the public during the war period. Monument officers attached to the armies took care of precious objects found in the theatres of war. The possibility of atomic warfare has changed the picture. The course to be followed in any future war would depend largely on the definition of danger zone and on how iar ahead warning could be given of enemy action.

There seems to be scant hope that any practical measures could be taken to save museum objects in case of an armed conflict between world powers.

3. Presentation.—While museum structures are discussed in MUSEUM ARCHITECTURE. it should be noted that museums in Europe have been successfully housed in churches, *e.g.,* the Schnütgen-Museum in Cologne; in monasteries, *e.g.,* Augustiner

Kloster Museum, Freiburg im Breisgau, Ger.; and especially in palaces; *e.g.,* the Louvre in Paris, the Pitti palace in Florence. the Palazzo Bianco in Genoa, Hampton Court near London, and Schleissheim near Munich. In 1957 an 18th-century palace, the Capodimonte in Naples, was turned into one of the most impressive modern museums in Europe without essentially altering its structure. While the traditional or romantic atmosphere of historic buildings lends itself to the accommodation of art or historical collections, new buildings are more appropriate for museums of science and industry.

Whatever structure houses a museum, it must offer exhibition space, storage facilities, offices, workshops and lounges for the public; thus it sometimes happens that less space is devoted to exhibition space than to the rest of the museum.

Museum visitors of previous generations were less demanding than those today. The public now expects from the museum the same attention to its convenience and welfare as it expects from commerce and industry. Visitors are entitled to adequate lighting, wise presentation of objects. and easy-to-read, conveniently located labels. Despite rapidly changing trends, which compel museums to be particularly discerning in their exhibition methods, the underlying idea of every good museum installation is still the one defined by G. B. Goode (*q.v.*) in 1888. "It must be made with the strictest attention to system." An order need not be followed pedantically; it can and should be modified if there are good reasons to do so. Chronological order is the one followed in most history and art museums, though the functions of the objects in these two types of museums are quite different. Order by material or species may be followed in decorative arts and science museums, though in both cases additional group exhibits, demonstrating the affinity, diversity or evolution of objects, may be arranged. In the museum of decorative arts, objects might be selected for display on the basis of their similarity of form, purpose. colour or some other quality. In the 1930s the Museum of Decorative Art in Cologne was arranged in this fashion.

Labels.—The question of labels is one of the most troublesome. Certainly labels are not as necessary in the art museum as in other museums which must explain their objects to the visitor. Frequently there is a lack of introductory labels telling why certain objects are brought together to form a unit or to exemplify a theme, such as baroque style. electricity or U.S. Civil War. There are no predetermined rules governing all labels; it is necessary to determine the proper label for each case. Whether a label is short or long, made by script, print, engraving or photography, it is essential that it be legible to everyone, including the great number of persons with impaired vision. Labels should not be hidden, as they often are, for aesthetic reasons. What is gained in appearance is lost in convenience.

Study Collections.—The steady accumulation of objects has made it impossible to continue the early practice of displaying everything in the collection; most museums, therefore, divide their collections into objects for exhibit and objects in storage. The idea of this dual arrangement was advanced by K. F. Schinkel when the Berlin museum opened in 1833. About the middle of the 19th century this system was introduced in science museums in England and in the U.S., and around 1903 Francis 4. Bather recommended it for art museums. The difficulty is that in long-established museums, space is at a premium. and it is difficult to arrange for study collections. A notable example of a building planned to solve the problem is the Fitzwilliam museum in Cambridge, Eng. The ideal method of putting a study collection to use is to make it accessible to visitors without requiring them to apply for admission. If a study collection is provided, its multiple uses must be considered. In natural history museums? for example, many visitors besides the naturalist may be interested in special objects. Thus if it is possible to arrange a study collection, it is neither necessary nor desirable to have all parts of the permanent collection constantly or: view. There can be a rotation of objects or a succession of planned exhibitions, as was done at the Danzig Historical museum st Oliva; the Museum of Costume in New York; and others.

Even in the study collection it is not possible to keep every object that has entered the museum. The upkeep of each item in the museum is costly; the study collection must be screened from time to time in order to eliminate objects that have become useless to the museum. Although the study collection represents a storage of sorts, it is also necessary to provide general storage space for other objects which must be kept for one reason or another.

Art Museums.—The manner in which objects in art museums are presented tends to reflect the style of interior decoration or window dressing generally fashionable. Though both the architect and the window dresser have ways of presenting objects attractively, the museum has its own essential methods of display, and only occasionally. in planning special exhibitions, mill outside help be used. Eccentric showmanship should not be used for the routine installation of permanent collections. An art museum object should be effective for its own merit, not for its manner of display. Proper preparation is necessary for satisfactory presentation. Damaged pieces must not look shabby; the amount of restoration to be executed involves technical considerations and matters of integrity. With paintings the question of frames must be decided. Uniform frames have been used (Kroeller Mueller Museum. Otterloo, Keth.) but not satisfactorily. While period frames could probably be used more frequently. copies of them, such as the plaster of paris imitations of the Louis XV style that often adorn Impressionist paintings. should be avoided. Frames consisting of bare strips of wood were used successfully at the Galleria di Palazzo Bianco at Genoa. There has been a tendency toward the adoption of this style: however. it should be used with caution. For the display of single small objects, a variety of methods has been used: glass trays. standard blocks or brackets attached to the wall of the case. and others.

Formerly the museum case was one of the most important pieces of museum furniture and was so standardized that the visitor became fatigued by platoons of similar cases. With newer and less rigid methods of exhibition. the standard case has dropped out of fashion, and museums have tended to use cases according to individual needs. If it consists of a thin metal skeleton with shelves, the case itself is inconspicuous. it permits a convenient view of objects and it allons frequent changes in exhibition material. Cases are often built into walls, or walls are constructed nith large openings in which objects may be placed. Open shelves are sometimes used to great advantage, but they present problems of security and cleanliness. The customary three shelves of the standard case have given way to blocks or shelves of varying sizes so that objects can be shown at different levels. If this system is carried to extremes, however, the visitor will not know where to focus his attention or nhere to begin the story that the contents of the case have to tell. Whatever the practice, the more it is standardized and follows set rules, the sooner it will seem dated and lessen the appeal of the object.

While exhibition techniques in art museums are relatively simple, proper lighting presents problems. In Europe there is a tendency to prefer daylight (side and skylight), whereas in the Cnited States artificial light is more the rule. Both are acceptable, but it should be remembered that a room in daylight can be very restful after artificially lighted rooms, and. moreover, a painting viewed in the sparkle of sunlight may reveal qualities not visible under artificial light.

The nay in which works of art are installed varies with the fashion of the day. Whether to crowd them or place them sparsely and whether to use symmetry or balanced asymmetry depends on the purpose and possibilities of the exhibit and on the sense of measure of the person nho installs it. The same can be said for the background, which can be a neutral colour or a sharply contrasting one, of monk's cloth or of precious velvet; it may create an environment. or it may isolate the object. Virtually everything has been in and out of fashion, and a successful installation in one museum will result in imitations by many others.

Decosatiae *Art Museums.*—Museums of decorative arts have a special difficulty, since they deal with such a great number of diversified objects which must be brought together to depict either the style of a period or the way of life of a particular era. In the

1930s it was believed that the period room might be the solution. However, this method did not prove practical. The subsequent tendency was to combine products of one period and to let these combinations, arranged to suit the modern view, follow each other in chronological order (Victoria and Albert museum, London; Rijksmuseum, Amsterdam). This method of exhibiting decorative art objects probably comes closest to fulfilling the museum's purpose of contributing to the understanding of earlier phases in the development of civilization.

An excellent solution to the problem of exhibiting the period room, but one which cannot be easily duplicated. is found at the Art Institute of Chicago. Precise reproductions in miniature of rooms, halls and other interiors, both European and American. are arranged in chronological order. The room itself, the decorations and furniture are copied from the best available models and are made exactly to scale. Mrs. James Ward Thorne was not only the originator of this ingenious scheme but, with a staff of well-trained craftsmen. carried it out successfully. These model rooms were exhibited throughout the United States and though entirely of modern manufacture, convey as well as. if not better than, any genuine period room the idea of past modes of life.

In addition to rooms illustrating the development of various styles, the museum of decorative art usually shows special collections illustrating the history of certain products; *e.g.,* glass or china. It may also provide a study collection for research work for the museum staff itself, as well as for visitors seeking information. Museum material need not be kept exclusively for one particular purpose. How flexibly it may be used can be seen in the may the Cluny museum in Paris was reorganized in 1952. This museum was a treasure trove of medieval riches of every conceivable kind. where the visitor could enjoy himself by selecting those items in which he was particularly interested and. with each successive visit. be surprised and delighted with new discoveries. The museum changed its character completely, however. and was arranged to serve as an illustrated textbook to interpret the civilization of the middle ages. Without question this is an effective way to present the contents of the museum; however, if such a radical method is chosen, it should be supplemented by other exhibits for the benefit of those whose interests go beyond the theme of the main exhibition.

Historic *Houses and* Restoration Projects.—Only the museum aspect of historic sites, *i.e.,* the means by which they are interpreted to the visitor, will be dealt with here. Projects of this type vary from the enormous undertaking at colonial Williamsburg, Va., to the site of an Indian stockade at Sitka National monument, Alaska. In every case two requirements must be met: the meaning of the project must be explained; and the site must be presented in such a way as to hold the visitor's interest. The explanation may be given throughout the museum, in a film or in a small display. The site may consist of an area or a house, restored or reconstructed, or it may consist of newly built structures. *In situ* objects may be supplemented by additional material. In the historical house the period room is a necessity for its special historical significance; here it is also useful in illustrating trends in the decorative arts.

History, *Science and Industry Museums.*—For history. science and industry museums the problems of presentation are not very different from those of the art museum. These museums. however, face the formidable task of finding adequate designers. Not all scholarly curators are good showmen, and it is sometimes necessary to engage an artist or architect to arrange exhibits. Primarily the task is to find a person who knows how to interpret the data correctly and in the best taste. If this is done, technical helps are available to produce fascinating exhibitions by the use of habitat groups. dioramas, photographs, mechanisms, laboratory experiment setups, replicas and objects of all kinds. Such exhibitions may be static! or they may he operated by visitors or demonstrators. There are immense difficulties involved in combining all the factors in an exhibit, such as educational purpose, technical accuracy. attractiveness and co-ordination with neighbouring objects. Moreover, developments must be presented logically, beginning with fundamentals and proceeding step by step to a higher level. If demonstrators are used, they can make exhibits far more effective; they can hold the attention longer than any label could, particularly if they assume that the visitor is not informed on the subject under discussion. Part of the effectiveness of the demonstrator can be attributed to the fact that the appeal is both to the sight and the hearing of the visitor, rather than to the sight alone.

In science and history museums. exhibits consist of special, original objects with the addition of technical devices for explanation; the history museum, however. is not bound to display as many original items of a specific type. The history museum may select objects as they become available or seem suitable for interpretation of a certain topic. One item can be substituted for another as long as its character as a symbol is maintained and it lends adequate support to the story. If pictorial material is not authentic. it should be so labeled; however, authentic material should be used as much as possible. This kind of display may be a collection of heterogeneous objects. but a well-defined, interpretive arrangement will account for and explain the objects presented. Unfortunately, history museums with well-planned, systematically organized collections. such as the Musée de l'Homme in Paris, are the exception rather than the rule.

III. HISTORY

A. General Development

1. Greek and Roman Origins.—In its original sense the Greek work *museion* was applied to a sanctuary dedicated to the Muses of Greek mythology. In the 3rd century B.C. the term designated that part of the palace of the Ptolemaic kings in Alexandria. Egy., that housed the library of Alexander the Great and was known as a place of learning. Yet though the term *museion* was not used to denote a collection of works of art, the idea of a public collection did exist in Greece. The Greek writer Pausanias (2nd century A.D.) said that in a building adjacent to the Propylaea on the Acropolis at Athens there was one hall called Pinakotheke, containing a collection of paintings. which n-as open to the public (hence the name of the Munich Pinakothek). No such collection is known in ancient Rome, but it is known that Roman generals plundered Greece and that many sculptures of Greek origin adorned public grounds and private houses. Throughout the early Christian centuries following the Hellenistic era. the idea of the museum as a place of inspiration or learning was lost. as was the institution of the Pinakotheke, though certainly the human habit of collecting never ceased. The history of collecting in general. however, does not form part of this outline; collecting is dealt with here only as a part of the history of museums.

2. Middle Ages.—The idea of visualizing spiritual forces in works of art, as a source of knowledge and inspiration, was recreated by the Christian church. In effect but not in name the medieval church was a museum not entirely unlike those of modern times. From the time of early Christianity, when symbols were drawn on the walls of the catacombs of Rome to fortify and inspire the faithful, through the middle ages. when richly carved portals and stained-glass windows told stories from the Scriptures: the church was the place where knowledge was conveyed not only by word but by visual aids as well. Two typical examples were St. Mark's in Venice. where the walls were covered with narrative mosaics and where fabulous treasures were displayed on special occasions, and the cathedral at Halle, Ger.. where Cardinal Albert of Brandenburg. Luther's antagonist, established an extraordinary collection of relics: set in sumptuous cases and provided with a printed and illustrated catalogue (*Heiltumsbuch,* 1510).

3. Renaissance.—It was not until the 16th century that the Greek term *museion* was used in Italy in its Italianized form, *museo.* During the Renaissance, Italian princes and noble families began to take an interest in the arts and in all branches of human knowledge. They brought out from their treasure vaults, called *guardaroba,* the rare artifacts which, up to then, had been stored for protection rather than for enjoyment. It added to the prestige of a great and learned man to be seen surrounded by precious or curious objects, which he generously allowed his friends to inspect. Obviously the collections kept in these studies

or writing cabinets, called *museo, studiolo, scrittojo* and other names. were of a heterogeneous character — stuffed animals and botanical rarities being mingled with works of art, freaks, artifacts and curios of every sort.

Among the ruling families of Italy who displayed their collections in such fashion were the Medici of Florence, the Gonzaga of Mantua, the Este of Ferrara and the Montefeltro of Urbino and Gubbio, all of whose treasures became the focal points of later museums. The panels made to cover the walls of the *studiolo* of Federigo of Montefeltro, duke of Urbino, at Gubbio after 1482, are the most representative of their type. Their intarsia shows symbols and allegories of the arts and sciences; these are now in the Metropolitan Museum of Art, New York city. An even richer decoration adorned the *studiolo* of Alfonso d'Este in Ferrara. which was decorated with paintings by the foremost artists of the period. One of these paintings. "The Feast of the Gods" by Giovanni Bellini, was acquired by the National gallery in Washington, D.C. Besides the great princes there were the scholars. such as Bishop Paolo Giovio (1483–1552) in Como, who specialized in collecting portraits of famous personalities, while Ulisse Aldrovandi of Bologna (1522–1605) and, somewhat later, Lodovico Settala (17th century) were famed for large scientific collections.

Across the Alps the *museo* was known by a variety of names. In France, Francis I (1494–1547) had a *cabinet de curiosité* at Fontainebleau, and Jean Baptiste Gaston, duke of Orléans (1608–60), among others! had one at the Palais du Luxembourg in Paris. In the old Holy Roman empire and throughout Scandinavia the term *Kunst und Wunderkammer* was used. One of these, belonging to Archduke Ferdinand of Austria (1529–95), at Ambras in the Tirol, was later inherited by the museum in Vienna; the *Kunstkammer* of Albert V of Bavaria (1528–79) became part of the Munich collections. In Copenhagen the most famous collection was that of the physician Ole Worm (1588–1654). In England the Tradescants, father (d. 1637?) and son (1608–62), established their Musaeum Tradescantianum (later incorporated in the Ashmolean museum in Oxford), defined by a contemporary as an "arch of novelties."

All of these *museos* from Bologna to Copenhagen were similar in character and were among the curiosities that the scholars or the gentlemen on the grand tour visited. Although the Italian *museo* of the Renaissance might contain small pieces of art, such as bronzes. medals, carvings, portraits and, occasionally. a small still life or nude (a cabinet piece), it was not the place where large pictures of mythological or religious subjects were kept. These were placed in a long *galleria.* By the end of the 16th century these galleries were an integral part of the residences of Italian princes. They also served for indoor exercise. It is possible that Sebastiano Serlio (1475–1554), the architect, was the first to suggest this type of building, at the beginning of the 16th century. The one best known, and still in existence, is the gallery built by Bernardo Buontalenti about 1581 on the top floor of the Uffizi palace in Florence. This type of promenade gallery, hung with pictures and adorned with sculpture, came to be an element in princeiy palaces throughout Europe. It represents the immediate predecessor of the art gallery of the 19th century, the principal difference being that the latter structure was lighted by skylights, following the example of the Louvre galleries (opened to the public in 1793), rather than by windows along one side.

The *museo* and the *galleria* were the two ancestors of the present-day art museum, which came into being around 1800, when the contents of the *museo* and *galleria* together were put on view to the public. There were, however, other types of collections. One was the accumulation of antique sculpture, such as that given to the city of Rome by Pope Sixtus IV in 1471. The antique statuary unearthed at every excavation in Rome had to be disposed of in some expedient way. These sculptures, later placed in the Capitoline museum, were set up, or stored, in the front loggia and under the arcades of the Palazzo dei Conservatori on the Capitoline hill. Later, under Pope Julius II, the Belvedere court of the Vatican was arranged to receive a collection of sculptures (hence the name "Apollo Belvedere"), which was much admired and studied by all artists who came to Rome. Undoubtedly these Roman collections of antique sculpture later inspired other art lovers to form similar collections, nhich they housed in galleries or buildings erected for that purpose (Antiquarium, Munich, after 1584; Xrundel house, London, before 1618; Temple of Antiques, Potsdam, Ger., 1768).

4. Baroque Period. — Eventually it mas obvious that some system was necessary for an orderly arrangement of these accumulations. In 1565 Samuel van Quiccheberg. a Flemish doctor in the service of Albert V of Bavaria. nrote a treatise on the subject under a lengthy title beginning *Inscriptiones . . .* According to Quiccheberg the ideal museum should represent the universe by means of a systematic classification of all subject matter. His treatise was widely read and even 100 years after its publication was used by John Tradescant when he catalogued his collection of scientific objects. which is now part of the Ashmolean museum at Oxford.

The most important among the theorists who folloned Quiccheberg was C. F. Neickelius. His *Museographia,* published in 1727, was the first handbook in the field of collecting and museography. With such literature available, collecting was no longer reserved for the few; an increasing number of persons became interested in the subject and in the possibilities collections offered for study. It nas a propitious moment for the collection owned by Sir Hans Sloane to be given to the British nation, his house in Bloornsbury, with all its contents, was opened to the public by act of parliament in 1759. This collection formed the nucleus of the British museum. Even earlier (1739) the Vatican collections had been opened to the public, and a part of the French royal collections could be seen at the Palais du Luxembourg after 1750, but in all these cases public admission was much restricted. Of the private art galleries which were started in the 17th century a very small number are still in existence; among those open to the public are the Galleria Doria-Pamphili in Rome and the Count Schonborn collection in Pommersfelden near Bamberg, Ger.

5. Late 18th and Early 19th Centuries. — It took an event as momentous as the French Revolution to transform the basic character of the museum into an institution for education. It was only after that revolution that it was recognized that the study of collections should be allowed to the many and not just to the privileged few. In order to make such study possible, however, better organization of collections was necessary, and this reorganization called for specialization. The efforts of the French Encyclopaedists in classifying human knowledge and making it accessible had been a step in this direction. Presently art treasures were taken from the old curio cabinets and placed nith those already in galleries. thus creating the art museum; scientific objects were gathered in the newly established museums of natural history, though a clear definition of such a museum did not come until later.

For nations with colonies, ethnology became an important subject, and somewhat specialized collections in this field were already established in the 18th century. In Great Britain the subject was covered by the British museum; Holland also had an early example in the Teyler's Museum in Haarlem, which opened in 1778.

The history museum as it is known today was not an early creation. Around 1800, certain classes of art monuments. such as tombstones, portraits, coins, medals and seals, began to be considered of historic interest, but they mere placed in art museums. By and large, the art museum was foremost in the evolution of the modern museum, and its pattern was followed by the others. Its development, therefore, deserves special attention.

During the French Revolution most of the collections onned by the French nobility were dispersed, the art market shifted to London and art objects streamed into English private collections. To prevent the export of French art and to care for the treasures which nere endangered, a commission was formed under Alexandre Lenoir. He established the Musée National des Monuments Français at the cloister of the Petits Augustins, nhich he planned to make "picturesque, educational and tasteful." It remained in existence until 1815, when it was dissolved during the

Bourbon restoration. More spectacular than Lenoir's efforts were the decrees that provided for the creation of a national museum in the old palace of the Louvre, later knonn as the Musée Napoléon, under the most capable direction of Vivant Denon. A tremendous number of confiscated works of art seized by Napoleon from all parts of Europe made up this museum, which. though short-lived. was one of the marvels of its time. The public, which was admitted without restriction. enjoyed immensely the privilege of seeing the finest art treasures of the world gathered under one roof. Richly illustrated publications by Count Clarac Jean Seroux d'Agincourt, Count Leopoldo Cicognara and others exploited the extraordinary opportunity of recording and making available to the peoples of Europe their heritage of great art. In ushering in the era of comparative studies, particularly of European art treasures, the Musée Napoléon was of great importance, but since it consisted of the spoils of war, Napoleon's victors very correctly insisted on returning as many of the stolen objects as possible to the rightful owners. As a consequence, there was an anakening of public interest in the heritage of national art, and efforts were begun to found museums on a national basis.

These public museums differed greatly from the earlier ones which, for better or worse, had reflected the tastes of their private owners. For example, under Louis XV, antique works of art and those of the Italian Renaissance that the king disliked had been placed in the Palais du Luxembourg in Paris, nhere the king would not see them. In his gallery in Potsdam, Frederick the Great collected paintings by Watteau and his school, ahich at that time were out of favour with the art world. Later he added certain late 17th-century paintings which suited his personal taste. Catherine II of Russia bought several private collections of paintings because, in the age of enlightenment. she felt it her duty to do so.

Vienna. with its huge collection. was exceptional, since there was little interference by the emperor. There the artist Christian von Mechel, who was director of the art collection, in 1781 arranged the paintings in chronological order by schools, and his system became the pattern for the newly established public museum. The print room, as it is known today in most large art museums. also originated in Vienna. There had been famous collections of prints ever since the 15th century, but only when Adam Bartsch was put in charge of the collection of Albert, duke of Saxe-Teschen (hence the name of the Albertina collection), was a collection systematically organized. The extraordinary quantity and quality of prints in this collection induced Bartsch to go one step further and establish *oeuvre* catalogues (inventories of works produced by an artist) of the masters of print making. As Bartsch based his work on other collections. as well as the Albertina, he came to be considered the Linnaeus of prints, creating the basis for future systematic work on prints.

In the new spirit of order and objectivity and with the aim of serving the public, art collections were started wherever they could be afforded or wherever enlightened rulers were willing to give up some of the treasures accumulated in their palaces. Such galleries were established in Budapest (1802), Prague (1818). Madrid (1819), London (1814), Berlin (1830), Munich (1836) and elsewhere. In all these collections Italian Renaissance and Dutch and Flemish 17th-century paintings dominated; far less attention was paid to sculpture. Little effort was spent in rounding out existing collections; acquisitions generally came only through bequests. perhaps from an extinct branch of the reigning house. Officers in charge of museums were high court officials or public servants, sometimes eminent connoisseurs or artists. but rarely scholars. In the decades after the middle of the 19th century most galleries limited their efforts to the presentation of objects in historical order, and, following the fashion of the day, they were arranged in a rather crowded manner.

6. Development of Decorative **Arts** Museums. — Before going further into the history of the museum, a digression concerning the decorative arts in museums is necessary. The conception of decorative arts presumes a conception of the fine arts (*q.v.*). The idea that some arts are fine or major and distinguished from others that are merely decorative or minor originated in the 17th century, when Royal Academies were established for the education of painters. sculptors and architects. Those who wished to master design and crafts were left to their own initiative or to training by guilds and their masters. The dividing line between the two categories. always somewhat artificial and never clearly defined, became more real and perhaps more justifiable during the early part of the 19th century. when objects produced by mechanical methods began to make their appearance, such as Sheffield plate, Wedgwood nare or lacquer products. These objects not incorrectly were thought of as works of decorative art. But then, by some strange method of simplification, a gold cup by Benvenuto Cellini or a stained glass window were included in this same category with furniture, ceramics. glass, textiles and other items. This classification would have been of little importance had it been only a matter of convenience or terminology. But unfortunately it tended to create a scale for evaluating works of art ahich was completely unreasonable. and tended to make objects in the field of the decorative arts appear less desirable for collectors. Therefore, at a time when collectors were, for the most part, busily trying to find the medieval paintings brought to light by the French Revolution and the Napoleonic era, it was indeed renarding to concentrate on a collection of church furnishings, household objects and other items which had been in use through the past ages. The first important collection of this type was made by Alexandre du Sommerard in Paris around 1830 and consisted of works primarily of medieval art. This collection was taken over by the French government in 1842 and was the nucleus of the present Cluny museum.

While Du Sommerard had started his collection because of his personal interest the first public museum for decorative art owed its existence to completely different reasons. The Crystal Palace exhibition held in London in 1851 had demonstrated that in the age of the machine good design was sadly lacking in the products of craftsmen, as well as those of industry. To improve the situation the Victoria and Albert museum was established. It was felt that a systematic collection arranged according to material, such as glass, wood and others. consisting of the best examples of the old craftsmanship, would provide the patterns which were so needed. Similar museums were established in Berlin, Munich, Vienna. Paris. Brussels, Stockholm, New York, etc.

Toward the end of the 19th century, when modern trends mere introduced in art and when copying old patterns and forms was no longer in fashion, these collections lost much of their importance for craftsmen. Nevertheless they retained their value as sources of inspiration and as records of technique or treatment of material and even won new recognition as collectors' items. Certainly the great collectors of the 19th century, such as the members of the Rothschild family, Sir Richard Wallace, Prince Anatoli Demidov, Frédéric Spitzer, Georg Hirth and J. Pierpont Morgan, had always been in competition with museums of decorative art. But with the museums' expanding their collections and nith more thorough knowledge gained through the increase of research work, there were growing numbers of connoisseurs and collectors who were acquiring decorative arts as eagerly as paintings had been collected earlier. When it became the style to decorate interiors by mixing modern furniture with antiques, even more lovers of such objects appeared.

After 1900 the endless collections of decorative arts material assembled in Kensington cases (the once famous glass cases on turned feet. usually painted black) were no longer appealing. Because of this lack of appeal and because interior decoration dealt so much nith styles of the past. it was thought expedient to assemble decorative arts material in so-called period rooms. However, results mere not what had been anticipated. Too many compromises had to be made; often substitutes were included. On the whole, the period rooms seemed static and did not give a true idea of the past or how people had lived.

After J. Pierpont Morgan gave his collections to the Metropolitan museum in New York and the Wadsworth athenaeum in Hartford, Conn., decorative arts objects were accepted in the U.S. as worthy of museum collections, but no special museums

like those in Europe mere established. The one exception was the Museum for the Arts of Decoration in New Tork. founded in 1896 and copied after the Musée des Arts Décoratifs in Paris.

7. Late 19th **and 20th** Centuries.—As the 19th century progressed, specific trends in museum work became marked. Following the pattern of the Victoria and Albert, which had given its collections a universal character, the idea that the museum should be representative of art in all its manifestations was generally accepted. When the French Impressionist painters and their followers became interested in Oriental and primitive arts, collectors and museums turned to this new realm, and representative pieces of exotic cultures were accepted in museums. As collections grew and knowledge in these new fields became highly specialized, museums showing non-European art were established. As scholarship in various fields of collecting grew, museums came to be recognized as valuable sources for serious study, and museum workers became experts in their fields. This development created definite and strong dividing lines between the various kinds of museums. Toward the end of the 19th century there were four distinct groups of museums: those concerned with art, with history, with science and with industry. The science group included museums of natural history, ethnology and anthropology. In all of these there was a tendency, throughout the entire second half of the 19th century, to make museums repositories for scholarly study rather than places of enjoyment. As museums grew and expanded, little thought was given to making them more inviting, and almost no thought at all to the interpretation of the contents for the public.

Recognition of the museum as an active educational institution began in a small way when John Ruskin stated that a museum should not only exhibit objects but should make some effort to interpret them to the public. These ideas were incorporated in plans which Ruskin brought before a parliamentary commission in 1857 to improve the taste and recreational habits of the working classes. Later Ruskin's ideas mere embodied in the Sheffield museum, Uorkshire, Eng., opened in 1875. Another approach to the same goal was made when the British museum, under the direction of Sir William Flower, divided its collections into introductory and systematic series and a study collection. Francis A. Bather, president of the British Museum association in 1903, endeavoured to transform "mere repositories into stimulating museums." Though other museums in England and on the continent (in Hamburg through Alfred Lichtwark) pursued such educational ideas, no general effort was made in Europe to solve these problems. In the United States the educational role of the museum began at an early stage, and during the first decades of the 20th century such museums as the Museum of Fine Arts, Boston, the Metropolitan Museum of Art in New York and the science museums in Cambridge (Mass.), New York, Washington and Chicago took the initiative in active interpretation from the art museum. U.S. museums realized the need to interpret the wealth of treasures they were accumulating so rapidly with their great financial resources. The museum was to appeal to a wide and diversified public, far less prepared to enjoy or understand its exhibits than was the European public, for which museum contents formed part of the past of their own nations.

Science museums also turned to the new task of interpretation and no longer considered their only duty to be merely to inventory species. Throughout the 20th century, museums in the United States were assuming an important place with other educational institutions.

Until World War I, museum work in Europe was conducted in a conservative and traditional way; decades passed without any changes. The one exception was Germany, where the dynamic personality of Wilhelm von Bode (1845–1929), the director-general of the museums in Prussia, influenced a change in the status of museums in Germany and abroad. Then, too, after the Russian, German and Austrian revolutions in 1918, when many of the art treasures of princely houses changed hands, new methods had to be applied to museum work. Because of the general instability a constant movement of art objects began, which continued long after World War II. This led to the great art exhibitions which, as mentioned earlier: gained such wide public appeal. Exhibitions of this kind required showmanship techniques, which were adopted by museums; many of them. in various parts of the world, were remodeled on a vast scale. Such changing activities, problems and purposes may well prevent museums from ever again stagnating as they did around 1900, when they were frequently referred to as mausoleums or morgues and were held in low esteem by the public.

Gnited States.—In the United States throughout the first half of the 19th century the public generally expected museums to be "depositories of curiosities to amuse an idle hour." But with the American Industrial exhibition held in New York city in 1853, there was a change, and new lines of thinking were initiated. Benjamin Silliman, Jr., the well-known Yale chemist, who had complained that neither the federal nor state governments had done anything to establish galleries and museums, hoped that the creation of such educational institutions would result from this exhibition. Even before such ideas were launched, private art collections owned by Henry Abbot and Thomas J. Bryan had been bequeathed to the New York Historical society. Patrons, such as William Blodgett, J. J. Jarvis, Henry Tuckerman and Charles C. Perkins, required two more decades, however, to convince the public that an art gallery comparable to the great European collections was worthy of any "great civilized metropolis." Their efforts were fulfilled in 1870, when the art museums in New York city and Boston, Mass.. were started, and the thriving era of U.S. museum development was initiated. One of the reasons for the astounding growth of this type of museum was its constant attention to the needs and wishes of the public. As U.S. museums grew in importance. some of them, like their European counterparts, began to specialize in certain fields. In New York city, for example, the Whitney Museum of American Art concentrated on the art of the 20th century, the Museum of Modern Art collected international modern art of the late 19th and the 20th centuries, and the Solomon R. Guggenheim museum limited itself primarily to abstract art. Institutions like the National gallery in Washington, D.C., and the Metropolitan Museum of Art in New Tork city devote their activities to many periods of art, though some may stress certain periods; *e.g.*, medieval and far eastern treasures at Boston, the Impressionists at Chicago, ecclesiastical riches at Cleveland and ceramics and early Dutch paintings at Philadelphia. Gradually U.S. museums evolved their own pattern, and in establishing educational features, they were more successful than European institutions. Besides the great museums in such cities as Baltimore, Boston, Chicago, Cincinnati, Cleveland, Detroit: Kansas City (Mo.), Minneapolis, New York, Philadelphia, San Francisco, St. Louis, Toledo, Washington (D.C.) and Worcester (Mass.), excellent smaller ones were established in Andover (Mass.), Buffalo, Cambridge (hlass.), Dallas, Denver, Hartford (Conn.), Houston, Indianapolis, Los Angeles, New Haven (Conn.), Portland (Ore.), Providence, Raleigh (N.C.), Richmond, Sarasota (Fla.), Seattle, Springfield (Mass.) and many other cities. A special development was the growth of college museums, two of the best being at Smith College, Northampton, Mass., and Oberlin college, Oberlin, O.

Some universities have organized expeditions and established institutes for studying the results. Among the most important museums which have been added to their universities are those at Philadelphia and Chicago. The University Museum of the University of Pennsylvania in Philadelphia (founded in 1889) ranks among the foremost museums of ethnology and archaeology, with outstanding collections of material about North and South America and Asia, most of which was acquired in field work done by the museum. The same is true of the Oriental Institute of The University of Chicago, which specializes in the near east and employs a staff to publish the results of its expeditions.

The picture of the U.S. art museum would not be complete without a word about the private collections that have been given to the public, particularly the magnificent Mellon bequest. In Europe most private collections which were not dissolved were co-ordinated in some way with existing museums; rarely did their owners leave their collections as museums, as in the case of the

Wallace collection in London, the Musée Jacquemart-André in Paris. the Six house in Amsterdam and the Rath museum in Budapest. In the United States a number of outstanding collections were left to existing museums, but more frequently a collector. wishing to perpetuate his memory. would leave his collection to his favourite city with the condition that it remain more or less unchanged. Such are the Walters collection in Baltimore, the Isabella Stewart Gardner museum in Boston. the Frick collection in New York. the Huntington collection in San Marino, Calif., and the Ringling collection in Sarasota. Andrew Mellon, honever. planned for his collection to form the nucleus of a national gallery of art to be established in Washington, D.C. No such collection existed in the capital because it had never been the policy of the federal government to expend tax money on art. At the time Mellon began gathering his collection it seemed almost impossible that a collection of paintings rivaling those in Europe ever could be put together. The success of Mellon's plan placed Washington among the foremost cities nith high-ranking art collections. When the gallery opened in 1941, western painting from its origin to well into the 19th century was splendidly represented. Later the gallery attracted other donors. and the Widener, Kress and Dale collections rounded out the already overwhelming array. The National Gallery of Art also became the centre for international art projects and related activities.

Peculiar to the U.S. are the community or civic centres, most often in middle-sized towns, and children's museums. In community centres, interest in art is usually, but not always, the focal point around which the various activities are grouped Loan exhibitions and shows by local artists are often the highlights of the annual programs. Art and crafts classes may be given, and photography, music and drama groups may be organized. The Des Moines Art centre is a typical institution of this kind. History is the special field of the Detroit Historical museum. A very general program is conducted at the Corning Museum of Glass.

A junior division may form part of the centre, or a special children's museum may be provided. The first children's museum nas established in Brooklyn in 1899, and there have been many since then. Very active programs for children are conducted at the Rochester (N.Y.) Museum of Arts and Sciences and the Buffalo Museum of Science. The Metropolitan Museum of Art reorganized its children's museum in 1958. Children's museums usually try to convey general, rather than specific, information, linking together various matters in ways understood and appreciated by children. Children are often given the opportunity to acquire or enlarge their skills in workshops and studios.

The development of U.S. museums continued at full swing through the mid-20th century, giving great promise of further development and improvement.

Great *Britain.*—After World War I the Fitzwilliam museum in Cambridge was one of the first British museums to rebuild completely; at the same time, the very important National hfuseum of Wales in Cardiff was reorganized. Folloning World War II, the National gallery. Victoria and Albert museum and the Tate gallery were completely rearranged to present to the visitor convenient portions of the tremendous collections which had accumulated. Old established museums in Edinburgh, Glasgow, Birmingham, Leeds, Liverpool and Manchester continued to be active through the mid-20th century; some of them took on new duties in preserving and making accessible the mansions in their neighbourhoods no longer used as residences.

British Commonwealth.—In the British Commonwealth, Canada has been very active in the museum field. A notable museum is the one in Ottawa, Ont , which has gained in importance through the acquisition of prominent paintings. In applied art and far eastern art the museum in Toronto. Ont., is outstanding. The National Gallery of Victoria in Melbourne, Victoria. Austr.. successfully built up a collection nhich includes European masterpieces beginning with Jan van Eyck. In the Union of South Africa important art museums were founded in Cape Tonn and Johannesburg. The oldest museum of art and ethnology in India is the Victoria and Albert museum in Bombay. The National Museum of India in New Delhi (founded in 1948) collects Indian antiquities; the Baroda Museum and Picture gallery was, at mid-20th century. the only one in India concerned with European art. Pakistan's museums are located in Karachi, Lahore and Peshanar.

France.—In France art museums are largely concentrated in Paris, the Louvre. with frequent donations of great private collections gren to be one of the most precious treasure houses of art in the world. Like other major museums the Louvre has made great strides in reorganizing its collections. Its sculptures have been placed to better advantage and appropriate, often dramatic. lighting has been installed to allow for evening openings, nhich have become famous and are well attended. Paintings. particularly those of great size, are no longer crowded on the walls and can be seen to greater advantage. The arrangement of pictures of smaller size against a background of elaborate period material is less fortunate.

The Cluny museum has been so reorganized that only the very finest objects of its collections are shonn, and these are arranged according to themes, often of sociological character. All the overflow has been stored and is not easily accessible. Old palaces, mansions and the buildings from the exhibition of 1900 nere for a long time considered adequate for various Parisian collections. But with the need for more space and adequate protection for museum objects, and with the exhibition of 1937 giving a stimulus, the Palais de Chaillot was erected to house the splendidly organized Musée de l'Homme and the Musée National des Monuments Français, a collection of plaster casts of old French sculptures. The latter museum was one of the few of its kind to remain in existence, since plaster casts had fallen into general disfavor. The Musée National d'Art hloderne also acquired a new building, providing ample space for its collection After World War II. provincial museums in France (Bourges. Dijon, Le Havre, Lyons, Nice. Reims. Tours, etc.) mere reorganized according to a general plan and their contents and presentation greatly improved.

French museum work was extended to Africa. where active museums in Algiers and Tunis have steadily increased their collections.

Germany.—The stimulus given to museums under the leadership of Wilhelm von Bode has been mentioned. The state museums in Berlin were so greatly improved that they rose from secondary importance to ranking position and dealt not only with European but also nith Oriental and U.S. art. Bode made acquisitions of considerable quality, and his improved exhibition techniques have been internationally accepted. World War II and the separation of Berlin into east and west sections completely disrupted this kind of work. But even before this development, activities in all German museums had been rudely cut off by the Nazi regime. Museums were deprived of works of art to which the Nazis nere opposed and nere used for indoctrinational purposes by presenting objects in a prejudicial manner. These practices were continued in east Germany after World War II by the Communists. An example of this type of museum is the one located in the former *Zeughaus,* "armory." of Berlin. which demonstrates the course of German history as it is seen behind the "iron curtain."

After World War II a building in west Berlin which Bode had planned as a study-storage building was found to be most useful to house what nas left of the collections once placed on the museum island, now cut off from the west. A wing mas added, and the building was used for collections of old paintings, sculpture, prints, drawings, ethnology and archaeology. Modern paintings nere placed in Charlottenburg palace, along with the only historical rooms, formerly inhabited by the kings of Prussia, remaining in Berlin. The remnants of the badly damaged Museum of Decorative Arts are also displayed in this place.

Hardly a city in Germany failed to rebuild or reorganize its museum. usually in an attractive and efficient manner. The picture gallery in Munich, the so-called Alte Pinakothek, was reconstructed. The Bayerisches Nationalmuseum, badly damaged during World War II, nas rebuilt and considerably enriched, as was the case nith the city museum in Munich, which received an

extraordinary number of Kandinsky paintings as a gift. The old Wallraf-Richartz-Museum in Cologne was rehoused in a very modern museum, built by Rudolf Schwarz. Also in Cologne, the Schnütgen-Museum, showing religious art. made clever use of an old church for its collections. The Folkwang Museum, formerly in Hagen, was once one of the few privately owned and endowed museums in Germany; it is now owned by the city of Essen. It played a leading role in the introduction of modern art. Though this museum, and others showing "degenerate art," lost valuable paintings by Cezanne, Van Gogh and the German Expressionists during the Nazi period, some of these have been replaced.

East German museums, including those in Berlin, suffered enormous losses after World War II, when their collections, which had been either in safekeeping or left in museums, were confiscated by Russian authorities. However, unknown to the western art world, these treasures were given good care in Leningrad, Moscow and Kiev. Some had been damaged, but while in custody many of them were restored with great skill and infinite patience. In 1955 the Soviet government decided to return the works of art that had been held in the Soviet Union. The Dresden Picture gallery was the first to benefit, after which other important collections from Berlin, Gotha, Leipzig, Dessau, Wörlitz, Meissen (7,000 molds owned by the porcelain manufactory) and other places were returned. The magnitude of this task is apparent when it is realized that the Hermitage museum alone housed more than 500,000 objects from German museums; it has been estimated that more than 300 boxcars were needed for the return operation. The objects once owned by the Berlin museums, among them the Pergamum altar: were restored to east Berlin. Since the museums once located on the museum island were destroyed or heavily damaged, the return of these collections necessitated an acceleration of the rebuilding of museums. The old palace in the centre of Berlin, the so-called Schloss, which housed the museum of decorative arts and other collections, was wantonly destroyed after the war; its loss was severely felt. The Kaiser Friedrich Museum, later called the Bode-Museum, and the old National-Galerie were among the most important old buildings that were, in part, made accessible again. The museums in Altenburg (a good collection of old Italian paintings), Arnstadt, Bautzen, Halle, Karl Marxstadt (the former Chemnitz) and Weimar became very active after World War II; many of them held exhibitions and even extended their collections.

Italy.—In Italy almost every city of any importance has a museum, and such cities as Florence, Milan, Naples, Rome, Turin and Venice have a number of first-rate ones. In addition, innumerable churches throughout the country constitute museums in themselves. Italy played a leading role in the post-World War II effort to reorganize museums; for example, the startling installation of pictures at the Palazzo Bianco in Genoa (1950) was widely discussed. In Milan the Brera gallery of old paintings, heavily damaged during the war, was newly installed in a more conservative but still pleasing fashion. In Milan, also, the collection of paintings, sculpture and decorative arts at the Castello Sforzesco was presented in a somewhat unorthodox and fanciful way, not always avoiding the danger of too rich background material. The collections of paintings and decorative arts, as well as some suites of historical rooms, at the Capodimonte palace (Naples) were opened in 1957. This museum was installed with great care and attention to detail. Lighting effects were arranged to provide even light at all times, and every effort was made to prevent museum fatigue and to provide as much aesthetic pleasure as possible. Capodimonte thus became one of the most delightful and efficiently arranged collections to be found anywhere. The Civico Museo Correr (decorative arts), the Cà Rezzonico, and the picture gallery at the Accademia, all in Venice, and the Uffizi gallery, in Florence, have been carefully reorganized to present their collections in the best possible nay. However, the Bargello, the world-famous sculpture museum in Florence, remained in a most unsatisfactory condition for many years. One of the most remarkable facts about Italian museums is the excellent way in which many small galleries and museums have been reorganized and installed; *e.g.*, Aquileia, Lodi, Viterbo.

Other *European Countries*.—All of the capitals and some of the large cities of the Scandinavian countries, such as Copenhagen, Stockholm. Oslo, Goteborg, Lund and Malmö, possess art collections, many of which are of great importance and date from the 18th century. The National museum in Helsinki, Fin.: is rich in ethnography and also owns a fine collection of pottery from the southwestern United States.

The Netherland's wealth of fine art is represented in museums in Amsterdam, Arnhem, Haarlem, The Hague, Rotterdam, Utrecht and many other cities. Belgium's store of art is housed in museums in Antwerp, Bruges, Brussels, Ghent, Liège and other places. Switzerland's best-known art museums are located in Basel, Berne, Fribourg, Geneva, Lausanne, Winterthur and Zurich.

Perhaps nowhere else in Europe is the great art inheritance of the past so concentrated and so well represented by the most superb paintings as in the Museo del Prado in Madrid, to which some of the best paintings of the Escorial have been added. The museums at Barcelona and Vich magnificently supplement the Prado in the Spanish medieval period. In Portugal the National museum in Lisbon is outstanding; the National Coach museum in Belém is of interest as one of the best of the specialized museums in Europe.

Austria mas able to preserve most of the immense treasure inherited from the, days of the monarchy. Museums are found in Vienna (Art museum, Museum of Fine Arts, Belvedere museum, Albertina Graphic Arts collection) and at Graz, Innsbruck, Klagenfurt, Linz and Salzburg.

Poland's great collection is in the National museum in Warsaw, which also houses works of art from Silesia formerly owned by museums in the eastern part of Germany. Other important Polish museums are in Cracow, Poznan and Gdahsk (Danzig).

In Czechoslovakia, Prague offers collections of art and science at the National museum. Other museums of note are in Brno, Olomouc and Bratislava. In Hungary the National museum at Budapest is famous for a collection of old masters. In Yugoslavia, Belgrade is the centre of the Slavic tradition, which is represented in several museums. Collections pertaining to Slovenian history and art are shown in Ljubljana and those pertaining to Croatian culture in Zagreb. The great tradition of Greece can be studied at the museums in Athens and Delphi.

Soviet *Union*.—In the U.S.S.R., old paintings are extraordinarily well represented in the Hermitage collection in Leningrad, originally a court museum. The collection now also includes modern European paintings, western decorative arts, as well as Scythian art and ancient objects from Greece and the near and far east. Icons and Russian art are shown at the State Russian museum in Leningrad. In Moscow the State Tretyakov gallery is representative of Russian art.

Until the mid-1950s the State Pushkin Museum of Fine Arts was very reluctant to show its rich collection of modern art from the Shchukin and Morozov collections. However, this policy changed, and paintings by Van Gogh, Cezanne, Matisse and others were put on view, together with a selection of paintings by old masters.

After 1956 the Kremlin was open to the public; its churches, some of its buildings and the fabulous collections of treasures, mostly of western art once owned by the tsars, were made accessible. The most important historical collection is at the State Historical museum in Moscow.

Near East.—In Turkey the museums in Ankara and Istanbul are rich in archaeological treasures. The Topkapu Palace museum in Istanbul houses a collection of decorative art, paintings and manuscripts. In Iraq there is the famous museum of archaeology in Baghdad, established in 1923. The national collection of Israel is in the Bezalel National museum in Jerusalem. Iran organized the Archaeological museum in 1936 and the Anthropological museum in Tehran in 1938. The museums in Cairo, Egy., own a wealth of Egyptian, Islamic and Coptic art.

Japan.—In Japan the Tokyo National museum, replacing the former Imperial Household museum, offers the best survey of Japanese art. Kyoto's Municipal museum is a branch of the former Imperial Household museum and shows old Japanese art.

In nearby Nara the National museum, as well as many shrines in the temple district, display treasures of old Japanese art: especially notenorthy are the Hōryūji temple and the Shōsō-in Treasure depository.

South America.—Mexico is particularly active in the museum field. Notable are the National Museum of Anthropology and the National Historical museum in Mexico City. There are also museums of importance in Morelia, Guadalajara and Oaxaca.

In Argentina, besides the museums in Buenos Aires. there is a museum of note in Córdoba. In Rio de Janeiro. Braz.. there is a Museum of Modern Art, housed in a completely modern building. The art museum in São Paulo has become well known for its fine collection of old and modern masters, probably the most representative of European art in South America. In Bolivia, the National museum "Tihuanacu" in La Paz is important. Chile's museums are concentrated in Santiago. Ecuador has a museum of note in Quito. Peru owns a number of museums in Lima and a collection in Cuzco. In Venezuela. Caracas offers several museums.

B. History Museums

1. General Development.— The purpose of the principal collection of the history museum should be to illustrate themes or visualize ideas. As long as the principles guiding the arrangement of a display are clearly defined and one exhibit follows the next in logical sequence, there is no objection to presenting certain specialized collections having to do with a historic event, a great man or something similar. But any digressions should be made clear so that the visitor never loses track of the idea running through the entire show. The essential difference between the purposes of the art museum and the historical museum is that the art object eventually must speak for itself. whereas a historical object, the sword of a hero. for example, must be evaluated in a very different way. What is important is its character as a symbol (though it may also have interest as a piece of art) and the sequence of thoughts this symbol may induce. The visitor cannot be expected to start this chain of thinking; therefore, it is the duty of the museum display to weave the objects that are shown into the story it wishes to tell. If this is not done, the object is nothing more than a curio, such as those in the medieval curio cabinets. Today a contemporary photograph of the Confederate Libby prison in Richmond, Va., is considered more impressive than a genuine brick from Libby prison, which used to be among the objects seen in historical society museums. It should not be forgotten that when history museums tell their stories they risk the danger of being accused of indoctrination; a case in point is the proper presentation of the American Civil War. Controversial issues must be presented in an unprejudiced way, with fairness to all the issues involved.

2. United States.— In the United States the history museum had a promising beginning. A native of Geneva, Switz., Pierre Eugene du Simitiere (1736–84), who settled in Philadelphia, opened a curio cabinet in the city sometime prior to 1776. More important than the establishment of the cabinet was Du Simitiere's idea of collecting all documentary evidence pertaining to the American Revolution. In this he aimed directly at what came to be held as one of the main purposes of the historical museum; *i.e.*, to illustrate a thesis or theme. After his death Du Simitière's collection was scattered, part going to Charles Willson Peale for the museum he opened in Philadelphia in 1785. This museum: like others in New York (Tammany society, Scudder's) and in Boston (Jeremy Belknap's museum), prospered briefly but then lagged. This situation changed when Phineas T. Barnum began in 1842 to monopolize the museum as a business. Soon people were much entertained by his "most pleasant and attractive place of public amusement on the continent." Barnum's renown was so great that even such distinguished citizens as Henry Ward Beecher, Horace Greeley and William Cullen Bryant thought that Barnum would be the right man to head a national museum. They sponsored a petition on his behalf and Pres. Andrew Johnson endorsed the plan. However, on March 3, 1868, fire destroyed Barnum's collection before the plan could be carried through. When in 1869 the American Museum of Natural History in New York was founded, with J. Pierpont Morgan as one of the committee. the final quietus was put on the plan. From this period on. the development of the historical museum was based mainly on the activities of historical societies, many of which established museums. Like those in Europe, these societies accumulated a great deal of material, but it was not organized in a manner to inspire and educate the public. At that time one event aroused far more interest than any historical society could possibly do. In 1859 the Mt. Vernon Ladies' association gained control of George Washington's country home and made it a national shrine. This, together with the earlier acquisition of Washington's headquarters at Newburgh, N.Y., established an early precedent for the designation of historic sites and was the beginning of the preservation movement. Preservation is an activity intimately related to the responsibilities of the historical museum. Temporary exhibitions were successful and stimulating in this respect. The Philadelphia Centennial, held in 1876, gave rise to the idea of restoring Independence hall and advertising it as a site of national significance. When the Smithsonian institution organized a division of history as a part of the United States National museum, it was a promising beginning, but the department was never very active.

On the federal level a new basis for matters pertaining to the appreciation and understanding of history was established in 1906 with the passage of the Antiquities act, which concerned the preservation of antiquities situated on government lands; in 1935 mas added the Historical Sites act, which authorized the government to acquire and preserve historic sites. With the aid of these acts and the branch of history of the National Park service, established in 1935, the government was able to protect historic monuments, to do justice to the historical past and to develop a good deal of educational work. The branch of history immediately set to work to define categories of archaeology and historic sites and structures illustrating the rise of American civilization. Guided by these definitions, sites for protection were selected and developed as historic areas. Frequently historical museums pertaining to a certain area, so-called trailside museums, were added for better interpretation. The sites which have been established, *e.g.*, Ocmulgee National monument. Salem Maritime National Historic site! or whose establishment is planned, represent a very impressive national museum of American civilization. (See National Park System, The.) On the state level a number of ambitious programs for historic houses have been developed in California, Illinois, New Jersey and other states. The Abraham Lincoln homestead in Springfield, Ill., is an example. Private initiative also worked toward the preservation and interpretation of the historic past in establishing colonial Williamsburg (Va.), Greenfield village (Alich.), Old Sturbridge village (Mass.), La Purisima Concepción mission (Calif.) and many others. One museum which cannot be classified easily is the Henry Francis du Pont Winterthur museum in Winterthur, Del. The founder of this museum intended to collect the most outstanding examples of American arts and crafts: as well as objects of everyday usage, in order to illustrate the history of Xmerican civilization. The objects were placed on display in their natural environment. The effect was intensified by making the collections available to the public only through conducted tours by guides capable of informing the public about every possible detail of the collection. Another museum based entirely on the collection of American material, including the presentation of objects placed in the open air, *e.g.*, steamboat, covered bridge, was established at Shelburne, Vt., by Mrs. J. Watson Webb.

The development of the motorcar and the road system made the countryside more accessible and increased interest in historic house museums, structures notable because of their historic associations or their artistic qualities. The idea was not new; Isaac Newton's birthplace at Woolsthorpe, Lincolnshire, Eng., and other places of similar interest had been shown to visitors in the 18th century. The intention was to make the historic house and its furnishings as authentic as possible. After the German revolution in 1918 some of the former royal palaces were refurnished on the

basis of old inventories to resemble as much as possible their appearance in their heyday. Later the same was attempted in French palaces and in many English mansions which were opened to the public.

In the United States the idea received wide acclaim, and hundreds of such houses, dating from the 17th century (Paul Revere house, Boston) to the 20th century (Vizcaya, Miami, Fla.). were opened for inspection. Two trends in the visualization of history are evident. The more conservative one is represented by the historical museum. which has evolved from the tradition of the historical-society collection. The other derives from the historical-house movement. which goes back to 1859, nhen Mt. Vernon was established as a site. The latter is also related to the open-air museums of Scandinavia.

3. Europe. — History museums date from the period when romantic ideals, which were born at the time of the French Revolution. and national ambition nhich thrived after the Kapoleonic Wars, inspired the peoples of Europe to recall the glory of bygone days. especially those of medieval chivalry. Thus national historical collections were started with the aim of gathering the remainders of the heroic past. In the group of these historical museums the Germanisches Nationalmuseum in Nürnberg, founded in 1852 by Hans von Aufsess. was apparently the first. In the closing days of the Holy Roman empire and before the second *Reich* had been established, Aufsess created an institution to collect objects of historical importance and to study and interpret the civilization of the German-speaking peoples. This idea. it is well to note, was rooted in romanticism, rather than the chauvinism of later pan-Germanism. In the course of its gronth the Germanisches Nationalmuseum tended to lose sight of its original purpose and began to resemble an art museum, a course nhich was later avoided but which many other historical and applied art museums folloaed to their detriment. Museums built more or less on the principle of the Germanisches Kationalmuseum nere later established in Prague (National museum); Munich (Bayerisches Nationalmuseum); Amsterdam (Rijksmuseum); and Zurich (Schweizerisches Landesmuseum).

Peasant life, folk art and folklore at first seemed to be simple and unromantic topics and were largely neglected by the national museums. It mas in this field that Kordiska Museet in Stockholm under Arthur Hazelius took the lead in the 1870s. Having become interested in the entire field of folklore after a study of ethnographical problems, Hazelius planned to start folk-art centres and open-air museums. Hazelius' undertaking came at a decisive moment, for the machine age already had begun to threaten the continuance of folkways. From the time of Hazelius, Scandinavian countries have led in the movement that he originated. While Nordiska Museet, with its archives and study material, remained the centre of the movement, open-air museums were started at Skansen in Stockholm (1891); at Bygdoy (1804) and at Maihaugen, in Lillehammer, Nor.; at Aarhus (1909) and Lyngby (1901), Den.; and in Finland. Folk and folklore collections nere also started in most European countries (Berlin, 1889; Cardiff, 1907; Paris, 1937). In the U.S., open-air museums were started in several places, such as Dearborn, Mich. (1928); Sturbridge, Mass. (1936); Cooperstown, N.Y. (1899); and Shelburne, Vt. (1953); an international folk-art museum was established in Santa Fe, N.M. (1953).

Outside Scandinavia, historical societies, along with the national museums, played the important role. Many of these societies maintained city or regional museums. Most of these were overcrowded; they lacked system; and sentimental and personal points of view were overemphasized. The educational value of these institutions was open to question, and, after much controversy, it was recognized that this type of museum could best serve its purpose by using its objects to tell a story or to interpret a theme. When the Rheinisches Museum (historical), Cologne, opened in 1936 and the Musée de l'Homme (ethnographical), Paris, in 1937, both followed a pattern of displaying their objects according to a sequence of ideas rather than to a system of classification. The most important historical collection in Russia is the State Historical museum in Moscow. In Warsaw, historical collections mere placed in buildings newly built behind historical facades (1954).

C. Science Museums

1. General Development. — The museum of science, perhaps more than any other, mas in a period of transition at mid-20th century; the period of concentration on the survey of nature mas ending. Science had reaped an extraordinary harvest from the tremendous accumulation of material that museums had arranged so prodigiously for more than a century. The time had come for museums to benefit from the results science had achieved and to visualize the problems with which man is faced wherever he turns.

Answers were sought to many questions in the fields of biology, physiology and ecology, to name only a few. The interest of the public was directed toward complex situations and was no longer satisfied with a presentation of unrelated facts or collections of specimens, however complete they might be. Presentations explaining conquest of the air or soil erosion draw the attention of the visitor and help him understand the problems that must be faced in everyday life. Museums of science embrace activities in an extraordinary variety of scientific and other fields, such as economics. Among other subjects the relationship of man to nature requires continual re-examination, and the all important theme of protection of natural resources must be brought to everyone's attention. Museums which grasped the new conception of their purpose found a following eager to learn and understand.

When the Paris Musée National d'Histoire Naturelle (Jardin des Plantes) was reorganized in 1793, its name expressed its activities — the study of geology and biology. Since that time, however, museums of natural history have embraced the entire field of pure science: so that the name science museum has come to be a more suitable one. In the United States some of the greatest institutions have taken the somewhat confusing name of museum of science and industry, though their field in general is applied science — the application of science to industry and to the activities of man. In Europe the situation is similar, since museums concerned with pure science have no specific name indicating their purpose. For matters of classification it is necessary to distinguish the museums of natural history, science, anthropology, and ethnology from the museums of applied science in industry and company museums. As was seen earlier, the museum of natural history, originating in the *museo* or curio cabinet, began to take its own course after such scientists as the Comte de Buffon and Linnaeus made their great inventories of nature and when, following these, collections of specimens were made. The problem of evolution was introduced, and in time Darwin's ideas took hold on museums. After science "turned from picking apart to putting together" (Coleman), the public became less interested in species than in their relationship. The science museums of the United States sensed these trends quickly and caught the interest of the public to an extent which was rarely equaled abroad. Inasmuch as science museums made it their business to visualize complex problems and relate topics to each other, the dividing lines between the branches of science, such as natural history, biology, ethnology and anthropology, could not be drawn closely, nor did it appear necessary to do so.

2. United States. — In the United States the first museum of natural history was founded in Charleston, S.C., in 1773 (incorporated in the Public museum after 1907). That this museum was established at such an early date is due to the fact that the southern part of the eastern seaboard had by that time been explored by scientists like Mark Catesby and John Bartram. Moreover, the marked European interest in the fauna and flora of the new continent may have called for similar attention in the colonies. With his short-lived curio cabinet established in Philadelphia, Du Simitière followed Charleston shortly after 1773. Best known of all early museums was Charles Willson Peale's establishment, which opened in Philadelphia in 1785. It contained some objects of historic interest and many portraits of famous Americans, painted by Peale; there was also a large collection of scientific objects, among them the mastodon Peale himself had excavated. Peale gave talks interpreting his museum. P. T. Barnum con-

TABLE I.—*Selective List of Museums in the United States*
(A=Art; H=History; I= Industry; S=Science)

City	Museum
Albany, N.Y	Albany Institute of History and Art (1791, A H)
Albuquerque, N.M	Museum of Anthropology (1928, S)
Andover, Mass	Addison Gallery of American Art (1930, A)
Ann Arbor, Mich.	Museums of the University of Michigan (1837, S)
Baltimore. Md.	Baltimore Museum of Art (1914, A)
Baltimore, Md.	Walters Art galleries (1931, A)
Birmingham Ala.	Birmingham Museum of Art (1951, A)
Bloomfield gills, Mich.	Cranbrook Institute of Science (1930, S)
Bloomfield Hills, Mich.	Bloomfield Museum of Cranbrook Academy of Art (1930, A)
Boston, Mass.	Institute of Contemporary Art (1936, A)
Boston, Mass.	Isabella Stewart Gardner museum (1900, A)
Boston, Mass.	Museum of Fine Arts (1870, A)
Boston, Mass.	Societv for the Preservation of New England Antiquities (1910, A)
Brunswick, Me.	Bowdoin College Museum of Fine Arts (1894, A)
Buffalo, N.Y.	Albright Art gallery (1905, A)
Buffalo, N.Y.	Buffalo Museum of Science (1861, S)
Cambridge, Mass.	Museum of Comparative Zoology (1859, S)
Cambridge, Mass.	William Hayes Fogg Art museum (1895, A)
Charleston, S.C.	Charleston museum (1773, S H)
Chicago, Ill.	Art Institute of Chicago (1879, A)
Chicago, Ill.	Chicago Historical society (1856, H)
Chicago, Ill.	Chicago Natural History museum (1893, S A)
Chicago, Ill.	Museum of Science and Industry (1926, I S)
Chicago, Ill.	Oriental institute (1931 A)
Cincinnati, O.	Cincinnati Art museum (1880, A)
Cleveland, O.	Cleveland Museum of Art (1913, A)
Cleveland, O.	Cleveland Museum of Natural History (1920, S)
Colorado Springs, Colo.	Colorado Springs Fine Arts centre (1919, A)
Columbus, O.	Ohio State museum (1885, H S)
Cooperstown, N.Y.	National Baseball Hall of Fame and museum (1939, H)
Cooperstown, N.Y.	New York State Historical association (1899, A H)
Corning, N.Y.	Corning Museum of Glass (1931, I)
Dallas, Tex.	Dallas Museum of Fine Arts (1902, A)
Davenport, Ia.	Davenport Municipal Art gallery (1925, A)
Dayton, O.	Dayton Art institute (1913, A)
Denver, Colo.	Denver Art museum (1917, A)
Denver, Colo.	Colorado Museum of Natural History (1900, S)
Detroit, Mich.	Historical museum (1928, H)
Detroit, Mich.	Detroit Institute of Arts (1884, A)
Doylestown, Pa.	Bucks County Historical society (1880, A H I)
Ft. Worth, Tex.	Ft. Worth Art museum (1910, A)
Hartford, Conn.	Wadsworth athenaeum (1842, A)
Honolulu, Hawaii	Bernice P. Bishop museum (1889, S)
Honolulu, Hawaii	Honolulu Academy of Arts (1922, A)
Houston, Tex.	hluseum of Fine Arts of Houston (1925, A)
Indianapolis, Ind	John Herron Art museum (1883, A)
Kansas City, Mo.	William Rockhill Nelson Gallery of Art (1915, A)
Lawrence, Kan.	Thayer Museum of Art (1928, A)
Los Angeles, Calif.	Los Angeles County museum (1911, A S)
Los Angeles, Calif.	Southwest museum (1903, A H S)
Louisville, Ky.	J. B. Speed Art museum (1925, A)
Manchester, N.H.	Currier Gallery of Art (1915, A)
Milwaukee, Wis.	Milwaukee Art institute (1888, A)
Milwaukee, Wis.	Milwaukee Public library, art department (1897, H S)
Minneapolis, Minn.	Minneapolis Institute of Arts (1883, A)
hfinneapolis, Minn.	Walker Art centre (1939, A)
Newark, N.J.	Newark Museum association (1909, A H I S)
New Haven Conn.	Peabody Museum of Natural History (1866. S)
New Haven: Conn.	Yale University Art gallery (1831. A)
New London, Conn.	Lyman Allyn museum (1932, A)
New Orleans La.	Isaac Delgado Museum of Art (1910, A)
New Orleans: La.	Louisiana State museum (1906, A H S)
Newport News, Va.	Mariner's museum (1930, I)
New York, N.Y.	American Museum of Natural History (1869, S)
New York, N.Y.	Brooklyn museum (1889, A S)
New York, N.Y.	Brooklyn Institute of Arts and Sciences (1823, I S)
New York, N.Y.	Frick collection (1935, A)
New York. N.Y.	Hispanic Society of America (1904, A)
New York, N.Y.	Jewish museum (1947, A H)
New York, S.Y.	Metropolitan Museum of Art (1870, A)
New York, N.Y.	hluseum of the American Indian (1916, H S)
New York, N.Y.	hluseum of the American Numismatic society (1908, A)
New York, N.Y.	Museum for the Arts of Decoration (Cooper Union) (1896, A)
New York, N.Y.	Museum of the City of New York (1923, H)
New I'ork, N.Y.	Museum of Rlodern Art (1929, A)
New York, N.Y.	Museum of Non-Objective Painting (1937, A)
New York, N.Y.	New York Historical society (1804, A H)
New York, N.Y.	Picrpont Morgan library (1924, A)
New York, N.Y.	Whitney Museum of American Art (1930, A)
Northampton, Mass.	Smith College hluseum of Art (1881, A)
Oberlin, O.	Dudley Peter Allen Art museum (1917, A)
Omaha, Neb.	Joslyn Art museum (1931, A)
Philadelphia, Pa.	Academy of Natural Sciences of Philadelphia (1812, S)
Philadelphia, Pa.	Atwater Kent museum (1939, H)
Philadelphia, Pa.	Commercial museum (1894, I)
Philadelphia, Pa.	Franklin Institute of the State of Pennsylvania (1824, I)
Philadelphia, Pa.	Historical Society of Pennsylvania (1834, H)
Philadelphia, Pa.	Pennsylvania Academy of the Fine Arts (1805, A)
Philadelphia, Pa.	Philadelphia Museum of Art (1875, A)
Philadelphia, Pa.	University Museum of the University of Pennsylvania (1889, A S)
Pittsburgh, Pa.	Carnegie Institute Department of Fine Arts (1896, A)
Pittsburgh, Pa.	Carnegie museum (1895, S)
Pittsfield, Mass.	Berkshire museum (1903, H S)
Portland, Ore.	Portland Art museum (1892, A)
Princeton, N.J.	Art museum (1889, A)
Providence, R.I.	Rhode Island School of Design, Museum of Art (1877, A)
Richmond Va.	Virginia Museum of Fine Arts (1919, A)
Rochester, N.Y.	hluseum of Arts and Sciences (1914, H I S)
Rochester, N.Y.	Memorial Art gallery (1913, A)
Sacramento, Calif.	E. B. Crocker Art gallery (1885, A)
St. Louis, Mo.	City Art museum (1912, h)
Salem. Mass.	Essex institute (1848, A H)
Salem, Mass.	Peabody Museum of Salem (1867, H I S)
San Diego, Calif.	Fine Arts Society of San Diego (1925, A)
San Francisco, Calif.	California Academy of Sciences (1853, S)
San Francisco, Calif.	California Palace of the Legion of Honor (1924, A)
San Francisco, Calif.	M. H. de Young Memorial museum (1895, A)
San Francisco. Calif.	San Francisco Museum of Art (1921, A)
San Marino, Calif	Henry E. Huntington Library and Art gallery (1919, A)
Santa Barbara, Calif.	Santa Barbara Museum of Art (1938, A)
Santa Fe, N.M.	Museum of International Folk Art (1950, A H)
Santa Fe, N.M.	Museum of New Mexico (1909, A H)
Sarasota. Fla.	John and Mabel Ringling Museum of Art (1946, A H)
Seattle, Wash.	Seattle Art Museum (1906, A)
Springfield, Mass.	Museum of Fine Arts (1933, A)
Syracuse, N.Y.	Museum of Fine Arts (1896, A)
Toledo. O.	Toledo Museum of Art (1901, A)
Tucson, Ariz.	Arizona State museum (1893, H S)
Tulsa, Okla.	Philbrook Art centre (1939, A)
Washington, D.C.	Corcoran Gallery of Art (1869, A)
Washington, D.C.	Dumbarton Oaks Research Library and collection (1940, A)
Washington, D.C.	Freer Gallery of Art (1923, A)
Washington, D.C.	Army Medical museum (1862, S)
Washington, D.C.	National Collection of Fine Arts (1906, A)
Washington, D.C.	National Gallery of Art (1937, A)
Washington, D.C.	Phillips collection (1918, A)
Washington, D.C.	Textile Museum of the District of Columbia (1925, A I)
Washington, D.C.	U.S. National museum (1875, A H I S)
Wellesley, Mass.	Farnsworth Art museum (1875, A)
Williamsburg, Va.	Colonial Williamsburg (1931, A H I)
Williamstown, Mass.	Lawrence Art museum (1927, A)
Winterthur, Del.	Henry Francis du Pont Winterthur museum (1951, A H)
Worcester, Mass.	Worcester Art museum (1896, A)

sidered museum work a business requiring shonmanship. In addition to these. there were collections such as those established by the Academy of Natural Sciences of Philadelphia (founded 1812) and the Boston Society of Natural History (1830) Both museums still rank high and contain valuable material. The great era of the U.S natural history museum was initiated under the leadership of Louis Agassiz, through the foundation of the Museum of Comparative Zoology, as a part of Harvard university in 1859. Agassiz' great plan to establish a museum with working collections for the specialists and scientifically arranged displays for general instruction was carried out. Theories concerning displays changed as times changed. but the museum remained active and was able to adhere to the fundamental idea of its founder.

U.S. National Museum.—The story of the United States National museum in Washington. D.C., is an involved one. It dates from a collection of objects included in the Smithson bequest of 1826. There were abortive efforts to create a national institute for the promotion of science in 1846. The present name was no: legally adopted by the government collection until 1876, when the Centennial exhibition was held. Prior to this Samuel F. Baird, the secretary of the Smithsonian institution, had been "keeper of the cabinet," and it was due to his influence that the cabinet was made a national museum and a new building dedicated in 1881. George Brown Goode became assistant director in 1887 and until his death in 1896 was in full charge of the museum. Goode was an extraordinarily' able administrator and an inspired museum man who recognized the needs of his time and nho abounded in ideas that he knew how to put into effect. In the course of its development the Smithsonian institution created a number of subdivisions, some of which were dedicated to the fine arts (United States National museum, Sational Gallery of Art, Freer Gallery of Art), others being concerned with specialized scientific fields (National Air museum, Astrophysical observatory, Bureau of American Ethnology and others).

American Museum of Natural History.—The founding of the American Museum of Natural History in Sew York in 1869 marked an important step in U.S. museum history because with this event the interest of the public in the museum as an institution was definitely recognized. The city of New York provided the building and its maintenance, while the scientific work was taken care of by private funds, a system which later was adopted elsewhere. True to its policy, the museum developed "the study

TABLE 11.—Selective List of Museums Outside the United States

Country and City	Museum
Algeria	
Algiers	Musée National d'Alger (1930, paintings, sculpture, minor arts)
Argentina	
Buenos Aires	Museo Argentino de Ciencias Naturales (1823, science)
	Museo Histórico Kacional (1890, colonial, 19th-century art)
	Museo Nacional de Bellas Artes (1895, modern paintings)
Austria	
Vienna	Gemaldesammlung der Akademie der Bildenden Kunste (1820, old masters)
	Kunsthistorisches Museum (1891, oriental, ancient art, old masters, minor arts)
	Katurhistorisches Museum (1889, science)
	Österreichische Galerie (1923, old masters, modern paintings)
	Österreichisches Museum fur Kunst und Industrie (1863, minor arts)
Australia	
Adelaide	National Gallery of South Australia (1881, paintings)
	South Australian museum (1856, science)
Brisbane	Queensland museum (18jj, science)
	Queensland National Art gallery
Melbourne	National Gallery of Victoria (1859, paintings, minor arts)
Sydney	Australian museum (1827, science)
	National Art Gallery of New South Wales
Belgium	
Antwerp	Koninklijk Museum voor Schone Kunsten (1810, mostly old masters)
Bruges	Musée des Beaux-Arts (old masters)
Brussels	Musée Royal du Congo Belge (1897, science)
	Musée Royal d'Histoire Naturelle de Belgique (1842, science)
	Musées Royaux d'Art et d'Histoire (1835, ancient art, historical objects, minor artsi
	Musées Royaux des Beaux-Arts de Belgique (1830, old masters, modern paintings)
Liège	Musée des Beaux-Arts (1819, paintings of all periods)
Bolivia	
La Paz	Museo Nacional "Tihuanacu" (1925, archaeology, science)
Potosf	Museo Nacional de la Casa de Moneda de Potosf (1938, colonial and minor arts)
Brazil	
Pará	Museu Goeldi de História Natural e Etnografia (1871, science)
Rio de Janeiro	Museu de Arte Moderna (1951, paintings)
	iiluseu Histórico Nacional (1922, historical objects, minor arts)
	Museu Nacional (1818, science)
	Rfuseu Nacional de Belas Artes (1816, Brazilian paintings)
Bulgaria	
Sofia	National museum (1893, art of all periods)
	Natural Science museum (1889, science)
Canada	
Halifax	Nova Scotia museum (1868, science, historical objects)
Montrea	Montreal Museum of Fine Arts (1860, paintings, minor arts)
Ottawa	National Gallery of Canada (1880, paintings of all periods)
	National Museum of Canada (1842, science)
Toronto	Art Gallery of Toronto (1900, European, American paintings)
	Royal Ontario Museum (1912, science, archaeology)
Chile	
Santiago	Museo Nacional de Bellas Artes (1880, Chilean paintings)
	Museo Histórico Nacional de Chile (1911, anthropology, historical objects, minor arts)
	Museo Nacional de Historia Natural (1830, science)
China (Formosa/Taiwan)	National Palace museum
	National Central museum
China (People's Republic)	Museum of Historical Relics
	National Peking Palace museum (Chinese art)
Colombia	
Bogotá	Museo de Arte Colonial (1942, colonial art)
	Museo de Bellas Xrtes (European, colonial paintings)
	Museo del Instituto de la Salle (1905, science)
	Museo Nacional (1824, historical objects, art)
	Museo Nacional de Etnologia y Arqueología (1931, sciencei
	Museo del Oro (1936, native gold objects)
Costa Rica	
San José	Museo Nacional (1885, archaeology, industrial arts, science)
Cuba	
Havana	Instituto Nacional de Investigationes Científicos y Museo (science)
	Museo Nacional (1913, archaeology, art)
Czechoslovakia	
Prague	National museum (1818, prehistory, archaeology, art, science)
	National Technical museum
Denmark	
Copenhagen	Danske Folke Museum (1879, folklore)
	Kunstindustrimuseet (1894, minor arts)
	Nationalmuseet (1807, prehistory, archaeology, ethnography, ancient art)
	Naturhistorisk Museum (1921, science)
	Ny Carlsberg Glyptothek (1888, ancient art)
	Rosenberg Slot (minor arts, old paintings)
	Statens Museum for Kunst (1760, art of all periods)
Frederiksborg	Det Nationalhistoriske Museum (1877, historical ohjects, paintings)
Dominican Republic	
Ciudad Trujillo	Galería Nacional de Bellas Artes (art)

Country and City	Museum
Dominican Republic	
Ciudad Trujillo—Cont	Museo Kacional (1927, archaeology, ethnography, paintings, minor arts)
Ecuador	
Quito	Museo Unico Nacional (1916, colonial, contemporary paintings, minor arts)
	Museos de la Universidad Central del Ecuador (science)
Egypt	
Cairo	Arab Art Museum (1881)
	Coptic museum (1908)
	Egyptian museum (1900)
	Geological museum (1898)
El Salvador	
San Salvador	Museo Nacional (1883, science and industry)
	Museo Nacional de El Salvador (1940, archaeology)
Finland	
Helsinki	Kansallismuseo (1893, archaeology, ethnology, history)
France	
Amiens	Musée de Picardie (1854, old masters, minor arts, historical objects)
Chautilly	Musée de Chantilly (1885, old masters, minor arts)
Colmar	Musée d'Unterlinden (1847, old masters, sculpture, Grunewald paintings)
Dijon	Musée des Beaux-Arts (1799, old masters, sculpture, minor arts)
Lille	Musée des Beaux-Arts (1801, old masters, archaeology)
Lyons	Musée des Beaux-Arts (1801, old, modern masters, minor arts)
Paris	Musée des Arts Decoratifs (1880, minor arts)
	Musée du Conservatoire National des Arts et Métiers (1794, models of machines)
	Musée Guimet (1883, art and religion of orient and far east)
	Musée National d'Histoire Naturelle (1635, science)
	Musée de l'Homme (1937, ethnography)
	Musée du Louvre (1793, all periods of art)
	Musée National des Monuments Français (1882, plaster casts of French sculpture)
	Musée National d'Art Moderne (1937, modern paintings)
	Musée National des Arts et Traditions Populaires (1937, folklore)
	Musée des Thermes et de l'Hôtel de Cluny (1844, mediaeval minor arts)
Rouen	Musée des Beaux-Arts et de Céramique (archaeology, ancient art)
St. Germain-en-Laye	Musée des Antiquités Nationales (1862, archaeology)
Strasbourg	Musée des Beaux-Arts (1803, old masters, sculpture, minor arts)
Tours	Musée des Beaux-Arts (1790–93, old masters, sculpture, minor arts)
Versailles	Musée National d'Histoire de France (1837, paintings)
Germany (western)	
Augsburg	Staatliche Gemäldesammlung (1835) and Schaezler Haus (1854, old masters, sculpture)
Bamherg	Staatliche Gemäldesammlung (old masters)
Berlin (west)	Museum Dahlem (1951, paintings, sculptures, prints and drawings of all periods, minor arts, far eastern art, ethnology)
	Schloss Charlottenbura (minor arts, temporarv exhibitions)
Bremen	Kunsthalle Bremen (1823, paintings of all periods)
Brunswick	Herzog Anton Ulrich-Museum (1754, old masters, minor arts)
Cassel	Hessisches Landesmuseum (1580, paintings and sculpture of all periods, minor arts, historical ohjects)
Cologne	Wallraf-Richartz-Museum (1824, paintings, sculpture of all periods)
	Rheinisches Rluseum (1936, history, folklore)
	Schnütgen-Museum (1906, religious art)
Darmstadt	Hessisches Landesmuseum (1790, old masters, sculpture, historical objects, etc., sciences)
Donaueschingen	Fiirstlich Fiirstenbergische Sammlungen (1868, old masters)
Dortmund	Museum fur Kunst und Kulturgeschichte (1883, old masters, minor arts, historical objects)
Diisseldorf	Kunstsammlungen der Stadt Diisseldorf (paintings of all periods, sculpture and minor arts)
Frankfurt	Stadelsches Kunstinstitut (1817, paintings all periods)
	Stadtische Museen (paintings, sculpture of all periods, minor arts, historiral ohjects)
Hamburg	Kunsthalle (1869, paintings, sculpture of all periods)
	Museum für Kunst und Gewerbe (1874, minor arts)
	Hamburgisches Museum für Völkerkunde und Vorgeschichte (1850, ethnology, anthropology, prehistory)
Hanover	Niedersachsisches Landesmuseum Hannover (1856, old masters and sculpture)
Karlsruhe	Staatliche Kunsthalle (1803, 18th century, paintings of all periods)
Lubeck	Staatliche Museen (1824, paintings, sculpture of all periods, minor arts)
Mainz	Romisch-germanisches Zentralmuseum (1852, prehistory, archaeology, ancient art)
Mannheim	Stadtische Kunsthalle (1909, art of all periods)
Munich	Bayerische Staatsgemäldesammlungen (1825, paintings of all periods)
	Bayerisches Nationalmuseum (1855, minor arts, old paintings and sculpture)
	Deutsches Museum (1903, industry, science)
	Wissenschaftliche Sammlungen des Staates, München (science, ethnology, anthropology)
Nürnberg	Germanisches Nationalmuseum (1852, historical objects, minor arts, old paintings and sculpture)
Stuttgart	Württembergische Landeskunstsammlungen (prehistory, art of all periods, historical objects)
Wiesbaden	Nassauisches Landesmuseum (1821, paintings of all periods, minor arts, science)

TABLE 11.—Selective List of ***Museums*** *Outside the United States—Cont'd.*

Country and City	Museum
Würzburg	Mainfränkisches Museum (1913, sculpture, paintings, minor arts)
Germany (eastern)	
Altenburg	Lindenau museum (old Italian masters)
Berlin (east)	Staatliche hluseen zu Berlin (1830, ancient, oriental and Egyptian art, paintings of all periods, sculpture)
	Museum für Deutsche Geschichte
Dresden	Deutsches Hygiene Museum
	Staatliche Kuustsammlungen Dresden (art)
	Staatliche Museum fur Volkerkunde (ethnography)
	Museum für Volkskunst (folk art)
Leipzig	Museum der bildenden Kunste (1837, paintings of all periods)
	Museum fur Völkerkunde Leipzig (ethnography)
	Stadtisches Kunstgewerbe Museum (1837, minor arts)
Weimar	Staatliche Kunstsammlungen (1923, paintings of all periods)
Great Britain	
Barnard Castle	Bowes museum (1869, European art, mediaeval to 19th century)
Birmingham	Museum and Art gallery (1867, paintings, archaeology, science)
Cambridge	Fitzwilliam museum (1816, paintings of all periods, minor arts, ancient, Egyptian art)
Cardiff	National Museum of Wales (1907, archaeology, minor arts, folklore, science)
Dulwich	Dulwich College gallery (1626, old masters)
Edinburgh	National Gallery of Scotland (1859, paintings of all periods)
	Xational Museum of Antiquities of Scotland (1780, prehistory, ancient art, archaeology)
	Royal Scottish museum (1854, archaeology, minor arts, science, technology)
	Scottish National Portrait gallery (1882)
Glasgow	Art Galleries and museum (1856, painting. of all periods, minor arts, science)
Greenwich	National Maritime museum (1934, maritime history)
Hull	hlunicipal museum (archaeology, minor arts, industry, science)
Leeds	Leeds City museums (1820, archaeology, science)
Liverpool	Liverpool Public museums (1851, science, archaeology)
	Walker Art gallery (1877, mainly English paintings)
London	British museum (1753, archaeology, ancient, oriental, far eastern art, books)
	British museum (Natural History)
	Geological museum (1835, geology)
	Imperial War museum (1917, historical objects)
	National gallery (1824, paintings of all periods)
	National Portrait gallery (18j7)
	Royal College of Surgeons' museum (1813, science)
	Science museum (1857, science and industry)
	South Kensington Imperial institute (1887, industry)
	Tate gallery (1897, British paintings from 17th century to contemporary)
	Victoria and Albert museum (1852, minor arts, sculpture)
	Wallace collection (1900, paintings, minor arts from the Renaissance to 18th century)
Manchester	Manchester museum (1821, archaeology, science)
Oxford	Ashmolean museum (1683, archaeology, ancient, oriental art, paintings of old masters, minor arts)
	Pitt River museum (1883, ethnology)
Greece	
Athens	National Archaeological museum (1866, archaeology, art)
Guatemala	
Guatemala city	Museo Nacional de Historia y Bellas Artes (1935, historical objects, works of art)
Haiti	
Port au Prince	Musée Sational (1938, historical objects)
	Musée du Peuple Haitien (1950, archaeology, folklore)
Honduras	
Tegucigalpa	Museo Nacional (1925, science, archaeology)
Hungary	
Budapest	Hungarian National Historical museum (1802, art, history, science)
	Hungarian Museum of Fine Arts (1896, all fields of art)
	Hungarian National Museum of Natural History (1820, science)
Iceland	
Reykjavik	National museum (1863, archaeology)
	Museum of Natural History (1889, science)
India	
Baroda	Baroda Museum and Picture gallery (1894, European art, science)
Bombay	Victoria and Albert museum (1855, Indian archaeology, science)
Calcutta	Indian museum (1813, 1867, science and industry)
New Delhi	National Museum of India (1948, Indian archaeology, art)
	National Gallery of Modern Art (1956)
Indonesia	
Djakarta	Museum of Archaeology (1868)
Iran	
Tehran	Anthropological museum (1938)
	Archaeological museum (1936)
Iraq	
Baghdad	Iraq museum (1923, archaeology, near eastern art)
Irish Republic	
Dublin	National museum (1731, archaeology, art, industry, science)
Israel	
Jerusalem	Bezalel National museum (1906, Jewish religions art)
	Museum of Jewish Antiquities (1941, archaeology)
Tel Aviv	Tel Aviv Museum of Art (1931, modern art)
Italy	
Bergamo	Galleria dell'Accademia Carrara (1796, old masters:
Bologna	Museo Civico (1881, archaeology, old masters, minor arts)
Bologna—cont.	Museo di Storia Naturale (1884, science)
	Pinacoteca Nazionale (1808, old masters)
Faenza	Museo Internazionale delle Ceramiche (1908, minor arts)
Ferrara	Pinacoteca Civica (1836, old masters)
Florence	Galleria dell'hccademia (end of 18th century, old masters)
	Galleria Palatina (Pitti) (17th century, old masters)
	Galleria degli Uffizi (16th century, old masters)
	hluseo Nazionale (Bargello) (1865, Renaissance sculpture, minor arts)
Genoa	Galleria di Palazzo Bianco (1892, old masters)
	Museo Civico di Storia Naturale (1867, science)
Milan	Museo Civico (Castello Sforcesco) (1900, archaeology, sculpture, old masters, minor arts)
	Museo Poldi Pezzoli (1887, old masters)
	Pinacoteca di Brera (1809, old masters)
Modena	Galleria, Museo e Medagliere Estense (15th century, old masters)
Naples	Museo Nazionale (1800, ancient art)
	Museo Nazionale di S. Martino (1872, minor arts)
	Museo e Gallerie Nazionale di Capodimonte (1738, old and 19th-century masters, minor arts)
Palermo	Galleria Nazionale della Sicilia (old masters)
Parma	Galleria Nazionale (1752, old masters)
Rome	Galleria Nazionale d'Arte Antica (1895, old masters)
	Galleria Nazionale d'Arte Moderna (1883, 19th-century paintings)
	Musei Capitolini (1734, ancient sculpture)
	Musei e Gallerie di Pittura del Vaticano (ancient and Renaissance art)
	Museo e Galleria Borghese (1901, old masters)
	Musei del Laterano (1843, ancient art, early Christian art. ethnology)
	Museo Nazionale Romano (1889, ancient art)
	Museo di Palazzo Venezia (1921, old masters, sculpture, minor arts)
Siena	Pinacoteca Nazionale (1930, old masters)
Turin	Galleria Sabauda (1832, old masters)
	Museo di Antichità (19th century, prehistory, archaeology)
Crbino	Galleria Nazionale delle Marche (1912, old masters)
Venice	Gallerie dell'Accademia (1756, old masters)
	Civico Museo Correr (1830, minor arts)
	Raccolte del Settecento Veneziano a ca' Rezzonico (1936, minor arts)
Japan	
Kyoto	Kyoto National museum (1889, mostly paintings from temples)
Nara	Nara National museum (1895, mostly sculptures from temples)
	Hōryūji temple (paintings and sculpture)
Tokyo	National museum (1873, all fields of eastern art)
	National Science museum (1931)
Lebanon	
Beirut	National Museum of the Lebanon (1920, archaeology)
Mexico	
Mexico City	Museo Nacional de Artes Plásticas (1947, modern art)
	Galerias Nacionales de Pintura y Escultura (colonial and European paintings up to 19th century)
	Museo de Arte Popular (folk art)
	Museo Nacional de Historia (1822, historical objects, paintings, minor arts)
	Museo de Historia Natural (1915, science)
	Museo de Flora y Fauna Nacional (1937, sciencej
	Museo Xacional de Antropologia (1825)
Monaco	
Monte Carlo	Musée Océanographique (1899, science)
Netlierlands	
Amsterdam	Rijksmuseum (1808, painting, sculpture, minor arts, historical objects)
	Stedelijk Museum (1895, modern paintings)
Arnhem	Rijksmuseum voor Volkskunde "Het Nederlands Openluchtmuseum" (1918, folklore)
Haarlem	Teyler's Museum (1778, science)
The Hague	Gemeentemuseum (1883, minor arts, modern paintings)
	Koninklijk Kabinet van Schilderiien (Mauritshuis) (1821, old masters)
Leyden	Rijksmuseum van Natuurlijke Historie (1820, science)
Rotterdam	Museum Boymans (1847, old masters, modern paintings, minor arts)
Utrecht	Centraal Museum der gemeente Utrecht (old masters, minor arts, archaeology)
New Zealand	
Aucbland	Auckland Institute and Museum (1852, science)
Wellington	Dominion museum (1865, science)
Nicaragua	
hianagua	Museo Nacioual de Nicaragua
Norway	
Bygdøy	Norsk Folkemuseum (1894, folklore)
Oslo	Kunstindustrimuseet i Oslo (1876, minor arts)
	Nasjonalgalleriet (1837, paintings of all periods)
	Universitetets Etnografiske Museum (1857, science)
Trondheim	Folkemuseet (1913, folklore)
Pakistan	
Karachi	National Museum of Pakistan (1950, Indian archaeology and art)
Lahore	Central museum (1864, Indian sculpture and paintings)
Peshawar	Museum (1907, Ghandara sculpture)
Panamá	
Panamá city	Museo Nacional de Panamá (1925, science, archaeology, ethnology, historical objects)
Paraguay	
Asunción	Museo de Historia Natural y Etnografia (1929, science)

TABLE II.—*Selective* List of *Museums Outside the* United States—Cont'd.

Country and City	Museum
Peru	
Lima	Museo Nacional de la Repdblica (archaeology, anthropology, colonial art)
	Museo Nacional de Bellas Artes (1947, paintings of all periods)
	Rfuseo de Historia Natural "Javier Prado" (1918, science)
Philippines	
Manila	National Museum (1901, historical objects, science)
Poland	
Cracow	National museum (1879, art of all periods)
Poznan	Museum of Natural Science (1903, science)
Warsaw	Museum Zoologicum Polonicum (science)
	State Archaeological museum (1928, archaeology)
	Kational museum (1862, paintings, minor arts)
Portugal	
Lisbon	Museu Nacional de Arte Antiga (1883, art of all periods)
	Museu Nacional de Historia Natural (science)
Rumania	
Bucharest	Museum of Art and Archaeology (1912)
	Natural History museum (1834, science)
Spain	
Barcelona	Museo de Bellas Artes de Cataluña (Arte Antiguo) (1934, mediaeval paintings and sculpture)
Madrid	Museo de Ciencias Naturales (1771, science)
	Museo Etnolhgico (1875, science)
	Rfuseo Arqueológico Nacional (1867, archaeology)
	Museo del Prado (1819, paintings of all periods, sculpture)
South Africa, Union of	
Bloemfontein	National museum (1877, history)
Cape Town	South African museum (1855, science)
	South African National gallery (1871, paintings)
Sweden	
Göteborg	Göteborgs Museum (1861, art of all periods, historical objects, science)
Lund	Kulturhistoriska Museet (1882, archaeology, art, science, historical objects)
Malmo	Museum (1841, art, science)
Stockholm	Nationalmuseum (1792, paintings of all periods)
	Naturhistoriska Riksmuseet (1819, science)
	Nordiska Museet (1873, ethnology, minor arts, folklore)
	Skansen (1891, folklore)
Switzerland	
Basle	Museum für Völkerkunde und Schweizerisches Museum fur Volkskunde (1892, ethnology, folklore)
	Oeffentlichie Kunstsammlung (1662, paintings of all periods, minor arts)
Berne	Kunstmuseum (1879, paintings of all periods)
	Naturhistorisches hluseum (1694, science)
Geneva	Musée d'Art et d'Histoire (1910, paintings of all periods, minor arts)
	Musée d'Histoire Naturelle (1811, science)
Winterthur	Kunstmuseum (1866, paintings and sculpture from 18th century to the present time)
Zurich	Kunsthaus (1787, paintings from 15th century to the present time)
	Schweizerisches Landesmuseum (1890, prehistory, historical objects, minor arts)
Syria	
Damascus	National museum (1919, archaeology, minor arts)
Thailand	
Bangkok	National museum (1926, archaeology, minor arts)
Tunisia	
Tunis	Musée du Bardo (1888, archaeology and art)
Turkey	
Ankara	Archaeological museum (1923, archaeology, ancient art)
Istanbul	Archaeological Museums of Istanbul (1869, ancient and oriental art)
	Topkapu Palace museum (1924, minor arts)
U.S.S.R.	
Kiev	Museum of Russian Art
	Museum of Western and Eastern Art (old and modern masters)
Leningrad	State Hermitage museum (1764, old and modern masters and archacology)
	Museum of the History of Religion
	State Russian museum (Russian art)
Moscow.	Farm Kuskowo hluseum of Ceramics (near Moscow) (glass, ceramics, 18th-century paintings)
	State Historical museum
	Kremlin museum (decorative arts, carriages, armor)
	State Museum of Anthropology
	hluseum of Modern Western Art
	State Museum of Eastern Cultures
	State Museum of the U.S.S.R. Peoples
	State Pushkin Museum of Fine Arts (old masters, minor arts)
	Museum of the Revolution
	State Tretyakov gallery (Russian art)
	Ostankino palace (near Moscow): Museum of Works Done by Serfs (18th-century paintings)
Uruguay	
Montevideo	Museo Histórico Nacional (1900, historical objects)
	Museo de Historia Natural (1837, science)
	Museo Nacional de Bellas Artes (1911, Uruguayan paintings)
Venezuela	
Caracas	Museo de Arte Colonial (1942)
	Museo de Bellas Artes (1938, Venezuelan and European paintings)
	Museo de Ciencias Naturales (1940, science)
Yugoslavia	
Belgrade	Ethnographical museum (1901, science, folklore)
	Belgrade Natural Science museum (1901, science)
	Museum of Art and Archaeology (1901)
Ljubljana	National Art gallery (1918, old masters, especially Slovenian)
	National museum (1821, prehistory, archaeology)
Zagreb	Croatian National museum (1880, science, history)

of natural sciences, advanced the general knowledge of kindred subjects and furnished popular instruction" to an untold number of visitors. To continue to enjoy such popularity it was necessary at times to modify the original concept of the museum. The museum embraces all branches of natural history and anthropology, as well as the whole field of ecology. It also has become a centre for the study of many scientific problems of world concern.

Chicago Natural History Museum.—This museum was founded at the close of the World's Columbian Exposition of 1893 with the aid of Marshall Field, for whom it was originally named. It has expanded in an extraordinary way. By the early 1950s the museum had sent out more than 400 expeditions to all parts of the world, thus receiving much important material. Keeping close contact with the Chicago school system, the museum provides schools with unusually fine circulating exhibits.

Other C.S. *Museums.*—Among the other museums; the Buffalo Museum of Science (organized in 1861) deserves special attention, since it began to arrange its exhibits with special reference to educational needs at a very early date. The museum also became well known as a training centre for museum workers.

3. Europe. — In selecting some of the most important museums of science in Europe, it seems appropriate to begin with the Jardin des Plantes in Paris, which possibly is the oldest one in existence. It was founded in 1626 as an herb garden for medical purposes; its present collections include specimens collected by Buffon around 1739. From the early 18th century the Jardin des Plantes served as an educational institution, gradually extending its activities until it comprised a huge conglomeration of experimental gardens, living specimens of animals, and large collections in which courses were given and to which the public was admitted. In 1793 the institution was reorganized as a kind of public university of science based on its manifold collections.

Throughout the 19th century, science museums with general interests or with special interests in anthropology and ethnology were established all over the norld. The French geographer Edmé François Jomard nas the first to point out the possibilities of museums of ethnology, his ideas being carried out in Copenhagen in 1841.

The oldest science museum in Great Britain is the Ashmolean museum, established in 1683 by the University of Oxford to house the Tradescant collection given by Elias Ashmole. In 1925 the museum was completely reorganized as a museum to illustrate the history of science. Great Britain's most important natural history museum. a branch of the British museum, originated in the science material of Sir Hans Sloane. It occupied premises at South Kensington in 1881–86. The museum is supplemented by the Geological museum, Kew gardens (*q.v.*), with its herbarium and other botanical collections, and the Royal College of Surgeons' museum. nhich is devoted to anatomy.

Among the privately organized museums are two that deserve special attention. One, the Pitt River museum (now part of Oxford university), is unique in that it illustrates the evolution of civilization nithout regard to race and thus admits material not always found in museums of ethnology. The other is a local museum but one nhich proved nithout precedent in its far-reaching influence as an educational institution. This is the Haslemere museum, founded by Sir Jonathan Hutchinson in 1888. It was Hutchinson's idea to create a local museum which would illustrate for the layman the history of man and the natural sciences. It was arranged so that visitors could see the material at close range and. if possible, handle it; they could also see groning plants in the museum garden and study birdlore. Charts, such as comparative schedules of geology and human history, form substantial

parts of the collection.

In Germany the Berlin Museum of Ethnology was one of the outstanding museums of its kind. Under the leadership of Adolf Bastian it accumulated extraordinary collections. particularly from the Americas and Asia. The building and much of its valuable collections were destroyed during and after World War II. What was left of the collections is shown in Dahlem (west Berlin). Most countries, in all parts of the world, have natural history museums. Usually they are the last to be reorganized to suit modern needs.

The planetarium and the aquarium also became accepted institutions much favoured by the public. The oldest aquarium is in Naples (established in 1872). The first planetarium was constructed by Carl Zeiss in Jena, Ger., between 1919 and 1924 for the Deutsches Museum in Munich; the first one to be opened in the United States was the Adler planetarium in Chicago (1930).

D. Industry Museums

1. General Development. — The museum of science and industry is concerned with spreading knowledge about the application of science to industry and what this means in the pattern of our civilization. During the early years of the museum of science and industry questions were raised as to whether these new museums would merely represent the wonders of industry without rendering educational service and without implying any social aspects. These questions were answered in the guidebook of the Chicago Museum of Science and Industry. which stated as early as 1936 that the museum would be concerned with man as a social being. As long as museums of industry recognized the social implications of progress in industry they would never become exhibitions promoting industry for its own sake. Museums of science and industry do not try to illustrate fully and comprehensively all of their subject. To a certain extent this task is done by so-called company museums. These are museums created by industry in which the history of particular products is recorded. One of the earliest of this type of museum nas the Button museum of the Waldes company in Prague. Bohemia, established in 1916. which included models of all the fastening devices of the norld and which even published a scholarly bulletin. Specialized museums of this kind were created throughout Europe and the U.S. Other specialized museums owe their existence to the interest of collectors, to communities or governments wishing to foster commercial products. Some museums of this type are: carving (Oberammergau, Ger.); ceramics (Faenza, Italy; Sèvres, France); circus (Sarasota, Fla.); coaches (Belém, Port.; Compiègne, France; Nymphenburg, Ger.); farming (Cooperstonn, N.T.; Cassville. Wis.); glass (Corning, N.Y.); iron (Rouen, France); lacquer (Cologne, Ger.); steel (Worcester, Mass.); taxes (Freudenstadt, Ger.).

2. United States. — The Franklin institute in Philadelphia, Pa., was founded in 1824 for the "study and progress of the mechanical arts and applied science" and is one of the oldest institutions in the United States. It was housed for nearly a century in a building on Seventh street and was moved to its present structure in 1923. The building houses the library of the institute and the Fels planetarium, as well as the museum. Many of its exhibits represent the most modern techniques employed in the science museum field. It exhibits both the basic physical sciences and their applications in industry. Its first industrial exhibition was held in 1824 and was aimed at the encouragement and development of the country's early industries. This initial exhibition mas so successful that it was repeated annually for a number of years. and these were the first major industrial exhibitions in the Cnited States. In addition to its exhibits on pure and applied science, many of which are visitor-operated, historical exhibits in sea, land and air transportation and other fields are on display. Its publication, *Franklin Institute Journal*, first published in 1826, has always maintained a high standard, being devoted to developments in the fields of science and their applications to industry. Lectures on pure and applied science have been given since 1824. The institute's library houses an outstanding collection of scientific literature.

The Museum of Science and Industry in Chicago owes its existence to the interest of Julius Rosenwald who had seen the Deutsches Museum in Munich and wished to see a museum of this type established in the U.S. In spite of its relatively recent origin (1916), this museum has attained an outstanding position and attracts several million visitors a year by its dynamic and ever growing installations. Its subject matter includes the basic physical sciences and their application to various industries. Neither a repository for historic materials nor a research institution: it devotes all its efforts to serving the general public and school groups as an educational institution. No uniform method of display is utilized. Each exhibition area is individually designed to present to the visitor a sequential, educational story. Extensive use of visitor-participation devices and demonstrations is made. Among the exhibits, sometimes of enormous size and scope. there are a full-sized coal mine, an operating foundry, a typical farm with full-sized farmhouse, silo, barn, milkhouse and a brooder with live baby chicks. Areas of from 5,000 to 10,000 sq.ft. are devoted to exhibits on such subjects as the automobile, electricity, lumber, rubber, etc. Extensive exhibits in the fields of physics, chemistry and medicine are displayed. The museum is constantly changing, no exhibit being considered permanent. When, as the result of new developments in science and industry or the availability of better exhibition techniques, an exhibit begins losing its interest for the public, it is brought up to date or replaced entirely. Because of its large audience and educational effectiveness, it is heavily supported by industry. New exhibits were being installed at the rate of $1,000,000 per year in the mid-1950s.

The Museum of Science in Boston (1947; formerly the New England Museum of Natural History) also developed rapidly and showed great promise.

3. Europe. — The Musée du Conservatoire National des Arts et Métiers of Paris, founded in 1794, is the world's oldest technical museum and has accumulated a large collection of technical objects. While this state institution, covering 97,000 sq.ft. of floor space on three floors, has kept its traditional austere arrangement as a repository for many years, the Palais de la Découverte answers the need to explain ideas and facts to the public. Based on the ideas of Henri de Jouvenel, this museum presents problems of applied science in an artistic setting and in a highly spirited way. The Science museum in London became administratively independent in 1909. A government institution under the ministry of education, its function is to serve as a repository for the preservation of objects important in the progress of science or in the history of invention. It also aims at presenting information on the basic laws of the physical sciences and their applications through the exhibition of scientific instruments, apparatus, machines and other objects. Many of its installations follow more recently developed exhibition techniques, temporary exhibits being held regularly.

While the Deutsches Museum in Munich (founded in 1903) was opened as late as 1925, it turned out to be the most progressive of its kind and became the pattern for a number of others which were founded later, such as the Museum of Science and Industry in Chicago. The museum owed its existence entirely to the extraordinary initiative of Oscar von Miller, who convinced industry and government authorities of the usefulness of his idea and then started to build up this museum of technology over a period of two decades. The museum owned extremely valuable collections in the history of technology, as well as in the basic physical sciences. A considerable part of these objects were destroyed during World War II. It was, however, rebuilt. Miller was an early leader in developing visitor-operated and demonstration techniques, which, once they had been applied and made use of, could be and were developed by other museums in many directions. Tekniska Museet in Stockholm is one of several museums that followed Oscar von Miller's intentions but later developed methods of its own.

Many countries have old established museums of science and industry of sorts, *e.g.*, Calcutta, established 1814, or have started or reorganized industry museums along the pattern of the

Deutsches Museum. In 1956 Czechoslovakia opened its first museum for science and industry, in Prague. In all instances museums of science and industry have turned out to be among the most popular ones. If visitor figures are regarded as decisive, then one might say that science museums have won in the competition with the older and once all-important art museum. It should be remembered that however important figures may seem they alone do not count. What matters is the effect the museum has on the visitor. How deep this goes and in what it results cannot be analyzed.

See also BOTANICAL GARDENS; LIBRARIES; ZOOLOGICAL GARDENS.

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MUSH (*Muş*), a village in the vilayet of Mus, Asiatic Turkey. It is situated at the mouth of a gorge in the mountains on the south side of the plain. the surrounding hills being covered with vineyards and some oak scrub. The castle, of which there are some remains: is said to have been built by Mushig, an Armenian king of the province Daron. who founded the town. Good roads lead to Erzerum and Bitlis. There were (1955) 10,487 inhabitants. The winter climate is cold. with a heavy snowfall. Several miles to the west at the edge of the plain is the celebrated monastery of Surp Garabed or St. John the Baptist, an important place of Armenian pilgrimage.

Mush plain. 3j mi. long by 12 mi. broad: is very fertile. growing wheat and tobacco. The Murad or eastern Euphrates traverses the western end of the plain and disappears into a narrow mountain gorge there. Wood is scarce and the usual fuel is *tezek* or dried cow dung. There are several sulfur springs, and earthquakes are frequent and sometimes severe.

MUSHET STEEL: see STEELS, ALLOY; TOOL STEEL.

END OF VOLUME FIFTEEN

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